WHITE PAPER

Predicting Terrorist Attacks by Automating Integrative Complexity

BLUF. Given the scope and lethality of Salafi-Jihadi extremist groups like ISIS, any tool that can contribute to predicting attacks by a terrorist organization months in advance can greatly serve the goals of both national and international security. One such method could involve supervised automation of identifying integrative complexity (IC) in English and other languages based on verbal content authored by extremist group members. While tools predicting catastrophic events are not new,[1] they typically focus on larger datasets and do not limit themselves to attacks by a specific group. Predicting when an attack is likely to occur based on IC patterns could lead to better understanding of the group's behavior in general, in addition to mitigating and eventually deterring future attacks. A multi-disciplinary team with expertise in terrorism, language (e.g., Arabic), semantics and rhetoric, computational linguistics, social science methods, and experience in coding for IC[2] is well-suited for this challenge.

What is integrative complexity (IC)?

Integrative complexity (IC) refers to the cognitive structure implied in a speaker's verbal content, specifically the textual features of a document that (1) identify different dimensions of an issue as well as (2) the integration of the ideas. The paragraph is the traditional unit of analysis for IC.[3] Often researchers analyze a random selection of five paragraphs from each source, which could include blogs, text and audio speeches or messages, interview transcripts, and regularly-updated magazines.

The fact that IC reflects structure and not content can be illustrated by a paragraph describing a number of reasons why one presidential candidate is great versus another paragraph describing why the same candidate is terrible; each paragraph should receive the same low IC score because structurally, they are only taking a single perspective, regardless of the validity behind their arguments or the nature of their positions. And while the focus of IC is on the text and not meant to characterize the author in terms of personality or skills, IC is nonetheless influenced by both personal and situational variables.[4] Coding for IC (and related constructs) is complicated,[5] and involves a 44-page codebook. Scores range from 1-7, with higher numbers indicating greater complexity[6] (see endnotes for an example[7]).

Researchers have also identified two additional types of complexity under the concept of a "multiple complexity model": *Elaborative complexity,* or when a single idea or theme is argued in a complex manner and *dialectical complexity*, or when an idea or theme is characterized from various perspectives.[8] These types of complexity augment but do not replace IC, and all three types have been explored in various studies, though IC most frequently (and therefore is the focus of this paper).

Researchers have identified varying IC in the speeches of leaders before and after crises, detecting a drop in IC preceding surprise attacks (the invasion of the Soviet Union by Nazi Germany, the Japanese attack on Pearl Harbor, the North Korean invasion of South Korea)[9] as well as a decrease prior to repeated outbreaks of war based on the speeches of at least one of the relevant heads of state.[10] That said, other variables such as level of involvement in the crisis at

hand (e.g., some states are more involved than others) can impact IC and alter the pattern.[11] The nature of the involvement can also vary by person and thus impact IC: For example, in one study the Russian Minister of Defense's IC dropped while Putin's remained the same during the decision to seize Crimea.[12] In addition, IC has been analyzed in American and Soviet foreign policy statements,[13] President Obama's weekly radio addresses,[14] and face-to-face negotiations between guerrillas and government representatives.[15] Perhaps the most creative application involved not analyzing IC but encouraging it: Authors integrated the concept into several courses to reduce Muslim-British cultural barriers by promoting the IC of the course participants.[16]

High-IC verbal production has also been positively correlated with liberal political ideology[17] and, in contrast, conservative political extremity[18] — a difference that might have been due in part to measuring the complexity of very different samples but nonetheless raises the importance of mediating or moderating factors. IC has increased under situations where people are held accountable for their justifications[19] and decreased in groups where a member represents an extreme position in comparison to groups without such a member.[20] Dialectical complexity has decreased when participants were required to lie.[21] Additional variables that have been explored with IC include biculturalism,[22] motive imagery, values, and power,[23] religious fundamentalism,[24] and most recently the impact of media on IC within the rhetoric of politicians.[25]

How does IC relate to terrorism?

Early researchers analyzed the translated[26] written content of terrorists and non-terrorists. For example, one study identified low IC in Osama bin Laden's content compared to the rhetoric of George W. Bush, Tony Blair, and officials of al-Qaeda (AQ) and the Taliban.[27] Another study compared the verbal content of two factions of al-Qaeda to two non-violent control groups who share similar goals and ideology with their AQ factions. Both terrorist groups exhibited lower IC than their control groups.[28] Another study measured varying levels of IC as expressed in two different terrorist magazines, one of which showed increasing IC over time (*Inspire*) and the other maintaining IC (*Azan*).[29] Paralleling other findings, the terrorist magazines demonstrated lower IC than other types of magazines.

Case studies of detecting IC in verbal content by one terrorist (bin Laden) and two non-terrorist leaders involved in various crises described a drop in IC preceding conflicts, though the number of preceding months varied.[30] One study which compared the public rhetoric between terrorist and non-terrorist groups found that terrorists' rhetoric was significantly lower than non-terrorists on IC and both elaborative and dialectical increased up to two months prior to an attack, but then dialectical dropped a month prior while elaborative would rise.[31]

Questions that arise due to gaps in the terrorism/complexity literature include:

- What adjustment might be required of IC, dialectical, and elaborative to fit Arabic, if any, and would the results replicate the English findings?
- Would analyzing sentiment in addition to all types of complexity offer greater predictability for attacks 3, 2, or 1 month prior?
- Does complexity vary to reflect the speaker's communicative intent (e.g., urging compliance as opposed to rationalize a position)?

- Would constructs related to integrative complexity, such as dialectical thinking,[32] even applying a keyword-driven approach,[33] contribute to greater predictive power with respect to forecasting terrorist attacks?

- Would all three types of complexity vary more predictably if accounting for the detailed nature of an attack, i.e., target, method, motive, and scope, as well as the level of involvement of the speaker/author in relation to the attack? (Some research has replicated the drop in IC of a government spokesperson in his editorials prior to both large and small-scale attacks by that government, the latter including attacks on individuals[34])

What are the challenges in manual coding for IC?

This proposal focuses on automating annotation for IC via *supervised* automation, which uses machine learning. While IC should be the primary objective, ideally human annotators would annotate/code for all three types of complexity on large amounts of training data from terrorist group members that then support the development of algorithms. Even with supervised methods, however, "researchers would need to keep an eye on changing habits of speech and the consequently inevitable slippage between any automated system and the forms of language conveying integrative complexity," according to Tetlock, one of the founders of the concept.[35]

Neither keywords nor paragraph length are regarded as reliable indicators of IC[36] and the explicit versus implicit nature of IC levels contributes to coding challenges. Also, bias has the potential to influence coding since higher IC can (incorrectly) be regarded more favorably[37] despite the fact that the structure and not the content of the words is assessed. Furthermore, the manual details multiple categories of "unscorable texts", an obvious gap in applying this methodology.[38]

What are the challenges of automation for IC?

Several computational implementations purport to calculate IC.[39] Traditionally, IC coders analyze text paragraph by paragraph, assigning a score to the natural language based on the whole body of that writing. Computational researchers want to rely on *unsupervised* methods (no manual coding), however, which can lead to identifying a measure that attempts to approximate IC.[40] Implementations appear to use only English and the rules are either too simplistic or clear linguistic markers of complexity are simply absent.[41] Existing automated implementations build up aggregating scores word by word across a body of a text, causing linguistic, cultural, and situational context to be lost or degraded. In comparison to the manual approach of coding for IC, lexicon-based systems have limited ability to capture word sense (e.g. which meaning of *bomb* is meant by, "He really bombed his talk yesterday"?) and syntactic framing (e.g. "Mistakes were made" is very different from "I made mistakes.").

In addition, lexicon-based systems are often designed in English and converted to foreign languages using various methodologies, which may not be methodologically symmetric across languages. While lexicon-based systems are available in languages such as Arabic, the different lexicons may have different psychometric reliability. Lexicon-based systems may be more accurate for English than languages of freer word order, or greater morphological complexity, requiring additional levels of computational analysis. While lemmatization has been called a "handy trick" for calculating IC[42] in the English-language context, it is absolutely required across many languages.

What are some solutions to automating IC?

A key founder of IC supports a machine-learning approach to automation,[43] which requires addressing solutions to both annotation and automation challenges. Several approaches can offer a more streamlined annotation procedure and duration. Averaging scores per paragraph across coders is one option.[44] With respect to addressing repeated concerns of bias during coding/annotation, training data that directly played into pre-identified biases of annotators could be explicitly discussed during consensus sessions until bias was no longer evident or at least minimized. The data could also be scrubbed of information that could trigger a bias (e.g., replace all names with a generic name or replace with "NAME").[45] Employing linguistic and cultural experts might allow for successful coding of "unscorable text" features as satire and sarcasm[46] in both English and Arabic.

With respect to automation, machine learning can build document classification systems that can process complicated writing holistically, without falling back on a word-by-word analysis. Trained human experts can manually code natural language text and data scientists can build learning systems which infer the word context and stylistic rules in a document that would assign a code as a human expert would do. Furthermore, coding for sentiment and/or dialectical thinking in both English and Arabic could potentially increase the likelihood of successful forecasting. Given that terrorist groups like ISIS produce content in a vast number of languages, this effort should be expanded and require expertise not only in Arabic but perhaps in Pashto, Persian, Urdu, and other languages.

Ultimately, if automation can lead to successful pre-emptive identification of an attack for one group, then lessons learned can lead to more efficient tool development to apply to other terrorist groups. Perhaps in the future, a single tool could be trained to accommodate all groups. While the challenges are daunting, the right combination of knowledge and skills within the fields of terrorism, language, semantics and rhetoric, computational linguistics, and the social sciences has the potential to address the gaps for automating integrative complexity and produce a tool that could hugely benefit the realm of national and international security.

Authors: Dr. Wendy Chambers, Dr. Paul Rodrigues, Dr. Claudia Brugman, Dr. Susannah Paletz, Dr. Jennifer Boutz, Dr. Peter Weinberger, Mr. Alejandro Beutel

[1] Lockheed Martin, *World-Wide Integrated Crisis Early Warning System*, accessed May 26, 2017, http://www.lockheedmartin.com/us/products/W-ICEWS.html

[2] E.g., Lelyn Saner, Sharon Glazer, Susannah Paletz, Andrew Mathis, Ivica Pavisic, and Molly Barnes, "Priming of Relationship Structure: An Experimental Test of Interventions for Improving Cultural Perspective-Taking," *Center for Advanced Study of Language* Technical Report (2008).

[3] Gloria Baker-Brown, Elizabeth J. Ballard, Susan Bluck, Brian de Vries, Peter Suedfeld, and Phillip Tetlock, *Coding Manual for Conceptual/Integrative Complexity* (University of British Columbia and University of California, 1992), 12.

[4] Peter Suedfeld, "The Cognitive Processing of Politics and Politicians: Archival Studies of Conceptual and Integrative Complexity," *Journal of Personality* 78, no. 6 (2010): 1669-1702.

[5] An example of a score of 2 regarding the subject of enforced retirement: "Enforced retirement at 65 is probably beneficial to our society. To be sure, it is difficult to force the resignation of long-time employees in order to make room for the upcoming generation. We should, however, give highest priority to creating opportunities for the new generation to explore their ideas. This need may be especially critical in view of the requirements of running a modern economy. More than ever, our country appears to require new ideas and fresh perspectives." From Peter Suedfeld, *The Scoring of Integrative Complexity as a Tool in Forecasting Adversary Intentions: Three Case Studies* (Vancouver: British Columbia University, Vancouver Department of Psychology, April 2010), 1-28.

[6] Baker-Brown, Ballard, Bluck, de Vries, Suedfeld, and Tetlock, *Coding Manual for Conceptual/Integrative Complexity*, 1-47.

[7] "*Integrative Complexity*...is a state variable, measuring the structure of cognitive processing across situations. It is explicitly not a personality variable, and IC scoring explicitly implies nothing about the source's personality. IC has two components, differentiation (the recognition of more than one legitimate point of view and/or relevant dimension relevant to the topic) and integration (the recognition of relationships among the differentiated items, through, e.g., interaction, trade-off, synthesis, or incorporation within a higher-level system)." From Peter Suedfeld, Ryan W. Cross, and Jelena Brcic, "Two Years of Ups and Downs: Barack Obama's Patterns of Integrative Complexity, Motive Imagery, and Values," *Political Psychology* 32, no. 6 (2011): 1009.

[8] Lucian Gideon Conway III, Felix Thoemmes, Amy M. Allison, Kirsten Hands Towgood, Michael J. Wagner, Kathleen Davey, Amanda Salcido, Amanda N. Stovall, Daniel P. Dodds, Kate Bongard, and Kathrene R. Conway, "Two Ways to Be Complex and Why They Matter: Implications for Attitude Strength and Lying," *Journal of Personality and Social Psychology* 95, no. 5 (2008): 1029-1044.

[9] Suedfeld, "The Cognitive Processing of Politics and Politicians," 1682-1694.

[10] Peter Suedfeld and Rajiv Jhangiani, "Cognitive Management in an Enduring International Rivalry: The Case of India and Pakistan," *Political Psychology* 30, no. 6 (2009): 937-951.

[11] Suedfeld, "The Cognitive Processing of Politics and Politicians," 1692.

[12] Mr. Brad Morrison, *Strategic Multi-Layer Assessment: Panel Discussion on the Gray Zone in Support of USSOCOM* (summary booklet from panel discussion, April 27, 2017, 8).

[13] Philip E. Tetlock, "Monitoring the Integrative Complexity of American and Soviet Policy Rhetoric: What Can Be Learned?" *Journal of Social Issues* 44, no. 2 (1988): 101-131.

[14] Suedfeld, Cross, and Brcic, "Two Years of Ups and Downs," 1007-1033.

[15] José Liht, Peter Suedfeld, and Andi Krawczyk, "Integrative Complexity in Face-to-Face Negotiations Between the Chiapas Guerrillas and the Mexican Government," *Political Psychology* 26, no. 4 (2005): 543-552.

[16] Dr. Sara Savage and Dr. Jose Liht, "Prevention of Violent Extremism Based on Promoting Value Complexity, Informed by Neuroscience and Deployed on the Internet," in *Looking Back, Looking Forward: Perspectives on Terrorism and Responses to It,* ed. Dr. Hriar Capayan, Dr. Valerie Sitterle, and LTC Matt Yandura (Strategic Multi-Layer Assessment Occasional White Paper, September 2013); Ryan J. Williams, "Network Hubs and Opportunity for Complex Thinking Among Young British Muslims," *Journal for the Scientific Study of Religion* 52, no. 3 (2013): 573–595.

[17] E.g., Philip E. Tetlock, "Cognitive Style and Political Ideology," *Personality Processes and Individual Differences* 45, no.1 (1983): 118-126; Philip E. Tetlock, "A Value Pluralism Model of Ideological Reasoning," *Journal of Personality and Social Psychology* 50, no. 4 (1986): 819-827.

[18] Alain Van Hiel and Ivan Mervielde, "The Measurement of Cognitive Complexity and Its Relationship with Political Extremism," *Political Psychology* 24, no. 4 (2003): 781-801.

[19] Philip E. Tetlock, "Accountability and Complexity of Thought," *Journal of Personality and Social Psychology* 45, no. 1 (1983): 74-83.

[20] Lyn M. Van Swol, Andrew Prahl, Miranda R. Kolb, Emily Acosta Lewis, and Cassandra Carlson, "The Language of Extremity: The Language of Extreme Members and How the Presence of Extremity Affects Group Discussion," *Journal of Language and Social Psychology* 35, no.6 (2016): 603-627.

[21] Conway III et al., "Two Ways to Be Complex and Why They Matter,"1029-1044.

[22] Carmit T. Tadmor & Philip E. Tetlock, "Biculturalism: A Model of the Effects of Second-Culture Exposure on Acculturation and Integrative Complexity," *Journal of Cross-Cultural Psychology* 37 (2006): 173-190.

[23] Suedfeld, Cross, and Brcic, "Two Years of Ups and Downs," 1007-1033; Allison G. Smith, Peter Suedfeld, Lucian G. Conway III, and David G. Winter, "The Language of Violence: Distinguishing Terrorist from Nonterrorist Groups by Thematic Content Analysis," *Dynamics of Asymmetric Conflict* 1, no. 2 (2008):142-163.

[24] José Liht, Lucian Gideon Conway III, Sara Savage, Weston White, and Katherine A. O'Neil, "Religious Fundamentalism: An Empirically Derived Construct and Measurement Scale," *Archive for the Psychology of Religion* 33 (2011): 299-323.

[25] Eran Amsalem, Tamir Sheafer, Stefaan Walgrave, Peter John Loewen, and Stuart N. Soroka, "Media Motivation and Elite Rhetoric in Comparative Perspective," *Political Communication* (2017):1–19.

[26] Smith, Suedfeld, Conway III, and Winter, "The Language of Violence," 142-163.

[27] Peter Suedfeld & Dana C. Leighton, "Early Communications in the War Against Terrorism," *Political Psychology* 23, no. 3 (2002): 585-599.

[28] Smith, Suedfeld, Conway III, and Winter, "The Language of Violence," 142-163.

[29] David B. Skillicorn and Edna F. Reid, "Language use in the Jihadist magazines Inspire and Azan," *Security Informatics* 3, no. 9 (2014): 1-16.

[30] Suedfeld, *The Scoring of Integrative Complexity as a Tool in Forecasting Adversary Intentions*, 1-28.

[31] Lucian Gideon Conway III, Laura Janelle Gornick, Shannon Houck, Kirsten Hands Towgood, and Kathrene R. Conway, "The Hidden Implications of Radical Group Rhetoric: Integrative Complexity and Terrorism," *Dynamics of Asymmetric Conflict* 4, no. 2 (2011): 155-165.

[32] Susannah Paletz and K. Peng, "Problem Finding and Contradiction: Examining the Relationship Between Naïve Dialectical Thinking, Ethnicity, and Creativity," *Creativity Research Journal 21* (2009): 139-151.

[33] M. Parker-Tapias and K. Peng, "Locating Cultures in the Theory of Planned Behavior" (paper presented at the American Psychological Association's Annual Convention, San Francisco, CA, 2001).

[34] Suedfeld, *The Scoring of Integrative Complexity as a Tool in Forecasting Adversary Intentions*, 1-28.

[35] Phillip E. Tetlock, S. Emlen Metz, Sydney E. Scott, and Peter Suedfeld, "Integrative Complexity Coding Raises Integratively Complex Issues," *Political Psychology* 35, no. 5 (2014): 626.

[36] Baker-Brown, Ballard, Bluck, de Vries, Suedfeld, and Tetlock, *Coding Manual for Conceptual/Integrative Complexity*, 3,9.

[37] Baker-Brown, Ballard, Bluck, de Vries, Suedfeld, and Tetlock, *Coding Manual for Conceptual/Integrative Complexity*, 4; Phil Torres, Yet Another Reason Trump is Bad News: He's Utterly Lacking in Integrative Complexity – And That's Dangerous, *Salon*, May 4, 2017 http://www.salon.com/2017/05/14/yet-another-reason-donald-trump-is-bad-news-hes-utterly-lacking-in-integrative-complexity-and-thats-dangerous/; Lucian Gideon Conway III, Shannon C. Houck, Laura Janelle Gornick, and Meredith Repke, "Ideologically Motivated Perceptions of Complexity: Believing Those Who Agree With You Are More Complex Than They Are," *Journal of Language and Social Psychology* 35, no. 6 (2016): 708-718.

[38] Baker-Brown, Ballard, Bluck, de Vries, Suedfeld, and Tetlock, *Coding Manual for Conceptual/Integrative Complexity*, 10-12.

[39] Lucian Gideon Conway III, Kathrene R. Conway, Laura Janelle Gornick, Shannon C. Houck, "Automated Integrative Complexity," *Political Society* 35, no. 5 (2014): 603-624; Michael D. Young and Maraget G. Hermann, "Increased Complexity has Its benefits," *Political Psychology* 35, no.5 (2014): 635-645.

[40] A commercial organization called ProfilerPlus.Org advertises IC automation but staff correctly caveat that they are not identifying IC as designed by the founders.

[41] E.g., see Houk, Conway III, and Gornick, "Automated Integrative Complexity," 647-659.

[42] Young and Hermann, "Increased Complexity has Its Benefits," 635-645.

[43] Tetlock, Metz, Scott, and Suedfeld, "Integrative Complexity Coding Raises Integratively Complex Issues," 626.

[44] Smith, Suedfeld, Conway III, and Winter, "The Language of Violence," 153.

[45] Tetlock, Metz, Scott, and Suedfeld, "Integrative Complexity Coding Raises Integratively Complex Issues," 630.

[46] Baker-Brown, Ballard, Bluck, de Vries, Suedfeld, and Tetlock, *Coding Manual for Conceptual/Integrative Complexity*, 10.