Conflict Resolution through Mutuality: Lessons from Bayesian Updating

Srijit Mishra

Conflict Resolution through Mutuality: Lessons from Bayesian Updating

Srijit Mishra

Indira Gandhi Institute of Development Research (IGIDR)
General Arun Kumar Vaidya Marg
Goregaon (E), Mumbai- 400065, INDIA
Email (corresponding author): srijit@igidr.ac.in

Abstract

If priors are deterministic (zero or unity) and conditional evidence is uncertain (lies between zero and one) then Bayesian updating will lead to posteriors that are the same as priors. This in a sense explains the persistence of fundamentalist belief. Under such a belief system, only if conditional evidence is deterministic and diametrically opposite to that of the prior then a process of change can set in. Conflict resolution is possible through dialogues that calls for mutual respect and allows reasonable pluralism – a Rawlsian prerequisite. If interaction is the basis then self-defeating scenarios can be avoided by giving space to others. Thus, in the political sphere one has to be accommodative.

Keywords:

Bayesian updating, belief polarization, conflict resolution, fundamentalist belief, interaction, mutual respect, reasonable pluralism.

JEL Code:

A13, C11

Conflict Resolution through Mutuality:
Lessons from Bayesian Updating

Srijit Mishra

"Probability does not exist" de Finetti (1970, p. x)

1 Introduction

Attempts at conflict resolution are welcome and it is in this context that the theme of the forthcoming *World Development Report 2011* is 'Conflict Security and Development'. However, it is a matter of concern that the differences, over time, instead of getting reduced may get aggravated; there is belief polarization. One possible way of conflict resolution is through mutuality and reasonable pluralism – a Rawlsian prerequisite that gives space to and respects others. This paper explores this with lessons from Bayesian updating.

Bayesian interpretation of probability is epistemic – a degree of belief, as against the frequentist tradition where it is a limiting ratio of a repeatable phenomena (Howie, 2002, p.1). In situations where it is difficult or impossible to obtain repeatable events like the occurrence of a terrorist strike tomorrow, the probability formed will be a belief about something that one is uncertain about (von Plato, 1994, p. 240).[1] This belief in a Bayesian sense is based on prior information and conditional evidence;[2] or, statistically one calculates posteriors that are reciprocal to priors and conditional evidence (Zellner, 1987, p. 208). In other words, prior information based hypothesis and conditional evidence can through Bayes' rule update the prior to a posterior hypothesis such that the posterior can now be a new prior, which with

---

[1] Usage of frequentist probability, in Baccini's (2001) understanding of Edgeworth and Venn cannot be of much help for choice under uncertainty; however, subjective probability in a Bayesian sense, as conceptualised by Frank Ramsey, has done remarkably well as a theory of rational decisions that led Davidson (1996) to even suggest such an approach for a theory of truth. Independent of the philosophical underpinnings of frequentist or Bayesian approach, Beebee and Papineau (1997) suggest that a prudentially correct choice is that of relative probability - subjective probability relative to knowledge set-up, as it will help one to act on, given that one wants such-and-such results.

[2] In a Bayesian framework prior probability is a degree of belief about the universe, and hence, any evidence from the universe is considered as conditional to the priors. It is for this that we use the term conditional evidence as against evidence; one can also refer to conditional evidence as sample proportions. Eckhardt (1997,

further conditional evidence will lead to further updating (Lange, 1999, p. 294). In case of fundamentalist belief, that is, to have a prior hypothesis that is deterministic (zero indicating total disbelief and unity indicating total conviction) updating through conditional evidence does not lead to a change in the initial position. Does this mean that once a fundamentalist, always a fundamentalist?

Explaining the persistence of a fundamentalist belief is a definite strength of Bayesian analysis, as the framework is meant to analyze something one is uncertain about. However, if there exists sufficient scientific evidence that is deterministic and diametrically opposite to the prior then there is room for the posterior to be different. An illustration is given with Kepler's use of Brahe's data to discover planetary laws of motion that conclusively proved Copernicus' heliocentric view (sun at the centre) as against the Church backed geocentric view (earth at the centre) of Brahe and thus dispelled the then prevailing popular belief (Guidry, 2002).

Alternatively, if one has to retain the uncertain nature of outcomes, it is proposed that the values of zero and unity remain out of bounds. This ensures scope for further revision. It is based on the premise that no knowledge is final; there is always scope for change. Interestingly, such an approach is consistent with multiplicity of views, or debates arising thereof. It is these that can also ensure change – say, emergence of a new position that could not be visualized earlier. In situations of conflict this could be explored through dialogue that calls for mutual respect and allows reasonable pluralism.

After this introductory section, section 2 introduces some notations and explains Bayes' rule. Section 3 explains the impossibility of updating fundamentalist belief. Section 4 shows how, under special situations, there is room for fundamentalist belief to change. Section 5 discusses a possible scope for Bayesian updating that accommodates multiple views. Concluding discussions are in section 6.

---

pp. 247-248) points out that any evidence that is not connected to priors or that is outside the domain of the universe will not be of help in Bayesian updating.

2 Notations and Bayes' Rule[3]

Prior information based hypothesis, *h*, conditional evidence, *e|h*, and posterior hypothesis, *h|e*, have their complementary denoted with a prefix Not, ~, and probability distributions, p(·), such that through axiom of certainty,

(1) $\sum p(\cdot)=1$.

Further, as per Bayes' rule,

(2) $p(h|e)=\{p(e|h)\times p(h)\}/[\{p(e|h)\times p(h)\}+\{p(e|\sim h)\times p(\sim h)\}]$.

If we introduce the notion of time, *t*=1, ..., *T*, to incorporate a series of conditional evidences such that at each *t*, equations (1) and (2) hold, but in addition to this one further assumes that posterior at time *t* is prior at time *t*+1,

(3) $p(h|e)_t= p(h)_{t+1}$.

It is possible that an outcome today will not lead to an impromptu commitment for tomorrow but for some other future date, $p(h|e)_t=p(h)_{t+\tau}$; $\tau=t+1$, ..., *T*. But then this can be entailed in equation (3), as elaborated in the discussion on persistence of fundamentalist belief below.

3 Persistence of Fundamentalist Belief

One considers belief to be persistent if the posterior is the same as the prior, or, in other words conditional evidence has no impact on changing the belief. This happens in two situations: when conditional evidences of mutually exclusive scenarios are equally likely; in equation (2) this can be the case when $p(e|h)=p(e|\sim h)=0.5$. This is so because conditional evidences give equal weight to all possible scenarios and as a result the weights that matter are that of the priors only. For instance, if after scientifically examining shape, size and structure of a coin the prior that the toss of a particular type of coin will be heads is 0.8 and that of tails is 0.2. However, after 10 throws one has conditional evidence that getting heads or tails is equally likely. Calculating posterior using Bayes' rule will show that they will be

---

[3] Discussion in Howie (2002, p. 30), Howson and Urbach (1989, pp. 284-288), Lange (1999), Lindley (1987),

the same as prior: heads 0.8 and tails 0.2. Now, let us go to the second situation, as it is relevant for the present discussion.

The second situation where posterior is equal to prior is when prior is based on fundamentalist belief, that is, prior is deterministic and takes the values of zero or unity. There is no scope for doubt – there can be no intermediary position. If the hypothesis has the prior as zero, p(h)=0, then the numerator in equation (2) because of the second term is zero, and hence, p($h|e$)=0. Similarly, if hypothesis has the prior as unity, p(h)=1, then from equation (1) it follows that p($\sim h$)=0 and as a result the second term in the denominator of equation (2) is zero, note that the remaining part of denominator is equal to the numerator, thus, p($h|e$)=1. In both the cases when the prior is a fundamentalist belief then the posterior also retains the fundamentalist belief.

While deriving the above result, a basic tenet of Bayesian inference has been violated, that is, probabilities are subjective, and hence, cannot be deterministic. This is a very valid point, but it turns out that this violation is our strength. What it implies is that if one begins with a fundamentalist belief or one is dogmatic then there is no scope for revision.[4] In other words, if one believes that a particular thing is true then any amount of conditional evidence that is probabilistic in nature will not cut much ice. This has two implications: first, if truth has been ascertained and the prior is deterministic then looking for further conditional evidences to prove or disprove can be a futile exercise that should be avoided; second, if one is dogmatic then it will act as a hindrance and all conditional evidences become redundant, thus, growth of knowledge is the casualty.

Now, say, the process of arriving at the prior could be a stochastic event. The observer began with an open mind, but saw or was made to see a particular thing leading to the average of a large number of observations giving a prior probability of zero, p(h)=0. A single observation to the contrary will give an average prior probability that is greater than zero, p(h)>0. This point is necessary to understand that the beliefs of a terrorist and also about a terrorist could

Press and Tanur (2001, p. 207), and Qin (1998) were of help.

[4] Kelly (2008), without taking recourse to Bayesian logic, argues the possibility of belief polarization either when an individual considers observations that are contrary to one's belief as misleading and dismisses them outright (a Kripkean dogmatist) or when an individual carefully scrutinizes such observation leading to fault finding and their dismissal. For a different discussion on belief polarization using Bayesian networks, see Jern, Chang and Kemp (2009).

just be one point of view that looks closed or dogmatic, but need not remain so. The deterministic prior will be done away with in section 5, but for the present purpose, sections 3 and 4, it is the implications from this that are relevant.

3.1 Tycho Brahe's Observations

To discuss the persistence of fundamentalist belief we first take the case of Tycho Brahe's observations on planetary movements. Brahe (1546-1601) who

"... was both a theorist and an observer. As a theorist, he believed to his last day in the year 1601 that the planet went round the sun and that the sun and the stars went round the earth as the fixed centre of the universe. As an observer, he made with infinite patience and integrity thousands of records of the stars and planets; upon these records Kepler, in due course, based his laws and brought the truth to light" (Beveridge, 1937, p. 478).

The point that one would like to make here is that Tycho Brahe was a believer of the geocentric universe of Aristotle and Ptolemy till his death. But, despite being wrong in his theories he was honest and careful in his observations (Beveridge, 1937, p. 479). His observations in the pre-telescopic era were remarkable and probably made him ask relevant questions and subsequently proposed an alternative that was in between Ptolemaic and Copernican model but did not question the geocentric view that the Earth was at the centre. However, he erred while rejecting Nicolai Copernicus' (1473-1543) heliocentric system published as *On the Revolutions of the Heavenly Bodies* when Copernicus lay on his deathbed; the work was dedicated to the Pope but did not find favour with the Church (Guidry, 2002). It is possible that Brahe's belief in the geocentric system prevented him from rigorously pursuing the observations that he collected, and thus, could not gain insights form the data. Interestingly enough, Johannes Kepler (1571-1630) who believed in the Copernican system used Brahe's data to obtain the results that he did, this will be elaborated in section 4.

3.2 Terrorism

Our second example is based on the recent terror attacks (it is the one on September 11, 2001 at World Trade Centre, New York that altered global thinking; the one in Mumbai, India that went on for three days starting from November 26, 2008; or the one on Sri Lankan cricket players on their way to Gaddafi stadium to play the third days match on March 3, 2009, at

Lahore, Pakistan; and many more).[5] There is an understanding that perpetrators of such attacks could have links with poverty (Isard and An, 2004). Or, that they have a fundamentalist belief – a totalistic ideology (Morgan, 2001 and Beck, 2001). Justification in the total conviction and belief might be political or guided by a particular interpretation of religion, in this case Islam. This, however, does not mean that Islam as a religion is responsible for the emergence of terrorism (Morgan, 2001).

In fact, as we will elaborate in the next section, Islam can be of help in changing the mind of the terrorist. However, existence of a fundamentalist belief means that prior is deterministic (say, unity), and hence, further arguments or conditional evidences are redundant and will have no impact on posterior. This takes us to the question posed in the first paragraph: Does this mean that once a fundamentalist, always a fundamentalist? The answer is No. Two different proposals emerge from some further discussion of Bayesian updating. A combination of these two, along with other proposals not mentioned here, will be relevant in our present concern against terrorism.

4. A Way Out: Conditional Evidence is Complementary to Prior

In the discussion in section 3, as per Bayesian tradition, it was implicitly assumed that conditional evidence is not deterministic, $0 < p(e|h) < 1$, it can not take the value of zero or unity. However, for the discussion in this section we waive that assumption and consider a situation where $p(e|h)$ is not only deterministic but also diametrically opposite to p(h), that is, if p(h)=1 then $p(e|h)$=0; and if p(h)=0 then $p(e|h)$=1. Now, if one puts these values in equation (2) then the denominator is zero, and hence, p(h|e)=undefined.[6]

One can interpret this result to explain situations where scientific experiments give results that dispel conventional belief. An undefined posterior could mean that things are not clear and it can be such that posteriors can have any value between zero and unity, $0 \leq p(h|e) \leq 1$. Or, in other words it could mean that some people still believe the conventional orthodoxy, others

---

[5] Llussa and Tavares (2006) is a review identifying the links between terrorism and economics, in particular the consequences of terror acts, contextualizing theoretical modes based on supposed individual, group and aggregate economic behaviour and on policy questions to tackle terrorism.

[6] It is undefined because it is in a position of conflict like Nelkin's (2000) two standpoints where, on the one hand, one believes in laws of nature and in that sense is deterministic, and on the other hand, one also believes in freedom and in that sense is for free choice.

go by the new result and yet others whose degree of belief is somewhere in between. This interpretation is like Nash's mass-action interpretation (Kuhn *et. al.*, 1995).

Further, from the mass-action interpretation it can be said that if there are a series of other experiments that also conclusively go against the conventional orthodoxy then there will be a shift in the posterior probability distribution towards the new finding: $p(h|e)_t \rightarrow p(e|h)_t$ as $t \rightarrow T > 2$; this should happen at $t=2$ because as per mass-action interpretation $p(h|e)_t > 0$ at $t=1$. However, in real life people may consider a series of different experiments as a single conditional evidence, and hence, there will be a time gap when the new idea is accepted across the whole population.[7] Let us elaborate on this with our two examples of Tycho Brahe and perpetrators of terrorism.

4.1 Kepler: Making Sense of Brahe's Observation

Tycho Brahe had appointed Johannes Kepler to assist him and the two had differences of opinion because the latter believed in the Copernican system. Brahe's distrust of Kepler and fear that the latter might use his data led him to restrict Kepler to work on the troublesome data of planet Mars. It so happened, that it is this same data that helped Kepler derive the three planetary laws of motion that conclusively proved the heliocentric system (Guidry, 2002). Thus, Kepler's result in a Bayesian sense is conditional evidence that is diametrically opposite to the prior of geocentric system. For the larger population, this would have made the posterior undefined, that is, some people would accept Kepler's result, others would have continued with the old orthodox view and yet others who would have some degree of belief in between the two (like Brahe who considered that the Sun and the Moon went around the Earth but the other planets went around the Sun). His contemporary Galileo Galilei (1564-1642), had some difference of opinion on the elliptical orbit of planets, but supported the heliocentric view and as a result did not find favour with the Catholic Church. It was only in 1758 that the Church did away with the prohibition on books propagating heliocentric view, and in 1822 that they allowed printing of such books in Rome. It is the work of William Herschel (1738-1822) and subsequent developments that led us to know that the Sun is not the centre of the universe, but one of the many stars in the galaxy.

---

[7] This is similar to stating, as Kandori, Mailath and Rob (1993, p. 31) point out, that uncertainties can lead to inertia.

4.2 Invoke Religion to Counter Terrorism, but…

In a socio-cultural and religious sphere one can definitely invoke religious scriptures to provide a different and diametrically opposite interpretation.[8] However, this approach should be considered only after addressing some of the other conditions that make such interpretations widely acceptable. Here one is referring to the political dimension or the invoking of religion to fight against some political injustice. If the fight is for a religious cause or duty (*jihad*), then dying for the same and in the process killing the enemy becomes acceptable. It may be reiterated that the identification of the enemy is not just religious, but it is also political.

The relevance of a political dimension comes out clearly in Wanniski (2001) who gives an extract of Ramzi Ahmed Yousef's statement to the court in his trial for bombing the World Trade Centre on February 26, 1993 where six people died; Yousef was sentenced for life imprisonment on January 8, 1998. Yousef's statement refers to American action in bombing Japan, war with Vietnam, and more particularly its embargo on Iraq and Cuba. In this context he has no regrets in being called a terrorist. He says: "Yes, I am a terrorist and I am proud of it. And I support terrorism so long as it was against the United States Government and against Israel, because you are more than terrorists; you are the one who invented terrorism and using it every day. You are butchers, liars and hypocrites." It is this political dimension that will be taken up in the next section by putting a restriction that the prior cannot be deterministic.

5 Prior cannot be Deterministic: Giving Space to Others

In section 3, the discussion more or less assumed that probability can be deterministic – zero or unity, which is somewhat contrary to Bayesian philosophy that is based on subjective

---

[8] For instance, Morgan (2001) gives some quotations from the *Qur'an*: "If you've killed one innocent person it's as if you've killed all of humanity." "Among the major sins of Islam is suicide. These are listed as 'enormities' in *Reliance of the Traveller*, a manual of Sharia in the tradition of Imam Shafi'i." "Whoever commits suicide with piece of iron will be punished with the same piece of iron in the Hell Fire…He who commits suicide by throttling shall keep on throttling himself in the Hell Fire (forever) and he who commits suicide by stabbing himself shall keep on stabbing himself in the Hell-Fire. (Narrated Jundab the Prophet Sahih Bukhari 2.445 and 2.446)." "Nor take life - which Allah has made sacred - except for just cause. And if anyone is slain wrongfully, we have given his heir authority (to demand retaliation or to forgive): but let him not exceed bounds in the matter of taking life (*Qur'an*, 17:33)." "Fight in the cause of Allah with those who fight with you, and do not exceed the limits, surely Allah does not love those who exceed the limits (*Qur'an*, 2:190-192)." "We must treat the enemy civilians and the innocents with kindness."

probability. We now consider that prior, as also conditional evidence, and posterior can be infinitesimally close but will not be equal to zero or unity,[9]

(4) $0+\varepsilon \leq p(\cdot) \leq 1-\varepsilon$

where ε is infinitesimally small, but greater than zero, or, one can also further restrict the boundary such that ε can be little larger, $0<\varepsilon<0.5$.

Now, if one gets conditional evidence that is contrary to prior then a series of such experiments will bring out a change in posterior in the direction of conditional evidence but can never attain a value that is zero or unity. In other words, if $p(h)_1>0.5$ and $p(e|h)_t>0.5$ then $p(h|e)_t \to 1$ as $t \to T=\infty$, note that by equation (4) $p(h|e)_t \neq 1$ indicating that the posterior tends towards unity in a limiting sense but it will never be equal to it.

In equation (4), particularly when ε is not infinitesimally small the conditional evidence will also be constrained by the limits possible to posterior,[10] or in other words the limits to posterior is itself a part of the prior information. Such restriction of equations (4), for the context under discussion, is akin to acceptance of multiple views – they cannot be dismissed outright.

To elaborate, if Bayesian updating is like a Darwinian evolutionary process of natural selection then principle of heredity (off springs have to resemble their parents more than other members of their species) and the principle of the struggle for existence (better-adapted individuals have more number of off springs) can be explained by replication dynamics.[11] This might ignore the principle of variation or diversity in the population,[12] a necessary prerequisite

---

[9] For deviation of probability from being deterministic by infinitesimal values and its relevance to calculation of posteriors see Arló-Costa (2001).

[10] This can be because of perturbation or random disturbances. We consider this randomness, following Kumar (2000), to be an outcome of the privileged information of various agents including that of nature.

[11] Replicator dynamics has been explained in Börgers (1996, p. 1382), as "a gradual process in which strategies which perform worse than the average become less frequent and strategies which perform better than the average become more frequent."

[12] Mukherjee, White and Wuyts (1998, p. 3) quote Gould (1996, p. 40) to suggest that: "we are still suffering from a legacy as old as Plato, a tendency to abstract a single ideal or average as the 'essence' of a system, and to devalue or ignore, variation among the individuals that constitute the whole population."

in the process of natural selection.[13] In other words, if interaction between sub-groups is necessary then a process where all the other sub-groups perish can be self-defeating.[14] Thus, continuity requires that there should be perturbation at some period that at least prevents some, if not all, sub-groups from not perishing in the process of interaction.[15] It is possible that the self-defeating outcome could be because of the method or analyzer's bias or something else; but then, these also need to be corrected leading to perturbation in the analysis. Thus, a Bayesian approach need not always be through the Bayes' rule.

Accepting multiple views warrants that we give space to others. In the present concern against terrorism, it means understanding the concerns of the Islamic world. This also means appreciating their point of view or grievances. For instance, the impact of depleted Uranium used in Gulf War of 1991 on the rise of cancer and birth defects in Iraq (Johnson, 2002).[16] This not only requires an initiation of dialogue and conversation at multiple levels such as government-to-government and people-to-people but an involvement in positive action. Further, note that conversations also have an ability to change beliefs and a reliance on conversational stance necessitates that people consider each other as responsible and free believers and desirers (Pettit and Smith, 1996).

Moves in this direction are welcome. It is in this context that United States' President, Barack Obama's policy initiatives to minimize or do away with the divide between the values and ideals of democracy and freedom versus security concerns to protect its citizens seems to show a lot of promise. In particular, see the arguments to build an Islamic community centre two blocks away from Ground Zero (Sabochik, 2010). As Huntington (1993) concludes, "For the relevant future, there will be no universal civilization, but instead a world of different

---

[13] This interpretation of the principles of natural selection involving heredity, struggle for existence, and variation has been based on an understanding of Gould (1991) and Visvanathan (1996).

[14] Krieger (1995) suggests that the probability of such self-defeating scenarios (that is, doom) is either zero or unity through an application of Kolmogorov probability theory for scenarios with lower tails in their distribution. There are instances where birth rank is used as Bayesian conditional to show that the probability of doomsday is zero, but Eckhardt (1997) shows that it is an improper use of evidence as conditional evidence.

[15] This can be because of randomness arising out of privileged information. In a Darwinian sense this can be as a result of mutation and it is this that ensures variation. Thus, it is not necessary for $p(e|h)_t > 0.5$, it can also be the case that $p(e|h)_t < 0.5$. By restricting the boundary of $p(\cdot)$, as in equation (4), one ensures a minimum variation necessary for interaction and such restrictions, one feels, will also constrain the Kandori, Mailath and Rob (1993) long-run equilibria.

[16] On denial of clemency to Mir Aimal Kasi one lost another opportunity of showing concern and winning a million hearts in the fight against terrorism. Note that Mr Kasi, a Pakistani citizen, was executed with lethal injection on November 14, 2002 for having killed two Central Intelligence Agency (CIA) employees and wounding three others on January 5 1993 in front of CIA headquarters Virginia (Glod & Weiss, 2002).

civilizations, each of which will have to learn to coexist with the others." Such an approach will also help the Islamic religious authorities to invoke scriptures that lead us to a world of live and let live. Or, as Rawls (2000) suggests, reasonable pluralism – a prerequisite that calls for giving space to and respect for others. True, that this is an early step and requires lot of caution, but succeed we will.

6 Conclusions

In this paper we try to understand fundamentalist belief through Bayesian updating, that is, when priors are deterministic. Doing away with a basic Bayesian philosophy of subjective probability turns out to be the strength in the present discussion because it can also explain persistence of fundamentalist belief. This result is used to explain why Brahe fails to go beyond geocentric consideration whereas Kepler using Brahe's data conclusively proves the heliocentric view. The role of belief including experiences and views of correct scientific inquiry has also influenced research in probability: Sir Ronald A. Fisher concerned with reduction and evaluation of experimental data believed and developed tools and methods as a frequentist, whereas Sir Harold Jeffreys who tried to calculate the internal structure of the earth was aware that conclusions will always be uncertain made important contributions as a Bayesian (Howie, 2002). Belief (not necessarily fundamentalist) but at least in a subjective sense has also had an impact on many great scientists (Press and Tanur, 2001).

As Kepler's result led to a shift in popular belief from geocentric to heliocentric view of universe, one feels that the involvement of Islamic religious authorities can act as an effective counter to the terrorist organizations who issue *fatwas* by invoking Islam. However, to create ground for the effective use of religion one has to take care of another condition that affects the fundamentalist mind – the political dimension.

To analyze this we make use of the conventional understanding of subjective probability, that is, it lies between zero and unity. One can also suggest a higher lower bound and a lower upper bound depending upon the context and this can be considered as part of the prior. This can be interpreted in social situations as one where multiple scenarios co-exist and form the basis for interaction. The role of associational interactions and their positive influence on Hindu-Muslim conflicts in some specific instances have been discussed by Varshney (2002).

Having identified the relevance of interaction in the political dimension it suggests that the world ought to be accommodative and appreciative about the views of Middle East. If Islam has to play a positive role in countering the role of violence, then conditions from outside should make it convenient. This requires a respect and appreciation for the other viewpoints; reasonable pluralism – a Rawlsian prerequisite. This approach, however, does not deny differences of opinion but rather considers it necessary for discussions and debates, a basic requirement in a civil society.

We do agree that the above two approaches proposed are to be used in conjunction with each other and do not exhaust all possible suggestions of tackling terrorism. This is consistent with our discussions using Bayesian updating in two ways. First, we are not dogmatic of our proposals and agree that these can only form a small part in our concern against terrorism. Second, by considering the existence of other possible methods we leave scope for multiple views. In fact, to tackle such a serious global concern the fight has to be in multiple directions.

References:

Arló-Costa, H. (2001) 'Bayesian Espistemology and Epestemic Conditionals: On the Status of the Export-Import Laws', *The Journal of Philosophy*, 98(11), 553-593.

Baccini, A. (2001) 'Frequentist Probability and Choice under Uncertainty', *History of Political Economy*, 33(4), 743-773.

Beck, A. T. (2001) 'Prisoners of Hate: The Mind of The Terrorist,' http://www.padesky.com/clinicalcorner/pdf/atb_prisoners_terrorists.pdf (4 January 2011).

Beebee, H. and Papineau, D. (1997) 'Probability as a Guide to Life', *The Journal of Philosophy*, 94(5), 217-243.

Beveridge, Sir W. (1937) 'The Place of the Social Science in Human Knowledge', *Politica*, 2(9), 459-479.

Börgers, T. (1996) 'On the Relevance of Learning and Evolution to Economic Theory', *The Economic Journal*, 106(438), 1374-1385.

de Finetti, B. (1970 [1990]) *Theory of Probability: A Critical Introductory Treatment*, Vol.1., Wiley Classics Library Edition, John Wiley and Sons, Chichester (first published

under the title *Teoria Delle Probabilitià* and first translated version published by John Wiley & Sons in 1974, translated by Antonio Machi and Adrian Smith).

Davidson, D. (1996) 'The Folly of Trying to Define Truth', *The Journal of Philosophy*, 93(6), 263-278.

Eckhardt, W. (1997) 'A Shooting-room View of Doomsday', *The Journal of Philosophy*, 94(5), 244-259.

Glod, M. and Weiss, E. M. (2002) 'Kasi Executed For CIA Slayings: U.S. Cautions Of Possible Attacks In Retaliation', *Washington Post*, http://www.washingtonpost.com/wp-dyn/articles/A56565-2002Nov14.html (18 November 2002).

Gould, S. J. (1977 [1991]) *Ever Since Darwin: Reflections in Natural History*, Penguin, Harmondsworth.

Gould, S. J. (1996) *Full House: The Spread of Excellence from Plato to Darwin*, Harmony Books, New York (as referred to by Mukherjee, White and Wuyts, 1998).

Guidry, M. W. (2002) 'The Copernican Model: A Sun-centered Solar System', 'The Observations of Tycho Brahe', and 'Johannes Kepler: The Laws of Planetary Motion', *Astronomy 161: The Solar System*, http://csep10.phys.utk.edu/astr161/lect/index.html (4 January 2011).

Howie, D. (2002) *Interpreting Probability: Controversies and Developments in the Early Twentieth Century*, Cambridge University Press, Cambridge.

Howson, C. and Urbach, P. (1989) *Scientific Reasoning: The Bayesian Approach*, Open Court, Ca Salle, Illinois.

Huntington, S. P. (1993) 'The Clash of Civilization?', *Foreign Affairs*, Summer, http://history.club.fatih.edu.tr/103%20Huntington%20Clash%20of%20Civilizations%20full%20text.htm (9 March 2009).

Isard, W. and An, J. (2004) 'A Hierarchical Decision-Making Model for Progress in Reducing Three Evils: Terrorism, Poverty and Environmental Degradation', *Peace Economics, Peace Science and Public Policy*, 10(3), Article 1, http://www.bepress.com/peps/vol10/iss3/1/ (9 March 2009).

Johnson, L. (2002) 'Iraqi cancers, birth defects blamed on U.S. depleted uranium', http://seattlepi.nwsource.com/national/95178_du12.shtml (4 January 2011)

Jern, A., Chang, K. and Kemp, C. (2009) 'Bayesian Belief Polarization', in Y. Bengio and D. Schuurmans and J. Lafferty and C. K. I. Williams and A. Culotta (eds.) *Advances in*

Neural Information Processing Systems, Vol. 22, http://books.nips.cc/papers/files/nips22/NIPS2009_0599.pdf (4 January 2011).

Kandori, M., Mailath, G. J. and Rob, R. (1993) 'Learning, Mutation, and Long Run Equilibria in Games', *Econometrica*, 61(1), 29-56.

Kelly, T. (2008) 'Disagreement, Dogmatism, and Belief Polarization', *The Journal of Philosophy*, 105(10), 611-633.

Kuhn, H. W., Harsanyi, J. C., Selten, R., Weibull, J. W., van Damme, E., Nash, J. F. (Jr.) and Hammerstein, P. (1995) 'The work of John F Nash, Jr. in game theory, A celebration of John F Nash, Jr.', *Duke Mathematical Journal*, 81(1), 1-29.

Kumar, T. K. (2000) 'Time to Make Time and Aggregate Shocks Endogenous', Working Paper EI/TKK/00-4, Econometrics Institute, Bangalore.

Krieger, M. H. (1995) 'Could the Probability of Doom be Zero or One', *The Journal of Philosophy*, 92 (7), 382-387.

Lindley, D. V. (1987) 'Thomas Bayes (1702-1761)', in J. Eatwell, M. Milgate and P. Newman (eds.) *The New Palgrave: A Dictionary of Economics*, 207-208, Macmillan, London.

Llussa, F., and Tavares, J. (2006) 'Economics and Terrorism: What We Know, What We Should Know and the Data We Need', in E. Nikolaidou (ed.) *Proceedings of the 10th Annual International Conference on Economics and Security*, 187-248, South East European Research Centre (SEERC), Thessaloniki.

Lange, M. (1999) 'Calibration and The Epistemological Role of Bayesian Conditionalization', *The Journal of Philosophy*, 96 (6), 294-324.

Martin, J. L. (2002) 'Power, Authority, and the Constraint of Belief System', *American Journal of Sociology*, 107(4), 861-904.

Mishra, S. (2003) 'Understanding Fundamentalist Belief Through Bayesian Updating', Indira Gandhi Institute of Development Research (IGIDR) Working Paper No. WP-2003-002, IGIDR, Mumbai, http://www.igidr.ac.in/pdf/publication/WP-2003-002.pdf (3 January 2011).

Mishra, S. (2009). Counter Conflict through Mutuality: Lessons from Bayesian Updating, presented at 'Quantitative Approaches to Public Policy – Conference in Honour of Professor T. Krishna Kumar' [held in conjunction with Fourth Annual International Conference on Public Policy and Management] at the Indian Institute of Management Bangalore (IIMB) in collaboration with IGIDR, Mumbai and Queen Mary, University

of London, 9-12 August 2009. IGIDR Proceedings/Project Reports Series No. PP-062-35, IGIDR, Mumbai, http://www.igidr.ac.in/pdf/publication/PP-062-35.pdf (3 January 2011)

Morgan, S. J. (2001) *The Mind of The Terrorist Fundamentalist*, Awe-Struck E-Books (read a version available at http://www.terrorpsychology.com/book.htm (12 November 2002).

Mukherjee, C., White, H. and Wuyts, M. (1998) *Econometrics and Data Analysis for Developing Countries*, Routledge, London.

Nelkin, D. K. (2000) 'Two Standpoints and the Belief in Freedom', *The Journal of Philosophy*, 97(10), 564-576.

Pettit, P. and Smith, M. (1996) 'Freedom in Belief and Desire', *The Journal of Philosophy*, 96(9), 429-449.

Press, S. J. and Tanur, J. M. (2001) *The subjectivity of scientists and the Bayesian approach*, John Wiley, New York.

Qin, D. (1998) 'Bayesian Econometric Methodology', in J. B. Davis, D. W. Hands and U. Mäki (eds.) *The Handbook of Economic Methodology*, 33-36, Edward Elgar, Cheltenham, UK.

Rawls, J. (2000) *Justice As Fairness: A Restatement*, The Belknap Press.

Sabochik, K. (2010) 'President Obama Celebrates Ramadan at White House Iftar Dinner', *The White House Blog*, 14 August 2010, http://www.whitehouse.gov/blog/2010/08/14/president-obama-celebrates-ramadan-white-house-iftar-dinner (2 January 2011).

von Plato, J. (1994) *Creating Modern Probability*, Cambridge University Press, Cambridge.

Varshney, A. (2002) *Ethnic Conflict and Civic Life: Hindus and Muslims in India*, Yale University Press, New Haven and London.

Visvanathan, S. (1996) 'Footnotes to Vavilov: An Essay on Gene Diversity', in F. Apffel-Marglin and S. Marglin (eds.) *Decolonizing Knowledge: From Development to Dialogue*, 306-339, Clarendon Press, Oxford.

Wanniski, J. (2001) 'The Mind of a Terrorist', *Memo on the Margin.* http://www.worldnetdaily.com/news/article.asp?ARTICLE_ID=24440 (12 November 2002).

Zellner, A. (1987) 'Bayesian Inference', In J. Eatwell, M. Milgate and P. Newman (eds.) *The New Palgrave: A Dictionary of Economics*, 208-218. Macmillan, London.