Public perceptions of biotechnology in South Africa

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A nationally representative survey of the South African public's perceptions of biotechnology provides new insights into the position of the sector in the public sphere. Familiarity with the concept of biotechnology, and awareness of GM food, have increased over the last decade, although these changes have occurred from a low base. Compared to Europeans, South Africans are more positive about the health implications of GM food, less critical about the environmental impact of GM food, and more positive about the economic consequences of GM food. Knowledge about biotechnology is positively correlated with younger age, higher educational attainment and higher living standard. For marginalised groups, particularly low-income groups in rural areas and traditional authority areas, engaging on the basis of indigenous knowledge systems may prove to be the most effective platform for communication. The concepts of DNA and genes are far better understood than those of genetic modification or GM food, and would therefore present a better starting point for engagement and knowledge transfer. Together, these considerations point towards new strategic imperatives for public engagement in the South African biotechnology sector. Public policy, and broader sectoral engagement strategies, need to take into account: (1) the highly dynamic nature of public perceptions, (2) the diversity of views held by different demographic groups and (3) the diversity of sources of information utilised and preferred by different demographic groups. These considerations would support a strategically targeted engagement approach that would leverage the rapidly growing public awareness of biotechnology in a constructive manner.

Significance:

- Provides new insights into public perceptions of biotechnology in South Africa
- Informs new strategic imperatives for public engagement in the South African biotechnology sector
- Quantifies changes over time and differences across demographic groups in biotechnology perceptions

Introduction

Biotechnology is widely seen as one of the critical domains of science and technology for the 21st century. It has a growing role, and further enormous potential, in the development and production of new classes of medicine, food, energy and industrial processes. These areas all offer great opportunities for sustainable human development and economic growth. However, despite this recognition, biotechnology faces several challenges in the public sphere. The public have a limited understanding of what biotechnology is, how it is governed, how knowledge is produced, and how the benefits are distributed and accrued. This limited understanding provides fertile ground for reservations about biotechnology's ethical, health and environmental implications. It also creates challenges for policymakers and other stakeholders who seek to foster constructive engagement between biotechnology institutions and the broader public. In a stratified society such as South Africa, with a wide range of economic activities characterised by varying degrees of technological intensity, and a diversity of social and economic strata with distinct attitudes towards and engagements with science[1], understanding public attitudes towards biotechnology is an essential prerequisite for developing evidence-based science engagement policy.

Recognising this need, in 2015 the Public Understanding of Biotechnology Programme of the South African Agency for Science and Technology Advancement commissioned a national survey of the South African public's perceptions of biotechnology. This paper reflects on the high-level findings emanating from this survey, in the context of the main theoretical approaches towards understanding public perceptions of biotechnology, and reviews of extant South African evidence and policy in this area. The full report[2] on which this paper is based provides an in-depth analysis, including regression analysis models and one-way analysis of variance (ANOVA) models.

Public perceptions of biotechnology: Theory and evidence

Biotechnology, in its broad sense, refers to 'any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use'[3]. In this sense, biotechnology has been evolving along with human civilisation for thousands of years, and is deeply embedded in the indigenous and local knowledge systems of all cultures. In its contemporary usage, biotechnology is often referred to as specifically related to applications of technologies for manipulating DNA.[4] This usage frames biotechnology as an inherently high-technology and knowledge-intensive activity, closely tied to advanced biological sciences. The juxtaposition between these two usages is particularly evident in and relevant to South Africa. The country's indigenous knowledge systems (IKS) harbour extensive knowledge related to using biological systems. At the same time, genetically modified (GM) organisms are commonly produced through commercial agriculture, and many research centres practise various forms of genetic manipulation, thus adding to the global biotechnology knowledge frontier.

It has been in the more restricted contemporary sense that biotechnology has entered global public discourse and been a source of contestation and controversy. The use of GM crops has prompted debates about food safety, genetic integrity, labelling policies and traceability of food.[4-7] These debates, including public actions such as

anti-GM campaigns and protests, have played out in various aspects of the public sphere, including the media, policymaking, and in public perceptions and attitudes.

Public perceptions of biotechnology are commonly studied within the broad theoretical ambit of the 'public understanding of science'.[8,9] Early efforts to promote an improved relationship between the public and science focused on increasing levels of knowledge about science, which was seen as a factor that was likely to enhance the capacity of the public to engage with science questions and decisions[10], and to foster public support for science[11]. However, the assumption that increased scientific knowledge causes more positive attitudes and relationships with science institutions came to be critiqued[12], and a broad spectrum of evidence from around the world has failed to provide a positive correlation between knowledge about science and positive attitudes towards science[13,14].

At the same time, the emphasis shifted from a 'deficit model', which viewed the public as being deficient in science knowledge, and requiring guidance and education, to more participative models which emphasise the agency of citizens to contribute to the relationship between science and society.[6,7] Subsequent efforts directed at better understanding these complexities in the relationship between knowledge and attitudes have served to shape the contemporary framework of the 'public understanding of science'. Questions were raised about the influence of demographics and cultural, social and political contexts.[15,16] The role of communication in shaping attitudes has also been re-appraised.[16,17]

The public understanding of science has remained the dominant framework for major empirical research projects focused on public perceptions of biotechnology, which includes a focus on science communication matters such as governance and trust relationships with institutions. The largest of these is the Eurobarometer[18-21], which provides nationally representative data for the European Union countries. Smaller surveys have been undertaken in certain developing and low-income country contexts[22-26], including India, China, Kenya and Ghana. Surveys in India have addressed the question of biotechnology and IKS[22], seeking to establish the extent of indigenous knowledge in terms that are more likely to be aligned with the knowledge bases of the broader population, particularly marginalised groups. In the African context, analyses of public debate and media representations have explored the position of biotechnology in the public sphere.[27,28] However, previous surveys in developing countries have all had small sample sizes, comprised of biotechnology stakeholders rather than the general public. None has therefore provided nationally representative data. In this sense, South Africa is the first country from the global South to develop national data on public perceptions of biotechnology. A consequence and limitation of this position is that developed countries provide the only direct international comparators.

Evidence and policy in South Africa

Two nationally representative surveys addressing perceptions of biotechnology have been undertaken in South Africa to date, the first in 2004[29], and the second in 2015[2]. The first survey, which was conducted by the Human Sciences Research Council, included questions related to food labelling, biotechnology knowledge constructs, attitudes towards biotechnology, trust in biotechnology institutions, sources of information about biotechnology, and interest in biotechnology. This survey highlighted the very limited public understanding of biotechnology at that time: 80% of respondents did not have any knowledge of biotechnology. Selected results from this survey serve as a baseline against which to chart change. As such, some of the measures were repeated in the 2015 survey.

Since the demise of apartheid, and the contemporaneous rise of biotechnology as a key technology platform, the South African government has developed a policy portfolio that is highly supportive of the biotechnology sector, providing a regulatory framework and overarching sectoral strategies. These national strategies have included measures to improve engagement between the institutions of biotechnology and the broader public. The national biotechnology strategy (2001)[30] aimed to address perceived shortfalls in the relationship between biotechnology institutions and the public through the inclusion of biotechnology issues in the school curriculum, as well as the provision of balanced information to the media. The Public Understanding of Biotechnology Programme was established by the Department of Science and Technology in 2003, with the aim of promoting awareness, knowledge, dialogue and debate related to biotechnology in South Africa. *The Bioeconomy Strategy* (2013)[31] included similar measures of support for public engagement activities.

Methodology

Survey design

As a basis for measuring public perceptions of biotechnology, use was made of a longstanding national household survey research infrastructure – the South African Social Attitudes Survey (SASAS) – that has been designed in accordance with international best practice, and which is also able to accommodate the unique characteristics of the South African public and South African biotechnology. The survey instrument included questions from surveys undertaken in Australia, the European Union and the USA, as well as selected questions from the 2004 nationally representative South African study.

Issues of comparability or equivalence required a carefully constructed response to meet the challenge of measuring South Africa's diverse biotechnology landscape with low levels of formal education and high levels of linguistic diversity. The methodology needed to address the challenges that have emerged from prior South African studies, the most significant of which is the issue of high levels of 'don't know' responses. It was imperative that research instruments be designed in such a way as to minimise the frequency of such a response. This required greater efforts to make questionnaire items more accessible to a broader South African public, including greater attention to issues of translation across all South African official languages and careful and discrete unpacking of the science constructs. Constructs for measuring perceptions of biotechnology as manifested in IKS were also included in order to benefit from the diversity of biotechnology knowledge, meanings and applications in the South African context, and make questionnaire items more accessible to broader sections of the South African population.

Survey methods

The survey was administered as part of the 13th annual round of the SASAS, which was conducted in 2015. The SASAS infrastructure consists of nationally representative, repeated cross-sectional surveys that have been conducted annually since 2003. Each survey round consists of a drawn sample of 3500 target respondents aged 16 years and older living in private residence and in workers' hostels. A sample of 500 Population Census enumeration areas is drawn, using probability to proportionate to size as primary sampling units, stratified by province, geographical sub-type and majority population group. Within each drawn area, seven dwelling units are randomly selected as visiting points, and finally one person is selected with equal probability from all persons that are age eligible at the visiting point using a Kish grid. In the case of the 2015 survey round, the final realised sample consisted of 2940 adult South Africans. Data are weighted to the representative of the South African population by means of benchmarking to the latest Mid-Year Population Estimates produced by Statistics South Africa.

Analytical methods

Analysis of the survey results presented here examines aggregate, national-level perceptions of biotechnology, in addition to differences in perceptions across select socio-demographic groups, including variation based on education, income, geographical location and racial group. The total margin of error for the SASAS data at the 95% level is 0.8%. This margin increases up to a maximum of 3.9% for the smallest subgroup examined in this paper. The margin of error on point estimates for different subgroups varies based on the sub-sample size. We therefore undertook one-way analysis of variance (ANOVA) with post-hoc tests to determine whether the observations and conclusions we report on were statistically valid.

Knowledge about biotechnology

Most South Africans (73%) reported having little or no knowledge about biotechnology; 27% reported being 'somewhat knowledgeable' or 'very knowledgeable' about biotechnology; and almost half of the public (46%) felt that biotechnology is 'too specialised for me to understand'. However, both bivariate and multivariate analysis (ordered logistic regression) revealed that more privileged groups (with higher living standards and higher educational attainment) reported considerably greater knowledge than less privileged groups, and were more confident in their ability to access biotechnology knowledge (for regression models see Gastrow et al.[2]). This finding holds true irrespective of whether one evaluates knowledge using subjective or objective indicators.

A review of changes in public perceptions of biotechnology between 2004 and 2015 (Table 1) shows a major increase in public awareness of biotechnology. Public familiarity with the term 'biotechnology' more than doubled during this period, from 21% of the population to 53%. Public awareness that GM foods form a part of their diet more than trebled, from 13% to 48%. We can hypothesise that these changes result from increased levels of education, increased access to information, and greater prominence of biotechnology in the public discourse during this period. It may be the case that the labelling of (some) GM foods has played a role. It is possible that the patterns of change could be partly methodologically determined, as the questions in the 2004 and 2015 SASAS surveys were not strictly identical. In 2004, a definition was firstly provided and then respondents were asked whether they had heard of the concept before, whereas in 2015 respondents were asked to report their level of familiarity with the term 'biotechnology' without a definition being provided beforehand. One could debate whether the 2004 approach of providing a definition led to a more definitive response or biased estimates of knowledge.

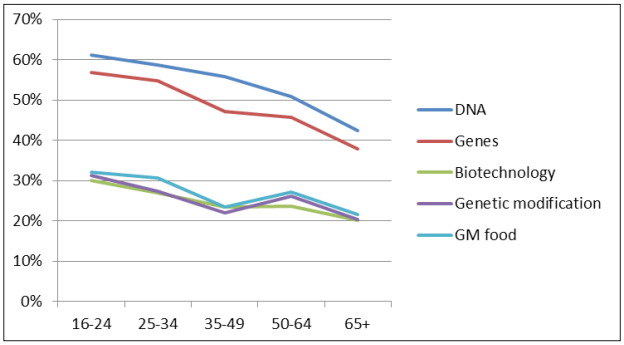
Consideration of a strong age gradient in relation to knowledge of biotechnology also suggests that as younger cohorts have come to account for larger proportions of the population, overall knowledge levels have increased – this points towards an inherent dynamism that over time articulates inter-generational changes in perceptions with overall societal perceptions. However, testing these hypotheses would require further research, including qualitative research.

Table 1: Comparison of biotechnology knowledge, 2004 and 2015 (% respondents)

	Are you familiar with the term 'biotechnology'?		Have you ever eaten GM food?	
	2004	2015	2004	2015
Yes	21	41	12	48
No	68	53	26	17
Don't know	11	7	63	36

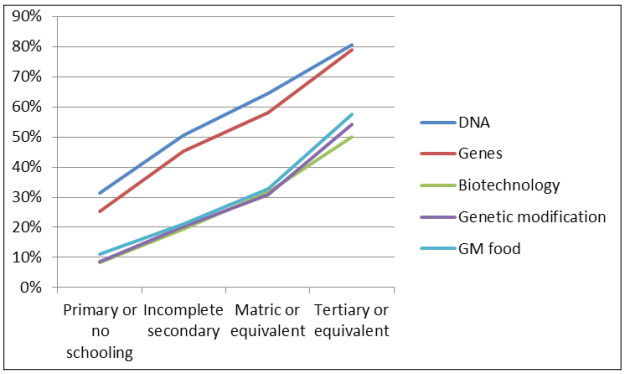
Note: Because of decimal rounding, totals may not add up to 100%.

Within the cluster of concepts that underpin the notion of biotechnology, some concepts are better understood by the public than others (Table 2). The terms 'genes' and 'DNA' are far more widely understood than 'biotechnology', 'genetic modification' or 'GM food'. In the case of DNA and genes, approximately a third expressed sufficient familiarity with the concept to be able to explain it to a friend, a figure that drops to barely a tenth for the other terms. We again find that those of a younger age and greater privilege consistently report higher levels of knowledge of all the core biotechnology concepts in the survey (Figures 1–3). Despite the clear gradient of variation in levels of knowledge of biotechnology concepts that exists based on age, educational attainment and standard of living, the knowledge gap between DNA and genes on the one hand and 'biotechnology', 'genetic modification' or 'GM food' on the other remains intact. There is little sign of convergence in knowledge between these different concepts among those with higher levels of education or standards of living. Although close to 80% of the tertiary educated feel able to explain the concepts of DNA and genes, this figure falls to barely half for the other concepts. This difference suggests that education alone is not the sole factor driving levels of biotechnology-related knowledge. Education certainly matters, and is likely to partly explain the inverse association observed between age and knowledge of biotechnology concepts.



South African Social Attitudes Survey 2015

Figure 1: Knowledge of core biotechnology concepts, by age group.



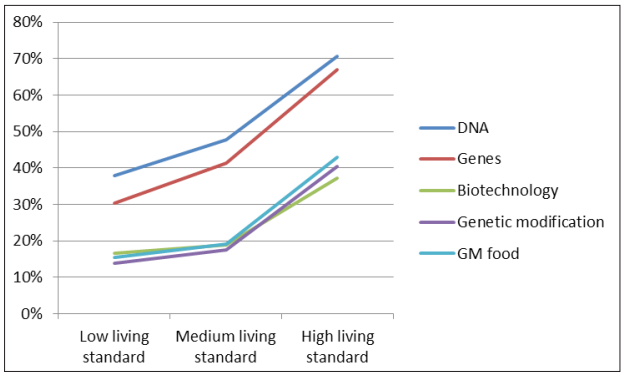
South African Social Attitudes Survey 2015

Figure 2: Knowledge of core biotechnology concepts, by education level.

Table 2: Knowledge of core biotechnology concepts (% respondents)

How familiar are you with the following terms?	Have not heard of it	Have heard of it, but know very little or nothing about it	Know enough about it to explain it to a friend	Do not know
DNA	19	45	34	3
Genes	25	43	29	4
Biotechnology	53	30	11	7
Genetic modification	53	27	13	7
Genetically modified food or GM food	51	29	14	7

Source: South African Social Attitudes Survey 2015



South African Social Attitudes Survey 2015

Figure 3: Knowledge of core biotechnology concepts, by standard of living.

Perceptions of GM food

Perceptions of food made from genetically modified crops (termed 'GM food') take the centre stage in terms of biotechnology-related media coverage and public controversy, both globally and in South Africa.[32] Internationally, debates about the ethical and environmental implications of agricultural biotechnology have had a significant impact on the sector, for example leading to the emergence of contrasting governance structures and market mechanisms in different jurisdictions.[33] In South Africa, media analysis has revealed polarised debates about health, safety and governance.[32] We examined summary results of the analysis of knowledge of GM food and attitudes towards GM food.

Knowledge of GM food

The South African public have generally low levels of knowledge and awareness of GM food. About half of the public (54%) were aware that GM crops are legally grown in South Africa. Looking at specific crops, 40% of the public were aware that GM maize is grown in South Africa, but awareness of GM cotton (4%) and GM soya (7%) was low. Similarly, in Australia, 41% of the public were aware of the country's main GM food crop (canola) compared to only 9% reporting awareness of a secondary crop (cotton).[34]

About half of the South African public (48%) were aware that their food contains GM products. Those who could identify GM maize as a legally grown crop in South Africa were substantially more likely to understand that they eat GM food, suggesting cognitive connections between understanding both the production and consumption of GM food. To determine the relative influence of different predictors on knowledge, ordered logistic regression analysis was performed. This analysis was based on a dependent variable that was an index of GM food knowledge constructed by combining a set of variables that focused on: (1) the belief that GM crops are allowed to be grown in South Africa, (2) how many of the three legally grown GM crops in South Africa (white and yellow maize, soya and cotton) respondents were able to correctly identify and (3) whether the respondent reported ever having eaten GM food. Again, the modelling revealed a positive age and social privilege effect.[2] Having previously engaged in traditional farming practices also increased the odds of being more knowledgeable about GM food – revealing a significant stratification between urban and rural areas, and an interplay between indigenous knowledge and biotechnology knowledge.

Attitudes towards GM food

As for attitudes towards biotechnology as a whole, attitudes towards GM food are highly dynamic. Since 2004 there has been a major increase in attitudes that favour the purchasing of GM food (Table 3). The proportion of the public that would purchase GM foods on the basis of health considerations increased from 59% to 77%, on cost considerations increased from 51% to 73%, and on environmental considerations from 50% to 68%. The share of adults providing 'don't know' answers to the three GM food statements (13% on average) is markedly lower than one might anticipate given that 51% indicated that they had not previously heard of GM food (Table 2). Although it is difficult to explain definitively why this might be the case, one possibility is that the questions are framed in a way that requires less cognitive effort to respond.[35]

The attitudes that underpin the general increase in awareness and acceptance of GM food between 2004 and 2015 are complex.

Table 4 summarises aggregated responses to questions related to ethics, safety, labelling, benefits and risks. As a consequence of generally low levels of knowledge, the South African public do not have strongly formed opinions about GM foods. Large proportions of the public did not engage with attitudinal questions about GM food, with 'don't know' responses averaging 29% on the items on the ethics of GM food, 26% on the items relating to the safety and labelling of GM food, and 33% on the items dealing with the benefits and risks of GM food. The main exception for which item non-response falls below the 20% threshold is in relation to the labelling of GM foods, which is an issue that the South African public are strongly in favour of.

Ethics

Public attitudes towards the ethics of GM food were polarised, with 41% agreeing and 36% disagreeing with the notion of GM foods as 'interfering in God's plan', or otherwise ethically wrong (30% and 44%, respectively, for agreeing and disagreeing). These data suggest that while on average South Africans do not reject GM food on general moral grounds, they do express some reservation on religious grounds. In comparison, the public were largely disengaged from assessing the ethics of the international corporations that play a role in the sector, with the largest share (39%) providing a 'don't know' response. This finding is conceivably a reflection of a lack of information or awareness of the behaviour of such corporations. Regression analysis revealed that level of self-rated religiosity, which was measured using a 0–10 end anchored scale where 0 represented 'not at all religious' and 10 'very religious', was not a significant predictor of these GM food ethics items.

Safety

In comparison to available data from the European Union, South Africans are considerably more positive about the health implications of GM food. While 49% of the South African public believe that 'GM foods are safe to eat', a Eurobarometer study[18] found that only 21% of Europeans share this view. South Africans also appear slightly less critical of the environmental impact of GM crops, with 45% of South Africans viewing GM crops as having a higher environmental cost than traditional farming methods, a view held by 52% of Europeans.

Benefits and risks

South Africans are also more positive about the economic consequences of GM food, with 53% believing that 'GM foods are good for the economy', compared to only 31% of Europeans.[19] Levels of engagement with the issue were lower: 31% responded 'don't know', compared to 19% in Europe. Younger South Africans were more positive than older South Africans about the economic benefits of GM food. Farmers were perceived to benefit from GM crops, but commercial farmers were seen to benefit more than subsistence farmers. The environmental impact of GM crops was commonly seen to be higher than traditional farming methods. The overall risk–benefit assessment of GM foods was positive, with 46% perceiving a net benefit, and 19% a net risk. Younger generations and those with higher levels of education were more likely to regard GM foods as a benefit to society.

Perceptions of medical biotechnology

The constructs chosen to test knowledge about medical biotechnology were questions related to genetic testing to treat inherited diseases, gene therapy to treat inherited diseases, and the production of medicine using GM organisms (Table 5). The aggregated results for these are similar, with approximately half of the sample indicating no knowledge, a quarter having heard of it, but not having much more knowledge, and 6–7% having substantial knowledge. Bivariate and ordered logistic regression analyses revealed that greater knowledge about medical applications of biotechnology is associated with lower age and higher levels of privilege. Educational attainment appears to exert the strongest positive association with knowledge of medical biotechnology.

Table 3: Summary of key changes in responses to GM maize (% respondents), 2004–2015

	I would buy GM maize if it were healthier		I would buy GM maize if it cost less than ordinary maize		I would buy GM maize if it were grown in a less damaging way to the environment	
	2004	2015	2004	2015	2004	2015
Agree	67	77	53	73	56	68
Disagree	15	11	27	15	24	16
Don't know	18	12	20	12	20	16

Table 4: Summary of attitudes towards GM food (% respondents)

	Agree	Disagree	Don't know
Ethics of GM food			
The genetic modification of food is interfering in God's plan	41	36	23
The genetic modification of food is wrong	30	44	26
The international corporations that make GM foods act in an ethical manner	38	24	39
Safety and labelling			
GM foods are safe to eat	49	21	30
The long-term health effects of eating GM foods are unknown	52	18	31
Products containing GM foods should be labelled	75	7	18
Benefits and risks			
GM foods are good for the economy	53	16	31
GM foods benefit large-scale commercial farmers	56	13	31
GM foods benefit small-scale subsistence farmers	43	23	34
GM foods provide more secure access to food for my family	47	22	31
The environmental cost of farming GM crops is higher than that of traditional farming methods	45	17	38
Overall, GM foods provide more benefits than risks for society	46	19	36

Source: South African Social Attitudes Survey 2015

Table 5: Perceptions of medical applications of biotechnology (% respondents)

Biotechnology is also used in medicine. How familiar are you with the following medical uses of biotechnology?	Have not heard of it	Have heard of it, but know very little or nothing about it	Know enough about it to explain it to a friend	Don't know
Genetic testing to detect inherited diseases	49	28	7	16
Gene therapy to treat genetic conditions	52	25	7	16
Production of medicines using GM organisms	52	23	7	18
		Agree	**Disagree**	**Don't know**
Using GM organisms in the production of medicine is intervening in God's work		39	33	28
Using GM organisms in the production of medicine is wrong		26	43	31
The international corporations that use biotechnology to make new medicines act in an ethical manner		38	22	41

Source: South African Social Attitudes Survey 2015

In the context of a high level of 'don't know' responses, the public were polarised in their views about medical biotechnology 'intervening in God's work' (39% agreed and 33% disagreed) and in their views about whether it is 'ethically wrong' (26% agreed and 43% disagreed). The public demonstrated greater cognitive difficultly in responding to the issue of corporate ethics in medical biotechnology, with 41% answering 'don't know' to the related question. This response is conceivably a consequence of constrained knowledge and information with which to make an assessment. Only 22% of the public were concerned with the ethics of these corporations. While this concern is commonly shared across age groups, there was a moderate positive association with education and living standard levels. While 19% of those with primary or no formal schooling expressed such concern, this progressively rose to a high of 31% among those with a tertiary qualification. Similarly, only 14% of those with a low living standard expressed concern about corporate ethics in the field of medical biotechnology, rising to 22–23% for those with medium and high living standards.

Governance and regulation

Understanding preferences regarding the governance and regulation of biotechnology is critical for the policy formulation process, particularly with regard to communication and public engagement related to biotechnology. A total of 44% of South Africans felt that GM foods were effectively regulated by the government, although 38% responded 'don't know' to the question. The South African public felt that the governance of biotechnology should be most strongly influenced by commercial farmers, university scientists, and environmental groups/NGOs (Table 6). The least favoured institutions for this purpose are seen to be international corporations, the media and religious organisations. However, the public appear to favour a mode of 'consensus governance', in which all the main stakeholders play a role.

Indigenous knowledge systems and biotechnology

South Africans have commonly used biotechnology in the context of indigenous knowledge systems and practices. As indicated in Table 7, 47% reported using traditional medicines with varying frequencies, 44% reported using biological processes to prepare food, and 38% reported using traditional farming practices. South Africans have a greater experience of biotechnology-related traditional practices and knowledge bases than they do of biotechnology in the narrower sense. High levels of awareness and usage in daily life position IKS-based biotechnology as a potential platform for engagement with the majority of the South African population. Groups with low incomes and low levels of education may find it difficult to engage with concepts of mainstream biotechnology, but harbour rich traditions of knowledge and the practice of IKS that may be successfully leveraged to build greater awareness of biotechnology in the more modern sense.

Sources of information

On aggregate, radio and television are the most preferred channels through which people would want to receive information about biotechnology, particularly for those in rural areas and with lower incomes (Table 8). Younger age cohorts are more likely to prefer a mix of all sources of information, except for radio. Younger generations are also far more likely than older generations to favour the Internet to obtain information. Those with higher levels of education and living standards are more inclined to opt for the Internet and print media, and less likely to report a preference for the radio. Those living on rural farms are significantly less likely to select any of the media channels as a source for obtaining information about biotechnology relative to those residing in other geographical locations. This array of preferences highlights the communications challenge that confronts public engagement efforts, and points to the need for a diversified and targeted approach.

Table 6: Summary of responses to governance and the institutions of biotechnology (% respondents)

The development and use of biotechnology is governed by various laws and policies. I am going to list a number of groups in society. How much influence do you think they should have in making these laws and policies?	A great deal of influence	A fair amount	A little influence	None at all	Don't know
Commercial farmers	45	23	7	7	18
University scientists	41	26	8	8	18
Environmental groups/NGOs	39	28	5	9	18
South African businesses	38	27	9	9	18
Small scale/subsistence farmers	38	26	10	9	18
South African government	39	24	10	10	18
International corporations	29	30	12	10	20
The general public	27	29	13	12	19
Media	23	30	14	15	18
Religious organisations	20	26	17	19	18

Source: South African Social Attitudes Survey 2015

Table 7: Summary of responses to biotechnology and indigenous knowledge systems (% respondents)

How often have you engaged in the following traditional practices?	Often	Sometimes	A few times	Rarely	Never	Don't know
Using traditional medicines (such as wild herbs)	12	24	11	11	37	5
Making food that uses biological processes (such as brewing traditional beer or processing sour milk)	11	21	12	10	42	5
Traditional farming practices (such as growing crops using the traditional knowledge of your community)	12	17	9	9	47	6

Source: South African Social Attitudes Survey 2015

Table 8: Sources of information on biotechnology (% respondents)

If you wanted to learn more about biotechnology, how likely would you be to get your information from the following sources?	Very likely	Somewhat likely	Not very likely	Not likely at all	Don't know
TV	51	21	12	12	4
Radio	35	25	17	18	5
Print media (books, newspapers and magazines)	27	29	19	20	5
Internet	34	20	12	29	5
School or college	26	20	15	34	5
Science centre	29	16	14	36	6
Friends or family	23	23	19	30	5

Source: South African Social Attitudes Survey 2015

The risks and benefits of biotechnology

Only about half of the South African public (53%) were able to conclusively evaluate biotechnology as 'more of a benefit' or 'more of a risk' in general, with a marginal tendency among this group towards a benefit perspective (30% vs 23%). The other half (47%) were fairly evenly split between those registering neutrality or indifference (25%) and those offering a 'don't know' response (22%). This pattern shows that on aggregate the South African public is divided on this matter, with virtually equivalent shares opting for each of the four categories (beneficial, risky, indifferent, uncertain). There are nonetheless distinct variations relative to this average perspective when one analyses the results by various socio-demographic attributes.

White and Indian South Africans were more likely to see biotechnology as an overall risk to society compared to black and coloured South Africans. This finding is largely because lower levels of uncertainly and neutrality/indifference have been replaced by a greater awareness of risk. In the case of Indian respondents, a sense of risk outweighs declaring it as more beneficial (37% vs 24%), but among white respondents lower indifference and uncertainty levels have resulted in a rise in shares reporting risky and beneficial evaluations, to the extent that both are equally mentioned (37% vs 36%). Higher living standards were associated with an decreased likelihood of viewing biotechnology as beneficial or of being uncertain, a rise in neutrality or indifference, and virtually unchanged levels of perceived risk.

Increased educational attainment was associated with lower levels of item non-response, falling from 31% for those with primary or no schooling to 10% among those with a tertiary qualification, as well as fairly indistinguishable levels of neutrality/indifference (ranging between 23–26%). For those with an incomplete secondary education or matric qualification, the decreased level of uncertainty translates into higher shares reporting biotechnology as more of a benefit, so that the percentage point difference for these adults ranges between 9 and 11 percentage points higher in general than the share mentioning it as more of a risk. However, for those with tertiary education, the further decrease in uncertainty is accompanied by both a rise in the share mentioning it as a benefit and a risk, to the extent that the two are virtually level (33% benefit; 31% risk). This finding suggests that providing more education will not necessarily equate into an increased likelihood of viewing biotechnology as beneficial. Instead, with more education, there appears to be a greater recognition of the benefits as well as the risks. This is a noteworthy finding, because education is ultimately about producing critically engaged citizens who would be able to appreciate both the inherent promise and risks associated with the emergence and adoption of new technologies.

Reflections on biotechnology, public engagement and policy

Public engagement by the biotechnology sector in South Africa takes place in the context of escalating public familiarity with biotechnology and its related products: familiarity with the concept of biotechnology more than doubled between 2004 and 2015, and awareness of GM foods more than tripled. However, these changes have occurred from a low base, and knowledge about biotechnology is still constrained in South Africa: 73% of the public reported having limited or no knowledge about biotechnology.

This scenario signals an opportunity for engagement between the institutions of biotechnology and the broader public, identifying a space for strategic interventions that would leverage this growing awareness in a constructive manner, in the absence of strongly entrenched or preconceived perceptions. In comparison with Europe, where public knowledge is more developed, and public attitudes more defined, South Africans are more positive about the health implications of GM food, less critical about the environmental impact of GM food, and more positive about the economic consequences of GM food.

Inter-generational dynamics play a central role in these perceptual changes. Knowledge about biotechnology is positively correlated with younger age. Younger generations were more positive about a variety of biotechnology-related issues, including the economic benefits of GM food and the overall risk/benefit assessment of biotechnology. Understanding the causes of these correlations presents an objective for future research. Whatever the causes, the implication is that the future South African public is likely to be more knowledgeable about biotechnology, and have more sharply defined attitudes towards biotechnology.

Privilege, in the form of educational attainment and living standard, is also correlated with greater knowledge and more defined attitudinal positions. This highlights the importance of taking distinct approaches towards engagement with privileged and marginalised groups, which would need to be based on distinct sets of knowledge constructs, and which would encounter different sets of attitudes. For marginalised groups, particularly low-income groups in rural areas and traditional authority areas, engaging on the basis of IKS may prove to be the most effective platform for effective communication.

There are a variety of other dimensions along which engagement strategies and practices could be structured to better respond to public perceptions. The concepts of DNA and genes are reportedly far better understood than those of genetic modification or GM food, and would therefore present a better starting point for engagement and knowledge transfer. Preferences for sources of information differ widely among demographic groups, and communication strategies should be

constructed on this basis: for the young and privileged the Internet is central; for the marginalised and rural, radio is central. When it comes to the governance of biotechnology, the public place their highest trust in commercial farmers, university scientists and environmental groups – suggesting that these social actors should have a role to play in public engagement policy and practice.

Together, these considerations point towards new strategic imperatives for public engagement in the South African biotechnology sector. Public policy, and broader sectoral engagement strategies, need to take into account: (1) the highly dynamic nature of public perceptions, (2) the diversity of views held by different demographic groups and (3) the diversity of sources of information utilised and preferred by different demographic groups. These considerations would support a strategically targeted engagement approach that would leverage the rapidly growing public awareness of biotechnology in a constructive manner.

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Authors' contributions

M.G. was responsible for the conceptualisation, methodology and data analysis; for writing the initial and revised drafts; for providing project leadership and project management; and for acquiring the funding. B.R. was responsible for the conceptualisation, methodology, data collection, sample analysis and data analysis and validation; for critical reviewing of the writing; and for providing project management. V.R. was responsible for the conceptualisation and methodology; and for critical reviewing of the writing. S.I. was responsible for the conceptualisation and methodology.

References

1. Reddy V, Gastrow M, Juan A, Roberts B. Public attitudes to science in South Africa. S Afr J Sci. 2013;109(1–2), Art. #1200, 8 pages. https://doi.org/10.1590/sajs.2013/1200
2. Gastrow M, Roberts B, Reddy V, Ismail S. Public perceptions of biotechnology in South Africa. Report for the Public Understanding of Biotechnology Programme. Pretoria: South African Agency for Science and Technology Advancement; 2016. Available from: http://www.pub.ac.za/wp-content/uploads/2016/10/Public-Perceptions-to-Biotechnology.pdf
3. Convention on Biological Diversity [homepage on the Internet]. No date [cited 2017 Oct 16]. Available from: http://www.cbd.int/
4. Bauer MW. Public perception and mass media in the biotechnology controversy. Int J Public Opin Res. 2005;17(1):5–22. https://doi.org/10.1093/ijpor/edh054
5. Gaskell G, Allansdottir A, Allum N, Corchero C, Fischler C, Hampel J, et al. Europeans and biotechnology in 2005: Patterns and trends. Final report on Eurobarometer 64.3 [document on the Internet]. c2006 [cited 2017 Oct 16]. Available from: http://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs_244b_en.pdf
6. Macer DR, Azariah J, Srinives P. Attitudes to biotechnology in Asia. Int J Biotechnol. 2000;2(4):313–332. https://doi.org/10.1504/IJBT.2000.000142
7. Aernie P. Attitudes in the public debates on agricultural biotechnology in developing countries. Afr Technol Dev Forum J. 2005;2(1):8–10.
8. Miller JD. Public understanding of, and attitudes toward, scientific research: What we know and what we need to know. Public Underst Sci. 2004;13(3):273–294. https://doi.org/10.1177/0963662504044908
9. Bauer MW, Shukla R, Allum N. The culture of science: How the public relates to science across the globe: New York: Routledge; 2012.
10. Miller J. The measurement of civic scientific literacy. Public Underst Sci. 1998;7:203–223. https://doi.org/10.1088/0963-6625/7/3/001
11. Durant J. Participatory technology assessment and the democratic model of the public understanding of science. Sci Public Policy. 1999;26(5):313–319. https://doi.org/10.3152/147154399781782329
12. Evans G, Durant J. The relationship between knowledge and attitudes in the public understanding of science in Britain. Public Underst Sci. 1995;4(1):57–74. https://doi.org/10.1088/0963-6625/4/1/004
13. Allum N, Sturgis P, Tabourazi D, Brunton-Smith I. Science knowledge and attitudes across cultures: A meta-analysis. Public Underst Sci. 2008;17(1):35–54. https://doi.org/10.1177/0963662506070159
14. Bauer MW, Allum N, Miller S. What can we learn from 25 years of PUS survey research? Liberating and expanding the agenda. Public Underst Sci. 2007;16(1):79–95. https://doi.org/10.1177/0963662506071287
15. Sturgis P, Allum N. Science in society: Re-evaluating the deficit model of public attitudes. Public Underst Sci. 2004;13:55–74. https://doi.org/10.1177/0963662504042690
16. Bauer M, Petkova K, Boyadjieva P. Public knowledge of and attitudes to science: Alternative measures that may end the "science war". Sci Technol Human Values. 2000;25(1):30–51. https://doi.org/10.1177/016224390002500102
17. Gregory J, Lock S. Evolution of "public understanding of science": Public engagement as a tool of science policy in the UK. Sociol Compass. 2008;2(4):1252–1265. https://doi.org/10.1111/j.1751-9020.2008.00137.x
18. INRA (Europe). The Europeans and biotechnology: Eurobarometer 52.1. Luxembourg: The European Commission; 2000.
19. European Commission, European Parliament. Eurobarometer 73.1: The European Parliament, biotechnology, and science and technology, January-February 2010. Cologne/Ann Arbor, MI: GESIS/Inter-university Consortium for Political and Social Research; 2013. https://doi.org/10.3886/ICPSR31483
20. INRA (Europe). The Europeans and modern biotechnology: European opinions on modern biotechnology. Eurobarometer 46.1. Luxembourg: The European Commission; 1997.
21. Gaskell G, Allum N, Stares S. Europeans and biotechnology in 2002: Eurobarometer 58.0. Brussels: European Commission; 2003.
22. Shukla R. India science report. Delhi: National Council of Applied Economic Research; 2005.
23. Huang J, Qiu H, Bai J, Pray C. Awareness, acceptance of and willingness to buy genetically modified foods in urban China. Appetite. 2006;46(2):144–151. https://doi.org/10.1016/j.appet.2005.11.005
24. Kimenju SC, De Groote H, Karugia J, Mbogoh S, Poland D. Consumer awareness and attitudes toward GM foods in Kenya. Afr J Biotechnol. 2005;4(10):1066–1075.
25. Krishna VV, Qaim M. Consumer attitudes toward GM food and pesticide residues in India. Rev Agric Econ. 2008;30(2):233–251. https://doi.org/10.1111/j.1467-9353.2008.00402.x
26. Quaye W, Yawson I, Yawson RM, Williams IE. Acceptance of biotechnology and social-cultural implications in Ghana. Afr J Biotechnol. 2009;8(9):1997–2003.
27. Mwale PN. Societal deliberation on genetically modified maize in southern Africa: The debateness and publicness of the Zambian national consultation on genetically modified maize food aid in 2002. Public Underst Sci. 2006;15(1):89–102. https://doi.org/10.1177/0963662506058386
28. Mwale PN. The babelisation of debate on GM maize via the media in southern Africa in 2002. Social Dyn. 2010;36(1):112–121. https://doi.org/10.1080/02533950903561346
29. Rule S, Langa Z. HSRC client survey 2004 – Report for the Public Understanding of Biotechnology Programme of the South African Agency for Science and Technology Advancement. Unpublished report 2005.
30. South African Department of Arts, Culture, Science and Technology (DACST). A national biotechnology strategy for South Africa. Pretoria: DACST; 2001. Available from: http://www.dst.gov.za/images/pdfs/dst_biotechnology_strategy.PDF
31. South African Department of Science and Technology (DST). The bio-economy strategy. Pretoria: DST; 2013. Available from: https://www.gov.za/sites/www.gov.za/files/Bioeconomy%20Strategy_a.pdf

32. Gastrow M. The public understanding of biotechnology in the media. A report for the National Advisory Council on Innovation and the National Biotechnology Advisory Committee. Unpublished report 2010.

33. Gaskell G, Bauer MW, Durant J, Allum NC. Worlds apart? The reception of genetically modified foods in Europe and the US. Science. 1999;285(5426):384–387. https://doi.org/10.1126/science.285.5426.384

34. Ipsos Social Research Institute. Community attitudes towards emerging technology issues – Biotechnology. Report of findings prepared for the Department of Industry, Innovation, Science, Research and Tertiary Education. Unpublished report 2013.

35. Shoemaker PJ, Eichholz M, Skewes EA. Item nonresponse: Distinguishing between don't know and refuse. Int J Public Opin Res. 2002;14:193–201. https://doi.org/10.1093/ijpor/14.2.193