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INNOVATION, LEARING AND RESILIENCY in COVERT ORGANIZATIONS

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1. ABSTRACT

We have become more adept at disrupting terrorist networks; nevertheless, adversaries continue to learn and adapt, posing an enduring threat to the security of America and its allies and partners.
2010 US Defense Quadrennial Review

Organizing principles and mechanisms of learning and innovation in complex adaptive systems are applied to covert organizations to develop a theoretically grounded, system dynamics framework for understanding their capacity for adaptation and resilience, and implications for interrupting learning and diffusion of innovations. This framework suggests different learning and innovation mechanisms depending on organizational structure, resulting in different capacities for resilience. Empirical data on terrorist organizations corroborates the predictions of the conceptual framework.

2. INTEGRATIVE THEORETICAL FOUNDATIONS

SYSTEM DYNAMICS

State properties and and governing equations for co-evolutionary resource utilization and production rates of interacting components

KEY CONCEPTS: THRESHOLDS, TIME DELAYS, FEEDBACK LOOPS, CO-EVOLUTOIN

COMPLEXITY SCIENCE

Self-organizing mechanisms by which systems respond to internally driven goals in presence of exogenous forces and shocks: learning, innovation, adaptation, evolution, punctuated equilibrium

KEY CONCEPTS: NETWORK STRUCTURES DETERMINE LEARNING AND THE EMERGENCE AND DIFFUSION OF INNOVATION

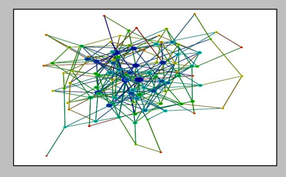
SOCIO-ECOLOGICAL RESILIENCE

The capacity of a system to absorb disturbance and re-organize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks

KEY CONCEPTS: DYNAMIC CYCLES OF STASIS, GROWTH, ACCUMULATION, RESTRUCTURING, RENEWAL

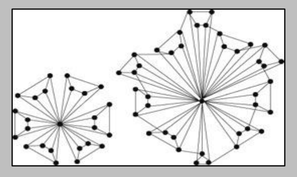
3. HYPOTHESIS

Different innovation mechanisms and adaptive capacities of terrorist organizations, their operative timeframes, and resiliency can be explained by network structures and their influence on complex system dynamics.



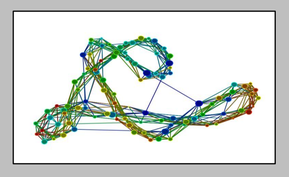
Erdos-Renyi Random

- Short path lengths; time separation of cause and effect
- Slow evolution
- Low probability outlier impact



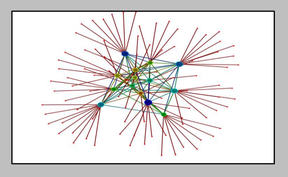
Windmill

- Optimize secrecy and efficiency Long transmission times
- Vulnerability to single point failure drives redundancy



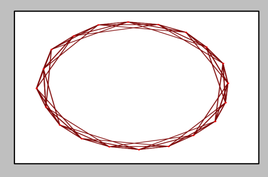
Small World

- Highly clustered
- Short paths through weak links
- Learning and innovation in spurts (punctuated equilibrium)



Core Periphery

- Dense core, sparse periphery
- High transmission rates
- Complex contagion and adaptation via thick inks



Ring

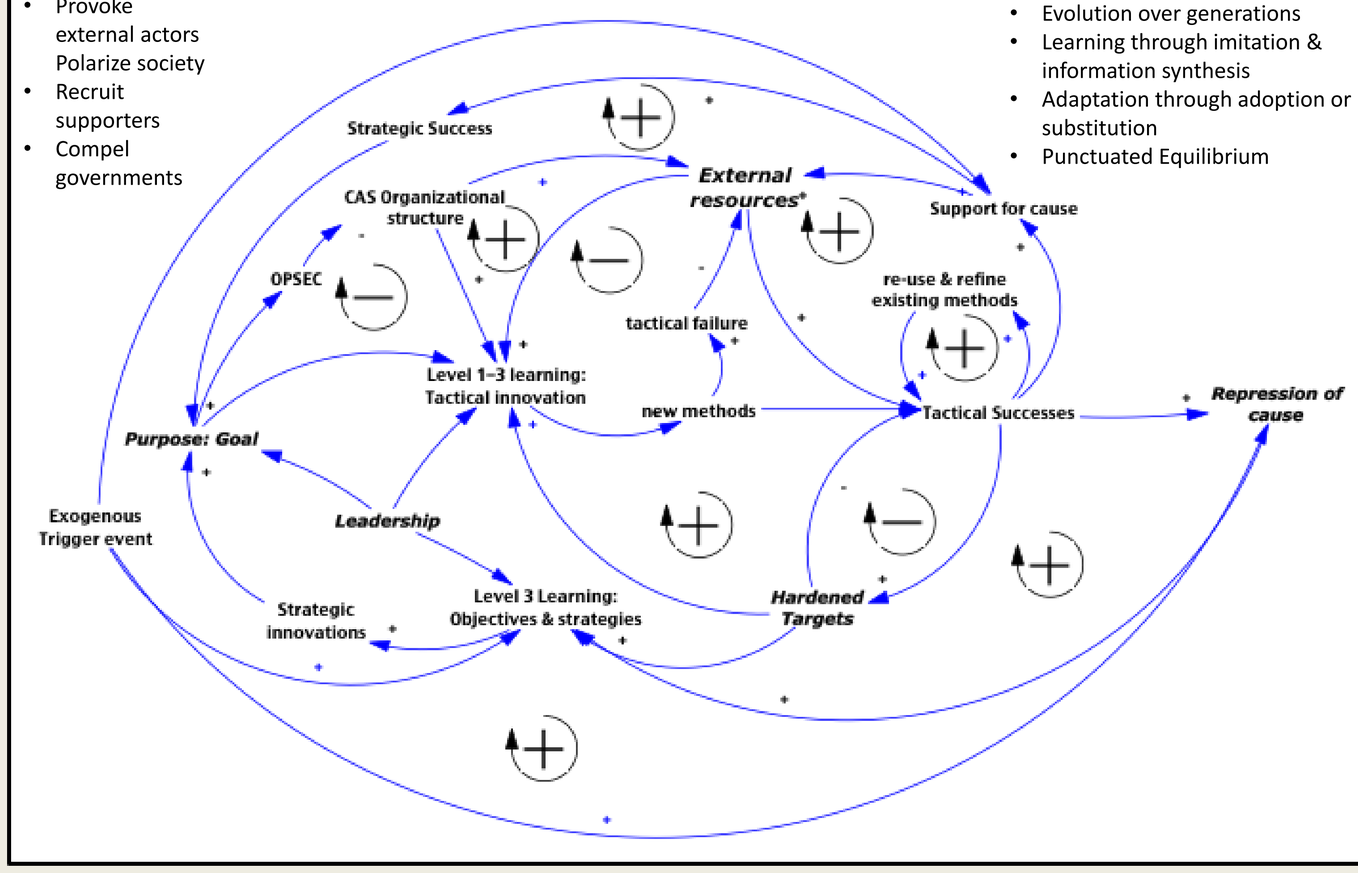
- Serial connections
- Maintain secrecy
- Impede innovation

4. INNOVATION AND LEARNING IN TERRORIST ORGANIZATIONS

Goals

- Provoke external actors Polarize society
- Recruit supporters
- Compel governments

Terrorist Innovation Model: Counteracting Feedback Loops

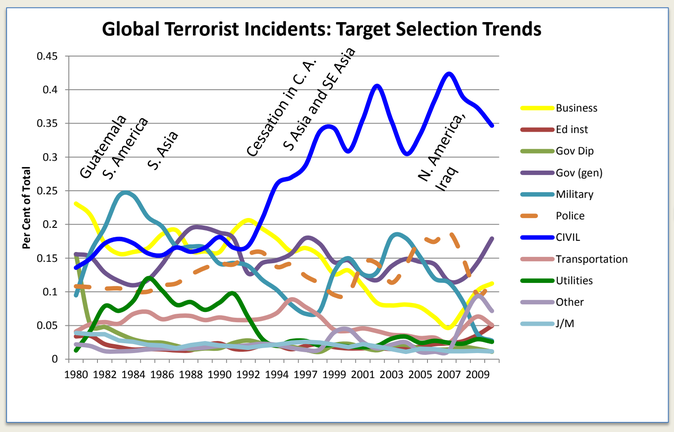


Innovation Mechanisms

- Evolution over generations
- Learning through imitation & information synthesis
- Adaptation through adoption or substitution
- Punctuated Equilibrium

Resiliency Attributes Depend on Structure

RESILIENCE = Capacity to absorb disturbance and reorganize under change and retain same function, structure, and feedbacks
ADAPTABILITY = capacity to influence resilience
TRANSFORMABILTIY = capacity to create new system when conditions are untenable
BASIN OF ATTRACTION = Region in state space in which the system tends to remain



Network Structure	Terrorist Organization	Degree	Est. size	Age	State Sponsor	Innovation	Innovation mode	AOO	Cause
Erdo-Renyi	Entrepreneurial Islamic	1	<100	~5	0	2	all	global	mixed
Windmill	AQ - Two Rivers	9	5000	9	0	2	immitation, evolution	Iraq	regional
	LeT (ISI)	8	300	14	1	2	immitation, evolution	Kashmir	local
Small World	Ansar al-Sunnah	6	700	10	0	3	adaptive	Iraq	regional
Core Periphery	Hizbollah	4	10-100K	32	1	4	adaptive, punctuated equilibrium	Lebanon	regional
Ring	IRA	3	700	95	0	2	learning, evolution	UK	local
Hierarchy	LTTE	0	8000	38	1	1	learning, evolution	Sri Lanka	local
	ELN	8	3000	50	1	1	learning, evolution	Columbia	local

Trends of successful groups show different patterns of innovation traceable to organizational structures shaped by culture, goals, resources, and environment.

5. Conclusions

Success by covert organizations breeds countermeasures. Resiliency requires innovation in the face of countermeasures. Two counteracting feedback loops compete with innovation drivers to strongly influence basins of attraction for terrorist organizations: (1) Need for secrecy and (2) Need for recognized successes (failure intolerant). Data trends affirm the conceptual model for structural influence on innovation mechanisms. Effective countermeasures must decrease, not lead to an increase in, network resiliency.
Next steps: Process tracing in longitudinal, comparative case studies.

Select References

Ahmed, E. et al (2005) "On complex adaptive systems and terrorism." *Physics Letters A* no. 337 (1/2):127-129.
Asal, V. et al (2009) "Big, Allied, and dangerous (BAAD) Database 1 - Lethality Data, 1998-2005".
Bar-Yam, Y (1997) *Dynamics of Complex Systems*, in *Studies in Nonlinearity*: Addison-Wesley.
Crutchfield, J. P. (2003) "When Evolution is Revolution - Origins of Innovation." Oxford University
Damon, C et al (2007) "Complex Contagions and the Weakness of Long Ties." *American Journal of Sociology* no. 113 (3)
Dolnik, A. (2009) *Understanding Terrorist Innovation*: Routledge.
Filk, Thomas, and Albrecht von Muller. Evolutionary Learning of Small Networks. Retrieved from http://www.igpp.de/english/tda/pdf/filkmueller08.pdf.
Forrester, J.W. (1968) *Principles of Systems*. Waltham, MA: Pegasus Communications.
Gallopín, G.C.(2006) "Linkages between vulnerability, resilience, and adaptive capacity" *Global Environmental Change* 16(3)
Gomez-Rodriguez, M. et al. (2010) Inferring Networks of Diffusion and Influence. In *16th International Conference on Knowledge Discovery and Data Mining*.
Gould, S.J. et al (1977) "Punctuated Equilibria" *Paleobiology* no. 3:115-151.
Hayden, N. (2006) "The Complexity of Terrorism: Social and Behavioral Understanding Trends for the Future." In *Mapping Terrorism Research: State of the Art, Gaps and Future Direction:* Routledge Publishing.
Holland, J. (1998) *Emergence: From Chaos to Order*: Addison-Wesley.
Jantsch, E. (1980) *The Self-Organizing Universe: Scientific and Human Implications of the Emerging Paradigm of Evolution*. Pergamon.
Kenney, M. (2004) "Competitive Learning: Understanding Interactions and Adaptations among Terrorist Networks and State Counter-Terrorist Bureaucracies." *Conference Papers -- International Studies Association*:1-4.
Luenberger, D.G. (1979) *Introduction to Dynamic Systems: Theory, Models & Applications*. NY: Wiley & Sons.
Marion, R. et al. (2003) Complexity Theory and Al Qaeda: Examining Complex Leadership. University of Nebraska.
National Consortium for the Study of Terrorism and Responses to Terrorism (START) (2012). *Global Terrorism Database*; Retrieved from http://www.start.umd.edu/gtd
Newman, M. E. J. et al (2002) "Random Graph Models of Social Networks." Santa Fe, NM: Santa Fe Institute.
Rasmussen, M. J., and M. M. Hafez.(2010) *Terrorist Innovations in Weapons of Mass Effect: Defense* Threat Reduction Agency.
Rogers, E. M. (1983) *Diffusion of Innovations*: New York Free Press.
Rogers, E. M. "Complex Adaptive Systems And The Diffusion Of Innovations." *The Public Sector Innovation Journal* 10 (3).
Rombach, M. P. et al. (2012) Core-Periphery Structure in Networks. Retrieved from http://arxiv.org/abs/1202.2684v1.
Sageman, M.(2011) *Understanding Terror Networks*: University of Pennsylvania Press.
Senge, P. M., and J. D. Sterman (1992) "Systems thinking and organizational learning" *European Journal of Operational Research* 59(1)
Subrahmanian, V.S., et al. (2013) *Computational Analysis of Terrorist Groups: Lashkar-e-Taiba*: Springer.
Smit, B. and J. Wandel. (2006) "Adaptation, adaptive capacity and vulnerability." *Global Environmental Change* no. 16 (3)
Walker, B. et al (2004) "Resilience, Adaptability and Transformability in Social-ecological Systems," Ecology and Society 9(2).
Wilkinson, Paul (2012) *Technology and Terrorism*, Taylor and Francis.
Xu, J, and H. Chen. (2008) "The Topology of Dark Networks." *Communications of the ACM* no. 51 (10):59-65.

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