Public attitudes to chemistry

Research report
TNS BMRB 2015

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ROYAL SOCIETY OF CHEMISTRY

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Foreword

As professional chemists, we thought that we knew how the public feels about chemistry, but we had no hard evidence to back this up. Now we do.

For the first time this study provides that evidence, and informs us how to better understand our audiences. As a passionate public advocate for chemistry I am happy to have been involved with this project in the scientific advisory group.

For me the most interesting and surprising finding is that the public perception of chemistry and chemicals is far more positive than professional chemists believed. Having said that, this view is coloured by some confusion over what a chemist is and what a chemist does. For example, the misidentification of chemists as pharmacists, which is a peculiarly British phenomenon.

While we have anticipated this result, we underestimated its scale. We will have to work hard to try to ensure that the noun 'chemist' is in future used for what we understand it to mean. We can't easily change the common meaning of a word but we can be consistent with the way we use it. When we talk about ourselves and our jobs and say "I'm a chemist" (and I am always proud to say it!) we could change it to "I am a scientist working in chemistry". And if we think that framing ourselves as scientists sounds obvious, we should look at these findings because it is not obvious at all. It could be a first important step in contributing to a more understandable use of a word that defines who we are.

This research shows that our views of public opinion can be too negative. Chemistry is our profession, our passion, and we care about it so much that we possibly are a little biased. Perhaps we have become defensive owing to poor press over decades. But we should challenge this view and instead start thinking about public opinion in a more evidence-based way.

This research shows us a better picture than anticipated but also a picture of neutrality towards chemistry. Instead of focusing on the minority of negative views we should try to address the neutrality expressed by so many people. I believe that it is with these people that we can make a difference.

We shouldn't rely on content-focused traditional approaches whose motivation is to educate others. We need to embrace a more strategic and contextual approach of public communication where as much planning goes into understanding our audience and crafting an effective narrative as it does in building the content.

To try to influence public attitudes towards chemistry we, as chemists, must rethink *our* attitudes towards the public.

Professor David Phillips CBE FRSC FRS

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Introduction

Overview of public science communication

This section aims to put this research in the context of current public science engagement knowledge and practice, and notes the ways in which the research has drawn on some of the key ideas and best practice in relation to communicating with the public about science.

Recent history and current practice

Science communication in the UK has undergone significant changes over the past 25 years. Science is no longer simply 'broadcast' to the public by experts, but is increasingly offered up for meaningful public debate. Scientists have been taught not only to talk, but increasingly also to listen.[1] Questions are no longer "does the public understand science", but "how do we engage in a two-way dialogue on science?"

Science communication has developed, recently moving away from what is termed the 'deficit model' of public attitudes towards science, to a new way of approaching interaction between the sciences and the public. The 'deficit model' is the idea that public concerns and scepticism about science and scientific developments can only be the result of a lack of understanding, and can thus be countered with providing people with rational evidence and information. In other words, it is to take the position that if only people understood the science, they wouldn't be worried about it.[2] Current approaches instead characterise the relationship much more in terms of the broader social implications of science, and do not attribute public concerns to cognitive deficit. Rather these concerns are understood as the product of genuine moral, social and political deliberations, questions of what is ethically acceptable, about who is affected by science and in what ways, who benefits and who makes money, and at what expense.[3] Modern science communication accepts that such concerns cannot be dismissed with scientific facts.

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[1] Stilgoe, J. and Sykes, K. *A little more conversation;* in 'The road ahead: Public Dialogue on Science and Technology; Sciencewise and BIS

[2] Sturgis, P. (January 2004) *Science in Society: Re-Evaluating the Deficit Model of Public Attitudes;* Public Understanding of Science vol. 13 no. 1 55-74

[3] Chilvers, J. and Macnaghten, P. (April 2011) *The Future of Science Governance: A review of public concerns, governance and institutional response*

Understanding public attitudes to chemistry

Our report is positioned firmly within this development, and aims to encourage the chemistry community to listen to the public, in terms of their starting point in relation to chemistry and what is meaningful for them, rather than identifying areas they struggle to understand or are confused or 'wrong' about. It does not assume views can be 'corrected', instead that they are important starting points for positive communication of chemistry.

Much of the current debate in public science communication is concerned primarily with engaging the public on potentially controversial issues, such as global warming, genetic modification, or nuclear power,[4] and how to involve the public in decision making in areas of ethical complexity. These are arguably less relevant when considering public attitudes towards a topic as broad as chemistry. There are however still highly relevant insights from the field of science communication that can be applied to how we understand and inquire into public attitudes to chemistry. This research has drawn on these learnings and applied them in a number of ways.

First it has taken seriously the importance of emotional connections and 'less rational' influences on individuals' views, understanding that these will need to be taken into account in order to engage in meaningful and positive discussions with the public.

Second it has emphasised the importance of looking at both sides that might be involved in engagement, considering that both the public and chemists have views about chemistry, and ideas about each other. This research offers ways to narrow the gap between these two groups, to help identify areas of mutual interest and opportunities for positive communication.

Third it has not assumed the existence of one homogenous public, but rather accepts that 'publics'[5] are plural and dynamic. Within this there is a need not only to understand an audience in depth, but also to start to identify different potential audiences. Different groups and individuals are likely to possess different concerns about chemistry, and different degrees of interest in and receptivity towards it. Acknowledging and exploring these differences will help chemists to tailor their communications to more successfully suit the publics' needs.

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[4] Wilsdon, J., Wynne, B., Stilgoe, J. (2005) *The Public Value of Science: Or how to ensure that science really matters*; Demos

[5] Mohr, A., Raman, S., Gibbs, B. (2013) *Which publics? When? Exploring the policy potential of involving different publics in dialogue around science and technology*

Context of the research

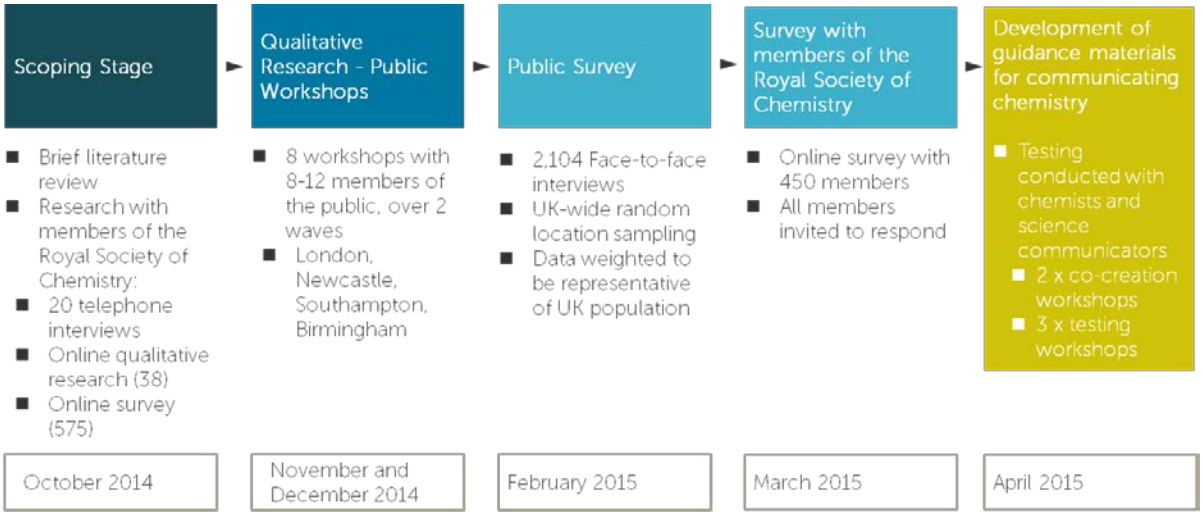
Though there has been much research conducted into public attitudes towards science, little data exists about their attitudes towards chemistry. Anecdotal evidence suggests that there is low public awareness and recognition of chemists' work and the integral role chemistry plays in society and the world. To successfully engage with the public, science communicators need to know whether this is true and, if so, what might be driving it.

The Royal Society of Chemistry commissioned TNS BMRB to conduct this research to provide well-grounded, robust data on the public's relationship with chemistry in the UK. This programme of research aimed to:

- **Understand "where people are" now** – by providing quantitative research to benchmark current public attitudes, awareness, interest, exposure and engagement towards **chemists**, **chemistry**, and **chemicals**
- **Explore what drives people's views** – by capturing holistic, rounded qualitative insight about what underlies public responses
- **Identify windows of opportunity** and 'hooks' to capture the public imagination
- Use evidence to produce guidance on opportunities and challenges in communicating chemistry to the public

Research methodology

The research comprised several stages, outlined below:



Scoping stage

Literature review

To ensure the research would be built on existing knowledge, we conducted a brief, targeted review of current data and insight around public attitudes, knowledge, awareness and engagement with chemistry. We identified over 30 key documents for the context of this research, including journal articles, books, and strategic documents (see technical report). This list was not intended to be exhaustive or representative of the literature at large, rather, to provide an initial grounding for our research team and to inform the iterative development of our research programme. This review will be referenced throughout this report and other relevant documents have been listed in the technical report.

In each stage of the research we also received the expert advice of the Royal Society of Chemistry's scientific advisory group (see technical report for more details).

Stakeholders interviews

We began the research by conducting 20 in-depth qualitative telephone interviews with members of the Royal Society of Chemistry, and experts in science communication. We wanted to gain an understanding of their perspective of the challenges and opportunities in communicating chemistry to the public; their objectives in relation to influencing public opinion; and who they saw as the main audience for communication. We also used this phase to generate ideas for the deliberative work with the public.

We undertook a short survey to measure the extent of public communication appetite and experience among membership. From the respondents of this survey we recruited 38 participants (a mix of staff and members) for a week-long online community discussion to explore issues in more detail and in a group setting, and to generate ideas to 'inspire' the public about chemistry

Qualitative research

Public workshops

We conducted qualitative research with the public to understand not only what people thought and felt, but why, and how strongly. Our workshops had several broad aims:

- To understand what people's knee-jerk responses are to chemistry, chemists, and chemicals
- To understand in depth what underlies these views
- To understand how different views interact – e.g. how views about chemicals influence views on chemistry/chemists
- To test potential routes for shifting views, in terms of messages, concepts and themes people most respond to
- To begin to identify sub-groups for segmentation
- To inform the development of the survey questionnaire

We organised eight reconvened workshops, each with 10-12 members of the public, held across four locations.[6] For each group the first workshop lasted 1.5 hours, and focused on understanding the public's 'starting point', exploring in detail their spontaneous views and emotional responses. Our method focussed on drawing out as much detail on associations as possible, to overcome potentially low engagement (i.e. if chemistry represented a low-salience subject for participants). Given that it was unlikely that people had ever deeply considered their views of chemistry before and it would potentially be difficult for people to articulate their views, we used a range of techniques to elicit a detailed, nuanced understanding of how people think, reason and feel about chemistry. We employed creative, projective techniques such as Implicit Association Testing in order to unpick implicit and emotional associations with chemistry and chemists (see technical report for more details).

Between the two workshops, participants were given homework tasks, designed to keep them engaged with the issues and to prompt them to consider things in more depth. We asked participants to think about how chemistry manifests itself in their everyday lives, discuss it with friends and family, and keep a record of those conversations.

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[6] Fieldwork in London, Southampton, Birmingham and Newcastle was conducted in November (Wave 1) and December (Wave 2)
For more details about how we recruited participants see technical report. Discussion guides and examples of the stimulus materials used can be found in the technical report.

The second workshop, lasting 2 hours, explored how the participants' views had progressed, and how they might shift further. After an initial discussion on the homework task we held a 'carousel' exercise, where we asked participants to examine five 'information stations' around different themes that were identified through the scoping stage and in discussions with the Royal Society of Chemistry. These covered different themes often used in activities with the public and ranged in tone, level of content, and media typology, in a range of formats such as mini-articles, leaflets, comic strips, posters and videos. The themes included: everyday chemistry (e.g. cooking, inspiring chemistry (e.g. comets); history of discoveries and chemistry heroes (e.g. the discovery of the contraceptive pill); myth-busting on chemicals (e.g. information on food additives); a day in the life of a chemist (e.g. what do chemists do).

Participants spent time at each station, recording what they liked most/least, what stood out to them and why, and the extent to which information changed their views about chemistry. Participants started at different tables and moved through the materials through different routes, to counter the impact of any ordering effects. Participants then discussed in a group the kinds of activities they felt they would likely engage with the most, designing their own chemistry TV programmes, public events and articles.

Vox-pops

Prior to the workshops, participants were invited to record short videos of themselves, describing their first associations and top-of-mind views about chemistry and chemists, before they had been influenced by any discussion in the groups. Similar videos were then recorded after both workshops had taken place, to examine whether and how views had changed. These allowed respondents the opportunity to record their thoughts in private, on an individual basis, apart from the group dynamic. Quotes from these are referenced in this report.

Public survey

We conducted a public survey to provide robust quantitative data for our research, working alongside the Royal Society of Chemistry and their scientific advisors to develop the questionnaire. We tested the questionnaire with members of the public via face-to-face interviews to check respondents' understanding of the questions, using the findings to adapt the final survey.

Fieldwork for this survey was conducted between 13th February and 25th February 2015 on the face-to-face TNS Omnibus survey using Computer Assisted Personal Interviewing (CAPI). A total of 2,104 adults aged 16 or over took part in the survey across the UK. Data was rim weighted to population targets set from the National Readership Survey for region, working status, gender and social grade. Rim weighting is an iterative process of correcting for biases in sub-groups of combined characteristics, such as age, gender and social grade to match to known population targets. Where percentages do not sum to 100%, or to net scores, this may be due to rounding, or when questions allow multiple answers.

More information on the development of the questionnaire and the methodology of this survey can be found in the technical report.

Chemists' survey

We conducted a separate survey with staff and members of the Royal Society of Chemistry to measure chemists' view of public attitudes to chemistry.

A total of 450 individuals took part in this web survey between 1st March and 15th March 2015. No weighting was applied to the data from this survey, as a suitable weighting source was not available. Therefore caution should be applied when considering the results, as they represent only the views of those who participated in the survey and may not generalise to the membership as a whole.

We asked participants to predict some of the responses from the public survey. This allowed us to compare how chemists thought the public would answer, and what the public actually said, providing a guide of the difference there might be between chemists' views on public attitudes and the reality of public attitudes in the UK.

Analysis

Analysis of research data

All qualitative interviews and workshops were audio recorded, and researchers made detailed notes of each. Materials created by respondents during the workshops were collected and analysed.

Our analysis of the qualitative data was iterative across all stages of the research, underpinned by individual researcher analysis, multiple debrief sessions with the research team, and regular feedback and discussion on emerging findings and hypotheses. We thematically organised the data and analysed it using a systematic approach, entailing entering summarised data into set analysis frameworks – allowing methodical coding, sorting and thematic analysis. This robust analysis method allowed us to draw out the diversity of opinions and experiences expressed by participants, as well as identify common themes across stages.

We undertook thorough meta-analysis to combine findings across stages, using qualitative insight to both inform the development of the questionnaire, and help interpret the survey data.

Where possible we compared our results with a number of other sources of survey information regarding public opinions about science in the UK including the Public Attitudes to Science (PAS) survey[7] and the Wellcome Trust Monitor.[8]

Any comparisons should be treated with appropriate caution as differences in the research design may have affected the results. For example:

- PAS and the Wellcome Trust Monitor use a random probability design and are ad hoc surveys (the TNS omnibus survey uses a random location design and covers a wide range of topics)
- Different organisations carried out the interviews at different time periods
- The order and length of the surveys differ – so questions may be subject to different biases (e.g. order effects, satisficing etc.)

[7] Public Attitudes to Science (PAS) is a survey of attitudes to science, scientists and science policy among the UK public. Five waves have been conducted so far, the most recent in 2014. It is conducted on behalf of the Department for Business, Innovation and Skills (BIS) and the Economic and Social Research Council (ESRC).

[8] The Wellcome Trust Monitor is a survey of the views of UK adults and young people (aged 14-18) on science, biomedical research and science education. Two waves have been conducted, the first in 2009 and the second in 2012.

Structure of the report

Chapter 1 provides some context to the research and briefly explores existing data on public attitudes to science and chemistry. Chapters 2-4 look at public attitudes to chemistry, chemists, and chemicals in turn, and represent a measurement of the public's starting point. Chapter 5 segments the survey population according to differing attitudes and beliefs. Finally, chapter 6 looks at how views change in response to different ideas, and potential areas of opportunities for public communication of chemistry.

Chapter 1: Science and the Public

What do we know already about public attitudes to science, and how does this relate to attitudes to chemistry? In this chapter we set the context for this research, exploring the current state of the evidence on public attitudes to science and chemistry. Starting with public views about science and scientists, and the degree to which we can assume overlap of these views with chemistry, we will then explore findings from the literature[9] on specific responses to chemistry, chemists and chemicals, conducted as part of the scoping stage of this research. Finally we will draw on the views of some of the members of the Royal Society of Chemistry themselves, in terms of their expectations of public perception of chemistry, their goals and aspirations in relation to future understanding of and engagement with chemistry, and their views on what successful public engagement could achieve.

Public engagement with science

As public engagement with science has become an increasingly pertinent issue for government, industry and the scientific community, there has been progressively greater investment into research programmes to try to understand public attitudes. Much of this investment has sought to understand public support or opposition to certain developments or technologies, interest in entering science education and careers, and how the public ought to be involved in decision-making around new technologies and legislation. Over the last 30 years there has also been a growing body of evidence into how people think about science generally, how engaged they are with it in their daily lives, and the extent to which they feel positive about its impacts on society.

The overall picture for the UK is positive, with research showing increases in public interest and engagement with science year on year:

- Four-fifths (81%) agree that science will make people's lives easier
- Three-quarters (76%) think scientific research makes a direct contribution to economic growth in the UK
- Over eight-in-ten (84%) agree that science is such a big part of our lives that we should all take an interest
- Over half (55%) think that the benefits of science outweigh any harmful effects, compared with 45% in 1988

[9] A list of the key documents included in the review can be found in the technical report.

- Seven-in-ten (72%) agree that it is important to know about it in their daily lives, compared with 57% in 1988.[10]

Belief in the positive impact of science is greatest when in reference to health and medicine. At least half of people in Europe expect that, 15 years from now, science and technological development will have a positive impact on health and medical care (65%), education and skills (60%), transport and transport infrastructure (59%), energy supply (58%), protection of the environment (57%), fight against climate change (54%) and quality of housing (50%).[11]

Looking at the UK, views of scientists are also positive – scientists in general are trusted, respected and thought to have an interest in societal good:

- Nine-in-ten (90%) think that scientists make a valuable contribution to society
- Eight-in-ten (83%) agree scientists want to make life better for the average person
- Nine-in-ten (90%) trust scientists working for universities to follow any rules and regulations[12]

However, science is not without its controversies, and more negative or ambivalent views are also uncovered in relation to specific issues like GM food[13] or nuclear energy.[14]

There are also concerns about the pace of change in science and government's ability to control it: two-fifths agree that the speed of development in science and technology is too fast to follow (42%) and means that these developments cannot be properly controlled by government (41%). Over half (55%) said people should not tamper with nature.[15]

While scientists are among the most trusted professionals in the UK[16] people sometimes mention some potentially negative traits: public trust in scientists outside the academic context is lower than the rate quoted above, with only 60%

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[10] Ipsos Mori (March 2014) *Public Attitudes to Science* available online at https://www.ipsos-mori.com/Assets/Docs/Polls/pas-2014-main-report.pdf
[11] TNS Opinion & Social (October 2014) *Public Perceptions of Science, Research and Innovation,* Special Eurobarometer 419
[12] Ipsos Mori (March 2014) *Public Attitudes to Science* available online (as above)
[13] https://www.food.gov.uk/science/research/ssres/foodsafetyss/gmfoodpublicattitudes
[14] https://www.ipsos-mori.com/researchpublications/researcharchive/3284/British-public-split-on-nuclear-power.aspx
[15] The Office of Science and Technology and the Wellcome Trust (October 2000) *British Attitudes to Science, Engineering and Technology* available online at http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_peda/documents/web_document/wtd003419.pdf
[16] Ipsos Mori (February 2014) *Ipsos MORI Veracity Index* available online (as above)

saying they trust scientists working for private companies, raising questions about their independence in regards to funding and industry. Scientists are also deemed likely to be poor communicators (40%), or to be secretive (50%).[17] Qualitative research has uncovered a perception that scientists are occasionally viewed by the public as 'not quite like us' – meaning that they perhaps operate to a different moral code, driven by a desire to discover and create without considering the consequences. 56% of people agreed that scientists seem to be trying new things without stopping to think about the risks.[18]

Chemistry and chemists can arguably hold claim to some of these well-studied and established perceptions of science and scientists. We cannot assume that the same set of attitudes would be consistent for chemistry as it is unclear to what extent the associations with science in general can be attributed to particular branches or disciplines.

Public engagement with chemistry

We conducted a review of the existing literature that looked specifically at chemists, chemistry, and chemicals. While there are numerous opinion pieces from scientists on these topics, there is a relatively low level of recent primary research with the public in this area, and limited independent reports written by non-scientists.

Chemists

The chemistry community often highlights the disconnect between chemists' self-image and their public image: whereas chemists saw themselves as entrepreneurial, environmentally conscious, good citizens and social benefactors, and creative[19] there was an expectation among the chemistry community that the public would not agree. Rather there was a widespread view that historically chemists have been associated with the stereotypes of men in white coats, holding scientific glassware, or with a formal, stuffy intellectual. This image has its most negative incarnation in the 'mad scientist', who creates chemical weapons and

[17] Ipsos Mori (March 2014) *Public Attitudes to Science* available online at https://www.ipsos-mori.com/Assets/Docs/Polls/pas-2014-main-report.pdf

[18] The Office of Science and Technology and the Wellcome Trust (October 2000) *British Attitudes to Science, Engineering and Technology* available online at http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_peda/documents/web_document/wtd003419.pdf

[19] Laszlo, P. (2007) *On the self-image of chemists*, 1950-200, in Schummer, J., Bensaude-Vincent, B. and van Tiggelen, B. (Eds.), The Public Image of Chemistry (pp. 329-367), New Jersey: World Scientific

pollutes the environment,[20] and in general makes and uses dangerous chemicals for ill purpose. Most of these ideas were assumptions, based on anecdotal evidence, and it was unclear to what extent this view was truly held by the public.

Chemistry

There was limited reference to public views of chemistry specifically in the literature, though there was occasional reference to an expectation among some chemists, that the public see chemistry as nasty, dangerous and polluting. This could be linked to chemistry's lack of public or media profile – and many commentators highlight how the coverage of chemistry stories in the news is in reference to *chemicals* (rather than chemistry) such as acid rain, CFCs, agrochemicals, pollution, biotechnology, and industrial accidents.[21]

There is an underlying assumption in the literature that the public's views about chemistry are connected to those about chemicals and the chemical industry – and that chemistry is likely to suffer from these negative associations. Controversies relating to chemical warfare, the thalidomide scandal, pollution and pesticides are also listed as contributing to public negativity.[22] As with public attitudes about chemists, no primary research was available to support these assumptions.

Chemicals

We found that a great deal of the literature on chemistry and society focusses specifically on the public's view of chemicals. There has been a view among some in the chemistry community that 'chemophobia'[23] – the irrational fear of chemicals – is a prevalent problem that needs addressing, and much discussion about the best way to do so. The dominant narrative has all the characteristics of the deficit model with the public's lack of understanding about chemicals, media coverage and product marketing messages leading to misperceptions, irrational fear, and an inability to correctly determine risk.[24]

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[20] Schummer, J., Bensaude-Vincent, B. & van Tiggelen, B. (2007) *The public image of chemistry*, New Jersey: World Scientific

[21] Levinson, R. (1998) *Public perceptions of chemistry,* in Science and the Public, MSc in Science Education (S802), The Open University

[22] Hartings, M. and Fahy, D. (2011) *Communicating chemistry for public engagement*, Nature Chemistry, 3, 674-677

[23] "Chemophobia is a fear of synthetic substances arising from "scare stories" and exaggerated claims about their dangers prevalent in the media" Entine, J. (18 January 2011) *Scared to Death: How Chemophobia Threatens Public Health*, American Council on Science and Health

[24] Davies, E. and Sanderson, K. (November 2014) *De-toxify the C-word and Toxic Shockers* in New Scientist

Views from the membership

We conducted telephone interviews, online qualitative research and two surveys with members of the Royal Society of Chemistry to understand what they knew and thought about public views on chemists and chemistry. The views echoed some of what was in the literature – namely that overall there was likely to be a negative perception of chemistry, and chemicals in particular, and that stereotypes would dominate the public's view of chemists. Though this was a common perception, many acknowledged that their views were mainly based on: their perceptions of chemistry's portrayal in the media and the way in which chemicals feature in public discourse; the lack of strong chemistry role models in the public sphere; their encounters with people who had bad memories of chemistry from their school days and people actively expressing negative views about chemicals (e.g. online).

When we asked staff and members of the Royal Society of Chemistry for their views about public perceptions:[25]

- More than half (56%) thought the majority (50% or over) of the public would say all chemicals are dangerous and harmful
- 80% thought the public would view chemists as unapproachable
- Only one third (31%) thought that at least 50% would agree that the benefits of chemistry are greater than any harmful effects

When we asked the chemists we were interviewing about their goals for communication of chemistry many mentioned a desire to overcome negative stereotypes, debunk myths surrounding chemicals, and to increase overall interest and engagement with chemistry among the general public. Central to this was a desire for people to see chemistry as underpinning things in their everyday life, and to see it as familiar and relevant, recognising its societal value.

[25] Data taken from Q1_4, Q1_8 and Q2 from the quantitative chemists' survey. The base for all questions is 450.

Chapter 2: Public attitudes to chemistry

Key findings:

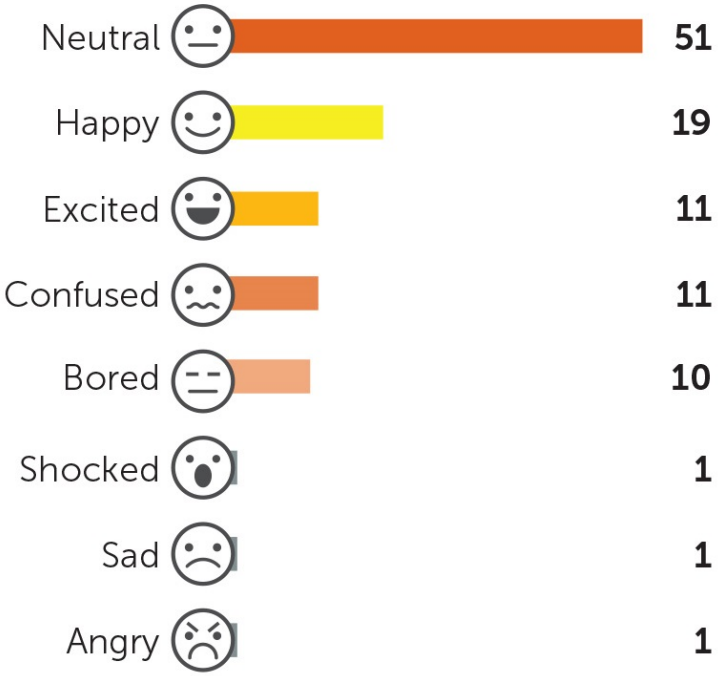
- Overall, people were positive about the impacts of chemistry and believed it to be beneficial to society. However, they also expressed neutrality about chemistry: they did not see it as personally relevant and lacked concrete examples of its applications; finding it much easier to specify and visualise negatives or stereotypes.
- The lack of associations and emotional neutrality is indicative of a void in people's engagement with chemistry, arguably caused by:
    - Limited 'encounters' with chemistry; with contact with chemistry mostly limited to TV news.
    - Limited recognition of chemistry in various industries or sciences – that are not labelled 'chemistry', leading to low awareness of chemistry's applications.
    - An over-reliance on school memories, meaning it is viewed in an academic and abstract context. For some, who did not enjoy chemistry at school, or found it difficult, this can also produce a sense of inferiority and disengagement.
- On the whole, people did not feel informed about chemistry, or particularly confident.

This chapter brings together the data from our public survey on attitudes to chemistry, as well as the qualitative work, helping understand in greater depth the reasons for public views. Following the approach taken to the survey and the workshops, the chapter will begin by exploring people's surface associations with chemistry and chemists, before presenting prompted, deeper and more reflective views. It will consider, where possible, how attitudes compare with those towards science more widely. Finally it examines how informed people felt they were, where they get information about chemistry, and who they trust.

General perceptions and engagement with chemistry

We asked respondents to describe how they feel about chemistry to measure their emotional response to chemistry.
Though interviews with chemists suggested results would be somewhat negative, half (51%) of the survey respondents stated that they had neutral feelings towards chemistry; and on balance people reported slightly more positive feelings than negative (figure 2.1)

Figure 2.1: Feelings towards chemistry (%)



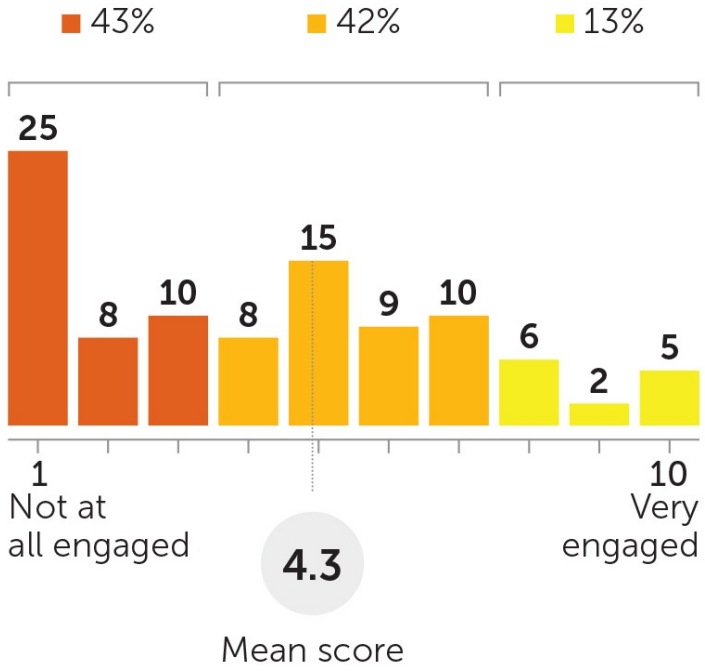
Q.4B Which of the following describes how you feel about chemistry? Base: All respondents (2,104 UK adults 16+) *Multi-coded*

Men were more likely than women to say that chemistry makes them feel happy (23% and 16% respectively), while women were more likely than men to say that chemistry makes them feel confused (13% compared with 9%). Young adults aged 16-24 were more likely to feel bored (18% compared with an average of 10%), while those from higher social grades (AB) and those educated to degree level were slightly more likely to feel excited (16% and 19% respectively, compared with an average of 11%).

Respondents' neutrality was underpinned by relatively low interest and engagement. When asked to rank engagement or interest with chemistry, on a scale of one to ten,[26] 43% gave a low score (1-3), 32% a moderate score (4-6) and 23% a high score (7-10). Feelings of neutrality were also reflected in the mean score (4.3).

[26] With one being not at all engaged and ten being very engaged.

Figure 2.2: Engagement/interest in chemistry (%)



Q.4A How engaged or interested are you with chemistry? Base: All respondents (2,104 UK adults 16+)

This mean engagement score was higher than average for respondents who were themselves chemists (7.4), individuals who had studied chemistry to A-level or beyond (6.4), people educated to degree level or higher (5.0) and those with an AB social grade (4.9). Once again there was a gender gap, with men having a higher engagement score compared with women (4.4 and 4.1 respectively),

Public understanding and appreciation of the societal value of chemistry

On the whole, the UK public recognises the societal value of chemistry, with six in ten (59%) agreeing that the benefits of chemistry outweigh any harmful effects.[27]

"My 'comic book' idea of [chemistry] would be experimenting with elements and substances, putting them together and seeing what happens. And chemists are the people who conduct these experiments. Hopefully for the good of the planet and mankind. That's my idea of it."
(Female, Vox-pops, pre-groups)

[27] There is however a general perception among members/employees of the Royal Society of Chemistry that the public do not appreciate the benefits of chemistry – only a third (33%) of members surveyed thought the public would agree that the benefits of chemistry are greater than any harmful effects.

Figure 2.3: Perceived benefits of chemistry

59%

of the public believe the benefits of **chemistry** are greater than any harmful effects

Q.6_01 Base: All respondents (2,104 UK adults 16+).

There were some differences by age. People aged 65 and over were more likely than average to agree that the benefits of chemistry outweigh any harmful effects (68% compared with 59% on average). Young people aged 16-24 held more neutral views, with around a third (36%) stating that they neither agree nor disagree with the statement compared with around a quarter (27%) overall.

Similar trends by age were found in the 2014 Public Attitudes to Science Survey (PAS),[28] in response to a similar question about science. If we look at the trend for how attitudes to science have differed since 1988 by generation, we see that people's attitudes do not simply change as they get older. Rather, attitudes are strongly linked to the era in which people were born with the younger generations generally more sceptical of the benefits of science relative to any harmful effects.[29]

Figure 2.4: Economic benefits of chemistry

72%

agree that **chemistry** research and developments make a direct contribution to economic growth in the UK

Q.6_04, Base: All respondents (2,104 UK adults 16+).

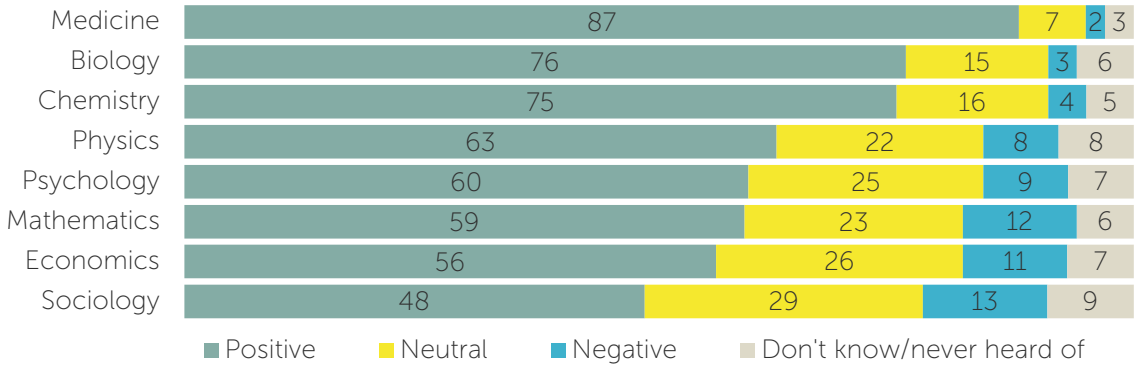
In our survey people were also overwhelmingly positive about the contribution chemistry makes to the UK economy, with three quarters (72%) agreeing that chemistry research and developments make a direct contribution to economic growth in the UK. This is not far from data on science in general (76%).[30]

Views about the effects of chemistry on our well-being were similarly positive: three quarters (75%) stated that they felt chemistry had a positive impact on well-being. Chemistry also performed well when placed in the context of other 'competing' subjects (physics, chemistry, biology, medicine, psychology,

[28] Ipsos Mori (March 2014) *Public Attitudes to Science* available online at https://www.ipsos-mori.com/Assets/Docs/Polls/pas-2014-main-report.pdf
[29] Ipsos Mori (March 2014) *Public Attitudes to Science* (as above)
[30] Ipsos Mori (March 2014) *Public Attitudes to Science* (as above)

mathematics, economics and sociology).[31] As might be expected medicine was viewed as having the most positive impact (87%); biology and chemistry followed (76% and 75% respectively), with all other subjects were ranked lower (See table 2.5). There were some differences in opinion by gender, with men more likely than women to state that chemistry (77% versus 73%), maths (63% versus 54%) and physics (70% versus 57%) have a positive impact on well-being.

Table 2.5: Perceived impact of sciences on well-being



Q.7B What impact do you think ... has on our well-being? Base: All respondents (2,104 UK adults 16+)

Our survey also measured perceptions of the role of chemistry in relation to a number of world problems: the extent to which it was part of the problem or the solution. The findings were positive with the majority of individuals stating that chemistry was part of the solution rather than the problem, across all of the issues asked (table 2.6).[32]

From the survey we see that there is neutrality and relatively low interest/engagement in chemistry currently, yet at the same time people are generally positive about its impacts. The following section looks more closely into reasons for views.

[31] For each subject individuals were asked to give a score between 1 and 5, where 5 is a very positive impact and 1 a very negative impact on well-being. Scores were grouped together so that a score of 4 or 5 was classed as positive and a score of 1 or 2 negative.

[32] For each world problems individuals were asked to give a score between 1 and 5, where 5 means chemistry only relates to the solution and 1 means chemistry only relates to the problem. Scores were grouped together so that a score of 4 or 5 was classed as part of the solution and a score of 1 or 2 part of the problem.

Table 2.6: Whether chemistry is seen as part of the problem or solution in…

	Whether part of the problem or solution (on a scale of 1-5, 1 being only the problem and 5 only the solution)	%
…Finding sustainable sources of energy to reduce dependency on oil	Problem (1-2)	6
	(3)	19
	Solution (4-5)	64
	Don't know	10
…Ensuring there is enough food for the world's population	Problem (1-2)	11
	(3)	24
	Solution (4-5)	55
	Don't know	8
…Access to clean, safe drinking water	Problem (1-2)	5
	(3)	14
	Solution (4-5)	74
	Don't know	6
…The rise in bacterial resistance to antibiotics	Problem (1-2)	13
	(3)	18
	Solution (4-5)	60
	Don't know	9
…Pollution	Problem (1-2)	19
	(3)	25
	Solution (4-5)	49
	Don't know	7

Q.8 For each one please can you tell me whether you feel that chemistry plays more of a role in the problem or the solution? Base: All respondents (2,104 UK adults 16+)

Associations with chemistry

Respondents had limited and narrow associations with chemistry, centring mainly on school. For many people, mentioning chemistry activated memories, symbols, and feelings linked to their school experience, and in the absence of other associations it was the predominant driver of responses, and an influential basis for

views. Though reliance on school examples is common when asking the public to discuss science,[33] it is the absence of *other* examples, not only top-of-mind but through further discussion, and general impassiveness that indicate an over-reliance on this association.

When asked unprompted people's top-of-mind associations with chemistry related primarily to school or teachers (21%), science (16%), and chemicals or chemical elements (14%), medicine (8%) and drugs (6%), and lab equipment such as Bunsen burners and test tubes (6%), many of which are arguably images and symbols from school experience (table 2.7). This was confirmed in the qualitative workshops, where respondents described how they had imagined the school laboratory setting in order to come up with associations with chemistry.

Table 2.7: Top-of-mind associations with chemistry

Associations (mentioned by at least 3% of the sample)	%
School/teacher	21
Science	16
Chemical(s)/elements	14
Medicine/Medication	8
Drugs/tablets/pills	6
Equipment/Bunsen burner/test tube	6
Research	5
Laboratory	4
Periodic table	3
Sexual attraction/chemistry between two people	3
Chemical reactions/interactions	3

Q.1 When I talk about chemistry, what comes to mind? Base: All respondents (2,104 UK adults 16+) *Multi-coded*

Despite their more recent experience of school, young people aged 16-24 were less likely than average to mention school or teachers (13% versus an average of

[33] "When science was discussed in the qualitative research focus groups, participants often used examples from school; initially the role of science in everyday life was mentioned only rarely." The Office of Science and Technology and the Wellcome Trust (October 2000) *British Attitudes to Science, Engineering and Technology* available online at http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_peda/documents/web_document/wtd003419.pdf

21%). They were however more likely than average to mention science more generally (29% compared with an average of 16%) and chemicals/elements (21% compared with an average of 14%). Insight from the qualitative research suggests that chemistry as a 'science' is also in some way linked to school – as respondents described chemistry as '*one of the three sciences studied at school*'.

Contrary to chemists' expectations, there were very few spontaneous negative associations, with only 1% mentioning chemistry being boring, difficult or confusing, and only 1% mentioning explosions or blowing things up.

The associations people held could be described as relatively functional, limited, and lacking in deep emotional connections. This came across strongly in the qualitative workshops, as participants struggled to come up with many distinctive images or ideas, defaulting largely to what they acknowledged to be stereotypes: labs, white coats, etc., and the images conjured by the memory of their experience at school: periodic tables, lab benches and equipment. Prior to the groups, participants were asked to record their thoughts and feelings about chemistry and chemists. Views were again generally neutral, with actively positive or negative views being the outliers.

> *"I don't really feel anything about chemistry… I don't know the sort of things that they do…It's quite a lot of advancements … but I can't think of anything off the top of my head."*
> (Female, Vox-pops, pre-group)

Top-of-mind associations were vague as people struggled to make connections with specific applications of chemistry or particular activities chemists were involved in, outside a school or pharmaceutical context.

Further exploration in the workshops elicited some more detailed, sensory, and granular connections to chemistry with many people mentioning:

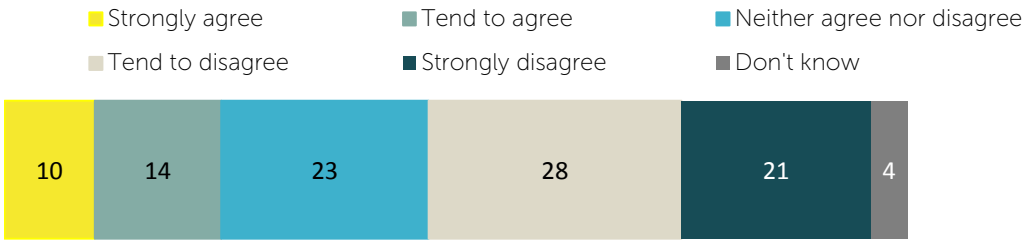
- Strong smells, of ammonia, sulphur, or gases – connecting respondents to memories of the classroom and the practice of chemistry at school.
- The possibility of accident, or symbols of danger/safety, represented through hazard signs, alarms and fire extinguishers – linked to safety precautions learnt at school
- The idea of the need for concentration: silence, or hushed, focused conversations – with the underlying notion that chemistry is difficult (and for some respondents, the sense it is too difficult for them)

These ideas further establish the strength of associations with school, though the ideas of silence and concentration introduce the idea of chemistry being difficult, and for some potentially inaccessible. This is explored further in the sections below.

Chemistry at school

The survey findings suggest that people have mixed feelings about the chemistry that they learnt at school, with a quarter (25%) agreeing that school had put them off chemistry.[34]

Figure 2.8: Whether agree/disagree that school put me off chemistry



Q.6_08 I'm now going to read out some statements about chemistry, for each one please could you tell me the extent to which you agree or disagree? "School put me off chemistry" Base: All respondents (2,104 UK adults 16+)

Findings from the 2014 PAS suggest public views held about science and school are in line with our findings about chemistry with 24% of people agreeing that school put them off science more generally. Women tended to have a more negative experience, with 28% agreeing that school put them off chemistry, compared with 21% of men. This is perhaps reflective of gender differences in relation to science as figures from the 2014 PAS show that women are also more likely than men to say that school put them off science (30% versus 17%)

We also asked how useful chemistry learnt at school is seen to be in people's lives. Overall three in ten (31%) agreed that the chemistry learnt at school has been useful in everyday life, while 45% disagreed (21% neither agreed nor disagreed and 5% said that they did not know).

As found previously there were some gender imbalances with men more likely to agree than women (47% compared with 35%). Young people aged 16-24 were more likely to disagree than average (51% versus 45%) although perhaps this could be reflective of the shorter time they have had to put learnings into practice or that they are still in education.

To place these findings into context it is useful to review answers to similar questions asked in the 2014 PAS in relation to science and maths. Half (51%) thought that the science learnt at school has been useful in everyday life; a third

[34] Figures in figure 2.8 for those who agreed that school put them off chemistry do not add to 25% due to rounding (10.4% strongly agree and 14.1% tend to agree).

(33%) disagreed. People were even more positive about the maths they learnt at school, with three quarters (76%) saying it had been useful in their everyday lives, and only 16% disagreed.

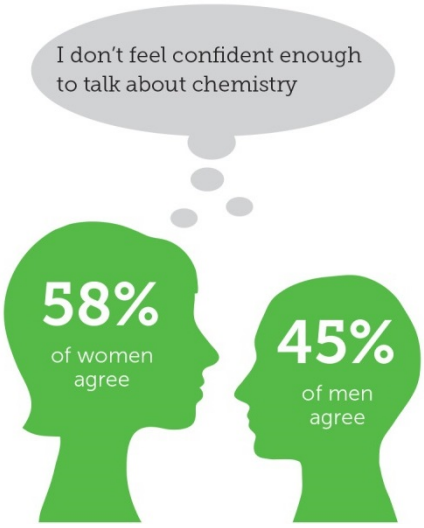
Confidence with chemistry

In our qualitative workshops people described how their negative or neutral experience at school resulted in feeling a lack of interest, neutrality and indifference; though for some, and particularly women, it elicited feelings of fear, panic, and insecurity.

> *"Chemistry doesn't really interest me. I never enjoyed it at school. I don't find it very accessible so I don't really have much of an opinion on it."*
> (Southampton Wave 1)

> *"Well I don't really know much about chemistry and the only feeling that springs to mind is panic because I didn't really enjoy it at school."*
> (Female, Vox-pops, pre-group)

Figure 2.9: Confidence about chemistry by gender



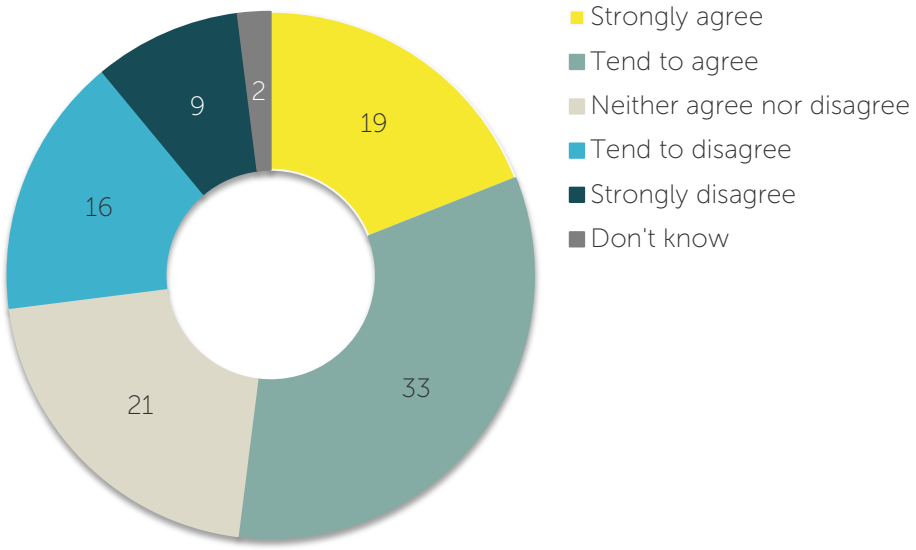
Q.6_07 Base: All respondents (2,104 UK adults 16+, 970 males, 1134

This translated into a lack of confidence generally surrounding the subject, with some respondents saying they tended to shy away from it, for example saying they would be unable to help with their children's chemistry homework.

In our public survey, just over half (52%) of respondents agreed that they did not feel confident enough to talk about chemistry, with one-in-four (25%) saying they disagreed.

A lack of confidence in talking about chemistry was more pronounced among women compared with men (see figure 2.9).

Figure 2.10: Whether agree or disagree with the statement: I don't feel confident talking about chemistry



Q.6_07 I'm now going to read out some statements about chemistry, for each one please could you tell me the extent to which you agree or disagree? "I don't feel confident enough to talk about chemistry" Base: All respondents (2,104 UK adults 16+)

Chemistry compared to science

We used projective techniques[35] in the qualitative workshops to elicit distinct characteristics of chemistry and science, common across the groups. We asked participants to imagine two rooms: one that represented 'chemistry' and one that represented 'science'.[36] In small groups participants then noted down their ideas, drew images together, and fed back to the other group. The characteristics of each are summarised in table 2.11 below.

[35] Projective techniques are employed in social psychology research to explore people's implicit, unconscious, and emotional associations, by asking them to apply characteristics to something external to them, 'projecting' their beliefs, assumptions and attitudes onto it. People are then asked to explain the reasons for their responses.

[36] This task is based on the Gestalt corridor technique. More information about this can be found the technical report.

Table 2.11: Comparative characteristics of chemistry and science

Chemistry	Science
Intimidating, hard to understand, would feel ignored "You wouldn't dare to touch anything"	Welcoming, friendly "I think it's more sociable in the science room...I think it will have more sociable people"
Serious	Fun
Methodical, repetitive work	Active, discovery, exploration
Chemistry not involved in the end product	Applied to the world
Quiet, silence, concentration	Busy, excitement, buzz
Inaccessible, hard "I feel we can relate to science a little bit more, surrounded by animals, plants, whereas in the chemistry room they're doing experiments, you need to be someone of a certain profession or qualified"	Open to non-experts "you don't have to have a science brain to understand what's going on"
Work going on in the background, 'behind closed doors'; hidden or secretive	Accessible to everyone
Microscopic, can't easily see what's going on	Visual, demonstrable

In making this comparison, we must take into account the fact that 'science' as a broad category allows respondents to connect to any aspect of science in which they have an interest, and any specific discipline will inevitably have comparatively less connection and personal relatability. However, this reveals some interesting differential qualities. Namely, people found it difficult to understand chemistry's place in the world outside school and drug research, in terms of how chemists' work applies to new technologies or developments. Chemistry was also seen to lack some of the fun and energy of science; being seen as much more serious in personality, comprising difficult, repetitive experiments. Further, it was seen as less related to the discovery of new things and less innovative than science in general. As a result people struggled to imagine how chemistry affected their daily lives, and regarded chemists as relatively lacking in agency – not being involved in the end-product of their work.

"[There's] nothing really relating to humanity about it. I don't think it has many positive or interesting connotations. I think the interesting things about science, which [have] quite high prestige, are things relating to physics and space exploration. And maybe biology as well, exploration of the environment. I think chemistry has quite boring connotations, it's just numbers, lab work, tests, things like that. But without a doubt, it does have importance in the scientific community."
(Male, Vox-pops, pre-group)

Conceived of as difficult for non-experts to understand, respondents viewed chemistry as a 'science for scientists', rather than for them.

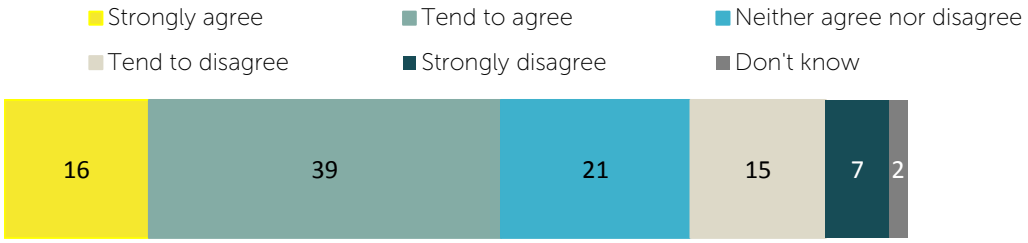
Relevance of chemistry

The 2013 Wellcome Trust Monitor highlighted that the chance to learn about things relevant to real life was one of the things that most encouraged the study of science.[37] It was clear in the qualitative workshops that people had low awareness of the ways in which chemistry was relevant to them – many of the associations were distant from themselves in terms of time (school), visibility (the hidden nature of dangerous chemistry), accessibility (being hard/difficult). Chemistry was viewed as more of an abstract discipline than an applied science.

In this context our public survey measured how important people thought it was to know about chemistry in their daily lives. The majority (55%) of the UK public agreed that it was, but there was also a lot of uncertainty or neutrality here, with one in five (21%) stating they neither agreed nor disagreed. This suggests that some people may struggle to see chemistry as personally relevant.

[37] Wellcome Trust (May 2013) *Wave 2 Tracking public views on science, biomedical research and science education* available online at http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_grants/documents/web_document/wtp053113.pdf

Figure 2.12: Whether agree or disagree that it is important to know about chemistry my daily life



Q.6_11 I'm now going to read out some statements about chemistry, for each one please could you tell me the extent to which you agree or disagree? "It is important to know about chemistry in my daily life" Base: All respondents (2,104 UK adults 16+)

A similar measure can be found in the 2014 PAS survey, where seven in ten (72%) agreed that it is important to know about science in their daily life. While the surveys are not directly comparable (see technical report), and it should be noted that science as a broader discipline is more likely to contain some aspects that are viewed as more relevant, the gap seen between science and chemistry suggests that individuals find it easier to relate science to their everyday lives. Other findings support a general UK interest in developments in science and technology compared to the average EU citizen.[38]

Those educated to degree level or higher were more likely than average to agree that chemistry is important in their daily life (65% versus an average of 55%). As you might expect those who felt informed about chemistry were more likely than those who did not feel informed to agree it is important (72% and 46%). Interest in science was also related, with two-thirds (67%) of those interested in science agreeing that chemistry is important in their daily life, compared with 36% of those who were not interested.

This data reflects findings from the qualitative workshops, with respondents who had higher education levels, higher income and generally more positive views about science[39] expressing greater degrees of connection to chemistry. They described chemistry not just as important, but suggested it was more *embedded* in their everyday lives, spontaneously saying it was 'all around them', and giving examples of particular aspects they regarded as important or personally interesting. This dynamic was also reflected in the segmentation (see chapter 5).

[38] European Commission (November 2013) *Special Eurobarometer 401, Responsible Research and Innovation (RRI), Science and Technology* available online at http://ec.europa.eu/public_opinion/archives/ebs/ebs_401_en.pdf

[39] Identified through individuals' responses to screening questions conducted as part of recruitment for the qualitative workshops.

"I feel chemistry is very important, I mean it's the basis of everything that we have at the minute, like soap, basic things you take for granted is all down to chemistry, and obviously the chemists who do it are very intelligent people. Not a lot of people would be able to do what they do, coming up with all these things, so I think it's very important to our daily life, and it's very under-appreciated."
(M, Vox-pops, pre-groups)

I bake a lot, and it's all about chemistry in baking as well, and I feel that without chemistry then I wouldn't be able to know how to bake a cake, even though I don't really measure things accurately. I also watch a lot of TV, like CSI, and that's all about chemistry and blood samples and DNA and things, and I just think it's really important, and that having chemists are really important in my daily life because I feel that I have an eczema problem, so without chemistry I don't think they'll be able to have the medicines that we have today.
(Female, Vox-pops, pre-groups)

I think chemistry is a crucial part of modern life and without it so many advances in modern life would not be possible. I'm talking about polymers and the plastics and also what's going on with regards to antibiotics. Which wouldn't be possible without the wonderful world of chemistry.
(Male, Vox-pops, pre-groups)

I think that chemistry goes on around us all the time, in everything we touch, taste, or smell. Chemistry is in plants, animals, fuel, formation of ice and snow. I also think of atoms, molecules, and particles that are too tiny to be seen with the eye. It is important because it is the study of chemicals and how and why substances interact with each other.
(Female, Vox-pops, pre-groups)

Finding out about chemistry

This section explores how informed people feel about chemistry; where they currently encounter information about chemistry, where they would actively go to seek out information about chemistry, trust in sources of information and interest in key current debates and developments in chemistry.

How informed are people?

The majority of people (55%) do not feel informed about chemistry in their everyday lives, while four in ten feel informed (41%).

Those who recognise the importance of chemistry in their daily lives are more likely to feel informed than those who do not, (53% compared with 24% respectively), however there is still a large proportion of people who recognise the importance of chemistry but do not feel informed about it.

This gap is also apparent in other research as similar findings were identified in relation to science more broadly in the 2014 PAS. In this survey 55% of people said that they did not feel informed about science. A similar question was also asked in special Eurobarometer 401,[40] which found that the majority of EU citizens do not feel informed about science.

How do people get their information currently and where would they go to actively seek information?

Most people stated that they hear or read stories about chemistry in their everyday life mostly through traditional media such as television (57%),[41] in the form of news programmes (44%) or other TV programmes (33%) and print newspapers (23%), either via broadsheet papers (13%) or tabloids (14%).

Although the vast majority (87%) of people stated they use the internet, only one in five (22%) said that they hear or read stories about chemistry online via online newspapers or news websites and only 16% mentioned social media. Although younger people aged 16-24 were more likely than average to mention social media (33% versus 16% overall).

This dominance of traditional media can also been seen in the 2014 PAS, where 59% stated that TV is one of their two most regular sources of information about science and a quarter (23%) said printed newspapers.

Some more informal routes of information were also cited with 17% hearing information from friends and family and 27% from reading product packaging. An additional 14% stated that they never hear or read stories about chemistry in their everyday life.

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[40] European Commission (November 2013) *Special Eurobarometer 401, Responsible Research and Innovation (RRI), Science and Technology* available online at http://ec.europa.eu/public_opinion/archives/ebs/ebs_401_en.pdf

[41] As this question is multi-coded this figure includes people who said news programmes or other TV programmes, please be aware that some people answered both of these. For example 460 people said they hear information via TV news programmes and 347 said they hear information via other TV programmes – 217 people said that they hear information from both sources. So 590 (57%) hear information from either source.

Table 2.13: Current sources of information about chemistry in everyday life

Sources (mentioned by at least 10% of the sample)	%
TV news programmes	44
TV other programmes	33
Product packaging	27
Online newspaper or news websites	22
Friends, family or work colleagues	17
Social media (Facebook, twitter, other social networking sites) or Blogs	16
Radio	15
Science magazines or Books	15
Print Tabloid newspapers (e.g. The Sun, The Mirror, The Daily Mail)	14
Print Broadsheet newspapers (e.g. The Guardian, The Independent, The Times, The Telegraph)	13
Visiting a science museum or attending public lecture	10
None of these	14

Q.10 From which of these, if any, do you hear or read stories about Chemistry in your everyday life? Base: Half sample (1,053 UK adults 16+) *Multi-coded*

In our qualitative workshops, respondents almost universally described a scarcity of media encounters with what they would recognise as chemistry – beyond news stories about drug development, vaccines, and advancements in findings cures for diseases.[42] This arguably demonstrates the limited ways in which participants were thinking about what 'counts' as chemistry – and though they may have been encountering chemistry-related news stories or programmes,[43] they were not necessarily recognising them as such.

> *"We know we're just gone for the stereotypes, but that's all you get on TV. It's BBC news, that stock footage of petri dishes and microscopes and the centrifuge. The BBC isn't going to bother sending a camera crew every time."*
> (Newcastle, Wave 1)

[42] Fieldwork was conducted in November and December 2014, when there was high media coverage of the Ebola outbreak.
[43] See chapter 6, which describes the qualitative workshops where participants were shown videos of chemistry careers, which were met with surprise and in some cases scepticism that these examples were about chemistry, rather than 'mechanical engineering' for example.

We also asked where they would go if they wanted or needed to actively seek out information about chemistry in their everyday life. **While people tended to hear and see information currently through more traditional medial sources, they were more likely to actively seek out information online.** Four out of the top five answers given were online: Google (48%), websites of research institutions or universities (18%), science books/magazines (13%), Wikipedia (13%) and online newspapers (13%).

Table 2.14: Sources of information would use to actively seek out information about chemistry in everyday life

Sources (mentioned by at least 10% of the sample)	%
The internet generally – e.g. Google or another search engine	48
Websites of research institutions or universities	18
Science magazines or books	13
Wikipedia	13
Online newspaper or news websites	13
Websites of chemical companies/pharmaceutical or other businesses	13
TV news programmes	11
Friends, family or work colleagues	11
Product packaging	10
TV other programmes	10

Q.11 If you needed or wanted to find information about Chemistry in your everyday life where would you go to actively seek information? Base: Half sample (1,053 UK adults 16+) *Multi-coded*

Qualitative findings from the 2014 PAS support the finding that people tend to use the internet to actively seek out information, in relation to science information more generally. The use of the internet to actively seek out information was also documented in the 2013 Wellcome Trust Monitor, which found that TV and newspapers were the most common passive sources of information on medical research while the internet was more commonly used when people were actively looking for this information.[44]

[44] Wellcome Trust (May 2013) *Wave 2 Tracking public views on science, biomedical research and science education* available online at

Trust in difference sources of information varied with the most trustworthy being Science museum/ festival/lecture (79%), science magazines or books (74%) and research institutions/universities (74%).

Tabloid newspapers (50%) and social media (47%) were more likely to be classed as untrustworthy. For many sources there was some ambiguity, particularly Wikipedia and social media. A quarter of people (25%) stated that they did not know how trustworthy Wikipedia is and the same proportion (24%) did not know how trustworthy social media is.

Table 2.15: Trust in different sources of information about chemistry

Sources of information	Trustworthy/untrustworthy	%
Science museum, science festival or public lecture	Trustworthy	79
	Untrustworthy	5
	Don't know	17
Websites of research institutions or universities	Trustworthy	74
	Untrustworthy	7
	Don't know	19
Science magazines or Books	Trustworthy	74
	Untrustworthy	7
	Don't know	19
TV and radio	Trustworthy	71
	Untrustworthy	19
	Don't know	11
Governmental websites	Trustworthy	60
	Untrustworthy	21
	Don't know	18
Broadsheet newspapers including online news sites (e.g. The Guardian, The Independent, The Times, The Telegraph)	Trustworthy	58
	Untrustworthy	26
	Don't know	16
Websites of campaigning	Trustworthy	58

http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_grants/documents/web_document/wtp053113.pdf

organisations or charities	Untrustworthy	21
	Don't know	21
Websites of chemical companies/pharmaceutical or other business	Trustworthy	56
	Untrustworthy	24
	Don't know	20
Wikipedia	Trustworthy	48
	Untrustworthy	27
	Don't know	25
Tabloid newspapers including online (e.g. The Sun, The Mirror, The Daily Mail)	Trustworthy	36
	Untrustworthy	50
	Don't know	14
Social media (Facebook, Twitter, other social networking sites) and blogs	Trustworthy	29
	Untrustworthy	47
	Don't know	24

Q.12 How trustworthy do you find ... as a source of information on chemistry in your everyday life? Base: Half sample (1,053 UK adults 16+)

Findings from the 2014 PAS survey suggest that people have ongoing concerns about the reporting of science, with seven in ten (71%) agreeing that "the media sensationalises science", however half (52%) think that the information they generally hear about science is generally true. Qualitative findings from the 2014 PAS highlighted that some people believed that Wikipedia science articles were usually written by lecturers, so could be considered trustworthy, While others treated it with suspicion. There are several on-going research projects looking at how much Wikipedia is perceived as a reliable source of information,[45] especially on health-related subjects and future findings will help to better understand the issue of trust in Wikipedia. In general few participants were found to trust social media sites as sources of science information and, in our qualitative workshops, respondents discussed perceptions of media 'scaremongering' in relation to chemicals – this is described in more detail in chapter 4.

[45] See: Trevena, L. (2011) *WikiProject Medicine,* BMJ 2011;342:d3387, accessed online at http://www.bmj.com/content/342/bmj.d3387 and Cancer Research UK https://meta.wikimedia.org/wiki/Research:Wiki4HE

Interest in key current debates and developments in chemistry

Overall there were high levels of interest in finding out more about developments across a wide range of topics related to chemistry. Interest ranged from 49% (in finding out more about developments in new communication technology such as smart phones) to 72% (in finding out what chemists are doing to develop new drugs, understand our bodies and brain and other breakthroughs in medical science). The top three answers given were:

- What chemists are doing to develop new drugs, understand our bodies and brain and other breakthroughs in medical science (72%)
- What chemists are doing to develop clean water technology (68%)
- What chemists are doing to make sure there's enough food to feed the world's population (65%)

Chapter 3: Public attitudes to chemists

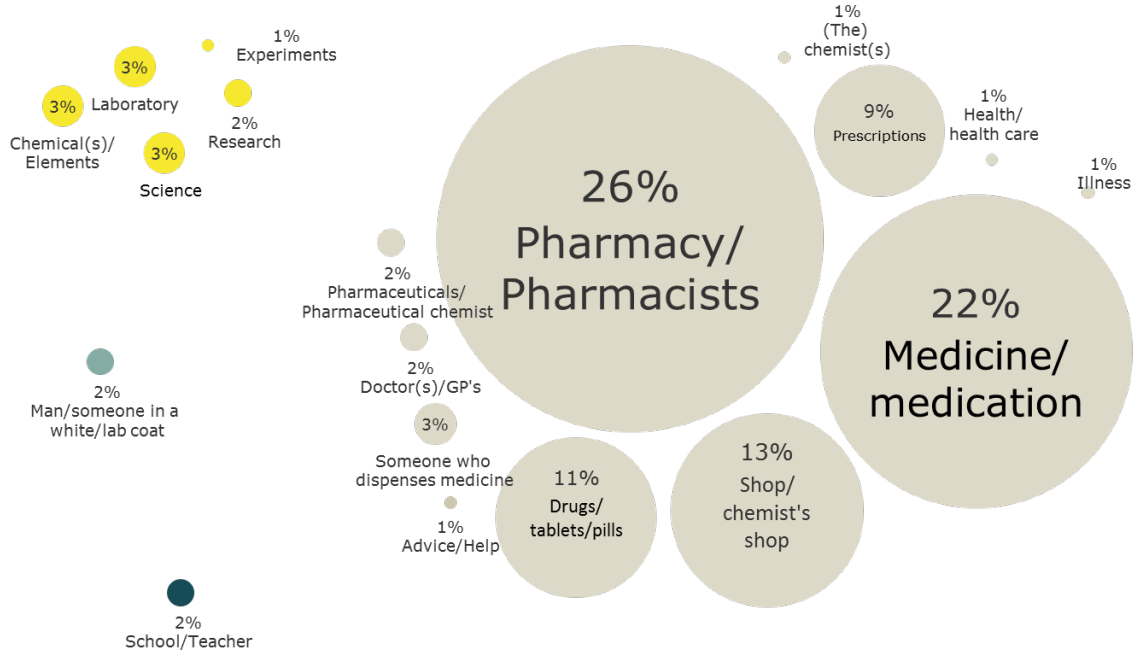
Key findings:

- Most people associate chemists with pharmacists, as they lack alternative examples of the kinds of industries chemists work in.
- Overall people viewed chemists positively, making a positive impact in the world and being trustworthy, honest and hardworking.
- Some of the negative views projected onto chemists stem from feelings of insecurity, related to chemistry more widely.

As with chapter 2, this section brings together the public survey data and the qualitative research findings, to understand attitudes to chemists and reasons for views. It starts with people's top of mind associations with the word chemist, and then explores in greater detail people's feelings towards chemical scientists.

Initial responses to the word chemist showed an overwhelming and strong association with pharmacists (26%), medication (22%), and the chemist's shop (13%). Only 2% mentioned school or teachers, despite 21% answering school or teacher in relation to chemistry, in the previous question in the survey.

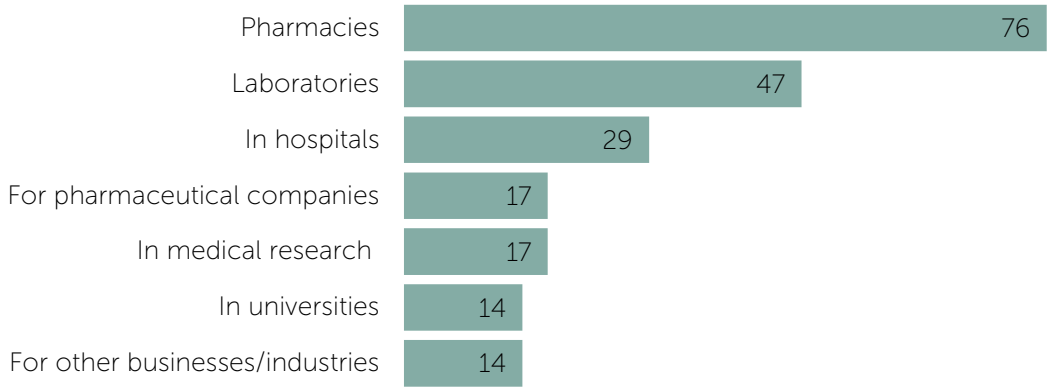
Table 3.1: People's top of mind associations with chemists



Q.2 When I talk about a chemist what comes to mind? Base: All respondents (2,104 UK adults 16+) *Multi-coded*

When asked where a chemist might work, three-quarters (76%) of respondents said a pharmacy, with one-in-four (25%) mentioning only pharmacies, and 31% mentioning only pharmacies or hospitals. The dominant image of the chemist is a pharmacist, and beyond this still has strongly medical and pharmaceutical connotations.

Figure 3.2: Top of mind perceptions on where a chemist might work (top 7 answers given)



Q.3 Where do you think chemists work? Base: All respondents (2,104 UK adults 16+) Multi-coded

At this point of the survey to try to overcome this strong association between "chemist" and "pharmacist", the interviewer provided a short explanation[46] to frame the chemist as a scientist that uses their knowledge of chemistry in their work.

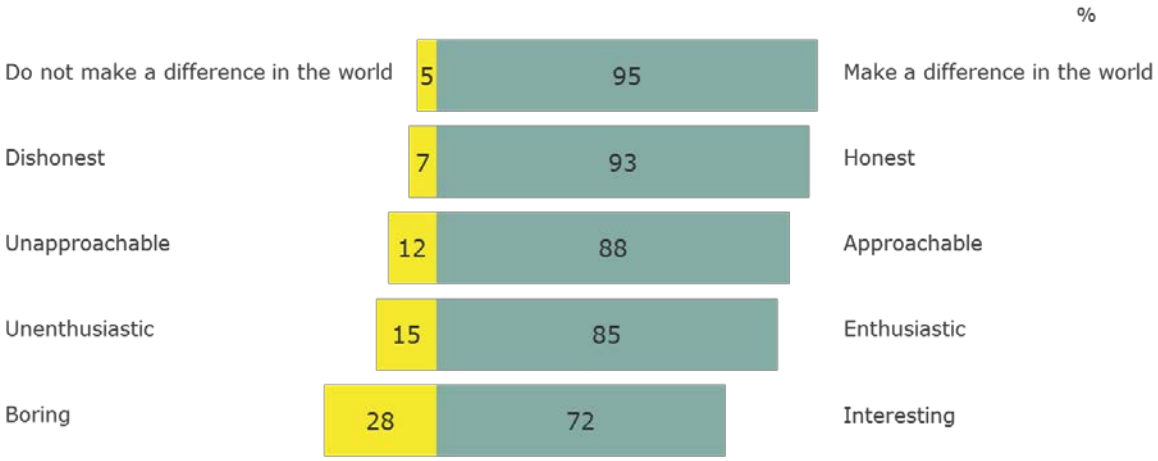
Opinions about chemists were highly positive, with 95% saying they thought chemists made a difference in the world, 93% saying they were honest, and 88% that they were approachable. This counters chemists' expectations as only 20% of them thought the public would view chemists as approachable. As mentioned above for these results we need to take into account the fact that respondents were likely to conflate chemists with pharmacists.

[46] After being asked in the public survey where chemists work they were read the following definition of a chemist to try to move people away from any stereotypes that might prevail: *A CHEMIST is a scientist who uses their knowledge of chemistry to understand what things are made of, create new materials and solve everyday problems with chemistry. Chemists work in a wide range of diverse settings, from developing new drugs, materials, flavours and even skin care products, to helping solve crime using forensic analysis. Please think about this definition when answering the following questions…*

Those who were not interested in scientific discoveries and those with low levels of engagement were more likely than average to find chemists boring (50% and 48% respectively compared to an average of 28%).

Young people aged 16-24 and those with children were also more likely than average to find chemists boring (38% and 32% respectively). Although they were no more likely than other groups to spontaneously mention school or teacher when asked what comes to mind when talking about a chemists or when asked where a chemist might work.

Figure 3.3: Perceptions of chemists



Q.5 Looking at these pairs of words or phrases, which one of each of these pairs comes closest to your current view of chemists? Base: All respondents (2,104 UK adults 16+)

Our survey results show encouragingly positive public views of chemists, contrary to some chemists' expectations.[47] This positivity, particularly relating to honesty and trust, was echoed in the qualitative workshops. Nevertheless, we would recommend some caution when interpreting these results, suggesting that in certain metrics, people's *degree* of support for chemists can to some extent be read as esteem for the profession of medical research and pharmacists. There are two main reasons for this:

First, in-depth discussion in the deliberative workshops revealed some negative perceptions of chemists, notably that they were not regarded as approachable, (whereas pharmacists were regarded as very approachable); and when compared to scientists, chemists were seen to lacking in agency (see table 2.11).

[47] 80% of respondents thought the public would view chemists as unapproachable. Source: Member's Survey, base 450 respondents.

Second, some respondents continued to conflate chemists with pharmacists, and to think predominantly of chemists as people mainly involved in development of drugs and medicines, *despite* explicit discussion of the different jobs chemists might be involved in. For example, in the second phase of workshops, after respondents had been introduced to a range of chemistry careers and specific jobs, another respondent noted her change in views since before taking part in the research:

> *"Chemists and chemistry are two separate things – "chemists" takes people to pharmacist but "chemistry" takes you to the lab."*
> (Southampton, Wave 1)

This was common across the groups, and for some the strength of the association took time to shift. As a result, survey responses should be interpreted with care, as it is possible that some respondents continued to make the association even when they knew it was not correct. However it is not to suggest that positive views do not exist in relation to chemists as scientists, as these were uncovered in deeper discussion in the qualitative workshops.

Attributes of a chemist – from the qualitative workshops

On the whole, images of chemists-as-scientists followed the same trend as views of chemistry, consisting predominantly of stereotypes. The 'mad scientist' image (male, middle-aged, wearing glasses and a lab coat) was replicated in almost all groups, with a few exceptions, with some people more likely to spontaneously say a chemist could be of either gender. However, respondents were not committed to these views, and readily acknowledged their characterisation of chemists as stereotypical, explaining that they were based on popular culture references, images from TV/news, and as a result of an absence of alternative examples.

> *"These are TV stereotypes, this is what the media portray."*
> (London Wave 1)

As with chemistry, perceptions of chemists' personalities expressed feelings of inferiority and social distance. Respondents uniformly said that chemists would be intelligent, but conscious of the 'intelligence gap' between themselves and the general public; wouldn't be relatable or sociable, or share similar interests. This echoes similar findings in relation to public attitudes to neuroscientists:

"The separation of self from science was underpinned by acute sensitivity to differentials in knowledge…Rather than a topic they could legitimately debate, the brain was the exclusive preserve of intellectual elite. The perceived complexity of the relevant knowledge precluded lay participation: unfamiliar, dense, and technical

language flagged scientific content as "not for me." The sense of an informational gulf between self and science therefore had a mutually reinforcing relationship with a social gulf between self and science. Scientific information was seen as so complex that those who comprehended it must be an entirely different category of person.[48]"

While these feelings can be applicable to many sciences and to some extent to science at large, they may be particularly amplified in relation to chemistry, a discipline that many viewed as particularly difficult. In the qualitative workshops, respondents described how chemistry required a particular kind of intelligence, given its abstract and complex nature. Chemists were described as clever to the point of fastidiousness, having a particular capacity and inclination for lists, order, and complexity – at the expense of sociability or relatability. These views reflect and are bound up in perceptions of chemistry, and it is clear that the conception of chemistry and chemists-as-scientists are mutually reinforcing for the public.

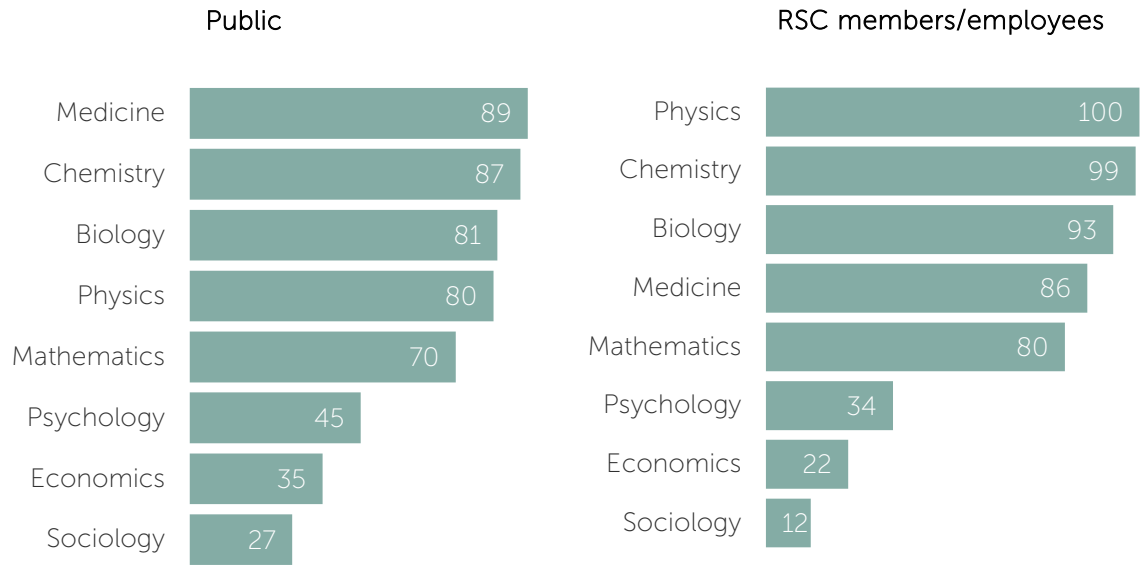
> *"[Chemists] are quite insular; you tend to think of them in a lab, not going out, unlike scientists."*
> (Birmingham, Wave 1)

In the survey, chemistry was deemed a 'hard science' in terms of how scientific it was compared to other disciplines (see figure 3.4). Though this isn't a question that measures perceived difficulty, it could be argued that lay distinctions between 'hard' and 'soft' sciences differentiate disciplines by rigour, complexity and impersonality on the 'hard' end of the scale, and more personal, understandable and everyday concepts on the 'soft' end.[49]

[48] O'Connor, C and Joffe, H. (2014) *Social Representations of Brain Research: Exploring Public (Dis)engagement With Contemporary Neuroscience*, Science Communication vol. 36(5) 617–645

[49] In the colloquial use of the term, hard sciences include complex (mathematical) rigour, and concern impersonal discoveries, seen as far removed from routine human experiences. On the other hand, 'softer sciences' are seen as related to more personal, understandable areas, and concern everyday concepts such as human relationships. Source: Frost, P. (2015) *Soft science and hard news,* accessed online at http://www.columbia.edu/cu/21stC/issue-1.1/soft.htm 07.05.15; and Storer, N. W. (1967) *The Hard Sciences and the Soft: Some Sociological Observations,* Bulletin of the Medical Library Association 55: 75-84

Figure 3.4: Scientific rating of disciplines (by the public and by Royal Society of Chemistry members/employees)



Public Survey Q.7A How scientific do you think ... is? Base: All respondents (2,104 UK adults 16+)
Member Survey Q5. How scientific do you think ... is? Base: All respondents (450)

Chemist profession

Though in-depth discussion and prompting, people were surprised and interested to learn of the range of industries that chemists might work in beyond the broad range of 'research projects', primarily encompassing pharmaceuticals/medicine, and to some degree for food or agricultural companies.

> *"I never would have thought that chemistry affects this industry. I'm surprised that they're not making tablets."*
> (Southampton, Wave 1)

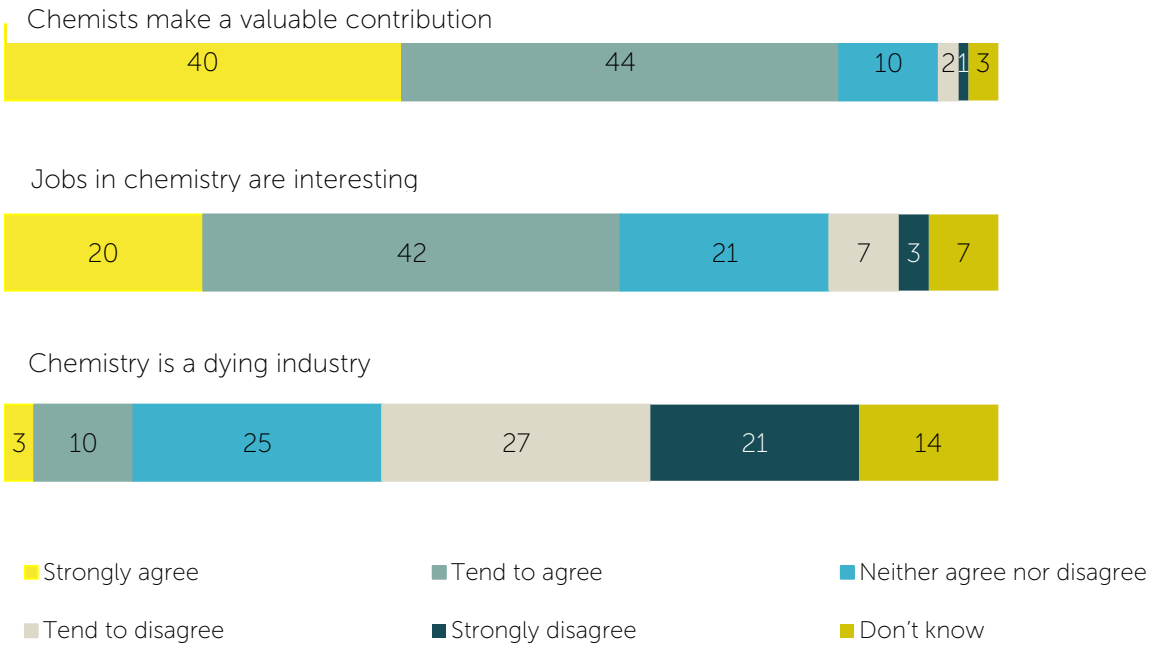
After watching videos depicting chemists in a range of industries, there was initially some scepticism that the jobs depicted were in fact related to chemistry, as they were seen as falling more into alternative professions, such as mechanical engineering, or biology. For others, the videos challenged their views and broadened the fields in which they could imagine chemists working.

> *"I don't think of that being chemistry; I associate cell level analysis with biology, he's a biochemist."*
> (London Wave 1)

Despite the qualitative research highlighting that individuals do not always acknowledge the range of industries that chemists work in the majority of people in our survey felt that chemists make a valuable contribution to society (84%). They were also generally positive about chemistry as a career, with six in ten (62%)

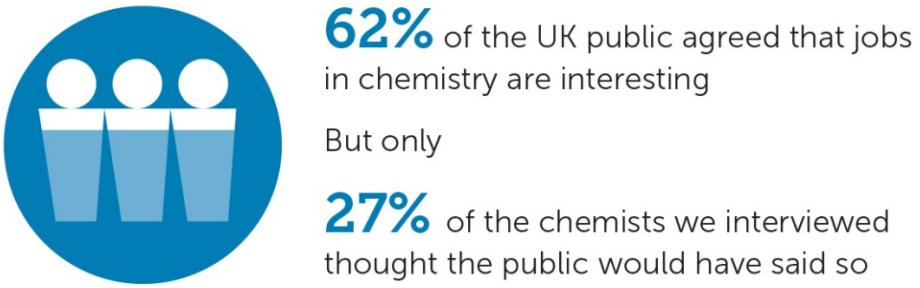
viewing jobs in chemistry as interesting and only 13% viewing chemistry as a dying industry. Similar findings were seen in the 2014 PAS – 73% agreed that jobs in science are very interesting and only 13% agreed that science is a dying industry in the UK. Younger people aged 16-24 were less likely than people aged 45 and over to agree that jobs in chemistry are interesting (54% and 66% respectively). This counters the expectations of chemists we interviewed, as only 27% thought the majority of the public would agree that jobs in chemistry are interesting (figure 3.6).

Figure 3.5: Public perceptions of chemists and jobs in chemistry



Q.6 I'm now going to read out some statements about chemistry, for each one please could you tell me the extent to which you agree or disagree? Base: All respondents (2,104 UK adults 16+)

Figure 3.6: Public perceptions of jobs in chemistry compared to expectations



Public Survey. Q.6 I'm now going to read out some statements about chemistry, for each one please could you tell me the extent to which you agree or disagree? Base: All respondents (2,104 UK adults 16+).
Member Survey Q1_3. What proportion of people do you think would agree that...Jobs in chemistry are interesting. Base: All respondents (450)

Chapter 4: Public attitudes to chemicals

Key findings:

- People were relatively neutral about chemicals, but had quite a nuanced, multifaceted understanding of them, containing both positive and negative attributes.
- Overall, top of mind associations with chemicals tended to be slightly more negative in character, as the word was used to refer to synthetic or harmful chemicals, and people do not feel adequately informed about their use. However, they were also believed to have positive impacts on society and the majority answered key questions aimed to test potential misconceptions correctly.
- Views on chemicals did not impact on views of chemistry and chemists.

In contrast to chemistry, there is already a fair amount of research and inquiry into public attitudes to chemicals,[50] driven by interest from government, regulators and industry, primarily to understand how to improve consumer confidence, and in relation to public backlash against the chemical industry following accidents, chemical spills, and media coverage. A lot of this work is concerned with attitudes towards particular types of chemicals, such as toxic chemicals; their use in specific contexts such as impact on the environment, or in relation to the governance of chemical developments such as monosodium glutamate (MSG). This chapter looks instead at attitudes to chemicals in a much broader sense, seeking to understand how people understand the term chemicals; their knowledge of and feelings about chemicals; and the basis and manoeuvrability of views. It also explores the degree of interaction between attitudes towards chemicals on the one hand, and perceptions of chemistry and chemists on the other.

Public meaning of chemicals

The way in which the word 'chemical' was commonly understood by participants in the workshops did not mirror the scientific one.[51] Universally they were referring to a sub-set of a particular type of chemicals with the following characteristics:

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[50] European Commission (February 2013) *Flash Eurobarometer 361, Chemicals* available online at http://ec.europa.eu/public_opinion/flash/fl_361_en.pdf and European Commission (September 2014) *Special Eurobarometer 416, Attitudes Of European Citizens Towards The Environment* available online at http://ec.europa.eu/public_opinion/archives/ebs/ebs_416_en.pdf

[51] Smith-Patten et al have described the evolution of the word 'extinction', where public usage of the term extinction has diverged from that of conservation scientists, leading to *"a disconnect between*

- A substance that is synthetic, or man-made
- A substance that is potentially toxic or harmful, or with unknown properties, that could have a negative impact on the environment or human health

Examples given included:

- Artificial preservatives and additives in food; pesticides; beauty treatments such as Botox
- Manufactured poisons and chemical weapons
- Substances requiring hazard labelling on packaging, such as household cleaning products

The surface and common meaning[52] of chemicals was thus a short-hand to refer to potentially harmful, synthetic materials, and/or specific areas of concern. Though this was the principal meaning, it was not the only meaning, and respondents showed their definitions were multiple and context-dependent.

Public understanding of chemicals

In the qualitative groups, respondents recognised that H_2O could be described as a chemical, that the periodic table showed different chemical elements, and that there are 'safe' chemicals as well as dangerous ones. This was reflected in our survey results, with three-in-four (75%) disagreeing that all chemicals are dangerous and harmful.

> *"The periodic table* means *everything is made of chemicals"*
> (London, Wave 1)

We included in our survey some questions to measure people's familiarity with concepts about chemicals. This comprised five statements, and respondents were asked to what extent they agreed or disagreed with each. Encouragingly the majority of individuals identified the correct answer, which suggests that misconceptions about chemicals are perhaps not as widespread as so many chemists expected.

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how scientists and the lay public understand extinction". See Smith-Patten et al (2015) *Is extinction forever?*, Public Understanding of Science, vol. 24 no. 4 481-495

[52] It could be argued that previous research studies conducted into public attitudes to chemicals are not only capturing attitudes about 'synthetic/harmful' chemicals as described here, but also that the research itself and the questions it asked also employ a lay definition, rather than a scientific one. For example, in Flash Eurobarometer 361 survey on chemicals, more than nine in ten respondents say that, in their opinion, cleaning products and paint contain chemical substances (96% and 95% respectively). Only three-in-four (75%) of the same sample said there were chemicals in in children's toys.

While not directly comparable, this data can be looked at in relation to data from the Flash Eurobarometer 361,[53] where seven-in-ten (69%) respondents said that it is not possible to eliminate chemical substances from our daily life while (29%) said that it is possible to do so. It is somewhat difficult to interpret these results, given the latter response could mean either:

a) everything is composed of chemical elements, thus they are unavoidable, or
b) the use of synthetic chemicals is so widespread as to be unavoidable.

People expressed more ambivalence in their responses to the idea of the relative safety of natural/synthetic chemicals with 15% stating that they did not know which were safer. While most (67%) agreed that chemicals *can be* natural (that is, disagreeing that all chemicals are man-made), two in five (40%) said natural chemicals are safer than man-made chemicals.

Table 4.1: Questions about chemicals

Statement	Agree/disagree	%
All chemicals are man-made	Agree	25
	Disagree	67
	Don't know	8
All chemicals are dangerous and harmful	Agree	19
	Disagree	75
	Don't know	6
Natural chemicals are safer than man-made chemicals	Agree	40
	Disagree	44
	Don't know	15
Everything including water and oxygen can be toxic at a certain dose	Agree	70
	Disagree	18
	Don't know	13
Everything is made of chemicals	Agree	60
	Disagree	30
	Don't know	11

Q.13_02 Can you tell me the extent to which you agree or disagree with the following statements? Base: All respondents (2,104 UK adults 16+)

[53] European Commission (February 2013) *Flash Eurobarometer 361, Chemicals* available online at http://ec.europa.eu/public_opinion/flash/fl_361_en.pdf

Figure 4.2: Whether agree/disagree that natural chemicals are safer than man-made chemicals

Q.13_03 Can you tell me the extent to which you agree or disagree with the following statements? Natural chemicals are safer than man-made chemicals Base: All respondents (2,104 UK adults 16+)

Certain groups within the population were more likely to agree that natural chemicals are safer than man-made chemicals. Women were more likely than men (44% and 37% respectively), ethnic minorities were more likely than white people (57% compared with 38%), individuals educated to GCSE level or below were more likely to agree than those educated to A-level or above (48% compared with 35%), lower social economic groups (DE) were more likely than higher socioeconomic groups (ABC1) (46% and 36%) and tabloid newspaper readers were more likely to agree than people who read broadsheet newspapers (46% and 31% respectively).

Despite some mixed feelings about man-made chemicals, the majority (63%) of people disagreed with the statement that chemistry is unnatural.

Figure 4.3: Whether agree/disagree that chemistry is unnatural

Q.6_09 I'm now going to read out some statements about chemistry, for each one please could you tell me the extent to which you agree or disagree? Chemistry is unnatural Base: All respondents (2,104 UK adults 16+)

The opposition between 'naturalness' and 'unnaturalness' is a common trope within public discussions of science, as people can think of 'science' acting on and changing 'nature', creating something 'unnatural' with potentially concerning consequences. The dichotomy between natural/synthetic, with definite positive and negative poles, is strongly felt and is a category underlying much of public

discourse and thinking. In the qualitative workshops, there was a strong and commonly held view that synthetic chemicals were necessarily less safe or more toxic than natural ones, and emotional push back against statements to the contrary. A few respondents did not feel as strongly that synthetic chemicals were definitely dangerous, and expressed resignation and mild indifference to their use in everyday products – though still maintained they were different in kind to natural chemicals.

> *"Synthetic chemicals versus natural chemicals – I've always thought they were different, so I'm not entirely convinced. What about the by-products created when making that chemical? There's bound to be wastage…I still think natural is better."*
> (Newcastle, Wave 2)

Some respondents in the groups had previously thought all chemicals were synthetic, and were surprised to learn that some chemicals with names that they recognised (E numbers, for example) could be the same as something naturally occurring.[54] Though this shift did nothing to upend the *natural=good / synthetic = bad* distinction, it made them feel more positive about the chemicals overall as it prompted them to think about natural chemicals.

Feelings about chemicals

Despite some seemingly negative connotations of chemicals, there was not an overall negative view of chemicals – rather there was one of neutrality (55%), with just under one-in-five (18%) reporting feeling positive (happy or excited).[55]

In the qualitative workshops, participants spontaneously described positive, neutral and negative attributes and categories of chemicals. People were asked about their top-of-mind associations, and then were prompted to think about what they knew and felt about the use of chemicals in various areas, such as food, and energy.[56]

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[54] Respondents picked up on detail of stimulus used in wave 2 of the qualitative groups, one stating "*Why is the synthetic food additive E300 bad, while the vitamin C in your freshly squeezed glass of orange juice is good? (even though they are both the same thing)"* and another stating "Many E numbers are of natural origin". See technical report for details.
[55] Q.4C Which of the following describes how you feel about chemicals? Base: All respondents (2,104 UK adults 16+)
[56] The full list of areas prompted was: (Unprompted top of mind), food, cosmetics, farms, clothing, medicine, energy. Associations were then sorted by the groups, into categories of the participants' own making.

Across the groups, the themes that emerged were:

- 'Everyday': in cleaning products and cosmetics, etc.
- 'Big' technologies: Nuclear weapons, fracking, solar energy
- 'Scary': weapons, suspicious, controversial, unseen or hidden, dangerous
- Negative applications/impacts: entering the food chain, environmentally unfriendly, animal testing, processed foods, GM food, misuse
- 'Experimental'/research: animal testing; Botox; medicinal chemicals; pesticides; GM food
- Positive: for a purpose, useful, critical/necessary, essential, enhancing, fundamental, regulated
- The future: out of mind, progress, short term good, unknown

Chemicals were primarily evaluated on whether their application was being used for social or environmental 'good' on the one hand, and whether there were unknown risks or consequences on the other. Though there was some wariness among respondents about the uses of chemicals in certain 'hidden' industries, in general people were fairly neutral about the use of every day chemicals.

> *"When you talk about chemicals and testing it becomes hush hush…they keep it all closed doors…people's perceptions of it are so varied because we don't understand the end game".*
> (Birmingham, Wave 2)

> *"It goes without saying that chemicals are part of food, with GM products. Now I wouldn't say so much that it bothers me, it being in food, because I think, people need to eat…and me personally, I'd rather have food that didn't go off straight away, than worry about organic."*
> (Southampton, Wave 2)

People recognised that chemicals were 'fundamental' and useful, though were generally unspecific about what these positive applications were beyond medicines and drug research.

There were also some more strongly negative views, particularly in relation to chemicals that were encountered or potentially eaten every day. Respondents felt they as consumers were unable to control how these chemicals were used, or properly understand the attendant risks, for example with some food additives or pesticides. This was a highly emotive area for some.

Feeling informed

Respondents spontaneously said that they recognised widespread 'media scaremongering' about chemicals, inconsistencies in advice about certain products or foods, and as a result generally disengaged from the issue. In the qualitative workshops, respondents said that chemicals were not a pressing area of concern for them, and not something they had thought about much before, or explicitly sought information about.

> *"It's not realistic to worry about chemicals in everyday life.'*
> (Southampton, Wave 1)

> *"If it's blown up in the media, then you might worry about it but everyone's so busy doing things what they are every day you don't think what role science plays in your life."*
> (Birmingham, Wave 1)

Given the nature of media coverage, however, people felt they did not have adequate information about chemicals to feel informed. Further, they felt it would be difficult for them to make decisions on the safety of certain chemicals as they would not possess the requisite knowledge, and that even scientists were unsure about the long-term impacts of some substances. During discussion, respondents said they did not feel that informed about chemicals, that they did not get trusted information about chemicals, with their information sources being the media, mainly news, and packaging and food labels.

> *"How can you know the long term effects, no one really knows do they?"*
> (London, Wave 1)

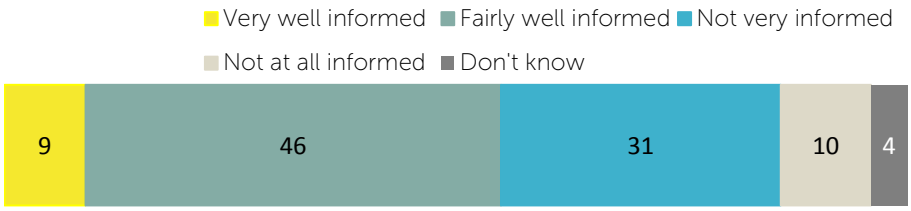
In our public survey, just over half (54%) of the UK public felt informed about chemicals in their daily lives, with one in ten (9%) feeling very informed and 45% feeling fairly informed.

Individuals with a lower social grade (C2DE) were more likely than those with a higher social grade (AB) to say that they do not feel informed about chemicals in their everyday lives (46% and 37% respectively).

People were more likely to feel informed about chemicals than chemistry more widely (54% compared with 41%). Although this is perhaps to be expected given the scope of chemistry is broad-ranging.

Findings from the Special Eurobarometer 461 highlight that the UK public feels relative well informed about the health impact of chemicals used in everyday products. Only 33% said that they lack this information. UK responses were among the lowest and lower than other country like Sweden (56%) and Greece (49%).

Figure 4.4: How well informed the public feel about chemicals in their daily lives



Q.9A How well informed do you feel about chemicals in your everyday life? Such as chemicals in cleaning products, cosmetics and materials in general. Base: All respondents (2,104 UK adults 16+)

Chemicals = chemistry?

A clear finding of this research was the associative separation that existed between chemicals and chemistry for respondents. Views and feelings about chemicals, positive or negative, were not attributed to chemistry or chemists. Notably, discussion about chemicals, even if it shifted people's views, had almost no subsequent impact on their views of chemistry or chemists. Not only did it fail to change views, but was in fact a relatively laboured connection to make in the qualitative groups, demonstrating the limited overlap between these categories.

Further, even among those who were most negative about chemicals, many had positive views of chemistry overall. In our public survey, 19% of respondents agreed with the statement "all chemicals are dangerous and harmful" – but 53% of this group still agreed that the benefits of chemistry are greater than any harmful effects.

There appear to be several reasons for this separation. Chemists escape tarnish by some of the more negative views of chemicals because they are viewed to have little to do with the direct production of harm, and to have little intention to do harm (linked to idea of noble motives, and potentially the perception that they have limited agency or involvement with the end product of their work). Though chemists might work with chemicals, it was 'corporations' who made decisions that could impact the public negatively, driven by profit rather than by societal good.

> *"Chemists don't make these decisions. It's all about money, chemists are the pawns."*
> (London, Wave 1)

Chemicals were not spontaneously associated with the development of drugs or medicines, despite preceding discussion focussing heavily on this in relation to chemists' work. This could in part explain the gap in connection between the two.

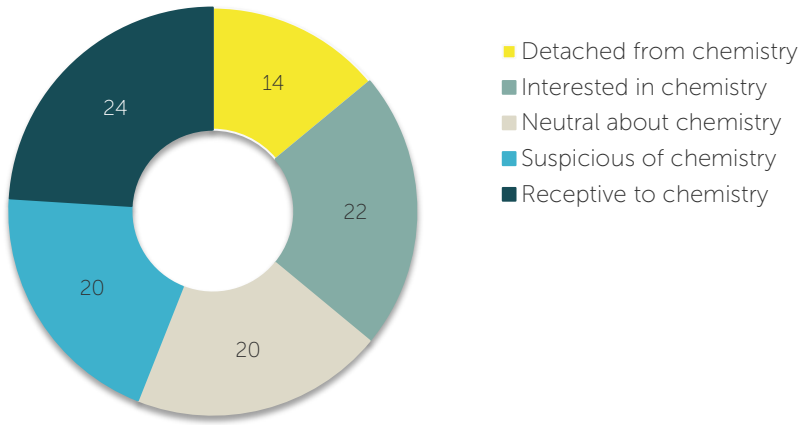
Chapter 5: Segmentation: how different people think differently about chemistry

To examine differences in attitudes beyond simple "bivariate" relationships (e.g. differences between men and women), TNS BMRB carried out a factor and cluster analysis of the responses to a number of key attitude statements on the quantitative survey. This is a statistical technique used to segment the population into distinct clusters of people who have similar attitudes to chemistry (more details can be found in the technical report).

It is worth noting that this is a purely attitudinal based segmentation and while we do still see some demographic differentiation falling out naturally, this is less dominant. Although this means the segments are less easy to identify with a traditional demographic route they have clearly defined attitudes and can help guide differential communications development and messaging.

The cluster analysis identified five distinct clusters. The chart below shows the proportion of the UK population that belongs to each cluster:[57]

Figure 5.1: Segmentation



Un-weighted base: 2,035 UK adults 16+

The rest of this chapter provides a description of each cluster. Where relevant, we have included some quotes from the qualitative research.

[57] 69 cases were excluded from the segmentation clusters – 46 cases were excluded because they said 'don't know' to all statements in Q8 & Q13 and a further 23 were deleted because they had more than 6 'don't know' responses at Q6.

Please note that the clusters group together people who tend to have similar attitudes across a range of areas, but not identical attitudes in each area. Therefore, if the people in one cluster are more likely to hold a certain view, this does not necessarily mean that most people in that cluster hold this view. Clusters should be seen as illustrative typologies rather than exactly representing the views of a group of the population.

We have given each cluster a name that reflects their overall stance. Again, it should be noted that these names cannot reflect the whole breadth of opinion within each cluster and instead are chosen to represent the overall defining characteristics.

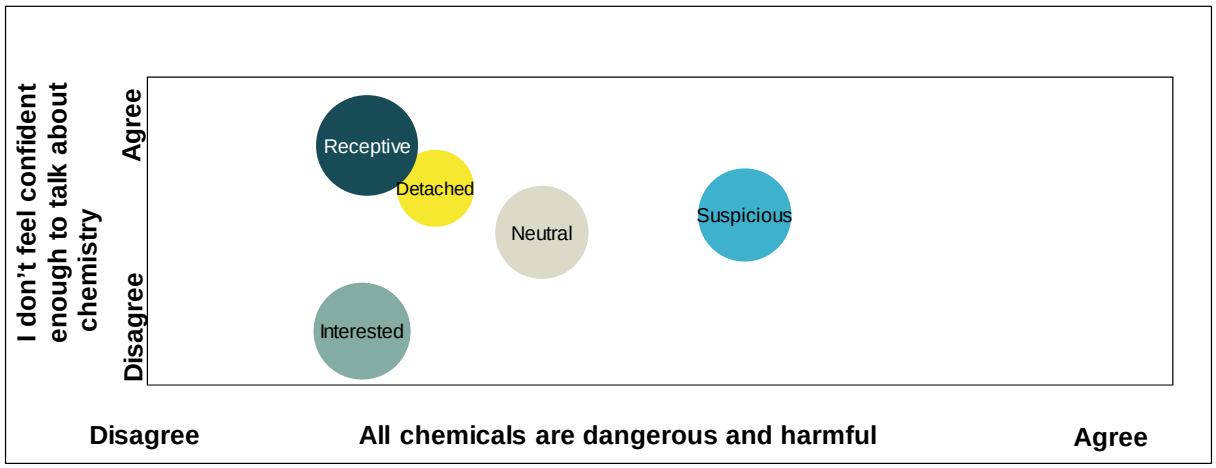
Please note that any comparisons made to the average (or overall percentage) refer to the combined figures across all segments (an un-weighted base of 2,035) and so they will not necessarily match the percentages quoted in the rest of the report (which are based on the full sample 2,104).[58]

Our five segments are

1. Detached from chemistry
2. Interested in chemistry
3. Neutral about chemistry
4. Suspicious of chemistry
5. Receptive to chemistry

Figure 5.2 demonstrates how the segments may be mapped to look at the relationships between attitudes commonly held by each group.

Figure 5.2: Belief that chemicals are dangerous and confidence to talk about chemistry



[58] In addition don't know codes were substituted with mean scores for the analysis of the following questions Q4a, Q6, Q7a, Q7b, Q8, Q9a, Q9b, Q13, Q16 and social class

Segment 1: Detached from chemistry

This is the smallest cluster, forming 14% of the total sample. Members of the detached from chemistry cluster are defined by their lack of interest in chemistry and scientific developments. They tend not to identify any benefits brought by chemistry and do not feel that it is important to know about chemistry in their daily lives.

Attitudes to chemistry

The detached from chemistry are less likely to understand or see the benefits of chemistry. They are least likely to agree that:

> *It is important to know about chemistry my daily life (25% agreeing compared with an average of 57%)*
>
> *The chemistry learnt at school has been useful in my daily life (10% agreeing compared with an average of 32%)*

Seeing or appreciating little personal benefit from chemistry, they are also less likely to make a positive connection between chemistry and well-being. In this segment only one in five (20%) said that they thought chemistry had a very positive impact on well-being compared with an average across all segments of 45%.

Along with the neutral about chemistry cluster, the detached from chemistry do not feel well informed about chemistry (75% said that they do not feel informed compared with an average of 57%) and are the least likely out of all of the groups to be interested in scientific developments (23% compared with an average of 67%).

This low level of interest is perhaps not surprising given this group struggles to appreciate the benefits of chemistry. This cluster also shows a lower-than-average interest in chemistry, with the lowest level of reported interest across all of the nine topics tested. The highest level of interest was seen in what chemists are doing to develop new drugs, understand our bodies and brains and other breakthroughs in medical science – although this was still substantially lower than average (26% were interested compared with an average of 76%).

It is not surprising therefore that when the detached from chemistry were asked to rate engagement/interest in chemistry on a scale of one to ten they were the least engaged cluster (73% gave a low score of 1-3 compared with 43% overall). Perhaps a feature of this lack of engagement is that many responded to attitudinal statements about chemistry by neither agreeing nor disagreeing.

This lack of engagement could be due to a perception that chemistry and chemists are boring. As this cluster were more likely than other clusters to say that chemistry makes them feel bored (25% compared with an average of 10%) and to perceive chemists as boring (54% compared with 27% overall). Unsurprisingly then the detached from chemistry are least likely to agree that jobs in chemistry are interesting (38% compared with 64% overall). Given that this cluster are least likely to have chemists/scientists among their friends/family or to work with chemists/scientists (15% versus 26% overall) it is likely that this perception of chemists and the chemistry profession is based on stereotypes (or their school teacher).

It could also however be due to a lack of confidence as the majority (64%) do not feel confident talking about chemistry, although they are not as unconfident as the receptive to chemistry cluster.

Demographics

The detached from chemistry are one of the less educated clusters alongside the neutral about chemistry. A quarter (24%) has no formal qualifications (compared with an average of 17%). They are relatively evenly spread across the different age groups but slightly more likely to be 16-24 (19% compared with an average of 14%) and 45-54 (22% compared with an average of 16%). Relatively few people from ethnic minority backgrounds belong to this cluster (6% compared with an average of 14%).

Media

The detached from chemistry are more likely than all other segments to say that they do not currently hear or read stories about chemistry/chemicals (30% compared with an average of 13%). On a similar note they are also less likely to regularly read newspapers (61% do not read a regular newspaper compared with an average of 47%).

The detached from chemistry also had more difficulty than other groups identifying how trustworthy different sources of information on chemistry/chemicals were and were more likely that average to response that they ‘don’t know’ across all of the sources asked about.

Segment 2: Interested in chemistry

The interested in chemistry cluster (22% of sample) is defined by high levels of engagement and interest in chemistry. They are the most likely segment to have studied science and/or be scientists and/or know or work with scientist.

Attitudes to chemistry

This cluster has very positive attitudes towards chemistry and they appreciate the benefits it brings to society. They are the group most likely to agree that:

> *It is important to know about chemistry my daily life (85% agree compared with 57% overall)*
>
> *The chemistry learnt at school has been useful in my daily life (70% agreeing compared with 32% overall).*

The interested in chemistry believe that chemistry has a very positive impact on well-being. Six in ten (60%) gave a very positive score (5) when asked what impact they thought chemistry had on well-being compared with an average of 45%.

The interested in chemistry are confident talking about chemistry in their daily life (63% feeling confident compared with 26% overall) and school did not put them off chemistry (87% disagreed that school put them off chemistry compared with an average of 52%). They also feel well informed about chemistry (80% feeling informed compared with 42% overall).

They are also the cluster most interested in scientific developments more broadly (92% versus 67% overall) and are interested in finding out more about a wide range of different aspects of chemistry.

Their interest perhaps reflects their relatively close proximity to chemistry/science in their lives. They are more likely than average to have chemists or scientists among their relatives, friends and family or to work with them (45%, versus 26% overall) and to have studied chemistry/science to at least A Level (44%, versus 21% overall).

As you might expect the interested in chemistry have higher levels of engagement than all other segments (36% gave a high score, of 8-10, compared with 14% overall).

They are more likely to say that chemistry makes them feel excited (25% versus 11% overall) or happy (38% versus 20%) and less likely to feel bored (1% versus 10%), confused (3% versus 11%) or neutral (38% versus 52%). This group is also most likely

to agree that jobs in chemistry are interesting (84% versus 64% overall) and to strongly agree that chemists make a valuable contribution to society (61% agreeing strongly compared with 41% overall).

Demographics

The interested in chemistry is spilt 61% male and 39% female, has above-average AB social grade representation (34% compared with 23% overall) and is well-educated (47% educated to degree level or higher compared with an average of 28%).

There is a broad representation of age groups, with the 55–65 years band being slightly higher than average (19% compared with an average of 15%).

Media

Of the broadsheets, the Guardian (13%) or the Daily Telegraph (11%) is favoured during the week, and of the tabloids 15% are regular Daily Mail readers.

When asked about the ways in which they receive information about chemistry or chemicals in their daily life, the interested in chemistry gave the widest range of sources, citing almost all vehicles tested more than average. Only 3% stated that they never hear or read stories about chemistry/chemicals compared with 13% overall. They were also more likely to cite a wide range of sources when asked where they would actively go to seek out information.

The interested in chemistry are more trusting than others of most sources of information about chemistry/chemicals, including websites of chemical companies, government websites and websites of research institutions or universities.

Segment 3: Neutral about chemistry

The neutral about chemistry cluster makes up 20% of the population. They have average levels of engagement and interest in chemistry and appreciate the societal benefits however they consider themselves to be the least informed of all segments. They appear to have some underlying worries about chemistry but perhaps struggle to fully understand and communicate these concerns and are not particularly interested in finding out more about chemistry.

Attitude to chemistry

The neutral about chemistry have neutral attitudes towards chemistry however they are "not anti-chemistry". Indeed they are more likely than the detached from chemistry and the suspicious of chemistry to feel that chemistry has a positive impact on well-being (56% felt that chemistry had a very positive impact – a score of five – compared with 45% on average).

Unlike the detached from chemistry, the suspicious of chemistry and the receptive to chemistry clusters, the neutral about chemistry do not appear to have had a negative experience of chemistry at school – 61% disagreed that school had put them off chemistry compared with an average of 52%.

Although not anti-chemistry, the neutral about chemistry appear slightly worried about certain aspects of chemistry – perhaps as they feel the least informed of all of the segments (93% do not feel informed compared with 57% overall). Despite feeling uninformed there does not appear to be a great desire to find out more about developments in chemistry and science.

Although the questionnaire did not specifically capture concerns about chemistry, some of the answers indicate that the neutral about chemistry may hold some common misconceptions about chemicals, although this is likely to be because they are uninformed rather than holding specific concerns about chemicals– 88% did not feel informed about chemicals compared to an average of 43%.

They are more likely to agree that:

> *Natural chemicals are safer than man-made chemicals (49% agree compared with 41% overall)*
>
> *All chemicals are man-made (35% agree versus 25% overall)*

Demographics

This group is slightly less well educated than most of the other segments with a quarter (24%) having no formal qualifications. This is to a certain extent reflected in their social class – one fifth (20% compared with an average of 15%) are social class E (reliant on state benefits) otherwise they are more likely than average (25% compared with 21%) to be social grade C2 (skilled manual workers).

This cluster, along with the suspicious about chemistry, has one of the highest proportions of people from ethnic minority backgrounds (20% versus 14% overall).

Media

The neutral about chemistry are less well defined than other clusters by their media consumption, which tends to be close to average.

As with the other groups, the information this group receives about chemistry comes mainly through television news and documentaries and the national press. They are however more likely than all other segments except the detached from chemistry to say that they do not hear or read stories about chemistry (23% compared with 13% overall).

Segment 4: Suspicious of chemistry

The suspicious of chemistry cluster (20% of the sample) are less likely to see the positive impact that chemistry has on well-being. However they feel fairly to well-informed about chemistry and are interested in finding out more about specific developments – particularly those that have a direct impact on them personally. They are also the group most likely to have a preference for natural rather than man-made chemicals.

Attitude to chemistry

The suspicious of chemistry like the detached from chemistry cluster were less likely to feel that chemistry has a positive impact on wellbeing (21% felt that chemistry had a very positive impact – a score of five – compared with 45% overall).

Unlike the neutral about chemistry they feel fairly to well-informed about chemistry (57% compared to an average of 42%) and are interested in finding out more about specific developments. In particular they are interested in developments that are likely to impact on them personally – such as food processing (79% interested compared with 65% overall), chemicals used in everyday life (76% compared with 62% overall), the history of medical drug discoveries (69% versus 59% overall) and what chemists are doing to develop new communications technologies such as smart phones (66% compared with 52% overall).

While the suspicious of chemistry did not have particularly strong opinions, they are a little unsure about chemistry as an industry:

51% disagree that chemistry is a dying industry compared with 61% overall

59% agree that jobs in chemistry are interesting compared with 64% overall

However what separates this segment out from others is their perception that chemistry is unnatural:

Chemistry is unnatural (34% agree compared with an average of 13%)

Natural chemicals are safer than man-made chemicals (73% agree compared with an average of 41%)

All chemicals are man-made (58% agree compared with an average of 25%)

All chemicals are dangerous and harmful (50% agree compared with an average of 20%)

Despite holding these views, like most other segments, this group has primarily neutral feelings towards chemistry (57% said that chemistry makes them feel neutral) and the majority (58%) also felt neutral about chemicals – however it is

worth noting that a few people in this segment (6%) said that chemicals make them feel angry.

It is possible that people in this group are just generally more worried about a wide range of issues (for example other research[59] has shown that tabloid newspaper readership is linked to higher levels of worry about crime).

Demographics

The suspicious of chemistry are slightly more likely to be aged between 35 and 44 (21% compared with an average of 16%). They are less likely to be from an affluent social class (AB) – 14% compared with 23% overall and are slightly more likely to be from social grade D (18% compared with an average of 14%) – otherwise they are fairly evenly spilt across social grade.

They have a higher than average representation of people from ethnic minority backgrounds (24% compared to 14% on average).

Media

The suspicious of chemistry have relatively average levels of trust for all sources of information about chemistry/chemicals although they are slightly more trusting than average of tabloid newspapers (49% trust tabloid newspapers compared with 35% on average). This is reflected in their newspaper readership as the two most common papers they read regularly are the Sun (15%) and the Daily Mail (15%).

[59] Office for National Statistics (March 2015) *Crime survey for England and Wales Chapter 2: Public Perceptions of Crime* available online at http://www.ons.gov.uk/ons/dcp171776_399681.pdf

Segment 5: Receptive to chemistry

24% of the sample belong to the receptive to chemistry cluster, making it the largest cluster. While they have average levels of engagement with chemistry they are quite interested in scientific developments more generally. They can see the benefits and contribution that chemistry makes however they do not think that they need to know about it in their daily lives. Overall they are the least confident group.

Attitudes to chemistry

The receptive to chemistry are less likely than other clusters to agree that "it is important to know about chemistry in my daily life" (43%, versus 57% overall). Despite this they have an appreciation of the societal value of chemistry and are more likely than average to agree that chemists make a valuable contribution to society (95% and 88% respectively) and were more likely to believe that chemistry has a very positive impact on well-being (56% compared with 45% overall).

The receptive to chemistry are the least confident and are more likely than other segments to agree that "I do not feel confident talking about chemistry" (78% compared with 53% overall).

Perhaps in part due to views held about the importance of chemistry in their everyday life, the receptive to chemistry are more likely that average to disagree that the chemistry learnt at school has been useful in their daily lives (72% versus 47% overall). They were also more likely to say that school had put them off chemistry (42% agreed compared with 25% overall).

Despite lacking in confidence, the receptive to chemistry exhibit high levels of interest in scientific discoveries (76% were interested compared with 67% overall). They are also particularly interested in finding out more about "the bigger picture" for developments in chemistry such as:

> *What chemists are doing to develop new drugs, understand our bodies and brains and other breakthrough in medical science (89% versus 76% overall)*
>
> *What chemists are doing to develop clean water technology (84% compared with 72% overall)*
>
> *What chemists are doing to make sure there's enough food to feed the world's population (85% compared with 69% overall)*

This suggests that perhaps their attitudes to everyday chemistry and the chemistry learnt at school may not be because they are not interested, but rather because they do not have the confidence in their ability.

The receptive to chemistry, like others, generally has neutral feelings about chemistry however they are more likely than average to say that chemistry makes them feel confused (18% versus 11% overall).

The receptive to chemistry are generally positive about chemists and are more likely than average to view chemists as interesting (79% compared with 73% overall).

Demographics

The receptive to chemistry are slightly more likely to be aged 65 or older (23% compared with 19% overall) and are from a range of social classes although slightly less likely to be from social grade D or E (23% compared to 29% overall). Given their age they are more likely to be retired (30% compared with 23% overall). Like the detached from chemistry cluster, the receptive to chemistry are more likely to be from a white background (95% compared to 86% on average).

Media

Television tends to be the receptive to chemistry most regular source of information on chemistry or chemicals (70% compared with an average of 58%). They are more likely than average to use the internet generally if they need or want to find out more information about chemistry or chemicals (60% compared with an average of 51%).

Chapter 6: Opportunities and challenges in communicating chemistry to the public

Key findings:

- People were fairly neutral about chemistry, and needed positive concrete examples to move them beyond this:
    - People responded most to everyday, tangible, and familiar examples, as this helped overcome chemistry's remoteness
    - They made a positive emotional connection to real life implications and outcomes of chemistry, that demonstrated impact on things that mattered to them
- People were deterred by use of scientific terminology and chemical diagrams, preferring simple language.

This chapter looks at potential areas for influencing views, based on what people responded to most positively in the workshops. It also highlights areas people found more confusing, or were sceptical about, and the channels through which they wanted information. This is then put in the context of chemists' objectives, to examine where their aims for engagement and the needs of the public align, indicating areas to focus on. Finally, it outlines some key principles for the communication of chemistry, based on the findings of this research and science communication generally.

This section provides the evidence and rationale behind the practical guidance for communicating chemistry.

Our communication toolkit can be found at rsc.il/pac

Challenges and opportunities

Current public attitudes to chemistry present a number of challenges and opportunities for communicators. Though the picture is much more positive than was expected, and there are few actively negative views to overcome, there are some inherent challenges involved in engaging people with a subject they feel relatively neutral about, and have limited interest in. Successful communication will need to bear this passivity in mind, and 'go where people are', recognising that self-selecting audiences to chemistry events will not be reflective of the general public. It will also provide people with a reason to engage, starting with things people are interested in.

The segmentation shows that while the proportion of the population that feels most disengaged, uninterested and uninformed about chemistry is smaller than imagined, it does exist. The data shows that these views are at least in part driven by poor experiences of being taught chemistry at school, prompting, for some, feelings of inferiority and insecurity in relation to the subject. Overcoming these feelings will require demonstrating ways of engaging with chemistry that are dissimilar to chemistry at school, showing it is not just for experts and scientists, and maximising accessibility by boosting the confidence of a wary audience.

Another perception challenge to overcome, though much more subtle, is that chemistry is viewed as abstract, distant from the individual, and not applied to the 'real world'. Though there was more of an emotional response to chemicals, people felt cold and removed from chemistry and chemists. This is driven in part by the limited encounters and interactions people have with chemistry and chemists, in their daily life and in media. It could be overcome through the propagation of tangible, concrete examples of what chemists do, and the diversification of images that are associated with chemists and chemistry in the public domain.

There was a prevalent view that chemists are pharmacists, and in many cases only pharmacists. This is a function of the lack of commonly-known alternatives, meaning people fall back on stereotypes and generic connections. Acknowledging that chemists are not pharmacists, but occupy a whole range of industries and careers will help dislodge this perception.

Many of these challenges can be read as the expression of a dearth of associations – which can be seen as an opportunity – a void that communicators are at liberty to fill with positive examples and role models. Chemistry's current reputation as being beneficial to society overall means people are primed and receptive to hearing more about the ways in which "it does this". Chemists themselves are also well-respected, with numerous positive characteristics attributed to them: including trustworthiness, integrity, and intelligence. The image of chemistry as being readily linked with chemical, industrial accidents, or being dangerous or unnatural – and chemists being implicated therein – is not there. Stereotypes that exist are both relatively innocuous – lab coats and Bunsen burners – and easily dislodged. People were readily moved from these superficial views to more interesting examples, and the topics exhibiting most success in doing so are explored in more detail below.

How? Routes for engagement

The following themes were tested in the qualitative workshops, through a variety of media, to start to identify the ideas and potential 'hooks' for the public to shift views and engender interest and inspiration about chemistry. Details of materials used can be found in the technical report, though a brief description of each is provided below.

Everyday chemistry

Chemistry of food and cooking, chemistry for non-experts

Across the workshops, this topic was the most popular. People responded positively to several aspects – the most significant of which was the idea that chemistry was not the sole territory of chemists and experts. The main take away from this was the idea that someone could have been 'failed' chemistry at school, not done a degree, yet still be using its principles. Chemistry was thus not only something they could do, but was something they were already doing. Food was a topic they had existing interest in, could easily relate to, and viewed as fun and creative.

> *"I thought there was lots of theory involved but now I see it's experimental; so you don't need to have studied it to understand it – you don't need a degree in chemistry."*
> (Newcastle Wave 2)

> *"Without realising, we are all chemists in the home when we are cooking."*
> (London, Wave 2)

> *"It doesn't feel above me…it doesn't feel academic now, it feels parts of everything, not an academic subject."*
> (Southampton, Wave 2)

Though people sometimes had mixed views about the protagonist of the video himself, determining their interest in the video, respondents liked the idea of having a celebrity spokesperson, who they said they would be willing to listen to. They were drawn in by his clear passion and excitement for the area.

People didn't talk about celebrity scientists – hardly anyone mentioned famous scientists (e.g. Brian Cox) when thinking of a TV programme about chemistry that they would watch, instead being much more interested in the idea of celebrity non-scientists being a presenter or involved in the show in some way (with scientists featuring to discuss their specialist topics). This could be related to the idea that a programme just with a scientist would have a more didactic tone. Some

respondents pointed out that they liked the fact that the material in this video was not overtly or explicitly about trying to make them interested in chemistry. Discomfort about this stemmed from the undertones of being 'educated', reinforcing existing sensitivity to knowledge differentials.

Inspiring chemistry

Clean water, renewable energy, global food security

Responses to these ideas were broadly positive and focused on the widespread applications chemistry had on important global issues that people cared about, but also on humans' 'most basic needs', and making everyday life easier. It had forged connections between chemistry and new areas and disciplines that respondents had not previously considered to be related. This left people with a positive emotional connection with chemistry, and greater appreciation, though perhaps slightly less appetite to find out more compared to some of the other topics.

> *"I thought before chemicals were harsh and synthetic but now think actually a lot is ethical and environmentally focused."*
> (London Wave 2)

> *"It's great that it can obviously improve the future health for particularly the world's poorer populations in mass-producing drugs and other antivirals. And obviously that's combining very much with biology and medicine, but you see how the chemistry side of that links in."*
> (Southampton, Wave 2)

Some respondents were less positive as they found the topic and/or format too dense, feeling renewable technologies were very complex areas which they struggled to grasp. Others became disheartened about the mention of industry and the connection between chemistry and profit, which they had not thought about before. This is a potential risk, as it challenges the perception that chemistry is about unambiguous societal benefit, and activated for some the view that chemists are in some degree complicit, even if not fully in control of the outcomes of their work.

> *"They invent these things and then these big national companies get hold of it and push it and push it to make more money and then they don't think about it well, they know about the dangers but they don't care."*
> (Southampton, Wave 2)

Discoveries and chemistry heroes

Aspirin and the discovery of the contraceptive pill

Respondents engaged positively with numerous details pertaining to the story of discovery, the history of medicine, and finding out more about something so heavily relied on today. As with the content related to Vitamin C/E300, some were pleasantly surprised that the components of drugs could be 'natural', rather than manufactured. They also responded well to the idea that discovery could be accidental, which made it seem exciting but also took it outside the province of experts only. A number of respondents highlighted surprise at the history of chemistry and science, as though they hadn't thought about it much had assumed it was relatively modern.

> *"It has natural roots; we go wrong when you can't link back to nature. I want to know more about how natural things are involved in the making of chemicals."*
> (London, Wave 2)

For some respondents this had personal interest and relevance, either as they were interested in medicine or the social impacts of the contraceptive pill, or had an interest in history. More generally people were appreciative of the wide-reaching impact of drug development, and it validated some existing views about chemists being hard-working and determined. However, as they had already connected medicine with chemistry, and dedication with chemists, their views of it did not shift significantly as a result.

> *"It's an interesting story about persistence, showing chemists don't give in, and evolving. Chemistry's always evolving."*
> (Newcastle, Wave 2)

> *"We basically wouldn't be here without chemists."*
> (Southampton, Wave 2)

Myth-busting about chemicals

Food additives, chemicals in water and the body

There was a positive reaction to the idea that chemicals, previously considered synthetic and harmful, could be naturally-occurring. This made people feel more positive about chemicals and food additives. People also responded well to material related to "the chemistry of love and emotions".

However there were mixed views in response to materials that tackled misconceptions about chemicals through rationalistic arguments – many people disagreed with statements contradicting things they strongly felt to be true – for example, that synthetic chemicals are as safe as natural ones. In some cases it raised suspicions about the implicit motivations of trying to sway their views, in others it activated underlying insecurities and confirmed their suspicions that they were 'not clever enough for chemistry'.

> *"The chemists are trying to justify the man-made and destructive element of chemistry."*
> (London, Wave 2)

> *"It makes me feel – why bother? – because I'm obviously wrong."*
> (Newcastle, Wave 2)

For some, who tended to feel more negative and uninformed about chemicals, statements that 'chemicals are everywhere' elicited feelings of disempowerment and helplessness, as they understood it to mean that harmful chemicals were inevitably contained in food, air and water, and were thus unavoidable.

> *"This causes me to feel there's nothing I can do about chemicals – I don't have a choice."* (Birmingham, Wave 2)

There were some positive responses to these ideas, particularly around the chemical composition of the body and the atmosphere, among those who already felt fairly engaged with and positive about chemicals.

A day in the life of a chemist

Normalising chemists, smartphone chemistry, 'not all chemists wear white coats'

The Royal Society of Chemistry career posters, "Not all chemists wear white coats"[60] were effective at piquing interest and starting to overcome stereotypes: as chemistry came across as energetic and fun, though respondents wanted more explanation and detail on what the careers were in order to have a more significant impact. Some mentioned that they saw the posters as more appropriate and attractive for students considering different career paths, than for adults. Concrete examples of chemists working in a variety of industries, and in particular working

[60] See technical report for details.

alongside other scientists, or in a multidisciplinary team, were effective in shifting views.

People also responded positively to description of the daily life of a chemist, helping them to seem more relatable, and overturning stereotypes about chemists working in labs.

> *"This is humanising, they're not just a middle aged person – this person is young and a team worker, making something we all use."*
> (London, Wave 2)

While some respondents had not imagined chemists to be involved in the development of smartphones and new technology, they were not interested in finding out more about the actual chemistry involved, perceiving it as complex and off-putting. Several pointed out that they were still unconvinced that these developers would 'count' as chemists, seeing them instead as engineers, linked to the perception that chemists were involved in the production of new substances, rather than the application of 'known' or 'already-discovered' ones.

"Some of the elements of the smart phone are old chemistry, so for example it's tin and lead but it's been *tin and lead for hundreds of years, it's been* known *to be tin and lead, so it's not really chemistry anymore, it's engineering or use of existing products."*
(Southampton, Wave 2)

Format, channel, medium

Universally, respondents preferred video and multimedia content, finding it the most engaging way to find out about an area they would not necessarily seek out. Videos that presented any scientific terms or longer words on-screen as a visual aid were also lauded, as respondents said they may have switched off if they heard the terminology but it went unexplained. In printed materials, colourful and vibrant images and the use of simple, clear visuals helped people to connect with the ideas, as respondents were quite resistant to reading dense information or anything that suggested complexity or difficulty. Throughout, 'showing rather than telling' was far more effective in conveying messages in compelling and convincing ways.

Respondents universally stated that attempts to try and engage the public on chemistry should be on TV, though said they may be more likely to attend public events that were appealing to children and families, and mixed chemistry communications with other activities that they would be interested in, such as food festivals, fireworks, or sports events.

Everyday personal communication is a very important channel of communication that and if chemistry is to become part of a public narrative communicators should work to make it more part of their everyday narrative, not just in formal outreach activities. More insight on how to get started and communicate chemistry can be found in the communication toolkit at rsc.li/pac

The right balance of science

There was relatively strong resistance to the inclusion of 'too much science' in materials. Specifically, chemicals diagrams and names, and scientific terminology, were extremely off-putting for some.

> *"I hated it, it smacked of a school textbook…too much chemistry!…it shows you'd need a hell of a lot more knowledge to get anywhere further than general interest in it."*
> (Newcastle, Wave 2)

Respondents were clear that communication about chemistry should use accessible language, focus on impacts, rather than the science, but could invite people who were interested to find out more if they wanted to.

Changes in views

Respondents in the workshops described three main areas in which their views had shifted:

- *I know more than I thought I did* – a view reached through engagement with personally relevant, every day, tangible examples, about areas already familiar
- *Chemists are more than pharmacists or stereotypes* – by exploring chemistry's concrete applications outside pharmaceuticals, and seeing their passion and interest in their work
- *Chemistry is all around us and impacts on my everyday life* – by discussing chemistry' involvement in and contribution to issues they felt an emotional connection to

The most significant change was in levels of confidence, and was a necessary first step for some respondents to enable them to engage with the other materials.

> *"As soon as my son comes home from school with science homework I always say go and ask your Dad, but now I might actually venture to look at it, and see if I could do anything. All those ideas I had and worries and negative vibe from*

school – that's what put me off, but I've got some interest in it now."
(Newcastle, Wave 2)

Although neutrality is not as difficult to challenge as outright negativity, it is still an active state, and people will need a credible reason to move beyond it. This will mean providing concrete examples, but also, demonstrating why chemistry matters and what people might gain from finding out more.

CASE STUDY: American Chemistry Council and Ogilvy US

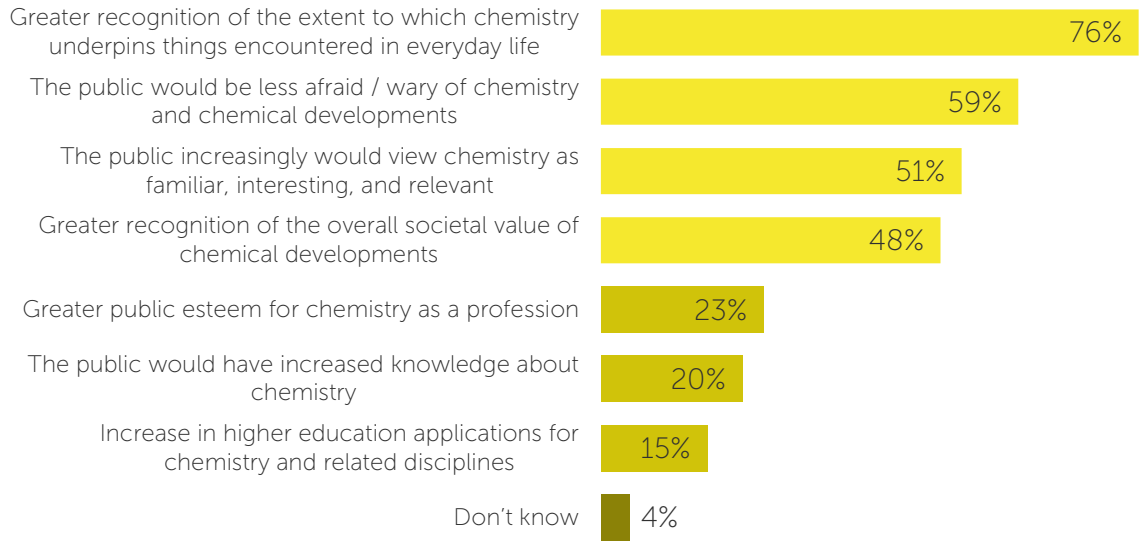
The American Chemistry Council (ACC) membership commissioned Ogilvy to develop a communications campaign, aiming to change public perceptions of the chemical industry: and challenge ideas that its products present a risk to individuals and communities. The campaign positioned chemistry and its benefits as essential to American life. The essential2 public education campaign was a multi-year communications initiative spanning employee communications, advertising, public relations, interactive outreach and a new Web site. Though a large-scale campaign with huge resources, given the challenge of changing public opinion and the need to start from scratch with each individual, the campaign was targeted and rolled out first to ACC's member employees, and then member company employees to leverage them to serve as industry ambassadors.

Objectives for chemistry communication

Wholesale overhaul of the public image of chemistry, chemists and chemicals is not a realistic or achievable goal, as demonstrated by the multi-million dollar campaign outlined in the case study below. However, there are clear areas of overlap between chemists' goals, and what the public is interested in/receptive to, that could help shape future communication.

In the scoping phase of the research members described their ideal outcomes for successful public communication of chemistry, which were that the public would be inspired and excited by chemistry, would recognise the extent to which it is all around them, and would not be afraid/wary of chemicals.

Table 6.1: Most important measures of successful public communication



Source: Online survey with RSC members: "Which of the following would you consider to be the three most important measures of a successful public communications campaign about chemistry?" Base: 575 *Multi-coded*

Encouragingly, most of these principal objectives align with the channels and messages for successful communication outlined in this chapter – namely that chemistry should be put forward as underpinning everyday life; shown to be familiar, interesting and relevant; with societal value. Reducing fear of chemicals and chemical developments is arguably less pertinent, given the lack of strong negativity in public opinion, and the risks of activating this for those who do feel worried and uninformed.

We hope that this research on public attitudes to chemistry will help members of the Royal Society of Chemistry and others interested in communicating chemistry to the public to better understand their audiences.

For more information about the research, visit rsc.li/pac

For more information on how the Royal Society of Chemistry is supporting its members to engage with people visit rsc.li/outreach