Positive and Negative Predictive Values of Polygraphs: Results from published "field" studies

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Introduction

In 1999, during an uproar over a spy scandal at the national laboratories, then Department of Energy Secretary Bill Richardson (now governor of New Mexico) implemented a sweeping polygraph program within the Department headquarters in Washington and the three nuclear weapons laboratories: Sandia, Los Alamos, and Lawrence Livermore National Laboratories. Over the protests of scientific staff and despite an in-depth study by the National Academy of Sciences questioning the value of screening polygraphs for national security purposes, thousands of polygraphs were administered in the subsequent 6 years. No spies were found, and the original person-of-interest leading to the Secretary's policy decision, Dr. Wen Ho Lee, was exonerated of espionage charges. It is not known how many careers were destroyed or compromised by polygraphers' conclusions that subjects were "deceptive" during their polygraph exams, but there is substantial testimonial data on the adverse effects of polygraphs[2].

In late 2006, the Department of Energy quietly retired the screening polygraph with neither explanation nor apology to those who suffered adverse effects from its use. For a moment, it appeared that the DOE – long known for its singular dysfunctionality among US government agencies – had actually learned something after squandering many tens of millions of dollars (while finding no spies) and did what is almost unheard of in government: reversing a demonstrably bad decision. But the withdrawal of the "screening" polygraph program at the national labs came with a catch: "random" counterintelligence polygraphs might still be administered to those employees with certain

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[1] This work is unfunded and the views expressed are solely those of the author who welcomes comments and corrections at: zalan8587@qwest.net. Statistical calculations may be found at: http://www.zelicoff.com/Polygraphs/NPV-PPV-calcs.xls. This paper and accompanying spreadsheet may be reproduced without the written consent of the author, though if referred to in other publications, standard citation practice should be followed.

[2] See: http://www.zelicoff.com/SMLR/EWAPage/PolygraphyFiles/EditTestimonialsPolygraphs.pdf.

clearances[3]. Indeed, that has now come to pass[4]. To many thoughtful readers it will doubtless be difficult to understand how a discredited and ineffective technology can be made a part of a credible national security program merely by renaming it.

The Polygraph *process* vs. the polygraph *examination*

I believe it is important to understand the distinction between polygraph *examination* or *test* and the activities that accompany the test. I refer to the latter as the polygraph *process* and it involves at least three parts (in addition to the actual polygraph test) in almost all circumstances:

- a pre-test registration in which the subject signs a document waving certain legal rights such as presence of an attorney, access to the polygraph record (including the video recording that is usually made during a polygraph for "quality control" purposes).

- A pre-test interview during which the polygrapher explains how the polygraph works (or, at least is purported to work) to identify deception, what questions will be asked and why (including the "control" question depending on the purpose of the test or the "format" of the test[5]), and, often an inquiry into medical conditions for which the subject has or is being treated. The latter may include a request (or, in the case of DOE polygraphs a demand) for the subject to provide a list of all medications, ostensibly to help the polygrapher "adjust" the polygraph machine (or his interpretation of the tracings) based on the effects of common medications

[3] The text of the DOE filing in the Code of Federal Regulations can be read at: http://www.fas.org/sgp/news/2006/09/fr092906.pdf

[4] See, for example: http://lanl-the-rest-of-the-story.blogspot.com/2007/04/doe-polygraph-program.html. This link includes a memorandum to employees from the Director for Security at Los Alamos National Laboratories explaining the "random sampling" process and commentary from Los Alamos staff (almost all of it anonymous, as the new policy guarantees loss of high-level security clearance for even objecting to the program.

[5] There many books and articles covering the polygraph process. Perhaps the two single best sources are: Lykken, David T. *A Tremor in the Blood.* McGraw Hill (New York), 1981; and Maschke, G. and Scalabrini, G.: *The Lie Behind the Lie Detector* (4th digital edition, 2005) available for free download at: http://www.antipolygraph.org/lie-behind-the-lie-detector.pdf.

on the polygraph[6]. Unfortunately, there are *no* published papers on the effects on any medications on the polygraph so the request is scientifically baseless and the polygraphers' interest in medications may be based in the belief that individuals taking certain medications (e.g. for anxiety or depression) are "high risk" security concerns, thereby providing a basis (and/or bias) for failing an individual during the actual polygraph test.

- If the polygrapher is suspicious that a subject was deceptive during the actual polygraph test (for whatever reason, which may have nothing at all to do with the polygraph machine tracings), a post-test interview may be administered. The post-testinterview is described well by Maschke and Scalabrini (2005)[7]:

> If the polygrapher suspects you of deception (and sometimes not), he or she will confront you with the polygraph charts and seek to obtain a confession from you. Interrogation techniques vary, but typically, the polygrapher will ask you to explain why you reacted strongly to a particular question. If you have truly responded strongly to a relevant question, no explanation short of a confession or damaging admission is likely to suffice. If the examiner is just bluffing, your truthful denials will be adequate, the examiner's doubts not- withstanding.
>
> In trying to obtain an admission, your polygrapher may try the following approaches (Janniro, 1991):
>
> • They didn't bring me here to ignore my report. The test confirms that you haven't been completely truthful. Your situation will only get worse if we don't get this cleared up.
>
> • The only thing that will help you now is to be completely truthful. When a person hides something or lies they usually regret it later on when the truth comes out... like it will in this situation.
>
> • We've all been in situations when we withheld something or told a lie about something that didn't seem too bad. But then, we had to tell another lie and another lie and another until the whole story fell apart.
>
> • It is no longer an issue as to whether you did this or not. The only

[6] Some polygraphers may also express concern that serious medical conditions (for example, heart disease) may make the polygraph exam too dangerous. While this may or may not be the case (there are no studies on this question in the medical literature nor is it likely that there ever will be), most individuals I have interviewed are frightened enough to comply with the polygrapher's request for medication lists.

[7] Maschke, ibid. Page 87

things left to discuss are why and how you got involved in this matter. In fact it is really an insult to my intelligence for you to tell me that you have been completely truthful here today.

• I promised that I would be honest with you here today [!] and you promised me the same thing. You and I both know that you haven't been truthful now. I could respect you more if you just told me that you don't know how to deal with this... that you don't want to confess.

• If you were to show me a picture of someone close to you, I could never persuade you that it was someone else. These charts are like a picture of truth or deception and we can't change them no matter what we say.

• A lie is like a cancer inside of you that eats away at you and never goes away until it is taken out. Then the body can get well.

Thus, the final decision on deception rendered by the polygrapher may have little to do with the polygraph test *per se* but rather with the activities that take place before and after the tracings are recorded during the formal polygraph test.

We will now assume, perhaps incorrectly, that the polygraph test itself is the basis for rendering a judgment on a subject's deception as is claimed by polygraphers. Thus, it can be thought of as just another diagnostic test – in this case with the diagnostic goal of identifying the presence or absence of "deception" -- akin to diagnosing a "disease" in medicine. From a scientific standpoint, assessing the value of a polygraph for making a diagnosis of deception is therefore no different than for any diagnostic test and thus a straightforward analysis of utility applies. [8]

Background on diagnostic testing

All diagnostic tests – in engineering, in physics, in medicine, and in the art of assessing deception -- are imperfect. In the medical and scientific literature, the tendency of a given test (when compared to some "gold standard") to miss the presence of a given condition or system state is called the false negative *rate* (FNR), referring to the likelihood (usually expressed as a percentage) of all situations where condition "x" is actually present wherein a given diagnostic test fails to identify the presence of that condition. ***Not*** conversely, the *false positive rate* (FPR) is the likelihood (again expressed as a percentage) of a given

[8] None of this is to say that an objective statistical analysis will change the views of decision-makers -- even at national laboratories where almost all of senior are highly trained scientists.

diagnostic test to incorrectly identify the presence of condition "x" when, in fact, it is *not* present. The arithmetic converses of the FNR and FPR are, respectively the *sensitivity* and the *specificity* of the test. Note that it is possible (indeed it is the rule) that some tests can be highly specific without being highly sensitive, and of course tests can be highly sensitive without being highly specific.

In Bayesian logic, sometimes called "post-testing revisionist" logic (as results of one test change one's confidence in the presence or absence of a condition), it is necessary, but not sufficient, to know the specificity and sensitivity of a diagnostic test in order to calculate the post-test confidence of the presence of condition "x".[9]

Although the polygraph literature is largely bereft of statistical analysis, there is some appreciation in the academic polygraph literature for the need for assessing the sensitivity and specificity of the polygraph test. The most comprehensive study of polygraphs, performed in 2001 by the National Research Council of the National Academy of Sciences, is particularly thorough in identifying these critical diagnostic characteristics of the polygraph, though the study authors are careful to point out that a paucity of published field experience limits any objective analysis of the actually utility of polygraphs in specific situations such as criminal justice or security screening. Regrettably, the lack of published data does not forestall claims of "accuracy," "usefulness," or "cost-effectiveness" of the polygraph (made almost exclusively by polygraphers or those who employ or hire them such as criminal defense attorneys and US government agencies).

Calculating confidence in polygraph results

When personal biases, judgments, and anecdotes are put aside as they must be in any objective analysis, there are but few studies that attempt to evaluate the practical effectiveness of polygraphs "in the field," that is, in *consequential* use where the polygrapher's assessment of the polygraph may affect legal decisions or awarding of a job or security clearance.[10] The studies which pass a minimal set of criteria for reproducibility, consistency, and blinding for observer bias are summarized in Figure 1 below[11].

[9] Many statistical textbooks and papers review Bayesian logic, and it will not be discussed in depth in this paper. However, explicit examples as pertain to polygraphs will be detailed in this monograph.

[10] Almost all published studies on polygraph diagnostic utility are based on simulated "mock crime" tests, generally performed in university psychology departments where the actual consequences of lying and being detected as deceptive are limited to the failure to collect a small monetary reward.

[11] *Handbook of Polygraph Testing,* edited by Murray Kleiner (Academic Press, 2002), p. 29, Table 1.9)

Study	Guilty				Innocent			
	n	% correct	% wrong	% inc.	*n*	% correct	% wrong	% inc.
Honts (1996)[a]	7	100	0	0	6	83	0	17
Honts and Raskin (1988)[b]	12	92	0	8	13	62	15	23
Patrick and Iacono (1991)[c]	52	92	2	6	37	30	24	46
Raskin *et al.* (1989)[d]	37	73	0	27	26	61	8	31
Means	108	89	1	10	82	59	12	29
Precent decisions		98	2			75	25	

a Subgroup of subjects confirmed by confession and evidence.
b Decision based only on comparisons to traditional comparison questions.
c Results from mean blind rescoring of the cases "verified with maximum certainty" (p. 235).
d These results are from an independent evaluation of the "Pure verification" cases.

Figure 1: Summary of field-polygraph studies

As footnotes (a) through (d) in the table make clear, the settings of these individual reports vary widely, making a strict meta-analysis impossible as methodology, "gold standard" for comparison, and other key metrics almost certainly differ. Further, the poor quality control in polygraphers' literature is abundantly illustrated in this table, where the "means" that are presented are not weighted by the size of the studies involved, thus conveying a false impression of the accuracy of the polygraph (defined in this case as the percentage of individuals classified correctly). Instead, a simple average of each of the columns is calculated. Even a freshman statistics course underscores the importance of *weighted* means, as does every published meta-analysis. Yet the authors of the relevant chapter of the *Handbook of Polygraph Testing* seem unconcerned with assigning the same significance to a study involving 13 subjects [Honts 1996] as one involving 89 subjects [Patrick and Iacono]. Little wonder that few serious scientists agree with polygraphers' assertions of the utility of their diagnostic tool.

Ignoring these limitations (which, if anything, bias the following calculations in favor of the polygraph's diagnostic value) in order for non-experts to understand the actual value of any diagnostic test, mathematicians have extended fundamental Bayesian principles and have introduced two additional constructs: *negative predictive value* (NPV) and *positive predictive value* (PPV). The NPV summarizes in one number (with appropriate confidence intervals) the answer to

the question: "if a subject has a negative result on a diagnostic test, how confident can one be that the condition in question does *not*, in fact, exist?" The PPV answers the question: "if a subject has a positive result on a diagnostic test, what confidence can one have that the condition we seek *does* in fact exist?"

Thus, in the specific case of the polygraph, NPV and PPV have the following practical interpretations:

- NPV means that if a subject *passes* a polygraph (that is, has no finding of deception according to the polygrapher's interpretation of the four physiologic tracings measured by the polygraph machine[12]), the likelihood that the subject is, in fact, not deceptive is of likelihood "z_1", expressed as a percentage between 0 and 100%.
- PPV means that if a subject *fails* a polygraph (that is has a positive finding of deception), the likelihood that the subject is, in fact, deceptive is of likelihood "z_2", expressed as a percentage between 0 and 100%.

NPV and PPV are well defined in Bayesian mathematics and are used routinely in choosing and assessing the results from medical diagnostic tests. For example, readers may be familiar with the "rapid strep throat" screening test (RSTST) that is used in physicians' offices. This test, which is based on measuring the binding of an antibody to a protein elaborated by the streptococcus organism, has a known sensitivity of approximately 98% and a specificity of 75%. *Depending on the prevalence of strep throat in the population as given by a gold standard test* (such as the labor intensive, slow, and expensive throat culture), an NPV and PPV can be calculated. Since the test has a false positive rate of about 25% (100-75%), during those times of the year (spring and summer) when invasive streptococcal disease of the throat is a rare cause of symptoms and/or disease in patients complaining of "sore throat" (perhaps 5% of sore throats in the summer are due to streptococcus species and thus carry no risk of complications such as rheumatic fever nor do they require antibiotic therapy), the PPV is low (about 30%), meaning that "in the spring or summer, a positive RSTST gives the physician a confidence of only 30% that the patient she is seeing with a sore throat does, *in fact*, have streptococcus as the cause." However, in the winter, when the

[12] Polygraph machines may or may not accurately measure the heart rate, respiratory rate and depth, galvanic skin response (electrical conductance of the skin), and blood pressure, but such considerations are ignored in this paper. To the extent that validation of these measurements is not known or is, in fact, shown to be poor, the utility of the polygraph is further undermined. As no agency has responsibility for validating the accuracy of any commercial polygraph machine (a situation we would find quite unacceptable for medical diagnostic tests, which must be approved by the Food and Drug Administration), no objective critique of polygraph *technologies* can be provided to the reader.

prevalence of streptococcus may be as high as 40% in patients with sore throat (again as given by some gold standard test such as the throat culture or biopsy), the PPV is well in excess of 60%, meaning that "in the winter, a positive RSTST gives the physician a confidence of more than 60% that the patient she is seeing with a sore throat does, *in fact,* have streptococcus as the cause." Most physicians would treat with antibiotics in the latter case but seek additional diagnostic information before prescribing penicillin in the former situation.

Note that PPV and NPV must be qualified by confidence intervals. Since polygraphers offer an interpretation of "no deception indicated" or "deception indicated" the polygraph is, for all intents and purposes, binary in nature, much like the RSTST. "Inconclusive" results complicate the statistical confidence calculations, but for the purposes of this paper (and with an obvious bias *in favor* of the polygraph), I will consider polygraph results to be binomially distributed based on the binary reporting of the polygrapher.

Using standard Monte Carlo techniques, the well known expressions for NPV and PPV and the table in Figure 1, above, the following results obtain (95% confidence intervals in parentheses)[13]:

- When the *inconclusive results are ignored*, the NPV of the polygraph is 97% (92% - 100%). Although inconclusive results are a fact of life (and thus difficult to ignore from a practical perspective) *utilizing this highly selected data*, it is reasonable to state that an individual who passes a polygraph is almost certainly not being deceptive.
- When *inconclusive results are considered to be errors of ambiguity*, the NPV of the polygraph falls to 73% (62.5% - 78.1%). Thus, the polygraph is better than flipping a coin, but hardly provide the kind of confidence one would want when making a personally consequential decision (such as whether to undergo a potentially dangerous surgical procedures. Would juries or agencies that grant security clearances want to rely on the polygraph when a deceptive individual is able to pass 27% (21.9% - 37.5%) of the time? I'm glad I don't have to make that decision[14].
- The PPV of the polygraph is 88% (82% - 87%) when inconclusive results

[13] Readers are invited to download an Excel spreadsheet summary of Table 1.9 from the *Handbook* along with NPV and PPV calculations (including binomially-based confidence intervals) from my website: http://www.zelicoff.com/Polygraphs/NPV-PPVcalcs.xls. Note that an add-on package called "PopTools" is required (for carrying out Monte Carlo simulations) and is available for free download courtesy of its author at: http://www.cse.csiro.au/poptools/download.htm.

are ignored.

- The PPV of the polygraph falls dramatically to 55.5% (45% - 60%) when inconclusive results are accounted for. Put another way, if a subject fails a polygraph, the probability that she is, in fact, being deceptive is little more than chance alone; that is, one could flip a coin and get virtually the same result for a positive test based on the published data.

Viewed graphically the results are as follows for NPV and PPV respectively:

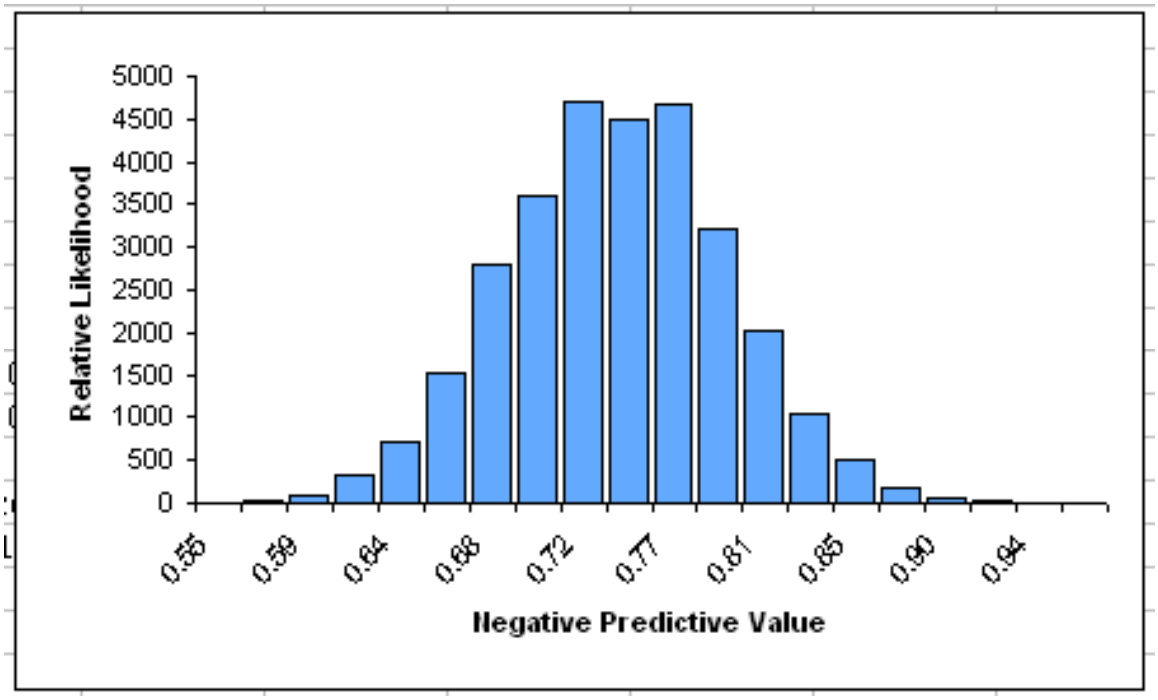

Figure 2: Distribution of NPV results from a Monte Carlo simulation (30,000 runs)

[14] And of course, I never would, as the science shows that relying on polygraph results, even as part of a systemic approach involving other tools, is manifestly foolish.

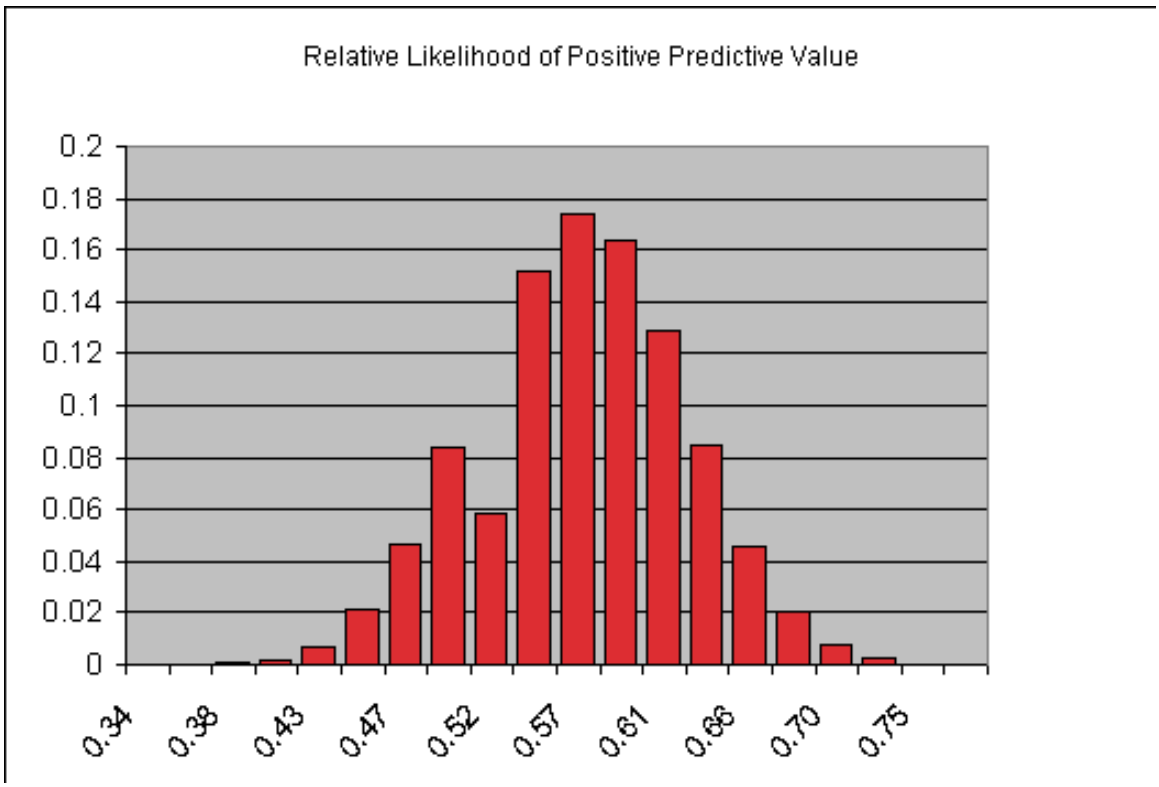

Figure 3: Distribution of PPV results from a Monte Carlo simulation (30,000 runs)

Summary

The polygraph makes for a very poor screening or "random" test for deception. The reason is that in such contexts, the vast majority of people are honest (especially those applying for security clearances) so that a negative test result adds little to what one knows *a priori*. At the same time, failing to pass a polygraph vastly overestimates the likelihood that the subject is, in fact, being deceptive (or, alternatively, offers very little additional diagnostic information than chance alone.) The only exception to the latter conclusion is in the situation where a subject actually *believes* that the polygrapher (with or without using the tracings from the polygraph test) can divine deception and thus confesses on the spot. As knowledge of the inherent inaccuracies of the polygraph spreads, the probability that any intelligent or informed individual would harbor such beliefs will drop.

Negative polygraph tests, especially in the national security community, are unsurprising as the overwhelming majority of people applying for a security clearance are, *a priori*, honest a loyal. Thus, one can be much more than 95% certain that a given individual proceeding through the screening process for a security clearance is loyal and intends or plans no misuse of classified

information. That the polygraph changes this pre-test probability from 95% to 97.5% when an individual passes the test is to merely question the cost-effectiveness of the polygraph: there is a small marginal benefit for enormous cost.

What costs are incurred for the very limited information value from the polygraph? In the context of continued security clearance screening using the polygraph (now in a "random" instead of a "periodic" mode, a distinction that is impossible to understand without the actual recorded experience of polygraph subjects at, for example, the national laboratories) the US Department of Energy refuses to reveal the cost of its polygraph program. In the commercial world, a polygraph examination costs on the order of $300, so let us assume that over the few years some 8,000 "random" polygraphs will be performed at the three US DOE national laboratories. Realizing that government costs for anything are almost always in excess of private industry costs, at the low end of any reasonable estimate about $2.5 million will be spent in direct costs on polygraphs. Former Secretary of Energy Bill Richardson estimated publicly and repeatedly in 2000, when he proposed a sweeping polygraph program, that "99.99% of all national laboratory employees are loyal Americans". Let's assume the governor overestimated the loyalty of national laboratory employees (perhaps for political reasons but more likely that like most senior government executives he is simply innumerate and doesn't realized that 99.99% means that only about 1 employee at the three main weapons laboratories is a disloyal agent of a foreign government or out to compromise government secrets), and that only 99.9% of the 5,000 people to be subjected to random polygraphs are "loyal." Let us further assume that the sensitivity of the polygraph for detecting deception (or spying or evil intent) is perfect. Thus, 0.1% of the 5,000 subjects or 5 individuals will be identified as true-positive "deceptive."

At the same time, given a false positive rate of 25%, some 1,000 people will undergo further security screening. The cost of this additional investigatory work is hard to estimate, but a conservative value of $10,000 per inquiry seems like a very low figure. Perhaps then $10 million will be spent investigating individuals who failed their polygraph.

Lawsuits will inevitably follow since the false positive rate is so high and let's assume that each of those costs, on average, $10,000 for a total of $10 million more. Thus, the total costs of finding 5 deceptive employees (if indeed there are even that many) is approximately $22.5 million, or about $4 million each. [15]

[15] Actually, this is an underestimate (see also the next paragraph in the body of the paper.) Since the sensitivity of the polygraph is only about 85%, only 4 out of 5 deceptive individuals will be found, thus the cost is closer to $5 million per deceptive subject found. In addition, one can only guess at the cost of *failing* to find

But the *real* cost of polygraphs comes in protean and quantitatively problematic forms: decreased morale among employees who come to see themselves as guilty until proven innocent; wasted staff time; converting once serious scientific institutions into laughable legacies that stoop to unscientific security procedures to protect vital national secrets; squandering of funds that could be much better spent on guards, computer security, and far more effective counterintelligence procedures; and the message sent to society at large: if polygraphs are good enough for the national laboratories, they may have a place in civil society as well.

It is difficult to image a single process that could do more damage to American democracy and sense of fair play than the polygraph. Unfortunately, scientific truth rarely manifests itself as rational policy in federal government. It is axiomatic to note that this realization is particularly disturbing as it obtains at US national laboratories as well.

Recommendations

There is no justification for "random" polygraphs, anymore than there was for the policy of "periodic polygraph screening", which the DOE quietly withdrew via a filing in the Federal Code of Regulations in December 2006 after nearly 7 years of operation, tens of millions of dollars of squandered funds, and not a single identified spy, miscreant, or ill-intentioned individual in the DOE national laboratories. Thus, the Congress should withhold any funding for random polygraph testing.

Contractors operating Los Alamos, Sandia, and Lawrence Livermore national laboratories should resist DOE directives to carry out such screening with a prospective study of the effects of polygraphs on morale and their effectiveness as a counterintelligence tool. To do anything less is unscientific, indicative of an absence of leadership skills, and undermines the claims of operating contractors that they add value to the national laboratories, justifying their operating fees.

Third, laboratory management should *require* that a statistical sample of routinely obtained polygraph videotapes be reviewed by an independent panel

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the other deceptive individual in this example of roughly 8,000 subjects who might be a truly harmful spy such as Aldrich Ames, or other now well-known, damaging spies who operated for years with the full confidence of the counter-intelligence departments at their government agencies. Thus, what is likely to be the second highest cost of all is the cost of false-confidence in the polygraph. Mr. Ames, for example, passed his CIA polygraph twice while selling highly sensitive documents to the Soviet Union/Russia.

of community leaders to be certain that polygraphers do not overstep their bounds with illicit inquisitions into private medical information or related matters that have no relevance to the polygraph. In addition, demeanor of polygraphers can be reviewed and reports provided to laboratory management which is responsible for the health, safety, and scientific independence of staff.

Fourth, the staff of Congressional intelligence committees (and perhaps the principles on those committees as well) should be subject to random polygraph screening. The intent here isn't to spread around the pain and embarrassments of polygraphs but rather to educate staff as to their inherent limitations and modest (perhaps non-existent) efficacy either as tools of deterrence or for investigation of Congressional leaks of national security information.

But given that it is not likely that these recommendations will be followed until much more damage is wrought, it may be up to individuals writing on laboratory blog sites to compile – anonymously if necessary – the accounts of polygraph subjects with a focus on the scope of questions, inquiry into medication prescriptions, medical conditions, personal relationships, and other protected information that have no place in polygraph testing. Polygraphers will, of course, object (and in my experience, strenuously so though they haven't a shred of scientific evidence to justify their quibbles. For example, polygraphers will assert that medications have "an effect" of the polygraph and that therefore they need to know about them in order to "accurately interpret the polygraph tracings", but their claim is unsupported by any study in the medical literature. [16]

Put another way, should a polygrapher elicit a history of use of, say, antidepressant medication[17] it is far more likely that such information will be used in a prejudicial way against an employee than to "adjust the polygraph interpretation" for effects of medications. There are no studies whatsoever to justify the latter.

Most national laboratory staff members are likely distressed to realize that the highly trained scientists who constitute most of management would vacate their training and intellect (let alone common sense) by failing to read the published

[16] Perhaps medications *do* affect the polygraph; if so, it is incumbent upon academic polygraph researchers to demonstrate such effects lest the questions be used for denying security clearances based on the bogus assessment of polygraphers untrained in either medicine or pharmacology.

[17] Unless the staff at the national laboratories differs dramatically from an age, sex, and economically-matched population of similarly trained professionals, at least 15% are on mood altering medications for treatment of mild to moderately severe mental illness such as depression, insomnia or anxiety.

literature on polygraphs and at least publicly question this peculiar DOE policy. Perhaps as time goes on (and after even more laboratory staff move on) a few thoughtful leaders in management will be willing to risk their careers to protect the scientific independence of the labs. In the short run, the adverse consequences of polygraphy may be ignorable, but in the longer term (and I suspect that means merely months to a few years) the impact will be strongly negative and possibly catastrophic for the labs.

It is unlikely that government or contractor management will seek to eliminate once and for all the wide-ranging inquisition that *is* the modern polygraph. Instead, individual scientists at the national laboratories will have to protest on now well-established scientific grounds if civil rights are to be protected along with the integrity and independence of the national laboratories in carrying out their critical scientific roles as apolitical arbiters of questions of national security importance. Publishing accounts of individuals' polygraph experiences (anonymously if necessary) is a worthwhile place to start.

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