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Cognitive biases in the assimilation of scientific information on global warming and genetically modified food ☆

Brandon R. McFadden [a,*], Jayson L. Lusk [b]

[a] Department of Food and Resource Economics, University of Florida, United States
[b] Department of Agricultural Economics, Oklahoma State University, United States

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ABSTRACT

The ability of scientific knowledge to contribute to public debate about societal risks depends on how the public assimilates information resulting from the scientific community. Bayesian decision theory assumes that people update a belief by allocating weights to a prior belief and new information to form a posterior belief. The purpose of this study was to determine the effects of prior beliefs on assimilation of scientific information and test several hypotheses about the manner in which people process scientific information on genetically modified food and global warming. Results indicated that assimilation of information is dependent on prior beliefs and that the failure to converge a posterior belief to information is a result of several factors including: misinterpreting information, illusionary correlations, selectively scrutinizing information, information-processing problems, knowledge, political affiliation, and cognitive function.

Introduction

The possible negative outcomes associated with societal risks such as genetically modified (GM) crops/foods and global warming (GW) are unclear, particularly for the general public. Therefore, individuals' decisions of whether to support or oppose GM crops or policies aimed to mitigate GW are made under uncertainty. Such decisions require individuals to assign subjective probabilities to possible outcomes, and these subjective measures may vary for two reasonable individuals (Savage, 1954).

Bayesian decision theory posits that an individual has a prior belief, receives new information, and then combines the prior belief with new information to form a posterior belief. The posterior belief is essentially an updated belief formed by allocating weights to a prior belief and the new information. Thus, a Bayesian approach provides a way of explaining how individuals incorporate new information to make decisions under uncertainty.

The Bayesian approach has been applied in a wide array of contexts such as game theory (e.g., Myerson, 1991), determining the economic value of weather information to agricultural producers (e.g., Doll, 1971; Banquet et al., 1976; Byerlee and Anderson, 1982; Marshall et al., 1996), projecting the evolution of agricultural yield expectations (e.g., Krause, 2008), determining returns of using soil sample information (e.g., Pautsch et al., 1999), and understanding how individuals update beliefs about GW from fluctuations in local weather (Deryugina, 2013), just to give a few examples. An implicit assumption when employing a Bayesian approach is that individuals process information optimally. However, information processing does not always conform to Bayesian decision theory. Posterior beliefs do not always converge to new information and may diverge in some instances. For example, while there appears to be a consensus in the scientific community about the safety of GM foods, the same cannot be said about public opinion. This disconnect implies that many people do not receive or accept scientific information, or it could be that they place greater weight on other types of non-scientific information.

Violations of the assumptions of Bayesian decision theory are thought to arise through a variety of heuristics and cognitive biases in decision making (e.g., Tversky and Kahneman, 1971, 1973, 1974; Kahneman and Tversky, 1972; Grether, 1980; El-Gamal and Grether, 1995; Zizzo et al., 2000; Charness and Levin, 2005; Charness et al., 2007). In the present study, we are interested in the effects of subjective prior beliefs on the acceptance of scientific information. Prior beliefs may affect how an individual processes new information; new information that is contrary to a prior belief is often met with skepticism. Distrust in information may result in an individual assigning more weight than is appropriate to a prior

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* Corresponding author at: 1121 McCarty Hall B, Gainesville, FL 32611, United States.
E-mail address: brandon.mcfadden@ufl.edu (B.R. McFadden).

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belief – conservatism – or possibly even reaffirm a prior belief contrary to new information – confirmation bias – when forming a posterior belief.

The purpose of this study is to determine how the public assimilates scientific information on GW and GM food and examines cognitive biases that cause belief perseverance or biased information assimilation. The objectives of this study are to determine whether: (1) information processing is independent of prior beliefs; and (2) previous theories about information processing are observed empirically in this context. Understanding how the public responds to scientific information is important because substantial resources are invested to mitigate societal risks. The economic value of scientific information is dependent on the ability of scientists to communicate with the general public in a way that scientific knowledge is received and understood.

The next section reviews the literature on information assimilation and derives some research hypotheses. Then, our research design and data collection approach are described. The following section presents the results, and the last section concludes.

Background

Conservatism bias occurs when an individual over-weights a subjective prior belief and under-weights new information. Conservatism has been observed in previous experiments by comparing posterior probabilities estimated by research participants to the predicted posterior probability estimate of an optimal Bayesian decision-maker (e.g., Phillips et al., 1966; Phillips and Edwards, 1966). However, probability estimation may be too complex for the average research participant and thus may not be an appropriate measure to formulate meaningful conclusions about belief perseverance (Pitz et al., 1967). Nevertheless, Kahan et al. (2011) posited that failure of scientific consensus to temper public disagreement was due to individuals perceiving expert support for a prior belief rather than a lack of willingness to adopt scientific evidence. In the present study, we specifically define conservatism as an individual giving no weight to new information and relying solely on a prior belief.[1]

Confirmation bias occurs when an individual biasedly assimilates new information to form a posterior belief that diverges from new information and converges to a prior belief. Previous experiments have observed confirmation bias for complex issues like capital punishment (e.g., Lord et al., 1979) and nuclear energy (e.g., Plous, 1991). Lord et al. (1979) provided two sets of information to all participants; one set of information indicated that capital punishment lowered murder rates and another set of information indicated that capital punishment increased murder rates. Plous (1991) provided identical ambiguous information to all participants. The majority of participants in both studies interpreted information to confirm a prior belief. Moreover, posterior beliefs diverged for the two groups; meaning that a pro participant formed a posterior belief more in favor of an issue and an anti participant formed a posterior belief less in favor of an issue. Based on this literature, we hypothesize that individuals will assimilate information, whether that assimilation be biased or unbiased, to confirm a prior belief.

Rabin and Schrag (1999) posited that confirmation bias can be attributed to the misinterpretation of new information rather than a violation of Bayesian updating *per se*. Such a phenomenon could explain the findings of Plous (1991), as ambiguous information is open to interpretation by research subjects. However, we present what we believe to be the scientific consensus on the issues of GM foods and GW, as reflected in statements by leading authorities; however, it must be noted that some people (including some scientists) disagree with these conclusions, and historically, there have been some "facts" on which most scientists agreed that were later proved incorrect. Thus, these societal risks and accompanying scientific information provide an appropriate scenario to examine the hypothesis that individuals misinterpret new information when displaying confirmation bias.

Rabin and Schrag (1999) also conjectured that information-processing problems, specifically selectively scrutinizing evidence and illusionary correlation, contribute to confirmation bias. Participants who received identical information in the Lord et al. (1979) study did indeed more closely dissect information that did not conform to a prior belief. Illusionary correlation occurs when an individual believes a correlation to exist between two events that uncorrelated, correlated but to a lesser extent than believed, or correlated in an opposite direction than believed (Chapman, 1967). We posit that greater illusionary correlation is expected to be associated with divergence from information.

It is possible that variations in familiarity, or knowledge, about a societal risk have some effect on information processing across individuals. Jang (2014) examined whether participants selected to read scientific information that confirmed or contradicted a prior belief. He concluded that participants who had a high level of perceived science knowledge were more likely to read scientific information that confirmed a prior belief. Conversely, participants with a high level of actual scientific knowledge, not just perceived, did not display confirmation bias when selecting scientific information to read. Based on this literature, we hypothesize that individuals with higher levels of perceived knowledge are more likely to suffer from biased assimilation and individuals with higher levels of actual knowledge are more likely to converge to information.

A point of contention is whether belief preservation is uniform for Democrats, or liberals, and Republicans, or conservatives. It has been argued that Republicans are more likely to deny scientific evidence (i.e., Mooney, 2005, 2012) or not fully understand possible impacts of societal risks (Hamilton et al., 2012). However, it has also been argued that Republicans and Democrats are equally susceptible to biased assimilation of scientific information (Kahan, 2013). Complicating the issue, the Anti-Reflexivity Thesis (McCright et al., 2013) posits that conservatives will trust science that provides innovations for economic production (i.e., GM crops) and distrust science that identifies negative impacts of economic production (i.e., GW), and liberals will behave in an opposite manner. We hypothesize that Democrats and Republicans will be more accepting of scientific information about GW and GM crops, respectively.

The method in which information is assimilated may depend on whether an individual processes information in a deliberative cognitive style, as presumed by a Bayesian approach, or in a more heuristic and subconscious style. Stanovich and West (2000) formally defined two generic modes of cognitive function, System 1 and System 2. System 1 and 2 can be thought of more generally as intuition and reasoning, respectively (Kahneman, 2003). Stanovich and West (2000) conjectured that the two systems likely interact in concert when processing information; however, System 2 may act as an override system for automatic information-processing results occurring from System 1. Ball and Quayle (2000) speculated that System 1 may serve as an escape hatch when processing demands increase and for information processing that is not automatic and Kahan (2013) concluded that individuals relying on System 2 were more prone to biased assimilation. Thus, we hypothesize that an individual's predisposition to rely on System 1 or System 2 affects information processing.

[1] Our specific definition of conservatism is not to be confused with *anchoring*, another cognitive bias, where estimates are biased toward initial or induced values (Tversky and Kahneman, 1974).