

Title: Methods for improving IAEA information analysis by reducing cognitive biases

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Abstract

This paper will explore how methods for reducing cognitive biases, which have been developed by the intelligence community, could be integrated into the analysis and assessment work carried out by the Department of Safeguards at the International Atomic Energy Agency (IAEA).

Under the IAEA's new strategy of information driven safeguards, the Agency is expected to reach conclusions on the 'completeness' of a state's nuclear activities based on ever growing amounts and types of information. This is a challenging task and requires analysts within the Department of Safeguards to develop new processes for combining evidence from disparate sources such as inspector reports, satellite imagery, scientific publications and nuclear trade information. This added complexity serves to increase the threat of cognitive biases significantly affecting the accuracy of the information assessments.

Cognitive biases are intrinsic to all forms of intelligence analysis and can be linked to several well publicised and recent intelligence failures. As a consequence of this, a number of analytical techniques and methods have been employed to reduce this subjectivity of organisations working across a range of fields from counter terrorism to political risk. These strategies employ a number of diagnostic, contrarian and imaginative thinking techniques such as: Analysis of Competing Hypotheses (ACH); Devil's Advocacy; and Red Teaming.

Analysis is to be carried out at King's College London in order to ascertain which combination of the aforementioned range of techniques would be best suited to nuclear safeguards analysis. Furthermore an assessment will be performed of how these techniques could be integrated within the IAEA's current workflow. This will incorporate key factors such as resource limitations and the time pressures involved in producing accurate and reliable reports.

1. Introduction

Following the discovery of Iraq's undeclared nuclear weapons activities in the 1990s, the past two decades have seen a rapid reshaping and strengthening of the IAEA safeguards system.[1] This new information-driven approach to safeguards places extra emphasis on producing efficient and accurate analyses in an effort to verify both the 'completeness' as well as the 'correctness' of a state's nuclear material and nuclear-related activities. While the Agency's analyses do not extend to assessing the intentions of a state in the nuclear field, evaluating the whole of a state's nuclear programme produces analyses of information through

¹ The Safeguards System of the International Atomic Energy Agency
<http://www.iaea.org/OurWork/SV/Safeguards/safeg_system.pdf> (2005)

an iterative process, whereby conclusions feed directly into the planning of future safeguards activities and follow-up actions.[2] This is a challenging task which is complicated by an increase in both the diversity and amount of safeguard relevant sources that require assessment by analysts.[3]

This amplification of both types and volumes of information has meant that there is an increased potential for cognitive biases to influence the outcomes of such analyses. As such, it is important to be aware of these biases when examining the activities of a state. This paper will thus examine the specific effect that cognitive biases can have on the accuracy of intelligence analysis, examine methods for reducing them, and discuss which particular techniques might be best integrated into the IAEA's evolving information analysis architecture.

2. Cognitive biases and their impact on information analysis

In decision-making, analysts and indeed all humans construct mental models. These are cognitive simplified representations of reality based on our experiences, assumptions and expectations.[4] While necessary to efficiently assimilate large volumes of disparate information and analyse complex situations, they can also lead to errors and inaccuracies. These are known as cognitive biases and occur directly as a result of our information processing strategies. In this sense, they are distinct from other common types of biases which can also skew analyses based on, for example, cultural, organizational, emotional, or self-motivated factors.[5] Cognitive biases can manifest in a variety of ways. For instance, analysts have a tendency to seek out and place extra emphasis on data that supports preconceived assumptions and expectations – an effect known as confirmation bias. This can result in the exclusion of conflicting data and the failure to consider alternative explanations. As cognitive biases are intrinsic to the human thought process, they are exceedingly difficult to eliminate and can have significant impact on even experienced analysts who have a basic awareness of their effects.

The Department of Safeguards at the IAEA is responsible for reaching conclusions on a state's entire nuclear activities.[6] This is a challenging task which requires analysts to have an understanding of how states might hypothetically launch future clandestine nuclear weapons programmes and judge the significance of likely early warning signatures. In this process, it is possible for analyses to be affected by both confirmation and availability bias, where evidence indicating the potential presence of biases may be overstated, and alternative explanations may not be properly considered.[7] A very simple example of how this might occur in a situation in which an analyst is tasked with forewarning of a reprocessing programme in a particular state is given by Stech and Elässer.[8] In a hypothetical scenario, an unusual quantity of krypton gas is detected at a particular location. The analyst, aware that krypton is a by-product of reprocessing, concludes that there is a high probability that the state has a clandestine nuclear weapons programme. However, in their analysis, the analyst fails to fully consider alternatives that might also explain the presence of krypton gas, such as a nearby oil pipeline or the start-up of a large scale declared reprocessing facility in a neighbouring state.[9]

The inherent difficulty of providing accurate analysis on a state's nuclear activities and the impact that cognitive biases can have in this process was recently highlighted by the inability of the United States'

² James Acton, 'The Problem with Nuclear Mind Reading', Survival No. 51, Vol. 1 <<http://www.informaworld.com/smpp/content~content=a908599274~db=all>> (2009).

³ These types of sources can include: open source information; commercial satellite imagery; state information; inspector reports (REDO).

⁴ A Tradecraft Primer: Structured Analytic Techniques for Improving Intelligence Analysis, Center for the Study of Intelligence, <<https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/books-and-monographs/Tradecraft%20Primer-apr09.pdf>> (March 2009).

⁵ Richards J. Heuer, Jr, 'Psychology of Intelligence Analysis', Center for the Study of Intelligence, <<https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/books-and-monographs/psychology-of-intelligence-analysis/PsychofIntelNew.pdf>> (1999).

⁶ 'The evolution of IAEA Safeguards', IAEA, <http://www-pub.iaea.org/MTCD/publications/PDF/NVS2_web.pdf>, November 1998.

⁷ Availability bias results in the overestimation of the probability of an event occurring

⁸ F. J. Stech and C. Elässer, 'Midway revisited: Deception by analysis of competing hypothesis', Mitre Corporation, Tech. Rep., (2004). Available at:

<http://www.mitre.org/work/tech_papers/tech_papers_04/stech_deception/stech_deception.pdf>.

⁹ Krypton gas is commonly used to test oil pipelines for leaks.

intelligence community to accurately assess Iraq's alleged Weapons of Mass Destruction (WMD) programmes in 2002.[10] In subsequent investigations by the Senate Select Committee on Intelligence and the WMD Commission, it was revealed that US analysts displayed cognitive rigidity in failing to question the presumption that Iraq had an active and expanded WMD programme.[11] US analysts were affected by confirmation bias in focusing on evidence that supported this hypothesis whilst both downplaying and disregarding evidence that discredited this assumption. One particular example of this case was the intelligence community's incorrect assessment that the attempted procurement of aluminium tubing by Iraq in 2001 was intended for a clandestine centrifuge enrichment programme. This conclusion was reached in spite of separate analyses conducted by the US Department of Energy and the IAEA - both of which concluded that, based on the quantities and type of tubing ordered, the items were more suited for use in Iraq's missile programme.[12] The WMD Commission later determined that this incorrect assessment by the intelligence community was a direct result of analysts' 'unwillingness to question prevailing assumptions that Iraq was attempting to reconstitute its nuclear program'.[13]

2.1 Methods for reducing cognitive biases

Studies have shown that the negative effects of cognitive biases in information analysis tend to manifest themselves in 'consistent and predictable' ways. [14] Consequently, a number of methods have been developed in an attempt to counteract the inherent inclusions of cognitive biases in analyses. Originally developed within the intelligence community their use has since spread to other sectors including business and the medical profession. These methods are designed to make the analysis process more explicit and less intuitive by making arguments more transparent, challenging key assumptions and identifying important missing evidence and alternative explanations. Different methods can vary widely both in terms of their sophistication, as well as the time and commitment necessary in order to master and apply them effectively.[15] While an analysis of all possible techniques is beyond the scope of this paper, the discussion below will focus on some of the most widely used methods: Analysis of Competing Hypotheses (ACH); Devil's Advocacy; and Red Teaming.

ACH is one of a number of structured thinking techniques that attempts to reduce cognitive biases by encouraging analysts to consider all reasonable hypotheses when evaluating a set of evidence.[16] This helps to prevent analysts from intuitively identifying one plausible explanation and then seeking evidence to support it. Since its initial development in the mid-1980s, the utility of ACH has been widely debated, and a number of variations of this technique have emerged which differ in terms of ease of use, time required and analytical benefit.[17] All ACH techniques make use of matrices as a visual aid to help analysts in their

¹⁰ 'Iraq's Continuing Programs for Weapons of Mass Destruction', National Intelligence Estimate (October 2002) (accessed via the Federation of American Scientists <<http://www.fas.org/irp/cia/product/iraq-wmd-nie.pdf>>); Report on the U.S. Intelligence Community's Prewar Intelligence Assessments on Iraq, Select Committee on Intelligence United States Senate, p.21 <<http://web.mit.edu/simsong/www/iraqreport2-textunder.pdf>> (July 2004).

¹¹ Unclassified Version of the Report of the Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction, (accessed via the US Government Printing Office <<http://www.gpoaccess.gov/wmd/index.html>> (April 2005).

¹² Comprehensive Report of the Special Advisor to the DCI on Iraq's WMD with Addendums, <http://permanent.access.gpo.gov/DuelferRpt/Volume_2.pdf#page=159>, p.21, (30 September 2004).

¹³ 'Iraq's Continuing Programs for Weapons of Mass Destruction', National Intelligence Estimate, p. 6 (October 2002) (accessed via the Federation of American Scientists <<http://www.fas.org/irp/cia/product/iraq-wmd-nie.pdf>>).

¹⁴ Richards J. Heuer, Jr, 'Psychology of Intelligence Analysis', Center for the Study of Intelligence, <<https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/books-and-monographs/psychology-of-intelligence-analysis/PsychofIntelNew.pdf>> (1999), p. 111-112.

¹⁵ <http://sourcesandmethods.blogspot.com/2008/12/top-5-intelligence-analysis-methods_12.html>

¹⁶ Richards J. Heuer, Jr, 'Psychology of Intelligence Analysis', Center for the Study of Intelligence, <<https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/books-and-monographs/psychology-of-intelligence-analysis/PsychofIntelNew.pdf>> (1999).

¹⁷ Richard J. Heuer, Jr., 'The Evolution of Structured Analytic Techniques' <http://www7.nationalacademies.org/bbcss/DNI_Heuer_Text.pdf>, (8 December 2009); Richard J. Heuer, Jr., 'How does Analysis of Competing Hypotheses (ACH) Improve Intelligence Analysis?' <<http://www.pherson.org/Library/H15.pdf>> (16 October 2005); Simon Pope, Audun Jøsang and David McAnally, "Formal Methods of Countering Deception and Misperception in Intelligence Analysis", Presented at the 11th ICCRTS: Coalition Command and Control in the Networked Era (2006).

simultaneous evaluation of competing hypotheses.[18] As shown in Figure 1 below, in the analysis of scenario where unexpected Krypton gas readings are detected at a location in country X, a matrix is created with hypotheses listed as headings across the top of a matrix and items of evidence listed down the left hand side.

Figure 1:

Example of a basic ACH matrix with hypothesis/evidence pairs evaluated as consistent (C), inconsistent (I), neutral (N) or non-applicable (N/A). Created with PARC software:
<http://www2.parc.com/istl/projects/ach/ach.html>.

	Type	Credibility	Relevance	H: 1	H: 2	H: 3	
				Country X is operating an undeclared reprocessing facility	Country X has been using Krypton to test oil and gas pipelines	Atmospheric transfer from a reprocessing facility in a neighbouring state	
	Weighted Inconsistency Score ⇄			-2.0	-0.0	-0.0	
	Enter Evidence						
E3	Recent IAEA inspector reports from nuclear sites in country X showing no diversion of nuclear materials or technologies	IAEA inspector reports	HIGH	HIGH	I	NA	NA
E2	Recent satellite imagery of country X showing the construction of a new unknown industrial plant	Commercial satellite imagery	HIGH	MEDIUM	C	N	NA
E1	Reports on country X's recent investment in its oil and gas infrastructure	Online and print media and subject experts	MEDIUM	MEDIUM	NA	C	NA

A cell in the matrix then relates to each hypothesis/evidence pair, and the value within that cell indicates whether the evidence is consistent with the hypothesis. Once the matrix has been prepared, the analyst attempts to disprove each hypothesis in turn. The hypothesis with the most credible supporting evidence is deemed the most likely possibility.

The utility of ACH as a tool in eliminating cognitive biases and enhancing intelligence analysis is the subject of some debate. Its primary strength, as described above, is that it forces analysts to simultaneously consider multiple hypotheses, helping to mitigate effects such as 'satisficing' - defined as a blend of satisfying and sufficing, implying minimum requirements be met rather than seeking an optimal solution. A major drawback, however, is that the application of ACH requires analysts to make a judgement on every hypothesis/evidence pair which, for a complex problem, can be very time-consuming. It is also difficult to judge its effectiveness at alleviating other cognitive biases as, to date, only a very limited number of studies

¹⁸ Tim van Gelder, "Bringing visual clarity to complex issues", <http://timvangelder.com/2007/12/31/hypothesis-testing-whats-wrong-with-ach/> (December 2007).

have looked into this question. The results from these have been mixed, with some demonstrating that ACH can reduce confirmation bias while the findings of others have been inconclusive.[19]

An alternative approach that has received renewed attention in recent times is Devil's Advocacy. This process was recommended as a method for improving intelligence analysis by both the 9/11 and WMD Commissions.[20] Devil's Advocacy is a contrarian thinking technique that involves the development of procedures for exposing alternative viewpoints. This is usually achieved through the use of either individuals or small teams appointed to challenge key assumptions in the prevailing analytical line and to argue minority positions. This can assist in reducing the development of mindsets dominant to one perspective, which if unchecked, can lead to the dismissal or downplaying of contradictory evidence.[21] A key advantage of Devil's Advocacy over other techniques is that both easy to understand and relatively simple to employ.

In Red Teaming analysts are transformed from observers into actors where they are tasked with providing analysis and viewpoints in the form of "first person" reports.[22] It is a technique that has been used both within the military and private sectors to gain a greater insight into adversary behaviour and deception, the influence of other key actors and to challenge key assumptions.[23] Red teaming is particularly useful in situations where a well established mindset may have developed within a group, it can be used to stimulate new thinking and alternative hypotheses. However, it is not easy to employ effectively as analysts must first develop an in-depth knowledge of the organisation in question's history, culture and decision making apparatus.

ACH, Devil's Advocacy and Red Teaming provide, in theory at least, a way of reducing the affects of cognitive biases in information analysis. However, in practice their utility is a subject of some debate.[24] While certain studies have shown that they can be useful in identifying and alleviating biases, others have shown that, if poorly employed, they could aggravate 'group think'.[25]

3. Integrating cognitive biases reduction techniques into IAEA information analysis procedures

When assessing which techniques, if any, the IAEA should employ to counter the effects of cognitive biases, it is important to consider the Agency's already stretched resources. Ideally, analysts should be able to effectively employ any technique adopted in their State Evaluation Process after a short training period and associated software should be open source and easily integrated to the IAEA's information

¹⁹ Andrew D. Brasfield, 'Forecasting Accuracy and Cognitive Bias in the Analysis of Competing Hypotheses', Annual Meeting of the International Studies Association <http://www.allacademic.com/meta/p_mla_apa_research_citation/3/1/3/5/5/pages313555/p313555-1.php> (February 2009); Field Evaluation in the Intelligence and Counterintelligence Context: Workshop Summary (2010) Board on Behavioral, Cognitive, and Sensory Sciences and Education (BCSSE) <http://www.nap.edu/openbook.php?record_id=12854&page=18> (2010).

²⁰ Eric Rosenbach, 'Intelligence Reform' <http://belfercenter.ksg.harvard.edu/publication/19154/intelligence_reform.html> (July 2009), citing The 9/11 Commission, 'The 9/11 Commission Report', <<http://www.9-11commission.gov/report/index.htm>> (August 2004) and The Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction, 'Report to the President of the United States', <http://www.fas.org/irp/offdocs/wmd_report.pdf> (March 2005).

²¹ A Tradecraft Primer: Structured Analytic Techniques for Improving Intelligence Analysis, Center for the Study of Intelligence, <<https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/books-and-monographs/Tradecraft%20Primer-apr09.pdf>> (March 2009).

²² A Guide to Red Teaming, The Development, Concepts and Doctrines Centre, UK Ministry of Defence, <<http://www.mod.uk/NR/rdonlyres/B0558FA0-6AA7-4226-A24C-2B7F3CCA9A7B/0/RedTeamingGuiderevised12Feb10Webversion.pdf>> (February 2010).

²³ Ibid.

²⁴ Richards J. Heuer, Jr, 'Psychology of Intelligence Analysis', Center for the Study of Intelligence, <<https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/books-and-monographs/psychology-of-intelligence-analysis/PsychofIntelNew.pdf>>, p.73 (1999).

²⁵ Alexander L. George and Erick Stern, 'Harnessing Conflict in Foreign Policy Making: From Devil's to Multiple Advocacy', Presidential Studies Quarterly, Volume 32, Issue 3, pages 484–505, <<http://onlinelibrary.wiley.com/doi/10.1111/j.1741-5705.2002.tb00003.x/abstract>>, September 2002 and Charlan Nemeth, Keith Brown, and John Rogers, "Devil's Advocate vs. Authentic Dissent: Stimulating Quantity and Quality," European Journal of Social Psychology, Volume 31, pp.707–20 (2001).

management architecture. Given these requirements we would recommend that as a minimum the Agency consider the employment of Devil's Advocacy. This technique does not require the use of expensive software packages or highly specialised training, and there is an extensive literature of practical steps detailing how it has been applied to other sectors.[26] Red Teaming in contrast can be much harder to implement effectively as it requires the assembly of a team with highly specialised technical and state specific knowledge. However, given the diverse range of experts that the IAEA has access to, this could potentially be accomplished without the need to provide analysts with excessive amounts of additional training.

ACH would also seem to be a promising technique that could be employed to help reduce cognitive biases. It is a more time consuming technique than Devil's Advocacy, both in terms of training and implementation, but it offers a number of additional benefits. These include an auditable trail of evidence showing how hypotheses were evaluated.[27] This would seem particularly valuable to the IAEA as it allows for subject, regional and technical specialists, that might only be on short term placements at the Agency, to reassess the strength of particular conclusions. ACH is most effective when employed collaboratively and this could be accomplished, for example, through the use of an internal IAEA wiki. Free open source software tools for semi-automating the construction and evaluation of the ACH matrix also now exist.[28] This should help to both reduce the time necessary to employ the technique and ease its integration into the Agency's evolving information management architecture.

Finally, ACH, Devil's Advocacy and Red Teaming are complementary techniques that could be employed by the IAEA in combination – if resources allow. For instance, Red Teaming could be employed at the start of the analysis process to help identify a wide range of potential explanations for a particular situation. ACH could then be used to test the validity of each hypothesis, before finally Devil's Advocacy could be employed to help decide between hypotheses with similar levels of inconsistency, when drawing final conclusions.

4. Conclusion

This paper has attempted to highlight how cognitive biases can have a significant effect on intelligence analysis, introduce a number of methods for reducing their effects, and finally, discuss briefly how these could be adopted by the IAEA. Devil's Advocacy, Red Teaming and ACH would all seem to be promising techniques that the Agency could integrate into its existing information analysis and management procedures. However, there is still a considerable amount of research that needs to be performed in assessing exactly how this might be best accomplished. This next step will be crucial, as studies have shown that the poor implementation of the aforementioned techniques can lead to the aggravation of the very biases that they seek to reduce.

²⁶ Alexander L. George and Erick Stern, 'Harnessing Conflict in Foreign Policy Making: From Devil's to Multiple Advocacy', *Presidential Studies Quarterly*, Volume 32, Issue 3, pages 484–505, <<http://onlinelibrary.wiley.com/doi/10.1111/j.1741-5705.2002.tb00003.x/abstract>>, September 2002 and Charlan Nemeth, Keith Brown, and John Rogers, "Devil's Advocate vs. Authentic Dissent: Stimulating Quantity and Quality," *European Journal of Social Psychology*, Volume 31, pp.707–20 (2001).

²⁷ Richards J. Heuer, Jr, 'Psychology of Intelligence Analysis', Center for the Study of Intelligence, <<https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/books-and-monographs/psychology-of-intelligence-analysis/PsychofIntelNew.pdf>> (1999).

²⁸ ACH, Palo Alto Research Center <<http://www2.parc.com/istl/projects/ach/ach.html>>, website accessed 17th October 2010; ACH, Competinghypotheses.org <<http://competinghypotheses.org/>>, website accessed 17th October 2010.