Attitudes to genetically modified food over time: how trust in organizations and the media cycle predict support.

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Abstract

This research examined public opinion towards Genetically Modified (GM) plants and animals for food, and how trust in organizations and media coverage explained attitudes towards these organisms. Nationally representative samples (*N*=8821) over ten years showed Australians were less positive toward GM animals compared to GM plants for food, especially in years where media coverage was high. Structural equation modeling found that positive attitudes towards different GM organisms (GMOs) for food were significantly associated with higher trust in Scientists and Regulators (e.g., governments), and with lower trust in Watchdogs (e.g., environmental movement). Public trust in Scientists and Watchdogs was a stronger predictor of attitudes toward the use of GM plants for food than animals, but only when media coverage was low. Results are discussed regarding the moral acceptability of GMOs for food, the media's role in shaping public opinion, and the role public trust in organizations has on attitudes towards GMOs.

Keywords

trust, attitudes, public opinion, media and science, GM food

1. Introduction

The use of Genetically Modified (GM) organisms for food is widely touted as a solution to current third world famine (Huang, Pray, & Rozelle, 2002), as well as future food shortages expected to occur alongside climate change (Godfray et al., 2010). Via genetic engineering, scientists can increase a plant or animal's resistance to disease and drought, enhance nutritional qualities, and increase crop yields, thereby producing a more efficient, cheaper and healthier food supply that is less reliant on potentially harmful pesticides (Wolfenbarger & Phifer, 2000). That the benefits outweigh the risks, however, is a claim that is fervently contested. Many argue that GM food from plants and animals present unknown health risks and pose a serious ecological threat (Augoustinos, Crabb, & Shepherd, 2009). A further concern is that intellectual property rights and patents associated with transgenic crops may lead to market capture and monopoly pricing (Lapan & Moschini, 2004).

Ultimately, the success of GM foods will depend upon government approval and market uptake, as well as the extent to which the public accept or reject either side of the debate. Public attitudes may influence the consumption of GM products, but can also influence government policy and regulation relating to their development, production, and distribution. Understanding public attitudes towards GM food is therefore important so that acceptable governance mechanisms can be developed that will generate trust and ultimately consumption. This research examines the level of support for GM foods (from both plants and animals) in the Australian context where the number of government approved GM crops is half that of the US and Japan (ISAAA, 2013).

Research suggests that Europeans are generally less supportive of GM food (Gaskell et al., 2000) compared to the US (Gaskell, Bauer, Durant, & Allum, 1999), Japan (Macer & Ng, 2000), South Africa (Aerni, 2005), and China (Li, Curtis, McCluskey, & Wahl, 2003). The differing levels of acceptance of GM crops across countries is thought to relate to familiarity with GM technology and trust (Sinemus & Egelhofer, 2007). There is significantly lower trust in regulatory authorities in Europe compared to the US (Gaskell et al., 1999), possibly because Europe has experienced a greater number of publicized food scares (Anderson & Jackson, 2003) compared to the US. However, the story in Australia is less clear as there has been relatively little controversy compared to Europe (Einsiedel, Jelsoe, & Breck, 2001), there is limited research on Australian public attitudes towards Genetic Engineering (GE) technology in general, trust in scientific expertise and acceptance of new technologies has remained consistently high for the past 10 years (Swinburne National Science and Technology Monitor, 2003-2012), and governments are only beginning to allow

the introduction of GM crops. Examining support for GM food in countries such as Australia therefore provides a unique opportunity to examine the interrelationships between public trust and attitudes over time in a country where GM crops are only starting to be introduced.

The response to GM foods in Australia has varied over time. Early public opinion surveys indicated that Australians were favorable towards GM products (Kelley, 1995; Norton, Lawrence, & Wood, 1998), with subsequent reports by Biotechnology Australia (Milward Brown, 2001, 2003; Yann Campbell Hoare Wheeler, [YCHW], 1999) indicating mixed levels of interest and awareness, perceptions of usefulness, and perceptions of risk towards GM organisms (GMOs; see Dietrich & Schibeci, 2003, for a review). Awareness and belief in the utility of "Gene Technology in Food and Drink" decreased significantly between 1999 and 2001, while perceived risk increased significantly during the same period leading to a decrease in positive attitudes towards eating GM foods (Milward Brown, 2003). Walls, Rogers-Hayden, Mohr, and O'Riordan (2005) attribute an increase in the social awareness of gene technology in 1998 and 1999 to an influx of media reports from the US and Europe, which was accompanied by an increase in local media exposure about safety concerns with GM food and an increase in public and political discourse surrounding the issues of safety. More recently, potential fear and concern that followed the controversial results published by Séralini have been widely reported in the media and may have fueled public perception and international regulation of GM food (Willingham, 2012). It is therefore reasonable to suggest that extensive media coverage could shape public perception of GM food, and more generally may have contributed to a ubiquitous distrust by Australians of government processes to regulate GM technology (Dietrich & Schibeci, 2003).

Despite the importance of understanding community attitudes towards GM technologies, research in Australia since the 1990s has been limited and inconsistent, even with the introduction of domestic regulation for Gene Technology in 2000. Subsequent Gene Technology and GM crop acts introduced by all Australian states and territories placed a moratorium on the commercial production of GM canola beginning in 2003 (Mewett et al., 2008). The two most populous states of Victoria and New South Wales approved production of GM canola in 2008, but not before several widely reported incidents of conventional canola crops being contaminated by GMOs (e.g., Breusch, 2005), incidents which spurred public debate about food safety.

Of the recent research, using a random sample of over 1200 Australians, Lockie, Lawrence, Lyons, and Grice (2005) reported that persons, on average, held negative attitudes towards GM food. However, in separate phone polls, commissioned by Biotechnology

Australia, it was reported that support increased steadily during this period, and a clear majority were then accepting of GM food crops (Cormick, 2007). Another study found that the type of organism involved is critical in acceptance (Mohr, Harrison, Wilson, Baghurst, & Syrette, 2007), where GM food derived from plants was more acceptable compared to animals, possibly highlighting a moral dimension of the concern toward GM animals for food. These mixed findings highlight a limitation in the interpretation of the trend in public support for GM food at different times due to methodological differences in the measurement of attitudes towards GM food (e.g., asking about GM food relative to other issues; equating support to benefit or risk). Furthermore, they underline the importance of understanding factors such as the type of organism involved in biotechnology in predicting attitudes towards GM food. The research reported here will examine for the first time attitudes and trust over time using the same methodology, and will compare attitudes towards the use of genetically modified animals and plants.

The role of trust in predicting attitudes towards GMOs for food

Trust is an important determinant of attitudes towards science and technology. Researchers posit that in the absence of detailed knowledge about biotechnology, individuals rely on social trust as a heuristic to reduce the complexity of science and risk management decisions (e.g., Critchley, 2008; Siegrist, 2000). Here it is argued that trust in the sources that carry out scientific research (i.e., institutions or organizations), as well as trust in the scientists, are factors crucial to understanding attitudes towards controversial and complex technologies such as GM food.

Trust in information sources has been shown to be important in the formation of attitudes towards biotechnologies such as GM food. Frewer et al. (2004) highlights the importance of "social trust", an institutional and issue general socio-political attitude about the reliance on institutions and experts involved in the management of risks and technologies, particularly in situations where individuals perceive no control over activities such as GM food. In a series of studies, Frewer, Hedderley, and Shepherd (1996, 1999) have demonstrated that source characteristics such as competence and trustworthiness are important in understanding public attitudes towards GE, as well as science communication about its applications (Frewer & Miles, 2003). In addition, studies by Siegrist (1999, 2000) suggest that the most important factor in the acceptance of GE applications is trust in the institutions or scientists involved in the research.

Considering the variation in attitudes between Europeans and North Americans towards biotechnology, researchers have argued that differences are related to trust patterns and not necessarily knowledge in science (Priest, Bonfadelli, & Rusanen, 2003). Priest et al. found that for some applications of biotechnology the best predictors of attitudes were the individual differences in trust afforded to competing institutional actors, called trust gaps, rather than absolute levels of trust (i.e., culture-specific) and individual differences in knowledge of science. For example, it was reported that support for food biotechnology was better predicted by the differences between trust in industry and environmental groups than individual level items such as knowledge. Taken together, these findings suggest the importance of relative trust in different organizations, emphasizing the distinctions that consumers make between different organizations, and that these judgments of trust are perhaps more salient when the biotechnology application is considered controversial or complex (i.e., GM animals for food).

Given these findings, trust in organizations therefore appears to be a key factor in determining attitudes towards GM food. In this context, trust has typically been conceptualized as public trust in scientists, universities, industry and government. For example, Lang and Hallman (2005) conceptualized overall trust as a combination of ratings on competence, transparency, public interest, and honesty. Furthermore they found that ratings across the organizations could be classified into three groups where evaluators (e.g., scientists) were most trusted, watchdogs (e.g., environmental organizations) were somewhat trusted, and industry and government were least trusted. Similarly, Gutteling, Hanssen, van der Veer, and Seydel (2006) found that government was least trusted, with Non-Governmental Organizations (NGOs) being more trusted in relation to GM food issues, and that these levels of trust were related to attitudes and behavioral measures (e.g., sign petitions against GM developments). Specifically, they showed that either a low level of trust in government or a high level of trust in NGOs was related to less favorable attitudes towards GM food and lower acceptance, when compared with those who expressed more trust in the government or lower trust in NGOs. Thus, it appears that trust in these organizations is important as it could act as a means of risk regulation, a finding also demonstrated by Lobb, Mazzocchi, and Traill (2007) who reported decreased trust in environmental movements and the media was associated with lower risk perception of food safety while increased trust in public authorities mitigated this risk.

Apart from research examining trust in organizations, Critchley (2008) demonstrated that the research context, perceived motivation and competence of stem cell scientists were

important predictors of trust in scientists and attitudes towards a morally controversial and scientifically complex area. In examining public support for a complex activity such as stem cell research, Critchley argued that persons rely on heuristics rather than knowledge about science to inform their attitudes, and thus evaluate the trust in those who have the responsibility for conducting and regulating the research. Thus, it appears that trust in scientists is important when people are concerned with moral or ethical issues regarding biotechnologies. Given this, it could be expected that trust in scientists would be a stronger predictor of GM animals than GM plants for food due to the increased moral complexity with altering the genetic makeup of animals compared to plants.

Moral Acceptance

Findings detailing the relationships between trust and attitudes towards GM food suggest that attitudes are influenced by contextual information such as the type of organism being modified. Research has highlighted that morality, which in the context of GM food relates to whether or not something is seen as natural or unnatural (Bauer, Durant, Gaskell, & Midden, 1997; Knight, 2009), is linked with attitude formation. Such moral objections have been argued to trigger disgust (Townsend & Campbell, 2004) and have been termed the "yuck" factor (Schmidt, 2008). Further, moral concerns regarding GM food can be separated into extrinsic and intrinsic dimensions, with intrinsic modifications being considered to be more "yucky" than those considered extrinsic.

Extrinsic moral concerns relate to the consequences of the technology and the perceived risk balanced against the purported outcomes (Frewer & Shepherd, 1995). Indeed, reviews suggest that risk perceptions (Finucane & Holup, 2005; Townsend, 2006) and perceived benefits (Frewer, Howard, & Shepherd, 1997; Gaskell et al., 2004) of the product are important in understanding attitudes towards GM food. So it could be argued that persons who place trust in the government and regulators would support GM plants for food, a less threatening or morally unacceptable application when compared with GM animals for food.

Intrinsic moral concerns, conversely, relate to the application of the technology and are rooted in the idea that genetic manipulation disobeys the laws of nature (Dietrich & Schibeci, 2003), and that humans are playing god (Frewer & Shepherd, 1995). Research suggests that the genetic modification of animals for food is considered less morally acceptable than the genetic modification of plants for food (Knight, 2007), and that consequently people hold more favorable attitudes towards plant as opposed to animal based GM food (Frewer, Hedderley, Howard, & Shepherd, 1997; Mohr et al., 2007).

While factors such as the perception of personal benefit from biotechnology significantly decrease the likelihood of moral objection to both plant and animal biotechnology, those who believed that it was an environmental risk perceived both applications as morally wrong (Evensen, Hoban, & Woodrum, 2000). Therefore, it is likely that trust placed in sources such as watchdogs (Lang & Hallman, 2005) would be an important predictor of level of support of GMOs for food. Furthermore, placing trust in regulatory or government agencies has been found to lessen the gap in attitudes between plant and animal based GM food (Hossain & Onyango, 2004; Pardo et al., 2009). Overall, this suggests that trust in those responsible for regulating safety (i.e., government) may be more important in predicting support for GM plants for food, while trust in scientists may be more important in predicting support for GM animals for food as scientists or their institutions (i.e., universities or research organizations) may be perceived to be those who are directly tampering with nature (Thompson, 2007). Trust in watchdogs (i.e., environmental groups) is also expected to be important in the predicting support for GMOs for food, but it is unclear as to the relative strength depending on the organism.

Aims and Hypotheses

The purpose of the present study is to investigate Australians' attitudes towards GM plants and animals for food over a 10 year period from 2003 to 2012. Our focus is to investigate public attitudes in Australia by examining the effect of trust in organizations and moral acceptance, as assessed by the difference between animals and plants, on support for GM food. As highlighted by the literature, attitudes vary not only by moral acceptance of the application but also depending on levels of trust in institutions, organizations and scientists. The study will primarily focus on the relative importance of trust in various actors (e.g., scientists, governments, watchdogs) in explaining support for GM plants and animals for food.

Firstly, as an exploratory aim, due to the absence of any consistent long term data on this topic, we will examine Australian attitudes towards GM plants and animals for food across 10 years. Secondly, it is hypothesized that attitudes towards GM plants for food will be more positive than attitudes towards GM animals for food given the research suggesting heightened moral concern associated with GM animals. Next, we investigate whether attitudes coincide with the extent of media coverage of GMOs in the Australian context. Finally, we provide some preliminary hypotheses explaining the role of trust in predicting attitudes towards different GMOs for food. We predict that trust in scientists (e.g., scientists

and universities) will be more important in explaining attitudes towards GM animals for food, whereas trust in regulatory sources (e.g., state and federal government) will be more important in explaining attitudes towards GM plants for food. Moreover, it is expected that trust in watchdogs (e.g., environmental groups) will negatively predict attitudes towards GM plants and animals for food, given that watchdogs in Australia have been generally opposed to GMOs, particularly crops; however, any difference in strength is treated as exploratory.

2. Method

Participants and procedure

Ten samples of Australians over the age of 18 years were collected annually between 2003 and 2012 as part of the Swinburne National Technology and Society Monitor using computer assisted telephone interviews[1]. Telephone numbers were selected randomly from all listed Australian phone numbers. A quota was used to ensure that the samples represented each State and Territory. Response rates were calculated according to the AAPOR's (2004) definitions and calculations (i.e., RR1-RR4) for each year and ranged between 8.9-31%, while cooperation and refusal rates ranged between 17.4-24.6% and 40.7-75.0% respectively. Data from 2003 were excluded from all analyses as they were collected by a third party, varied methodologically and lacked response rate information.

A sample weight based on the Australian Bureau of Statistics proportions for age group and gender was employed for all analyses due to an overrepresentation of females and older people. The samples were representative of the Australian population in terms of university education and church attendance[2]. As shown in Table 1, across the nine samples average church attendance was between less than once a year and at least once a year and overall 36.7% were university educated. Preliminary analyses were conducted to check the equivalency of these two basic demographic variables across the years. A Chi-square test was conducted to test for possible differences in education level (coded as holding a university degree or not) across years. The results indicated no difference between the numbers of university educated (N=3224) and non-university educated (N=5571; χ^2=14.78, df=8, p>.05) across years. A one-way between-groups ANOVA was also conducted to explore possible differences in religious attendance (1=never; 2=less than once a year; 3=at least once a year; 4=several times a year; 5=at least once a week) across the years. A statistically significant difference in religious attendance [F(8, 10062)=3.89, p<.001, η^2p=.003] across the years was found. Post-hoc comparisons (Student Newman–Keuls) indicated that religious attendance

was significantly higher in 2008 than all other years. Church attendance was therefore used as a covariate in subsequent analyses.

[TABLE 1 GOES APPROXIMATELY HERE]

Materials

Attitudes towards genetically modified foods. Attitudes were conceptualized as an affective evaluation of an attitude object, indicated by a generalized feeling of comfort or discomfort (Eagly & Chaiken, 1993). They were assessed by two 11-point items where respondents were asked to indicate how comfortable they were with new technologies. The scale ranged from 0="not at all comfortable" to 10="very comfortable". Specifically respondents were asked:

> I would now like to ask you how comfortable you are with different types of new technologies:
>
> 1. Genetically modified plants for food
> 2. Genetically modified animals for food

To control for the possibility of order effects, the two items were presented randomly across respondents, and were embedded amongst six other attitude targets not used in this research (e.g., donating blood for medical research, genetic testing).

Trust. Trust in scientists, regulators, and watchdogs were assessed by asking respondents how much they trust certain "people and organizations that you might depend upon for information about new technologies, such as genetically modified foods". The scale ranged from 0="don't trust at all" to 10="trust a very great deal". The nine statements used to conceptualize *Trust in Scientists*, *Trust in Regulators*, and *Trust in Watchdogs* were included amongst 9 other organizations (e.g., major Australian companies, hospitals) that were not used in the present research. *Trust in Scientists* was representative of trust in "universities", "scientists", and the "CSIRO (Commonwealth Scientific and Industrial Research Organisation)", *Trust in Regulators* was trust in "the public service", "the State government", "the Federal government", and *Trust in Watchdogs* was trust in "the environmental movement".

3. Results

Attitudes to GMOs over time

A mixed-design ANOVA was conducted to compare scores across attitudes to GMOs (plant vs. animal) and across years (2004-2012). There was a statistically significant main effect on attitudes for GMOs, $F(1, 9617)=2421.17$, $p<.001$, $\eta^2p=.201$[3] indicating that attitudes towards GM plants ($M=4.06$, $SD=3.08$) were significantly higher than attitudes towards GM animals ($M=2.90$, $SD=2.85$) averaged over time, thereby supporting our hypothesis. Attitudes to both GMOs averaged together also changed over time, $F(8,9617)=3.90$, $p<.001$, $\eta^2p=.003$. There was also an interaction between organism type and year [$F(8, 9617)=6.49$, $p<.001$, $\eta^2p=.005$], suggesting that the differences in attitudes across GMOs varied across the years. Nine paired t-tests were conducted to check whether these differences in attitudes to GMOs were significant for each year. As presented in Figure 1, attitudes towards GM plants were significantly more positive than attitudes towards GM animals in every year ($p<.001$).

[FIGURE 1 GOES APPROXIMATELY HERE]

To attempt to explain the significant differences in attitudes across years, we explored why attitudes across the two GMOs changed in some years relative to others. Using a comparable approach to Gaskell et al. (1999), our analysis inspected the frequency of news reports on GMOs for food in major Australian newspapers from 1990 to 2012[4]. This time frame captures Australia's Gene Technology Act (2000) up until the final survey in 2012, and is presented below in Figure 2.

[FIGURE 2 GOES APPROXIMATELY HERE]

After an initial peak in newspaper coverage in 1999, the data suggest a steady downward trend in the number of GMO stories from 2001 to 2010, with 2004 and 2008 being extraordinary years in the media coverage cycle. In these two years there is a spike in the number of reported stories which can be explained by the start of GM Crop Moratorium Acts in six of eight states and territories, and the end or extension of these freezes four years later (Mewett et al., 2008). When considered together with the data in Figure 1, the trend of reported stories, which are almost exclusively about GM plants, suggest that attitudes towards GM plants for food increase following years where there is less media coverage; after a steady increase in attitudes from its lowest level in 2004 up until 2008, there is a slight decline over the following years and a rebound to the highest recorded level in 2012. The pattern however is less clear for GM animals for food, due to scarce media coverage of GM

animals. A sudden increase in support in 2005 from the previous year, followed by a dip in 2006, and a rise in 2007 appear to distort what would otherwise reflect a trend similar to attitudes towards plants.

A post-hoc analysis examining differences in attitudes and trust across media cycle years[5] was conducted, and results are presented in Table 2. Results suggest that attitudes towards GMOs are significantly more positive in low compared to high media cycles. Further, aside from trust in the environmental movement which is significantly greater in high compared to low media cycles, all other trust indicators are greater in low compared to high media cycles and these are significantly different for both the scientists and the public service.

[TABLE 2 GOES APPROXIMATELY HERE]

Trust as a predictor of attitudes towards GMOs

Initially, two multi-sample structural equation models (SEMs) were computed to test the measurement equivalency of the proposed model across high and low media cycle years[6]. We were interested in comparing the strength of the structural paths across two time point (high and low media cycles) so we tested the measurement invariance across these two groups rather than across all nine time points. As Figure 3 shows, the model consisted of the seven measured trust variables as indicators of either a trust in scientists or regulators latent variable and the measured variable watchdogs (i.e., environmental movement). These trust variables then predicted attitudes towards both GM animals and plant for food. To ensure that the measurement part of the model was statistically equivalent across the two media cycle groups, a fully unconstrained model was compared to a constrained model where the factor loadings were constrained to be equal across the two groups (with 8958 cases and 68 and 62 free parameters respectively). Since we expected the structural part of the model to change across time all one way paths were allowed to be freely estimated (as were all intercepts)[7]. Scales of the explanatory latent variables were fixed at 1 and their means fixed at zero.

Although the Satorra-Bentler Scaled Chi Square difference test across the constrained and unconstrained models was significant at $p<.01$ ($\Delta\chi^2=19.81$, $\Delta df = 6$, $p=.003$), Wald tests comparing the strength of each factor loadings across the two media cycles did not reveal any statistical differences (all were at $p>.16$), apart from one exception. This was the factor loading for state governments which was significantly stronger (Wald=3.02, $p<.005$) in the

high group (standardised estimate=.76) than in the low group (standardised estimate=.69). Inspection of the other difference in the unconstrained factor loadings across time periods were small (i.e., ranged=.01-.04; see Figure 3 for actual standardised factor loadings for both times), and the model where the measurement models were constrained to be equal was a good fit with the data, χ^2=357.98, *df*=46, *p*<.001, *CFI*=.98, *TLI*=.97, *SRMR*=.03, *RMSEA*=.04 (90% CI=.04,.04). Because reasonable stability in the measurement model was found across media cycles, it was decided to assess the hypotheses relating to the strength of the structural predictors separately across the two groups. All standardised parameter estimates for both groups for the unconstrained model are shown in Figure 3.

[FIGURE 3 GOES APPROXIMATELY HERE]

As shown in Figure 3, trust in scientists, regulators, and watchdogs were all correlated with each other. Although trust in all three sources was significantly associated with attitudes towards both GM plants and animals, the pattern in the strength of these correlations was not in line with all of the hypotheses. As expected, higher trust in scientists and regulators was associated with more positive attitudes towards both GMOs, and higher trust in watchdogs was associated with more negative attitudes.

A series of Wald tests were computed to compare the strength of all trust predictors on attitudes towards animals and plants across within the two media cycle groups. The first set of constraints compared each trust predictor across the two media cycle groups. The results revealed that there were no significant differences (*p* values ranged from .16-.89) in the strength of the relationships across media cycle groups for any of the paths (Wald statistics ranged from -1.28-.38). Thus the importance of trust in science, regulators and watchdogs in predicting attitudes towards both GM sources was similar in the low and high media cycle groups.

The second set of Wald tests were designed to directly test the hypotheses. That is, they compared the ability of the three trust variables to predict attitudes towards GM plants with their ability to predict attitudes towards GM animals. Identical comparisons were made for each of the two media cycle groups. Contrary to our hypothesis, trust in scientists was a significantly stronger predictor of GM plants for food than it was for animals (see Figure 3 for the standardised estimates for both groups). Furthermore this difference was only found within the low media cycle group (Wald=4.14, *p*<.001). In the high media cycle group the

ability of trust to explain attitudes towards plants and animals was statistically similar (Wald=1.68, p=.09). The hypothesis relating to trust in regulators was also not supported, with no difference in the strength of the paths from trust in regulators to attitudes towards GM plants compared with GM animals in either group (low group: Wald=.58, p=.56; high group: Wald=.63, p=.53). A difference however was found between the strength of the paths linking GM plants and GM animals to trust in watchdogs, where trust in watchdogs was significantly more important in explaining attitudes towards plants than attitudes towards animals. Again, however, this difference was only evident within the low media cycle group (low group: Wald=-3.91, p<.001; high group: Wald=-63, p=.53)

4. Discussion

This research provided the first examination of public attitudes towards GMOs for food in Australia over time. The findings showed that respondents were significantly and consistently more favourable towards the use of GM plants for food compared with GM animals. Despite some fluctuations in the absolute levels across years related to the media cycle, public trust and its relationship with attitudes remained fairly consistent. Furthermore, it was found while trust in watchdogs, regulators and scientists were all important predictors of attitudes towards both GMOs, trust in scientists had the largest effect for increased positive attitudes. Trust in scientists was found to be more important in predicting attitudes towards GM plants than animals as was trust in watchdogs, but only in low media cycle years; trust in regulators was similarly important in explaining attitudes to both GMOs.

Attitudes towards GM food depend on type of organism

More positive attitudes towards GM food were reported when the modified organism was a plant as compared to an animal, a result in line with existing Australian (Mohr et al., 2007) and international findings (e.g., Frewer, Howard, et al., 1997; Hossain & Onyango, 2004; Knight, 2007). However, overall levels of support were still below the midpoint on the scale suggesting that Australians are not comfortable with either type of GM food, supporting the findings of Lockie et al. (2005) who reported that Australians were less positive toward GM food. However, whilst our research shows that Australians are more positive of GM plants than animals for food, it challenges the findings by Cormick (2007) that nearly three-quarters of Australians were accepting of GM food crops by 2007.

Australian attitudes towards GM food as a function of the media cycle

Providing a chronicle of attitudes towards GM food in Australia, this research showed that while relatively consistent over time, support for GMOs for food did shift relative to the media cycle. Our retrospective media analyses provided some context to understanding the trend of public attitudes towards GM food. Support for GM plants and animals was lower when there was greater media coverage about GM food. Overall there was a significant increase in support for GMOs for food when there was less media coverage, with support being at its lowest in those years where media reports were at their highest. These findings support recent literature (Flipse & Osseweijer, 2013) and the conclusions of Gaskell et al. (1999) who found that "increasing amounts of press coverage of technological controversies are associated with negative public perceptions" (p. 385). An explanation for the pattern of results could be that media saturation which, by and large, reflected the controversy surrounding GMOs in Australia may have negatively impacted on public attitudes, which then rebounded after reports disappeared from the news cycle. Previous research has indeed shown that attitudes do fluctuate over time relative to the volume of media coverage (Frewer, Miles, & Marsh, 2002). However, given the correlational nature of our study it is not possible to rule out that media coverage reflected and followed public concern.

Apart from some modest variation, any difference between attitudes towards GM plants and animals was remarkably stable across the years. There were, however, some minor variations, with support for GMOs widening in 2005 and then narrowing again in 2006. We are unable to account for these fluctuations, and the data suggest that relative differences between attitudes towards the two GMOs were quite stable and somewhat dependant on each other. Thus, while attitudes may indeed be impacted by the number of newspaper reports there is little to suggest that this occurs disproportionately depending on the type of GMO despite the coverage being almost exclusively about GM plants for food.

How trust in organizations predicts attitudes towards GM food

The current research also attempted to explain how levels of trust in scientists, regulators, and watchdogs would predict level of support for GM food depending on organism type, given that trust in various groups has been found to be important in explaining attitudes towards GM food (Frewer et al., 1996, 1999; Gutteling et al., 2006; Lang & Hallman, 2005). It was found that trust placed in scientists and organizations responsible for conducting research on new technologies was important in predicting attitudes towards GM plants and animals for food (Siegrist, 1999, 2000); however this was not in the expected direction. That is, those who reported higher trust in scientists had a significantly greater

effect on attitudes towards GM plants when compared with GM animals for food, but only in years where media coverage was low. A similar pattern in effect size was found between trust in watchdogs and attitudes towards GM food, but the negative relationship suggested that as trust in watchdogs increased attitudes towards GMOs decreased (and vice versa). Finally, trust in regulators was equally important in predicting attitudes towards both GM plants and animals for food in all years.

Unexpectedly, differences in the strength of trust sources to predict attitudes towards GM plants and animals were found depending on the level of media coverage. In years where media coverage was at its highest, each respective trust source did not differ in its ability to predict attitudes towards GM plants as compared to animals. However, in years where media coverage on the issue was lower, trust in scientists was more important in predicting attitudes towards GM plants than animals; similarly, trust or scepticism in environmental groups was more important in explaining attitudes towards GM plants than animals in these years. The meaning of this unexpected finding cannot be surmised from the results presented here without further in depth analysis of the content of media coverage in both high and low media cycles. Perhaps in times of high media coverage, stakeholders and sources other than scientists are more frequently cited in reports about specific GM events that emphasise plants more than animals (e.g., the 2007 Victorian moratorium on the commercial growing of genetically modified crops). This could reduce the reliance on trust in less mentioned sources such as scientists in attitude formation for certain topics compared (e.g., GM animals) to others (e.g., plants). Future research therefore needs to explore in more detail the nature of media reports to understand why different sources may be important for attitude formation at different times and why.

Additional evidence for the importance of trust was demonstrated by the inverse relationship between trust in watchdogs and support for GM food. Similar to research by Gutteling et al. (2006) who found that a high level of trust in NGOs or a low level of trust in the regulators led to less favourable attitudes, trust in environmental groups in Australia (who have generally opposed GMO technology) led to less positive attitudes towards both types of GMOs for food. Further, our data suggests that trust in environmental groups is heightened, while trust in scientists and some regulators (i.e., the public service) is lowered, during times when there is higher media coverage about GMOs for food, but these differences across media cycles do not impact on attitudes towards GMOs. So while the public is more trusting of organizations such as universities, the CSIRO, and scientists generally, trust or skepticism

in environmental organizations is more important than trust in regulatory agencies such as the government, in predicting attitudes towards GM food.

Our expectation that trust levels in scientists would be more important in predicting positive attitudes towards GM animals for food compared to plants was not upheld. Research has shown that although support differs depending on the application of the technology (e.g., GM animals for medical use versus non-medical use), social trust is equally important in predicting acceptance (Connor & Siegrist, 2010). It is still plausible that scientists are seen as tampering with nature (Thompson, 2007), but perhaps the trust measures were too broad to capture trust in scientists working in transgenic food research (as opposed to trust in scientists in general). It still may be the case that trust in these specific actors could be more important in predicting attitudes to GM animals for food compared to plants because these scientists, or indeed their employers, may be perceived to be playing god or tampering with nature (Frewer & Shepherd, 1995). Future studies should therefore examine how trust in specific types of science (i.e., scientists working on GMOs, organizations specifically engaged in GMO research) and trust in the organizations who employ them (e.g., government research organizations, private companies) explain the variance in attitudes towards GM animals for food.

Our findings show that trust in scientists and watchdogs were the most important predictor of attitudes towards GMOs food, specifically GM plants for food. Currently in Australia the requirement is to label food where the product contains artificially modified DNA or protein (Australia New Zealand Food Standards Code, 2012). This means only products containing GM DNA or protein, and not some end products of GM seed (e.g., canola oil) or feed (e.g., eggs, milk, meat) which do not contain GM DNA or protein, are required by law to be identified on the label. Thus, it is reasonable to suggest that the public are more aware of GM plants for food compared to GM animals, which is rarely reported, and therefore trust in organizations at present may play a smaller, but still significant part, in predicting attitude levels to an application which is currently non-existent. If future public dialogue were to consider the introduction of GM animals for food in Australia, then managing and promoting trust in people and organizations which the public depend upon for information about new technologies, including scientific reporting in the media, will be critical to the acceptance levels.

Conclusions

This research has provided the first comprehensive examination of attitudes towards different GMOs for food in Australia over time, as well as demonstrating the role of trust in

organizations in the formation of public support. Our results show that public attitudes towards either type of GMO for food are generally low, and this varies as a result of the type of organism, media coverage and portrayal of transgenic technologies for food.

The present study came from a series of annual national science and technology surveys that limited our ability to probe some of the other reasons behind why Australians were less positive towards GMOs for food. In addition to exploring how trust in specific actors, such as scientists or organizations working with GMOs, would explain level of attitudes towards GM food, in particular GM animals for food, future research should also consider respondents' levels of risk perception (e.g., Townsend, 2006) and perceived benefits (e.g., Gaskell et al., 2004) to understand how important moral acceptance (e.g., Knight, 2009), or the "yuck factor" associated with GMOs (e.g., Schmidt, 2008) is above and beyond these established factors.

A recent report forecasting future global issues published by the National Intelligence Council (2012) identified that "transgenic technologies - which enable the transfer of genes from one plant species to another to produce a plant with new or improved traits - hold the most promise for achieving food security in the next 15-20 years"(p. 93). Despite the potential benefits that may result from GM food technology and the safeguards in place, scandals tend to dominate media reports and subsequent public discourse leading to what may be "GM phobia" (Jayaraman & Jia, 2012). Assuming that some of the negative attitudes are due to a phobia, this research suggests that to avoid this and offset any potential influence from occurrences such as the recent Séralini affair (European Food Safety Authority, 2012) on public attitudes towards transgenic technologies in food, understanding and fostering trust in scientists and regulating organizations is critical, as is the media's role in shaping those discussions through science communication.

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Notes

[1] Detailed participant information can be found at http://www.swinburne.edu.au/lss/spru/spru-monitor.html

[2] For comparison figures using the Australian Bureau of Statistics (ABS) 2011 Census, see: http://www.abs.gov.au/. Note that ABS percentages are reported using one or no decimal points.

[3] Initially a mixed-design ANOVA with religious attendance as a covariate was used to test for differences between attitudes toward GMOs. However, no interaction effect was found between religious attendance and year so the data were analysed again excluding religiosity as a covariate.

[4] The following search terms and operands were used in Factiva: (("genetically modified" or "GMO" or "GMOs" or "GM" or "GE" or "genetically engineered") and ("soy" or "wheat" or "canola" or "corn" or "barley" or "crops" or "food" or "grain" or "animals")).

[5] High media cycle years (2004 & 2008) were classified as those where the frequency of coverage in the media was approximately twice that of other years.

[6] All SEM analyses were conducted using MPLUS version 7 (Muthén & Muthén, 2012) using the Maximum Liklihood Robust procedure (Yuan & Bentler, 2000) which adjusts the standard errors and chi-square statistic for nonnormality.

[7] Error variances were constrained across models.

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Table 1. Demographic characteristics over time.

	Percentage		*M* (SD)		*N*
	Females	University educated	Age	Church attendance	
2004	49.6	36.2	3.78 (1.78)	2.44 (1.51)	1012
2005	51.4	33.2	3.78 (1.78)	2.46 (1.58)	1010
2006	51.4	33.7	3.78 (1.78)	2.32 (1.62)	990
2007	51.4	37.0	3.78 (1.78)	2.40 (1.63)	989
2008	51.4	37.1	3.78 (1.78)	2.64 (1.66)	993
2009	48.0	37.3	3.84 (1.84)	2.33 (1.60)	997
2010	50.7	37.1	3.94 (1.86)	2.32 (1.60)	949
2011	52.4	38.5	3.96 (1.76)	2.43 (1.59)	937
2012	49.8	39.9	4.04 (1.80)	2.38 (1.62)	944
Total sample	50.6	36.7	3.85 (1.80)	2.41 (1.60)	8821

Weighted N for all variables. Range for church attendance: 1 = never, 2 = less than once a year, 3 = at least once a year, 4 = several times a year, and 5 = once a month or once a week. Range for age groups: 1 = 18–24 years, 2 = 25–34 years, 3 = 35–44 years, 4 = 45–54 years, 5 = 55–64 years, 6 = 65–74 years, 7 = 75–84 years, and 8 = 85–94 years.

Table 2. Comparison of attitudes toward GMOs and trust in people and organizations across low and high media cycles.

	Low media cycle		High media cycle		*t*	95% CI		Cohen's *d*
	M (*SD*)	*N*	*M* (*SD*)	*N*		*LL*	*UL*	
Attitudes								
GMOs for plant	4.23 (3.07)	6611	4.04 (3.12)	1954	2.48**	0.04	0.35	0.05
GMOs for animal	3.03 (2.86)	6617	2.86 (2.82)	1943	2.27*	0.02	0.31	0.05
Trust								
Universities	3.72 (0.96)	6668	3.69 (0.94)	1971	1.12	−0.02	0.08	0.02
Scientists	3.60 (0.95)	6715	3.43 (1.02)	1975	6.49**	0.12	0.22	0.23
CSIRO	3.78 (1.00)	6567	3.75 (1.03)	1949	1.44	−0.01	0.09	0.05
Public service	2.68 (1.17)	6713	2.60 (1.17)	1980	2.75**	0.02	0.14	0.06
State government	2.18 (1.25)	6746	2.14 (1.26)	1991	1.33	−0.02	0.11	0.03
Federal government	2.29 (1.32)	6756	2.29 (1.28)	1990	0.02	−0.07	0.07	0.00
Environmental movement	2.90 (1.25)	6668	2.97 (1.27)	1966	−2.28*	−0.14	−0.01	−0.05

CI: confidence interval; GMO: genetically modified crops; LL: lower limit; UL: upper limit; CSIRO: Commonwealth Scientific and Industrial Research Organisation.
Low media cycle: 2005–2007, 2009–2012. High media cycle: 2004, 2008.
**p < .01 *p < .05.

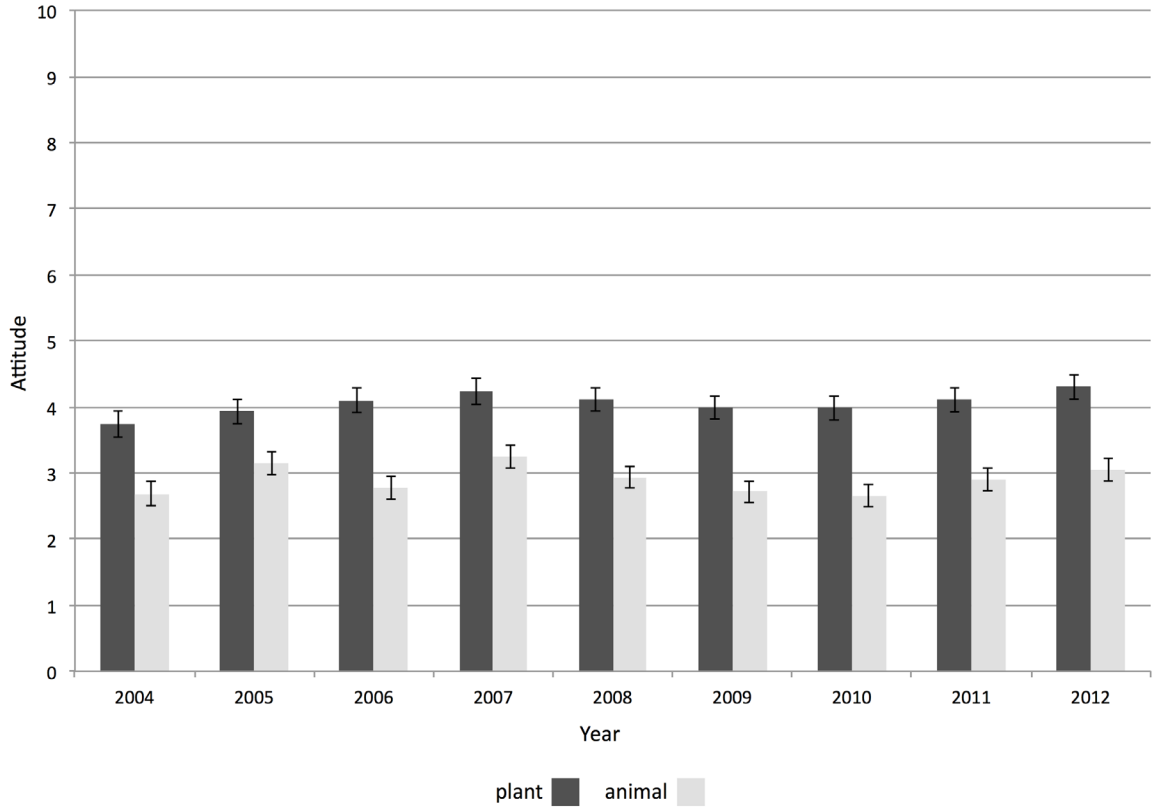

Figure 1. Attitudes toward genetically modified organisms (GMOs) for food over time. Error bars represent 95% confidence intervals.

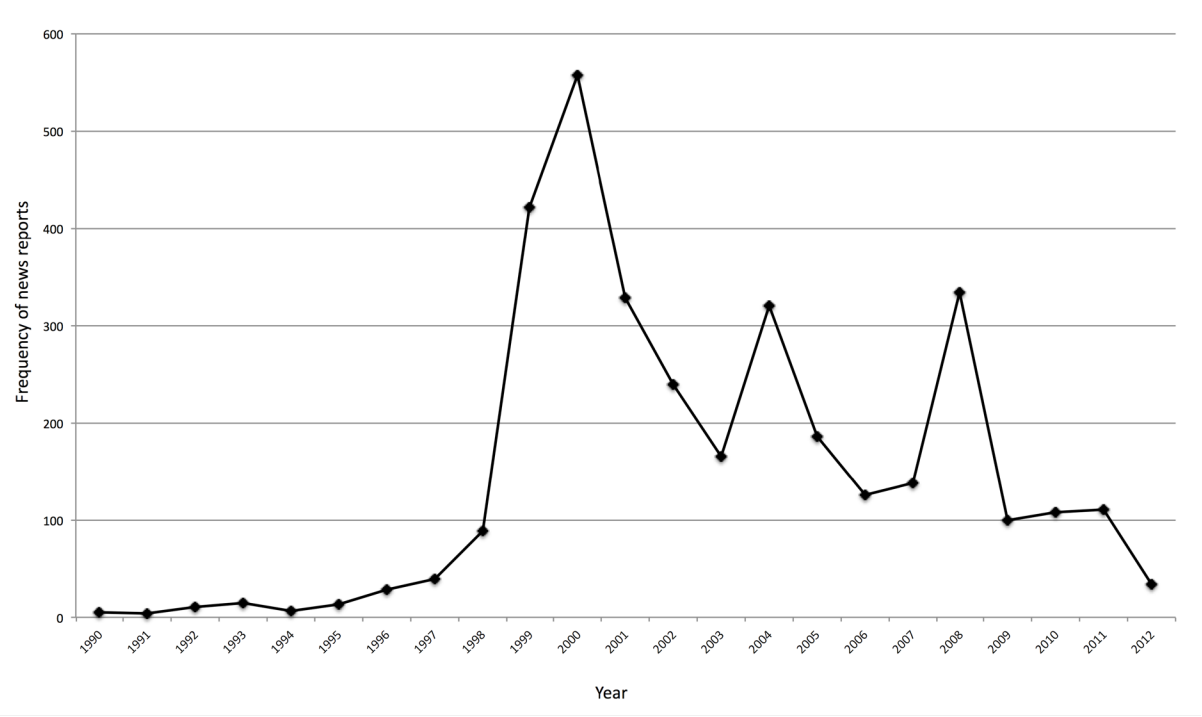

Figure 2. Frequency of coverage of genetically modified organisms (GMOs) in major Australian newspapers.

Major newspaper are the News Limited and Fairfax-owned dailies and their weekend editions for each of the state capitals, as well as the national paper The Australian. Each year represents the date range from the end of the previous survey until the date, except in years when no surveys were conducted (2000–2003) where dates represent calendar years. On average, time between surveys was approximately 1 year, however, data from 2012 were collected 6 months after 2011 survey. Dates can be located at http://www.swinburne.edu.au/lss/spru/spru-monitor.html; 20.3% of cases were classified as false-positives, and were removed from the data.

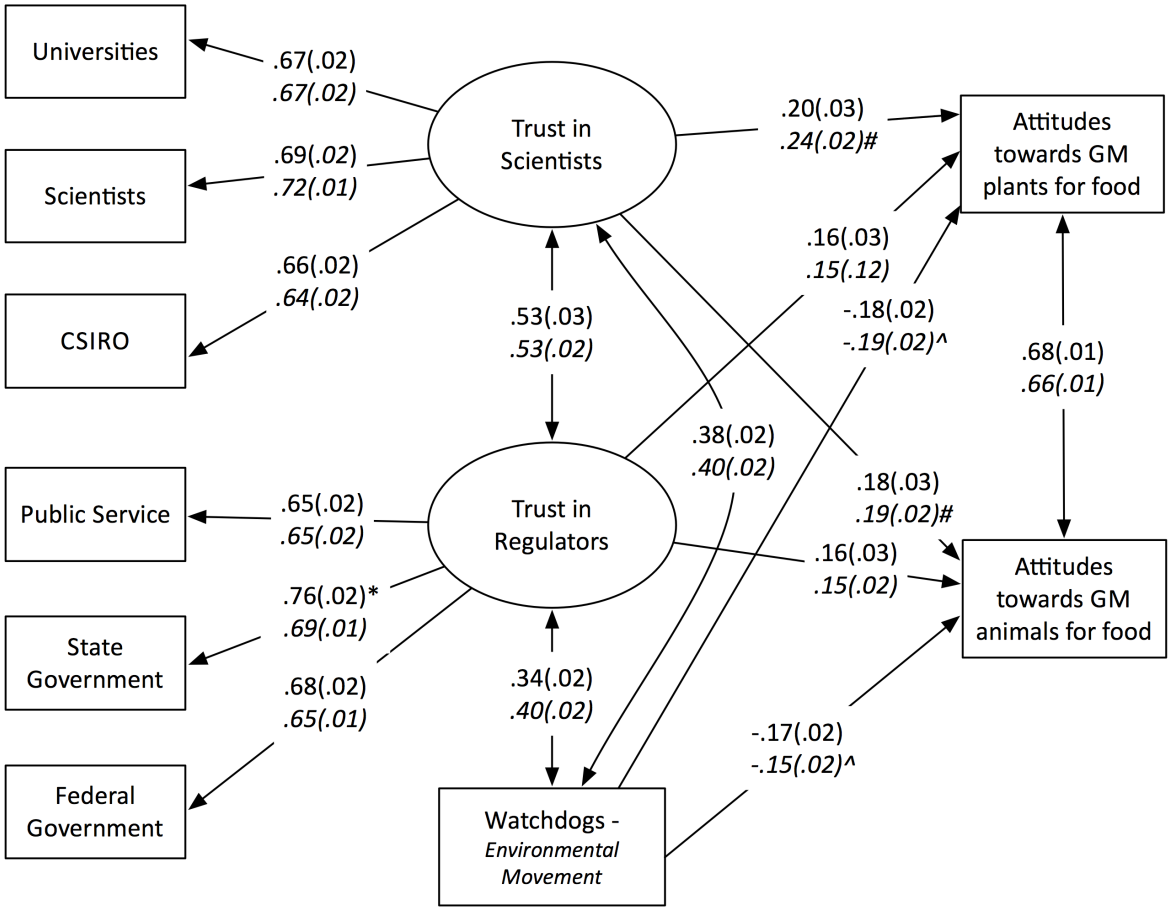

Figure 3. The best fitting model explaining the relationship between trust and attitudes toward genetically modified organisms (GMOs) for food across low and high media cycle years.

Notes: Italicized factor loadings are low media cycle years. High media cycle years are in normal type. All paths were significant at $p < .001$.

CSIRO: Commonwealth Scientific and Industrial Research Organisation; GMO: genetically modified crops.

*Indicates that the standardized factor loading was significantly different between low and high media cycle years.

# Indicates that trust in scientists had a significantly greater effect on attitudes toward GM plants for food when compared
to attitudes toward GM animals for food during low media years only.

^ Indicates that trust in watchdogs had a significantly greater effect on attitudes toward GM plants for food when compared to attitudes toward GM animals for food during low media years only.