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The Lafayette ESS Report is a useful tool for field polygraph practitioners. It assists with the rapid generation of a printable report that includes a statistical test result and a written conclusion using numerical scores. The scores are extracted from the recorded polygraph data using traditional visual feature extraction methods. ESS results are reported categorically as to whether the numerical test score differs at a statistically significant level from the empirical reference distributions for deception and truth-telling. Similar to the logic of hypothesis testing, the traditional statistic of interest is the p-value.

The logic or intuition of p-values can be easily lost on persons not trained in science and statistics, and p-values are often misunderstood and misused (Nelson, 2015a). The most common error is to regard a p-value as a measure of effect size or accuracy, wrongly taking the compliment of a p-value as a confidence level. Strictly speaking, p-values are an estimate of measurement error, not an estimate of classification error, and cannot themselves be thought of a confidence level or probability of deception or truth-telling.

To obtain a probability of deception or truth-telling it will be necessary to use *Bayesian* statistics (Bayes & Price, 1763; Berger, 1985; Gill, 2007; Gelman *et al.*, 2014; Winkler, 1972) for which a scientific test or experiment begins with a declaration of our prior knowledge or assumption about the probability associated with a possible conclusion. For example: a polygraph test can begin with a declaration of a prior probability estimate, based on prior available information suggesting that an examinee is deceptive or truthful. This is similar to the way that frequentist statistical methods begin with a declaration of an alpha level or tolerance for error at which a test statistic will be considered significant. Whereas, frequentist methods begin with a declaration of a prior probability estimate. Prior probabilities can be expressed as point estimates, but because the exact prior probabilities is unknown prior probabilities are often expressed as a prior probability distribution. The prior probability estimate can then be mathematically conditioned on the test statistic (Cohen, 1994) to increase the precision and effectiveness of the estimated probability of deception or truth-telling. As with other mathematical and statistical procedures, it is helpful to have well-designed computer software to assist in the calculations.

How to use the Lafayette ESS Report to obtain a probability of deception or truth-telling

Using the Lafayette ESS Report to obtain a probability of deception or truth-telling requires changing some settings in the LXSoftware preferences. First select the **Tools** \rightarrow **Preferences** menu item, and then choose the **Hand Score** item from the list of preference panels. As shown in Figure 1, scroll down to the **ESS section** and change the **Result Type** item to **Confidence Level**. Then change the **Bayesian Conditional** item to **Yes**. The default **Prior Probability** of **.5** can also be changed to any prior probability estimate.

Figure 1. Change the ESS Report Settings

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Activity Seat EDA - Multi-mode					
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Click **OK** after changing these settings. Then proceed to score the examination and generate the ESS Report from the manual score sheet. The Lafayette ESS Report Generator will use the data from the manual score sheet to calculate the Bayesian conditional probability of deception or truth-telling. The conditional probability is the prior probability estimate conditioned on the test statistic (p-value). Figures 2 and 3 show examples of the Lafayette ESS Report with conditional probabilities when the results are indicative of deception and truthtelling.

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Figure 2. Lafayette ESS Report with Bayesian conditional probability of deception.

Figure 3. Lafayette ESS Report with Bayesian conditional probability of truth-telling.

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The purpose of a scientific test is to quantify some interesting and important phenomena (e.g., personality tests, tests of cognitive or intellectual functioning, tests of credibility/deception/truth-telling, etc.) for which neither direct physical/linear measurement nor perfect deterministic observation is possible. A polygraph test can be thought of as a single subject science experiment (Nelson, 2015b). The purpose of a scientific experiment is to learn about some interesting phenomena by attempting to quantify the *effect* (i.e., change or difference compared to an alternative) of a process or procedure. Scientific experiments and scientific tests achieve these objectives through the use of measurable and observable proxy data for which there is a known statistical relationship (i.e., correlation) with the phenomena of interest, though the proxy data are not themselves the phenomena of interest. Because they are not deterministic, scientific tests are expected to quantify the margin of uncertainty associated with a conclusion.

The general name for the process of using available data to make conclusions about unavailable data is *inference.* Inference has been described as the most glamorous aspect of statistics (Efron, 1982; 1986), though not necessarily the most important. A polygraph test is intended to make a probabilistic inference about deception and truth-telling. Probabilistic inference is necessary because deception and truth-telling are amorphous (i.e., there is no physical substance) and cannot themselves be subject to evaluation with a physical unit of measurement¹. To the degree that confirmatory information may be forthcoming, polygraph test results might be thought of as a statistical prediction. It is important, however, to remember that we are neither predicting the past, which has already occurred, nor predicting the future, which is beyond the capabilities of the polygraph test results might be thought of as predict the likelihood that confirmatory information exists and can be obtained if pursued in a manner similar to the confirmatory information that was available for the empirical reference data with which the examination data are evaluated. Most importantly, all scientific test results and all scientific conclusions are ultimately probability statements, including when they are simplified to categorical conclusions.

Although the p-value is among the most common statistical metrics, it is not the most intuitive or easily understood. An important advantage of a conditional probability of deception or truth-telling is that the intuition and practical meaning of the probabilistic result will be simpler and more accessible for persons untrained in statistics. All that is necessary is a test statistic such as a p-value that can serve as a likelihood function to be conditioned on a prior probability estimate.

A useful source of prior probability information might be the base-rate or incidence rate at which a behavior or event is known to occur. Other sources of prior information might include a hunch, intuition, gut feeling, circumstantial evidence, observed inconsistencies, or any information for which we are willing to assert some associated probability value for deception or truth-telling. When there is very little information to anchor a prior probability estimate the solution is often to use a prior probability of .5 (50%).

All that is required to calculate a posterior probability of deception or truth-telling is a declaration of the assumed prior probability or the range or distribution of possible prior probabilities. The prior probability is then *conditioned* on a p-value or other testing statistic. Conditioning the prior probability on the test statistic is a mathematical operation involving Bayes' theorem. Although field practitioners will most often want to use a

¹ Another example of the difficulty of quantifying amorphous phenomena can be seen when testing intellectual functioning, for which IQ tests will use performance on questions and tasks as a proxy for intellectual abilities that are measured statistically or probabilistically using a measurement unit referred to as an *intelligence quotient*, which is an acknowledgement that the test does not actually measure a person's intelligence *per se*. Instead, IQ tests measure a person's intelligence quotient, which is a probabilistic unit of measurement for an amorphous phenomena.

computer to ensure that all calculations completed correctly, those who wish to develop expertise will want to become familiar with the mathematical formulae and calculations required to compute a conditional probability.

The conditional probability can also be thought of as a confidence level because it is intended to describe the level of classification error associated with a categorical conclusion that is accountable, calculable and replicable (i.e., without guessing). The conditional probability or confidence level offers the advantage of providing practical meaning that, is more intuitively understood, compared to the intuition for p-values, by persons untrained in scientific testing, probability, and measurement theories. Unlike a p-value, because it begins with a declared prior probability estimate for deception or truth-telling, a conditional probability can be thought of as a *probability of deception* or *probability of truth-telling*.

When considering a future in which the polygraph test will have to co-exist with other scientific credibility assessment tests in a forensic arena that will be increasingly regulated and held accountable for whether statements and assertions about test precision and outcome performance conform to real world experience, it will do the polygraph profession, the public, and the agencies we serve little good for field practitioners to neglect to make use of probability models and probabilistic thinking as applied to polygraph test results. Scientific tests are not expected to be infallible and are only expected to quantify the margin of uncertainty or level of confidence that can be assumed about or attributed to a result or conclusion. It is hoped that the Lafayette ESS Report Generator can assist field polygraph examiners and others to achieve the goals of scientific testing in the polygraph context – the goal of quantifying the margin of uncertainty and level of confidence associated with polygraph test results that are expressed as categorical conclusions of deception or truth-telling.

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