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HUME, MIRACLES, AND MATHEMATICS:

A CASE STUDY FOR THE USE AND PREVALENCE OF PROBABILISTIC ARGUMENTATION WITHIN BIBLICAL STUDIES

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In David Hume's *Enquiry,* he states: "No testimony is sufficient to establish a miracle, unless the testimony be of such a kind, that its falsehood would be more miraculous, than the fact, which it endeavours to establish... the superior only gives us an assurance suitable to that degree of force, which remains, after deducting the inferior."[1] Hume's statement may seem captive to the realm of philosophy. One could discuss how Hume eventually dismisses the existence of miracles not because he sees them as theoretically impossible, but rather because no witness could ever be reliable enough to show otherwise. But as Holder, Sobel,[2] Owen,[3] and others argue, Hume's statement is inherently mathematical. While these scholars have differing opinions as to whether miracles exist or not, all interpret Hume's statement in light of Bayes' theorem, a statistical technique developed by Thomas Bayes. In this paper, I will analyze the debate about Hume and miracles, arguing that under certain conditions the existence of a miracle

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[1] Rodney Holder, "Hume on Miracles: Bayesian Interpretation, Multiple Testimony, and the Existence of God." *The British Journal for the Philosophy of Science* 49, no 1 (1998): 50. (quoting Hume's *Enquiry*)

[2] Jordan Howard Sobel, "On the Evidence of Testimony for Miracles: A Bayesian Interpretation of David Hume's Analysis." *The Philosophical Quarterly* 37, no 147 (1987): 166-186.

[3] David Owen, "Hume Versus Price on Miracles and Prior Probabilities: Testimony and the Bayesian Calculation." *The Philosophical Quarterly* 37, no 147 (1987): 187-202.

could be rationally accepted. This discussion about Hume will serve as a case study, showing how mathematics and specifically probability can be integral to analyzing important questions present in philosophy and religion. I will then explore more broadly the realm of biblical studies, arguing that biblical historians frequently employ probabilistic argumentation and mathematical reasoning when assessing the truthfulness of biblical narratives. Finally, I will suggest that given the case study about miracles and the commonplace of probabilistic language in biblical studies, having a degree of mathematical literacy can be a useful and important tool in dissecting the arguments made by biblical historians today.

Hume and Bayes' Theorem

In Rodney Holder's article on Hume and miracles, he interprets Hume's statement above to be making an argument that draws upon the logic of Bayesian probabilities. Here, Hume brings up two significant probabilities: the probability of a witness making false testimony, and the a priori probability of a miracle occurring. Seeing the probabilities that Hume has stressed in his analysis, Holder uses Bayes' Theorem to mathematically express Hume's argument. Bayes' Theorem is a statistical technique that combines the use of a priori and conditional probabilities[4] in order to assess the likelihood of the event in question. In this case, the central event in question is this: what is the probability of a specific miracle having occurred (denoted by the variable "M" in the formulas to follow), given an individual's testimony to that specific miracle occurring (denoted "T"). Using these variables, Bayes' Theorem is as follows, where $P(T \mid M)$ is the conditional probability that testimony would be provided given that the miracle occurred, and $P(T \mid \sim M)$ is the conditional probability that an individual

[4] A conditional probability is the probability of event A occurring *given* that event B occurred and is denoted $P(A|B)$.

would provide testimony to the miracle occurring given that the miracle did not actually occur:

$$P(M\ |T) = \frac{P(T|M)*P(M)}{P(T|M)*P(M) + P(T|{\sim}M)*P({\sim}M)} \qquad \text{(Eq. 1)}$$

Since Hume argues that miracles are intrinsically improbable, the P(M) << 1 (a really small number), and the P(~M)=1 (technically, very close to 1). If the miracle occurs and someone is there to see it, it is almost certain that it will get reported, so P(T|M) = 1. Using Hume's assumptions and inserting these values, the following is left:

$$P(M\ |T) = \frac{P(M)}{P(M) + P(T|{\sim}M)} \qquad \text{(Eq. 2)}$$

Holder argues that for a miracle to be "rationally acceptable"[5] the probability of the miracle occurring given the testimony about that miracle must be greater than 0.5. Using the equation above, this means we are looking for what is greater, the a priori probability that the miracle occurred, or the probability that the witness testified to the specific miracle occurring, given that the miracle did not actually occur. Mathematically expressed:

(Eq. 3)

$$P(M) > P(T|{\sim}M) \textit{ indicates belief in a miraculous event is rational,}$$
$$P(M) < P(T|{\sim}M) \textit{ indicates belief in miraculous event is not rational}$$

Notice this is exactly where Hume left us, comparing the probabilities of a miraculous event to the conditional probability of false testimony.

[5] Rodney Holder, "Hume on Miracles: Bayesian Interpretation, Multiple Testimony, and the Existence of God." *The British Journal for the Philosophy of Science* 49, no 1 (1998): 51.

Now that the basics of Bayes' Theorem have been laid out, in order to assess whether or not Hume's intuition and arguments against miracles hold weight when expressed mathematically, we must explore the assumptions and simplifications used by later scholars who agree and disagree with Hume's analysis. Owen, in his article assessing Hume's argument and its Bayesian interpretation, makes some assumptions that cause him to diverge from Holder. Owen of course holds to the basic Bayes' Theorem presented in equation 1 above. However, he then proceeds to use a simplification of equation 1 in his analysis of Hume's arguments:[6]

(Eq. 4)

$$P(M\,|T) = \frac{P(T|M) * P(M)}{P(T|M) * P(M) + (1 - P(T|M)) * P(\sim M)}$$

Note the only difference here between Holder and Owen is that Owen replaces $P(T|\sim M)$ with $(1 - P(T|M))$. Owen notes that these two expressions are equal so long as $P(T|M) = P(\sim T|\sim M)$, where the last conditional probability means that the witness testified to any event other than event M, given that event M did not occur. As will be seen later, whether or not one accepts this as a justifiable becomes crucial in determining whether or not Hume's logic makes sense mathematically.

The issue with Owen's logic here is his assumption regarding the equality above. The variable *T* refers to a witness testifying that the specific event M occurred. So then, the negation of this statement, ~*T*, here refers to the same witness

[6] To keep mathematical notation consistent throughout this paper, I have translated Owen's notation into the notation already expressed by Holder. Owen uses the notation as follows:

$$= \frac{pt}{pt + (1 - p)(1 - t)}$$

making a testimony about some other event occurring. This could be any number of possible events, so long as the testimony is not about event M occurring. Thus, the event $\sim T \cap \sim M$ (meaning not T *and* not M) would include any possible scenarios where the witness testifies about an event other than M (or perhaps does not testify at all), and M does not actually occur. For example, say event A actually occurred, and the witness testified that event B occurred (the witness did not accurately report what happened). This scenario would be consistent with the expression $\sim T \cap \sim M$, as would a scenario where event A actually occurred, and the witness testified that event A actually occurred (the witness accurately reported what happened). How does this compare to the event $T \cap M$? The only scenario consistent with this expression is the scenario where the witness testifies that event M occurred, and event M did occur. Given the disparity between the number of compatible scenarios with each of these events, it would be incredibly unlikely that $P(T|M) = P(\sim T|\sim M)$. Given this, why does Owen make this error? If we are being sympathetic to Owen here, it appears that he means that the probability that the witness would testify to event M giving that M occurred should be equal to the probability that the witness would testify to a different event, say event A, given that event A actually occurred. Holder argues along a similar vein when noting his difference with Owen, saying that by being more careful with formulating the language used in describing the variables, the matter cannot be simplified the way Owen does.[7] It is important to stress here that Holder and Owen are not doing vastly different math: their approaches to this problem are quite similar. Rather, Holder is a bit more precise in how he defines his terms, and this leads to him rejecting one assumption that Owen makes.

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[7] Rodney Holder, "Hume on Miracles: Bayesian Interpretation, Multiple Testimony, and the Existence of God." *The British Journal for the Philosophy of Science* 49, no 1 (1998): 52.

As has already been shown, Holder disagrees with the way Owen simplifies $P(T|{\sim}M)$. Holder's logic centers around how he defines his terms: "our background knowledge K is that W [the witness] is in a position to make a report on what occurs and does so. T is, specifically a testimony for M, i.e. 'W states the M occurred'. But given that M did not occur there are many ways for W [the witness] to give a false report... and it is most unlikely that the false report W would come up with is M."[8] This leads Holder to provide the following formula:[9]

(Eq. 5)

$$P(T|{\sim}M) = P(W\ gives\ a\ false\ report) * P(the\ false\ report\ W\ gives\ is\ T)$$
$$= (1-t) * (1/n)$$

Again it must be stressed that the difference between Holder and Owen is small. All Holder does is recognize that if the witness were to give a false report, there are other possible false reports other than the exact event M. While the difference in their assumptions is small, this can produce a large effect on the end results. Factoring Holder's assumption into equation 2 and rearranging terms we have the following:

(Eq. 6)

$$P(M) > (1-t) * \left(\frac{1}{n}\right)$$
$$indicates\ a\ miraculous\ event\ can\ be\ rationally\ accepted,$$

$$P(M) < \ (1-t) * \left(\frac{1}{n}\right)$$
$$indicates\ a\ miraculous\ event\ cannot\ be\ rationally\ accepted$$

[8] Rodney Holder, "Hume on Miracles: Bayesian Interpretation, Multiple Testimony, and the Existence of God." *The British Journal for the Philosophy of Science* 49, no 1 (1998): 52.
[9] *n* here is the endless numbers of false reports that one could choose from.

Now Holder assumes that n would be sufficiently large, suggesting that there are a multitude of false reports to choose from. However, Holder's argument goes too far here, as it would be more likely that there are only a couple other explanations that one could be reasonably expected to testify to. For example, if one saw a healing and testified to a miracle occurring, there would be a couple other ways to possibly testify about the event: the work of a particular medicine, or the care of a doctor. So for our case, n would be greater than 1, but not very large. Even with this adjustment to Holder's argument, he still seems to have supplied a way in which one could rationally accept that a miracle has occurred. This is not the same as saying that Holder has proved that a particular miracle has occurred, or that this formula could determine if a specific event was a miracle. Rather, it is a response to Hume's earlier statement from his *Enquiry*, that in certain cases it may be rational to accept the existence of a miracle based on witness testimony.

Objections to Hume and the use of Bayesian Statistics

So far our discussion around Hume's argument against miracles is that using a formula like Bayes' theorem, centered around the idea of conditional probability, is an appropriate way to measure the reliability of testimony and the probability of a miracle (or any other event) occurring. While on different sides of the debate as to whether Hume was correct, Owen and Holder both agree that interpreting Hume in a Bayesian manner is appropriate, and that using prior probabilities in assessing the likelihood of a particular occurrence is a valid approach. However, there are some who have questioned the logic of using prior probabilities in assessing the reliability of witness testimony. In this next section, the thoughts of Richard Price, an eighteenth century mathematician, and David Cohen, a twentieth century philosopher, will be explored. Both Cohen and Price offer arguments as to why this probabilistic reasoning is an inappropriate way to measure things such as witness reliability. Furthermore, Cohen and Price show how this topic has implications far beyond the field of miracles, affecting things such as the reliability of a courtroom witness to the reliability of medical tests for diseases. Finally, we will examine the objections brought by Sobel, who argues that there are some limitations to Bayes' theorem, and provides examples where our intuition may show Bayes' theorem to not be entirely reasonable.

Sobel quotes Price as saying that, "the turning point in Mr. Hume's argument is... the principle, that no testimony should engage our belief, except the improbability in the falsehood of it is greater than that in the event which it attests... he [Price] maintains 'that improbabilities as such do not lessen the capacity of testimony to report truth."[10] Price provides a number of examples to show his case. His cases can generally be characterized as examples that appeal to our intuition, where we might be led to believe a trustworthy source despite the fact that there are long odds that the event being reported would actually occur. For example, Price provides the example of a newspaper that is generally accurate two out of every three times. This newspaper one day "reported the loss of a ferry boat during a crossing it had previously made safely two thousand times. In this case, Price asserts, "testimony that is accurate only two out of three times would overcome odds of thousands to one against."[11] In addition, Price offers another reason

[10] Jordan Howard Sobel, "On the Evidence of Testimony for Miracles: A Bayesian Interpretation of David Hume's Analysis." *The Philosophical Quarterly* 37, no 147 (1987): 177, quoting Richard Price's 4th dissertation.
[11] David Owen, "Hume Versus Price on Miracles and Prior Probabilities: Testimony and the Bayesian Calculation." *The Philosophical Quarterly* 37, no 147 (1987): 194.

that prior probabilities should not usually be relevant. Owen attempts to sympathetically give the case for Price's second argument as follows: "One could argue that the *likelihood* of the event reported, or the distribution of past occurrences or non-occurrences, is independent of the accuracy of the testimony, so that when we are to consider whether or not to believe testimony, only its accuracy should be taken into account."[12]

Owen also examines the arguments of a more recent philosopher, L.J. Cohen. Cohen comes to similar conclusions that Price does, but along a slightly different vein. Cohen will accept the use of prior probabilities and conditional statements when discussing the case of long term frequencies of a certain event, just like Hume. But if the concern is with the likelihood of one particular instance of an event occurring, the prior probabilities should be ignored.[13] This has some quite practical implications. Say one is experiencing health symptoms indicating that he or she has either disease A or B.[14] For every 20 people experiencing symptoms, 19 have A and 1 has B. We also know that the test is 80% accurate. Cohen might want to point out that if one was to use Bayes' theorem the probability

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Another example with the same newspaper is given, where 9 highly improbable events occur. Price alleges that Hume's probabilistic reasoning would lead us to believe none, despite the fact that with 9 events and a fairly accurate newspaper, it seems reasonable to think that we ought to believe some of them!

[12] David Owen, "Hume Versus Price on Miracles and Prior Probabilities: Testimony and the Bayesian Calculation." *The Philosophical Quarterly* 37, no 147 (1987): 195. Owen claims that Price's original argument does not mount much of a challenge to Hume, and so reformulates it in a way that provides a stronger attack against Hume's position.

[13] David Owen, "Hume Versus Price on Miracles and Prior Probabilities: Testimony and the Bayesian Calculation." *The Philosophical Quarterly* 37, no 147 (1987): 196.

[14] See Cohen describe this example on p. 196-198

that one actually has disease B, given that a B test result is provided, is only 17.39%.[15]

(Eq. 7)

$$P(have\ disease\ B|positive\ B\ test) = \frac{.80*.05}{.80*.05+.95*.20} = 17.39\%$$

If it is true that given a positive B test, there is only a 17.39% chance of actually having the B disease, then many might turn to wonder and ask, what is the point of taking the test at all?

But if we ignored the prior probabilities when assessing the chance that one particular individual has the disease, then we might decide to trust the results of the test. Owen describes how this is not simply a matter of academic debate, but has important applications: "suppose that the likelihood of a nuclear attack is one in a thousand, but that the accuracy of one's radar or other early warning devices is only about 99.8%. Would it be rational to act on the information given by one's equipment, or more rational not to set up such warning devices at all?"[16]

Owen's response to Price and Cohen's objections centers around the need for specificity of language. Recall the medical test, where the test is accurate 80% of the time. What does 80% of the time mean? If it means that looking at the subset of the population who have disease B, the test is correct 80% of the time, then we will get the surprising result above, where even if one tests positive for disease B, using Bayes'

[15] How we interpret the statement "accurate 80% of the time" really affects how this is calculated. This will be explored in the next section on precision of language. Also, this is meant purely as a hypothetical example, and is not an attempt to say that medical tests for diseases are not accurate enough to be worth taking.

[16] David Owen, "Hume Versus Price on Miracles and Prior Probabilities: Testimony and the Bayesian Calculation." *The Philosophical Quarterly* 37, no 147 (1987): 197.

theorem it would not make sense to trust the results of the test. But, what if 80% accuracy meant that if one tested positive for disease B, one had an 80% chance of actually having disease B? Well this would drastically change one's thinking, and if an individual tested positive for disease B, it would be quite logical to trust the results of the test! Where Cohen has confused his readers with his disease example is that he has been ambiguous with language that could cause one to mistake the value for the $P(have\ B|test\ positive\ for\ B)$ conditional with the $P(test\ positive\ for\ B|have\ B)$. What we are looking for in the final answer is former, but the example presents the 80% as if it should be final answer intuitively, and then uses the .8 figure as the latter probability in erroneously calculating Bayes' Theorem. Owen provides sufficient explanations to the rest of Price and Cohen's objections, which center around the same idea of ambiguous language. Owen is not providing a math lesson here: rather, the point to be made is linguistic. When using variations of the terms credible, reliable, and accurate, we must be acutely aware of and careful to define what those terms mean. A lack of specificity of language here creates the confusion highlighted in our previous examples.

Another interesting possible objection made against Hume/Bayesian probabilities comes from Sobel. in his reaction to the important work of Tversky and Kahneman.[17] Tversky and Kahneman give an experiment where they tell the following story: 85 taxicabs in a town are green, and the other 15 are blue. One taxicab is in an accident at night, where a witness, who can correctly identify the color 80% of the time, has identified the taxicab as blue. Kahneman and Tversky ask their subjects, what is the probability that the taxicab in the

[17] he is specifically citing their 1977 work, "Casual Thinking in Judgment under Uncertainty." Tversky and Kahneman here say that there taxicab experiments imply that people are irrational in their decision making. Sobel provides another possible way to tell the story of the results of their experiments.

accident was blue? The median response in their experiment was that there is an 80% chance that the cab is blue. Respondents to this scenario had no intuitive idea of Bayes' Theorem and conditional probability, and "when *updating* initial probabilities for the taxicab's being blue, these subjects in fact *ignored* them and set them aside."[18] If the experiment ended here, it would be no more than a real life example of an experiment almost identical to the hypotheticals concerning newspapers and disease testing above. But, Tversky and Kahneman take things one step farther: they do the exact same experiment, except instead of telling respondents that 85% of cabs are green and 15% are blue, they say that 85% of cabs involved in accidents are green and 15% of cabs involved in accidents are blue, providing no information as to the general percentage of taxicabs in the city. Given the same question as before, these subjects respond much differently than those told about the general ratio of taxicabs, as the median response is that there is a 55% chance that the taxicab was actually blue. In either scenario, if the subjects had responded by using Bayes' theorem, all would have answered 41%, which is much closer to the answer given by the second group of respondents. The typical response to this experiment might be that it shows how people's intuition is irrational and does not line up with the math. But, another explanation is that the Bayesian formulation we have been using might not be as robust as originally thought. In this experiment, which is a stronger piece of evidence that the specific taxicab in the accident might not actually be blue: 85% of cabs in the city are green, or 85% of cabs involved in accidents in the city are green? The latter, as it provides an additional piece of relevant information. If we only knew the former, and were then asked the *expected* ratio of blue to green cabs in accidents, 41% would be the correct

[18] Jordan Howard Sobel, "On the Evidence of Testimony for Miracles: A Bayesian Interpretation of David Hume's Analysis." *The Philosophical Quarterly* 37, no 147 (1987): 182.

answer. But the *actual* ratio in question will have some variation from our expected value. This means that using Bayes' theorem to find the results in both scenarios will lead to an accurate answer, in that in both scenarios the calculations will have been done correctly in accordance with the data given. Where these two scenarios differ is in their precision: scenario two has more detailed information and therefore we should have a higher level of confidence in them. To put another way, both Bayesian formulations give us a 41% chance that the cab is actually blue, but we can trust the 41% figure in scenario two more than we can trust the 41% figure in scenario one. Note also that in both scenarios, we did not change the reliability of the witness to the crash: the variance in confidence we have in our answer is so far due to completely to the difference in the quality of other prior evidence.

Sobel has a similar argument here. In his assessment that normal Bayesian probabilities may not always accurately reflect the situation at hand, he imagines how a perfectly rational being who is limited in data and capacities but logically omniscient in that he or she is quite certain of every logical necessity might assess the total credence-state of a particular problem.[19] "The main thing to say is that it might be better represented by a many-membered *set* of probability functions than by any single probability functions."[20] A Bayesian probability function might be a member of this set of functions, but not the only one used. These functions would then be combined into singular probabilities, which would be a sort of weighted average based on the accuracy and precision of the data available. These singular probabilities could be described by their quantities and qualities. The quantities are easy

[19] Jordan Howard Sobel, "On the Evidence of Testimony for Miracles: A Bayesian Interpretation of David Hume's Analysis." *The Philosophical Quarterly* 37, no 147 (1987): 183.
[20] Jordan Howard Sobel, "On the Evidence of Testimony for Miracles: A Bayesian Interpretation of David Hume's Analysis." *The Philosophical Quarterly* 37, no 147 (1987): 183.

enough to describe, as the end results from the calculation, for the example the 41% probability derived previously. Qualities, "would correspond to what some might term the 'weights' or 'degrees of ambiguity' of evidential bases for propositions, and to the confidence a person had in his various 'singular probabilities', displayed perhaps in his readiness to accept bets based on them."[21] In Tversky and Kahneman's example, I am more likely to place bets based on the second scenario rather than the first, despite the fact that both Bayesian probabilities are the same.

What conclusions can we draw from these objections to Hume and Bayesian probabilistic thinking? We can certainly see that we must certainly be careful in our language, and that terms such as reliability, credibility, and accuracy can mean different things depending on their context. In Owen's example, if a test is advertised as 80% accurate, does that mean that considering those who have the disease the "test is right 80% of the time," or does it mean that considering those whom the test indicates as having the disease, "it is right 80% of the time?"[22] As we have seen, these two statements mean drastically different things. By following Owen's lead, recognizing and clearing up some of the ambiguity in our language, it is fair to say that Price and Cohen's main objections to Hume and Bayes can be accounted for. While being more careful in our language can alleviate us from the objections of Price and Cohen, Sobel's critique is more interesting. Sobel does not claim that Bayesian statistics provide wrong or inaccurate results to a situation at hand; rather, he illustrates that Bayes' Theorem,

[21] Jordan Howard Sobel, "On the Evidence of Testimony for Miracles: A Bayesian Interpretation of David Hume's Analysis." *The Philosophical Quarterly* 37, no 147 (1987): 184.
[22] David Owen, "Hume Versus Price on Miracles and Prior Probabilities: Testimony and the Bayesian Calculation." *The Philosophical Quarterly* 37, no 147 (1987): 198.

while a good tool to use, is limited in its ability to assess the quality[23] of the evidence at hand.

Revisiting Miracles in Light of Sobel's Objection

Earlier, I concluded that given Holder and Owen's work interpreting Hume's statements on miracles in ways consistent with Bayes' theorem, Hume misses the mark on denying the existence of miracles based on probabilities, and that there could be cases where it may be reasonable to believe that a miracle has occurred. And while Sobel's argument using just Bayes' theorem is nearly identical and reaches the same conclusion as Owen, Sobel's argument that Bayes' theorem may not be all we need to look at when considering evidence of prior probabilities could be a strong counter to Holder and is essential to this discussion. When Sobel applies his additional argument to the miracle situation, he claims that that an individual's singular priors for and against miracles will be of the highest qualities. As he says, "probabilities averaged of such miracles, given their unambiguous inconsistency with what one takes to be the natural and necessary order of nature, will be concentrated closely around the average value."[24] Sobel is saying that the argument against miracles is like the second taxicab scenario, in that the quality of evidence (related to the prior probability that miracles are highly improbable) is extremely high. He claims that, "it is not that probabilities for miracles are apt to be of extraordinarily low and infinitesimal

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[23] As Jordan Howard Sobel defines it, described previously in relation to confidence levels or the precision of the data at hand.
[24] Jordan Howard Sobel, "On the Evidence of Testimony for Miracles: A Bayesian Interpretation of David Hume's Analysis." *The Philosophical Quarterly* 37, no 147 (1987): 184.

quantities, but that they are apt to be extraordinarily 'concentrated' and 'focused', and of highest quality."[25] This last statement summarizes the key assumption in Sobel's argument. He does believe that the probability of a miracle is low; but his primary argument here is that one should have a high degree of confidence in this low probability.

Sobel's arguments about confidence levels in prior probabilities are not specifically addressed by Holder. However interestingly enough, Holder does provide different examples of scenarios where we may be able to have more confidence in support of a result that provides evidence for the reasonability of a miracle. Holder's additional arguments center around the difference between individual and multiple independent testimony. It is intuitive that if there were two people who independently testified to the occurrence of event M, then to use Sobel's terms both the quantity and quality of the resulting probability would be higher. The higher quality of this singular probability can be explained as being akin to a larger sample size in a poll. Having a poll with 500 people is going to create a result that has lower variance than a poll showing the same result but with only 100 people. Both Holder and Sobel's additional arguments, beyond the basics of explaining Bayes' theorem, center around the quality of the evidence and the confidence level one would apply to the final probability. Unfortunately, their arguments here sidestep each other. One could perhaps rebut Sobel, claiming that he is making a huge assumption about the extremely high quality of a singular prior of a miracle occurring. Sobel does not give much justification for this assumption, other than saying that we all know that miracles do not occur, therefore the quality of our prior evidence against miracles is high. But in a discussion where Sobel's conclusion is that belief in a miracle is not reasonable, it would seem circular to suggest that the evidence

[25] Jordan Howard Sobel, "On the Evidence of Testimony for Miracles: A Bayesian Interpretation of David Hume's Analysis." *The Philosophical Quarterly* 37, no 147 (1987): 185.

for this is that we know miracles do not occur. On the other side, one could take issue with Holder by claiming that he creates a very neat and clean world in order to perform his mathematical analysis. For example, Holder assumes a highly reliable and trustworthy witness; how do we know if this condition is fulfilled in the real world? Furthermore, Holder assumes independent multiple testimony; it is an open question how often this condition could actually be fulfilled. All in all, my earlier assertion that given Hume's formulation, we should disagree with him and leave open the option that there could be cases where we could reasonably believe in the existence of a miracle, still holds weight given these additional arguments. However, the further arguments of multiple independent testimony and the quality of singular priors present quite a challenging situation to analyze. Needless to say, there is much room for further research and analysis on these two advancements of the argument beyond the basic Bayesian formula.

Probabilistic Language in Biblical Studies

So far, we have examined David Hume's probabilistic argument against the existence of miracles, and responses from modern day mathematicians and philosophers on both sides who use Bayes' theorem as the foundation for their argument in support of or against Hume. Overall, Holder's argument using Bayes' theorem is convincing, and should be seen as strong evidence that there could be cases where belief in the occurrence of a miracle is rational. However, given Sobel and Holder's arguments that go beyond the scope of the basic Bayesian formulation, the waters become muddied, and I have no tidy conclusion to offer. But, the purpose of this paper is not to prove Hume right or wrong; rather, it is to use the debate around Hume's argument as a case study for how scholars across disciplines integrate mathematical language and concepts into arguments that may at first glance seem to have nothing to do with math at all. If convinced of this, a few questions no doubt arise. First, why do scholars use this sort of language? Second, is probabilistic or mathematical reasoning an appropriate way to evaluate truth claims in the humanities? In the natural sciences the scientific method and statistical evaluation certainly dominate in the quest for truth. (although I would argue the conclusions drawn from the data involve a certain amount of storytelling as well) So is expressing arguments couched in probabilities and conditionals the humanities version of the scientific method? And finally, do scholars' probabilistic statements make sense when expressed mathematically? In this concluding section, I will zoom in on the field of biblical studies, to provide some examples of this sort of language being used and analyze the role it plays in developing arguments.

In discussing how biblical historians assess the historical truth of events in the bible, Bart Ehrman states that, "Historians more or less rank past events on the basis of the relative probability that they occurred. All that historians can do is show what *probably* happened in the past."[26] N.T. Wright sees the biblical historian as one who is, "looking... at evidence about the past, trying to reconstruct the probable course of events... defending such reconstructions.... on the scientific grounds of getting in the data, doing so with appropriate simplicity, and shedding light on other areas of research."[27] Marcus Borg discusses how empirical verification has become a staple of the modern worldview, forcing one to reduce truth, "to factuality, either scientifically verifiable or historically reliable facts."[28] Ernst Renan, arguing that the lack of modern day miracles should cause great doubt that biblical miracles

[26] Bart Ehrman, *Jesus, Interrupted:* (New York, NY: HarperCollins Publishers, 2009), 175.
[27] Marcus Borg and N.T. Wright, *The Meaning of Jesus: Two Visions* (San Francisco, CA: HarperCollins Publishers, 1999), 17.
[28] Ibid., 10.

occurred states that, "If it is proved that no contemporary miracle will bear inquiry, is it not probable that the miracles of the past... would equally present their share of illusion, if it were possible to criticise them in detail?"[29] As we can see from a brief survey of prominent biblical historians, the common hermeneutic in analyzing texts and their historical truth claims is to gather data, see what is verifiable, and then to express what is probable, possible, or unlikely to have occurred. This is exactly what the Jesus Seminar of the 1980s and 1990s set out to do, organizing Jesus' statements by whether they believed Jesus said something like what was written down, probably said what was written, did not say what was written but contains his ideas, or did not say the passage and the passage does not come from Jesus' tradition. Biblical historians follow this approach because we are captives of this worldview, as Borg says, "like all worldviews, it functions in our minds almost unconsciously, affecting what we think possible and what we pay attention to."[30]

While not outright rejecting the use the of probabilistic reasoning and empirical verification to assess the veracity of biblical truth claims, Borg does claim that this approach should certainly not be the exclusive way of assessing the truth of the bible. As he states, "I realized that there are well-authenticated experiences that radically transcend what the modern worldview can accommodate. I became aware that the modern worldview is itself a cultural construction, the product of a particular era in human intellectual history."[31] This is evident in his explanation of the truth of the post-Easter Jesus:

> the truth of Easter itself, does not depending upon their [Easter stories] being literally and historically

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[29] Ernest Renan, *The Life of Jesus (*Buffalo, NY: Prometheus Books, 1991), 22.
[30] Marcus Borg and N.T. Wright, *The Meaning of Jesus: Two Visions (*San Francisco, CA: HarperCollins Publishers, 1999), 10.
[31] Ibid., 11.

> factual. For me, the historical ground of Easter is very simple: the followers of Jesus, both then and now, continued to experience Jesus as a living reality after his death... Those experiences have taken a variety of forms. They include dramatic forms such as visions and mystical experiences, and less dramatic forms such as a sense of the presence of Jesus... The truth of Easter is grounded in these experiences, not in what happened (or didn't happen) on a particular Sunday almost two thousand years ago.[32]

Borg believes that this truth about Easter can be verified through different people's experiences, but not through some historical or scientific verification. He does not necessarily believe in the physical resurrection of Jesus, but still accepts that dramatic visions or mystical experiences of Jesus are an expression of the truth: "I think visions and apparitions can be true, by which I mean truthful disclosures of the way things are. I do not put them in the category of hallucinations."[33] I agree with Borg that these are experiences that could not be empirically verified with our five senses, or as Borg says, would not be caught on a video camera.[34] But Borg delineates between visions, which are truthful disclosures of the way things are, and hallucinations, which are not truthful disclosures of the way things are. So while he initially may seem to avoid issues of historical accuracy, and thus his arguments would not able to be evaluated by something like Bayes' theorem, he still must discern between whether a particular experience is a vision or hallucination. By making this distinguishment, Borg opens the door for questioning the validity of someone's experience. How should we question the validity of

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[32] Marcus Borg and N.T. Wright, *The Meaning of Jesus: Two Visions (*San Francisco, CA: HarperCollins Publishers, 1999), 135.
[33] Ibid., 133.
[34] Ibid., 132.

someone's experience? Do we assess the credibility of the individual who had the experience, and see whether the truth experienced lines up with other evidence we have? See how this is no different than what we did in the case study about Hume and miracles. So while Borg successfully posits that certain experiences cannot be evaluated through the five senses (or cannot be seen by a video camera), he is still in a sense stuck in the modern worldview by having to distinguish between the truth of certain dramatic experiences.

If we are still left in a situation where there must be some way to analyze the truthfulness of certain experiences or events in the bible, what should that standard be? In suggesting how we can see if it is possible that Jesus could have raised an individual from the dead (or been himself physically resurrected), Renan posits that a modern day thaumaturgus would need to prove that resurrection is indeed possible, and the power is to resurrect is vested within certain individuals:

> A commission... would be named. This commission would choose a corpse, would assure itself that the death was real... If, under such conditions, the resurrection were effected, a probability almost equal to certainty would be established. As, however, it ought to be possible always to repeat an experiment... the thaumaturgus would be invited to reproduce his marvelous act under other circumstances.[35]

For all the modern day thaumaturgi reading this, (after all, you are my target audience) the bar has not been set low. Wright describes this sort of approach to verifying biblical stories: "It is proposed that the way to study Jesus is to break the material

[35] Ernest Renan, *The Life of Jesus (*Buffalo, NY: Prometheus Books, 1991), 22.

down into its component parts and to evaluate these on the basis of certain rules."[36] In this case the relevant parts are resurrection stories, and the rule is, can resurrections be proved via the scientific method? Wright offers a different method that he still describes as, "the scientific method of hypothesis and verification,"[37] but yet looks nothing like what Renan describes above.

> The researcher, after a period of total and sometimes confusing immersion in the data, emerges with a hypothesis, a big picture of how everything fits together... it is tested against three criteria: Does it make sense of the data as they stand? Does it have an appropriate level of simplicity, or even elegance? Does it shed light on areas of research other than the one it was designed to cover?[38]

Wright notes that within biblical studies there is no universally agreed upon way to decide what gets to count as appropriate answers and evidence for these questions. This is certainly the subject of much debate. For the purpose of this paper, see how the answers to Wright's first question in particular invite the sorts of probabilistic language used in the discussion of Hume and miracles. As Wright notes, the data does not always present a coherent picture.[39] So pieces of data must be weighed against one another. This comes to light when the biblical historian tries to piece together the relationship between the four gospels: when was each written, which gospel copied from which other gospel, and what other sources were used? Wright describes how

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[36] Marcus Borg and N.T. Wright, *The Meaning of Jesus: Two Visions (*San Francisco, CA: HarperCollins Publishers, 1999), 23.
[37] Ibid., 22.
[38] Ibid.,, 22.
[39] Ibid., 20.

> Mutually incompatible theories abound as to where, when, and why the synoptic gospels came to final form. Since there is no agreement about sources, there is no agreement as to how and why the different evangelists used them. If, for instance, we believe that Matthew used Mark, we can discuss Matthew's theology on the basis of his editing of Mark. If we don't believe Matthew used Mark, we can't.[40]

These arguments quickly become about if-then statements, or probabilities of occurrence: regardless of whether of one's definition of a scientific method for historical analysis lines up with Renan or Wright, logical and mathematical reasoning becomes crucial in order to understand the arguments at hand.

From this survey of important biblical historians and scholars, we can conclude that mathematical language and probabilistic reasoning have an important role to play in ascertaining the truth, however one wishes to define it, of biblical narratives. Biblical historians' work is replete with argumentation that utilizes probabilistic reasoning, and is thus able to be analyzed through techniques such as Bayes' theorem. This means that to be able to assess the quality of arguments of philosophers, theologians, and historians, a degree of mathematical literacy may be required. I will now conclude with a story of how a bit of mathematical intuition may be helpful beyond the realm of biblical studies and miracles. Consider the story of Stanislav Petrov, former officer in the Soviet Air Defense Force, known as "the man who saved the world" from nuclear war in 1983. Petrov was in charge of monitoring the Soviet satellites that were supposed to tell the Air Defense Force when an American ballistic missile was in the air. At this time the Soviet Union was on high alert, as they had recently shot down a civilian airliner, killing 269 people on board, including 62 Americans (among them was a sitting U.S. congressman).

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[40] Marcus Borg and N.T. Wright, *The Meaning of Jesus: Two Visions (*San Francisco, CA: HarperCollins Publishers, 1999), 21.

Fearing retaliation, one day Petrov's radar screen showed five missiles had been launched by the U.S. towards the Soviet Union. Petrov claimed he had a "gut instinct,"[41] that this was a false alarm. Petrov noted that it would be odd for the U.S. to launch a strike, but to only send five missiles, instead of sending a salvo of hundreds. And while the satellites were certainly set up to prevent a false alarm, Petrov recognized that there was still the possibility for failure. Needing to make a decision fast, Petrov decided to not inform his superiors that missiles were on the way; only when sufficient time had passed and no missiles hit the Soviet Union did Petrov know he had made the right call. While Petrov most certainly was not frantically scribbling out Bayes' Theorem, his intuition lines up with the mathematical logic of conditional probability. Petrov's prior knowledge was that the chance that the U.S. would launch a strike was low, and if they did, they would most likely launch hundreds of missiles at once, not five. Petrov then had to update his knowledge based on new information: he saw five missiles on his radar. The question, expressed using Bayesian conditional probabilities: what is the probability the Americans are beginning a missile attack on the Soviet Union, given that the radar is showing five missiles coming towards the Soviet Union on the screen? This is the same question that Hume asks, only instead of in the realm of miracles, it was in the realm of nuclear defense. Given this, perhaps Thomas Bayes should also get the moniker, the man who saved the world?

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[41] Marc Bennetts, "Soviet Officer who Averted Cold War Nuclear disaster dies aged 77," The Guardian, September 18, 2017. https://www.theguardian.com/world/2017/sep/18/soviet-officer-who-averted-cold-war-nuclear-disaster-dies-aged-77

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