A New Approach to the Public Understanding of Science: The Public Consumption of Science and the Role of Worldviews

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Introduction

In this paper I am going to use ideas from the area of market research and cognitive science to give insights into ways of thinking about the public understanding of science (PUoS). More specifically it will look at how science may be understood as a 'brand' that is endorsed by members of the public if it fits in with the individual's 'worldview'. The operationalizable aspects of a person's worldview will be considered as a combination of possible cognitive heuristics. For now the comparison I will be drawing between brand consumerism and PUoS should be taken as analogous; however, I offer it as part of a new horizon in PUoS studies. How literal the comparison may be taken should be subject to further investigation but hopefully this paper will offer enough direction that the links may be taken seriously. Part of the conceptual aspect of this paper is to give a suitable grounding for 'worldview'. In my analysis of worldviews I will be borrowing from the work of Kuhn, Feynman and Dreyfus to separate out scientific 'knowledge' from 'understanding'. 'Worldview' will be linked to paradigms, which are knowledge based. 'Understanding' will be linked to a tacit intelligibility of the world from which both 'worldview' and 'paradigm' look to replicate but are distinct. In this gap I hope to show how science can come to occupy multiple meanings. Here there is not just 'science' but sciences. This will enable us to understand why bad or pseudo-science exists. Throughout this paper the main 'alternative' idea I will be addressing will be Intelligent Design Creationist science (IDC). Through a comparison made with a marketing research tool called Rule-Developing Experimentation (RDE) I will offer an explanatory device for why we come to endorse a particular science. This I suggest can be done through analysis of cognitive heuristics. The positive suggestion is that if the individual is made aware of how they are interpreting science through their worldview then room can be made for these biases, tailoring science education to the individual.

I would like to start from the observation that even in the most scientifically dependent stage in human history, what has been called 'bad' or 'pseudo-science' still exists. Typically we might think in bold examples such that I might be referring to the crystal healing of New Age mysticism. This we can put down to someone not knowing enough about how science operates. The standard account is that science offers up testable hypotheses, which make novel, precise prediction, which either do or do not meet up with observation. When observation and prediction fail to meet up we can say that the hypothesis has been falsified. Whilst this account has many problems with it, the idea that science progresses by a number of methodological principles is strong within the PUoS. To know these principles (i.e. experimentation, observation, evidence, theory, etc.) is to understand the methodological conception of science. We might be satisfied with this account when applied to New Age mysticism but if we take a harder look at the history of science and what scientists do this cannot be the case. Consider an idea like 'cold fusion'. In the popular literature it has been taken to be short-hand for pseudo or bad science where we can track the inevitable outcome of the methodology of science in settling disputes. Pigliucci places cold fusion along side climate change denialists and IDC (Pigliucci 2010, p.271) where there is a simple failure to look at the evidence. Yet the possibility for cold fusion was seriously considered by Noble Prize winner Julian Schwinger and his attempts to publish on the subject were thwarted by strong editorial censorship issues (Mehra & Milton 2000, p.550-552). More recently patents have been awarded for 'cold-fusion' reactors and there is some very real speculation about the phenomena's existence (Focardi & Rossi 2010; Stremmenos 2011). Looking again we see the possibility for telepathy and 'water memory' as being investigated by another Nobel Prize winner Brian Josephson (Stogratz 2004, p.50-51). Whether or not 'cold fusion' or 'telepathy' really exist is irrelevant but what is relevant is the idea that these people have won the highest awards of the scientific community and yet take seriously the possibility of 'bad' scientific ideas. Surely this cannot be because Schwinger and Josephson did not know enough science? What is more a simple suggestion such as Pigliucci's which is not uncommon, that 'bad' scientists ignore falsifying evidence cannot be how science progresses (Feyerabend 2010). It is part of what science needs but not what it is. The fact that highly respected scientists do endorse unorthodox ideas suggests to me that scientific understanding is different to scientific knowledge. In order to refine this point this distinction can be understood through some of Kuhn's concepts (1977; 1996) and Feynman's (2001) discussion on what science is for him. Scientific knowledge or the methodological interpretation of science will be aligned with 'paradigms'. 'Paradigms' in their function occupy a similar role to 'worldview'.

Scientific understanding is not knowledge. It is a tacit intelligibility or coping that scientists learn in the act of doing science in the world (Dreyfus 1991; 2002). It shows itself in Feynman's words, as type of 'wisdom' (2001, p.188) or 'essential tension' (Kuhn 1977; D'Agostino 2008). This wisdom or tension is in knowing when to break or ignore the normative methodological procedures of normal science. Next I will try and make the distinction between scientific knowledge and understanding clear and how worldviews and tacit intelligibility fit in.

Scientific Knowledge and Understanding

As the PUoS does not target scientists but typically seeks to inform non-scientists on what science is it already looks to interpret science through the methodological lens. In everyday discourse on science we are normally, if not always, referring to what Kuhn called 'normal science' (Kuhn 1996). This is science at its most uncontroversial, at its most routine. 'Normal science' can function effectively because scientists are given a 'worldview' by the dominant paradigm. Just exactly how we understand 'paradigm' can itself be a product of the methodological conception of science. This can account for some of the early criticisms of paradigms (Shapere 1964; Masterman 1970) where they were understood as methodological suggestions. 'Paradigm' is a type of worldview, which tells us how the world is. They tell us what to expect and what questions are meaningful. Paradigm is an articulation of the world at any given point in history. What is crucial to my distinction is that 'paradigm' or worldviews are not the same as the world. If they were then there would be no hope of progress in science at all. Paradigms like worldviews work at their best when they are invisible and can be mistaken for the world. That we are not seeing the world or ourselves as a product of history or culture but we are seeing just pure 'reality'. This would be the case if our articulation of the world were identical to the world but they never are and in this gap anomalies accumulate which bring about the demise of the paradigm. What allows whole paradigms to fall and 'reality' still be intelligible to us so that we can replace them is what I call 'understanding'. 'Understanding' is a tacit intelligibility of the world and it precedes the knowledge production of paradigms. In the case of paradigms and science 'tacit intelligibility' is acquired by scientists being involved in the 'world' of science. Collins (2010) has tried to analyse this involvement by varying levels of tacit and explicit knowledge and expertise (Collins & Evans 2007) but his concept of the 'tacit' is still epistemological which leaves the problem unsolved.

I use the term 'world' as in the sense of Dreyfus (1991; 2002) where it is a non-thing but a system of relations. When Kuhn talks of 'world change' (1996, p.150) I believe it is people conflating the world as a thing and as a system of relations that raises the greater problem of incommensurability. Kuhn is not referring to literally different worlds but a different understanding of the world which re-structures observations, facts, values and so on. As this has been taken to mean that scientists literally inhabit different realities through their paradigms the problem of incommensurability took priority (Newton-Smith 1981). It is because our understanding is not paradigm dependent that people are able to communicate across paradigms. If we could only communicate through our paradigms then incommensurability would be a real issue. The tacit intelligibility of the world does however exceed our paradigms and worldviews, which is why science can be conducted in the absence of a paradigm (Kuhn 1996, p.44). Kuhn's illustrations for 'world change' had him draw on concepts from Gestalt psychology and his subsequent 'linguistic turn' has been followed by much work in the cognitive sciences on scientific reasoning and perception (Gattei 2008; Bird 2012). This paper does not follow their lead as their attempts are to reduce the tacit understanding scientists have to methodological principles. I wish to look at the operative part of worldviews (cognitive heuristics) which have their basis in knowledge and so can be made explicitly known to the individual. As what we do 'see' is culturally conditioned we always see the world 'as' something and never just as pure reality, though this is what paradigms aim at. The invisibility of paradigms and our worldviews is a mark of their success. This historical location of paradigms plus our inability to think outside of them due to the restricted meanings available to us is what Stanford (2006) calls 'unconceived possible alternatives'. While this may all seem a bit abstract turning to the thoughts of Richard Feynman on what he believed science to be may help with these distinctions.

Feynman and What Science Is

In a paper called 'What is Science?' Richard Feynman attacks what I have been calling the methodological conception of science -the idea that science is the knowledge of principles, ideas, equations and so on. Feynman states that teaching textbooks on science are the 'watered-down and mixed-up words of Francis Bacon' (Feynman 2001, p.173). Feynman in his dislike of philosophers picks on the abstract suggestions of natural philosophers, which he argues have taken precedence in science education on what science is. 'And so what science is, is not what the philosophers have said it is and certainly not what the teacher editions [textbook] say it is' (Feynman 2001, p.173). Feynman says that scientists do not merely observe but exercise judgement in what to pay attention to. We always see the world 'as' something. Aristotle saw a geo-centric world, Newton saw a helio-centric world but both lived on the same literal earth. It is this judgement that I take to be part of the scientist's tacit understanding of science - the ability to treat ideas like 'falsification' as meaningful whilst also not being afraid to undermine them. An example of this professional 'judgement' can be seen in the Millikan Ehrenhaft controversy. Whilst nature has sided with Millikan, methodologically, it was Ehrenhaft who was doing the better science. 'Hand-written notebooks show that Millikan discarded 59% of the drops [oil drops], as they did not provide support for his hypothesis of the elementary electrical charge' (Oberheim 2006, p.117). Instead of revising his theory he simply considered the data as faulty (Niaz 2000). Here Millikan was right to see 59% of his observations not 'as' falsifying but 'as' faulty.

Feynman hesitates in giving a non-methodological account of science and acknowledges its difficulties. He quotes a poem about a centipede, which in the act of trying to work out how he runs falls over not knowing how to stand. Feynman likens this situation to the question 'what is science?' in that any explication of what science 'is' is more difficult than doing science. I take this to be because the tacit understanding exercised in doing science exceeds any methodological description of what science is. He then talks about the work of the scientist as a balancing act between science as an authoritative body of knowledge and the undermining of that authority. Science is the skill to 'pass on the accumulated wisdom, plus the wisdom that it might not be wisdom […] to teach both to accept and reject the past with a kind of balance that takes considerable skill. Science alone of all the subjects contains within itself the lesson of the danger of belief in the infallibility of the greatest teachers of the preceding generation' (Feynman 2001, p.188). He also says that learning words, definitions, equations, theories and so on are useful for doing science, as they are about science, but they themselves are not science (Feynman 2001, p.177). They only tell you about people, what people call things and the limits of human imagination. Feynman towards the end of his talk suggests that science is 'to find out *ab initiio* (sic), again from experience, what the situation is, rather than trusting the experience of the past in the form in which it was passed down' (Feynman 2001, p.185).

Most telling is that Feynman states that science is not its form. To say science is 'this or that method' is one of the ways science develops but is itself not science. He describes science as 'the belief in the ignorance of experts. When someone says science teaches such and such, he is using the word incorrectly. Science doesn't teach it; experience teaches it' (Feynman 2001, p.187). So on Feynman's account science is not an abstract principle, it is not learning definitions or calculations, it is not imitating what we take to be scientific, and it is not what people in the past have done. All of these I would identify as methodological notions of science.

Worldviews

How this fits into my argument is that I am suggesting that the methodological conception of science is what the average person understands science to be. Scientists have a tacit understanding of what science is as they do it. But to learn about it we have to construct an idealised version. We may omit certain controversies, the weaknesses in peer-review or falsification to keep it mirroring its methodological namesake. To say scientists use evidence tells us nothing. Evidence is always for something and that 'something' is dictated to us by the paradigm. Prior to Big-Bang theory the hiss of radio static was not considered evidence for the origins of the universe, they were just random noises. It took the Big-Bang paradigm to open up the possible meanings of interpretation for those same phenomena. Fred Hoyle famously refused to believe the universe could be expanding (Gregory 2005). Hoyle saw the universe 'as' static. Others saw it 'as' expanding. Here we might acknowledge what Kuhn calls the 'Plank effect' that paradigms are not disproved but the people who believe in them die out along with its ideas (Kuhn 1996, p.151). This 'as' I refer to is historically and socially grounded. It is the possibilities given to us by the world at a given time that allow us to consider them meaningful. A worldview like a paradigm tells us how the world is but is not identical to it. Whilst paradigms are quasi-worldviews for scientists, they are in a unique position to appreciate how science is not its paradigm by being involved in the non-methodological aspects of science and knowledge production. The average member of the public is a large step removed from this as they are only presented with science as a subject not a living practice. As most non-scientists are not in the business of changing what we see the world as our spectrum of possible meanings is vastly widened, as we have no such commitment to a single scientific paradigm. With this increased width in possible meanings 'science' becomes polysemic. This variety in meaning I liken to the variety of products in the supermarket. Our worldviews give us a unique understanding of what science is for us and which one we choose. A new horizon of studies may be achieved through the analysis and manipulation of cognitive heuristics we use in situating something as 'scientific'. Next I will develop the analogy between 'science' as brand consumerism and how our beliefs about things alter how we perceive them.

The possibility of cognitive heuristics in thinking about science may give us more effective methods for communicating science to the general public. This may be done by playing to or revealing these biases so they can be reflected on next time a news-worthy item on science is reported (Goldacre 2009). Where this has been done previously it was to explain why rational people believe irrational things (Shermer 2007; Goldacre 2009). Yet these still tend to portray 'science' as a methodological means from telling fact from fiction such we should just look at the evidence. Part of what I have been arguing is that 'evidence' is always evidence for something whose meaning may not be available to us or we may be tacitly choosing to ignore it until better evidence comes along such as the case with Millikan. There is, however, a difference between a scientist at the edge of knowledge using his tacit experience to ignore 'evidence' and a member of the public ignoring scientific evidence. As most non-scientists have not acquired the tacit understanding that goes into knowledge production. They do have the requisite skill to make such a call between competing theories.[1] Evidence is always for a theory. Non-scientists do not tend to have better competing theories as their worldviews are not limited by the rigours of paradigms, and sometimes are anachronistic to them. Here I see a philosophical challenge to worldviews as the possible available meanings allowable in worldviews are directly linked to the historical

[1] Those non-scientists that live on the edge of current scientific knowledge can acquire a tacit understanding of what the methodological standard has yet to realise. For example AIDS activists helped shape medical knowledge on the causation and treatment of HIV (Epstein 1996).

possibilities paradigms allow. For example, IDC believe the Earth is 6,000 years old. Partly because of a literal reading of the Bible but also because there is evidence against the reliability of carbon dating, gaps in the fossil record, and problems with the interpretation of data (Morris 2007). Yet, the limits of carbon dating were discovered using science. The observed gaps in the fossil record are an observation but it is then interpreted 'as' evidence for the implausibility of evolution. The 'observation' fails to account for its own possible interpretation, which is the problem they level at evolutionary scientists. The literal truth of the Bible is predicated on a methodological conception of truth, which has become valid due to the purveying success of science. The metaphor being the Bible is a kind of instruction manual for how the universe was created. What this shows is that worldviews are not linked to paradigms for their coherence but are conceptually bound to paradigms in the meanings available. Gordin (2012) explains that pseudo-science, either in form or content, is a sign of health in scientific discourse. The more pseudo-sciences a paradigm attracts the better it is as it can produce competing ideologies to react against. Hence the metaphysics of realism are required to have any theory or worldview that invokes anti-realism. Pseudo-science is a mixing up of the philosophical, metaphysical, historical and scientific that makes cognitive heuristics a useful tool for unpicking worldviews to reveal these antagonisms.

For a brief example of what I have in mind take the heuristic of 'availability' (Kahneman & Tversky 1972; 1973). This states that an event that is easier to imagine is perceived to be more probable, despite how actually likely or unlikely the event is. Here the media feed the public imagination where a plane crash is more sensational than a car accident. From this we tend develop greater fears about flying than driving in cars (Battersby 2010, p.207). Similarly if science can be coupled to a strong emotion like fear we are much more likely to respond to it. When *The Lancet* published one paper in 1998 linking the MMR vaccine to autism a majority of public opinion and media attention sided with the paper rather than the mountains of evidence to the contrary. This led to thousands of children being withdrawn from routine vaccinations (McIntyre & Leask 2008). One of the ironies of living in such a science dependent society is that one is much freer to believe or feel justified in our own opinions. Where medical health care is so good one can indulge in unhealthy activities and retain a quality of life. By analogy there is a kind of herd immunity to the effects of 'alternative' ideas. Taking this example literally, if you live in a society that practices immunisation this allows some members to follow alternative beliefs that vaccinations are bad and still remain healthy. The possible meanings of fluoride water conspiracies are just not available to people that do not have regular access to safe drinkable water but in developed countries we can indulge in such ideas. Next I will give an introduction to RDE, cognitive heuristics and the role worldviews play. Discussion up until now has been to include scientists. As my argument is to do with the PUoS most of the remaining discussion will be aimed at the non-scientist.

Rule Developing Experimentation

In the mid-1970's Howard Moskowitz was commissioned by 'Pepsi Cola' to find out what the correct amount of aspartame was to be added to Diet Pepsi. The received wisdom up until that point was there should be an optimum sweetness making the best drink. However, he did not find this but instead got messy data. The fact that Moskowitz could not retrieve any discernible pattern from the data began to trouble him. Moskowitz figured he and Pepsi had been asking the wrong question, that there was no such thing as the 'perfect' sweetness for Diet Pepsi; rather than looking for one ideal drink they should have been looking for multiple favourites. With this realisation Moskowitz went on to work for many large multinationals implementing this new approach to consumer research. The logic of the research method was to ultimately conclude that one could potentially identify a need where one did not exist basically telling the customer what they wanted. This belief was vindicated by his work with Campbell's who wanted to rival Ragú in the spaghetti sauce market. Instead of trying to develop the best singular spaghetti sauce he suggested they should diversify. From the data collected it indicated a hidden demand for 'extra-chunky' spaghetti sauce. What made this result all the more surprising was that such a product did not exist at the time (Gladwell 2011). The approach that Moskowitz started has left a legacy of 36 different types of spaghetti sauce in 6 varieties. Moskowitz describes RDE as 'a systematized solution-oriented business process of experimentation […] so that the developer and marketer discover what appeals to the customer, even if the customer can't articulate the need, much less the solution' (Moskowitz & Gofman 2007, p.3).

The two aspects of this approach that I find most pertinent to my analogy is that people desire variety and people may not know what they want but know it when they have it. I have termed this the 'Goldilock's Principle' that what we come to believe is just right for us. How reliable RDE is as a research tool does not interest me but it is the analogy it offers in its use and manipulation of cognitive heuristics that does. The comparison I am drawing with science is that instead of a quality like 'sweetness' science can alter in its metaphysical content and delivery.

Brands of Science

Just like the diverse range of products we see on supermarket shelves I argue that the PUoS competes in the market place of ideas. How representative those ideas are of our worldviews determines whether we endorse them or not. The problem is that unlike Pepsi or spaghetti sauce where there is no right or wrong we tend to think of science as a supplier of what is true. Those ideas that have no application to reality or whose effects are moot can have those outcomes re-interpreted for them by their worldview. For example in IDC the lack of intermediate fossils is evidence of the falsity of the theory of evolution rather than evidence that fossils are hard to preserve (Kitcher 1982). Creationists still drive cars that require petrol from million year old fossil fuels or use genetic treatments that require evolution to be at least approximately true. Again, the irony of the IDC position is *not* that it cannot be tested or it lacks any of the form of science but that it requires the evolutionary paradigm so its own practices can be meaningful. IDC has peer reviewed journals; there are qualified ID scientific professionals, that perform proper investigative science. As creation scientist Gary Parker says, 'what does it take to recognise evidence of creation? Just the ordinary tools of science: logic and observation' (Parker 2006, p.17). To see something 'as' evidence for one theory rather than another is preceded by a worldview where 'creation' makes sense. IDC is a science but just a really bad one. It makes a number of general observations and claims that rather than change the world trivially re-describe it. Organisms take after their own kind, no evidence of intermediate fossils, things appear designed. Not much can be done with this as a science and so leaves everything as it was found.

In PUoS people are not being asked to do science but think about it. Here we are dealing with people's beliefs and knowledge about something. So how does science as an idea compete in a market place of ideas? Taking the RDE model we look at the all the ways a science might differ. 'Textbook' science says there is definitely a right and wrong way to do things, some things are definitely true, others less likely, and some things so unlikely that we do not consider them as viable scientific options. When people say that what is 'observably true' or 'conclusively false' is what should count in science, they are actually asking after a 'brand' of science. For in making the previous statement about what commitments a science should have are themselves neither observably true nor conclusively false. If we think science is in the business of disclosing an ultimate reality, a culture free, objective description of 'what is' then this requires a particular metaphysics for it to be believable (Weinberg 2001). For this person paradigm, worldview and world becomes the same thing. This brand of science has been called 'scientism'. That science perfectly describes reality and can also act as a model for how we should live. Scientism locates fundamental meaning to human actions outside of people or culture, in the motion of atoms or electro-chemical pathways. In the other direction we have the radical postmodernist critique that science is an ethnocentric, patriarchal power structure, which only serves to suppress other 'forms-of-life'. Here the feminist critique of science offers another 'brand' of science (Longino 1987; 1994). With the rise in the ills caused by science and modern industry such as drug resistant bacteria, the destructive power of nuclear energy, climate change or even the challenge to religion, we may look for alternatives. In these accounts 'science' might stand for the oppressive, ultra modernist rationalization of life and so the person may not consider the alternative as 'science' but they would think that whatever discourse they did choose to believe in it does make 'truth' claims (even if relative), otherwise why believe it? The person who visits the homeopath does so because they believe it will make them better. No one rationally chooses to believe something false on purpose. A lot, if not all alternatives, 'sciences' aim at the methodological representation of science, however, as Feynman tells us science is not its form or content. It is in aspiring to meet this false image of science that some features become common:

> *1. Does it give an account of my reality?* We always see the world 'as' something, for some the world contains, energy fields and Higgs particles, for others, energy centres and chakras, or angels and demons. It has a disclosed ontology of objects.
>
> *2. Is it 'evidence' based?* No one rationally chooses to believe something that is wrong. 'Evidence' is always evidence for something, that is, to see the world 'as' something.
>
> *3. Is it organised?* Does the discourse use specialised language, customised practices, and is it organised around a 'school of thought'? For example, no one says 'water diluting' but instead we refer to a practice as 'homeopathy'. It has theory, laws and 'rules'. The law of similars, infinitesimals and succussion. The law of Infinitesimals uses 'Avogadro's Constant'. The 'succussion' stage involves 'potentization' which allows water to retain a memory of the active substance and so

> on. It all sounds authentic and sophisticated (Rogers 1970, pp.99-101; 1980, pp.329-321).[2]

Wider features of organisation would be, is there a central institution or authority to defer to?

Goldacre (2009) argues that to believe in alternative medicines is just to show an inadequate understanding of what an explanation, theory, or evidence is. Yet that cannot be strictly true. Our typical image of someone who contests evolution might be an ill-educated religious fundamentalist, yet two Nobel Prize winning physicists believed in 'pseudo-scientific' ideas. In our picking out 'evidence', 'theory', 'explanation', 'authority', or 'organising principles' we do so by what features that appeal or speak to us. It is here that I think the idea of RDE and cognitive heuristics could be used in either analysing someone's beliefs and maybe revealing the bias in them or making 'mainstream' science more palatable for those who might be intimidated by how their worldview is not reflected in orthodox science. The study of cognitive heuristics as used in advertising, economic forecasting and risk assessment is nothing new but I think this aspect of public understanding is being missed when dealing with a subject as seemingly objective as science. Here this could be a part of new horizon in PUoS studies. In the next section I will outline two cognitive heuristics that I believe are at work in how science is consumed.

Cognitive Heuristics

These are 'rules of thumb' we use when making decisions or form beliefs about the way the world is. Our prior experience of the

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[2] Rogers (1970; 1980) talks about infinite energy fields, the principles of homeodynamics, and helicy which is stated in symbolic form as *H* = *F*s-*T*1(*M*1?*E*1) *i f S-T* (*M*2 ? *E*2) *i - f S-Tn* (*Mn*?*En*) H = Helicy, ~ = the spiral of life, i = innovation.

world will help inform which heuristics we develop, such how experts gain a 'tacit' knowledge of their field. All professionals develop heuristics for use and in our everyday lives we use them as a means to making an approximate account of what we think is happening or going to happen. They are embedded within our language as pieces of cultural wisdom, such as 'if it looks too good to be true' which refers to our ability to deceive ourselves. For the sake of space I will only address two heuristics, the first has already been mentioned, 'availability' and the related heuristic of 'representativeness'.

Availability

The availability heuristic refers to the tendency for an event to be judged more probable to the extent that it is more easily imagined or recalled. Shocking or sensationalist headlines in the media or bold demonstrations of scientific innovation and failure are more likely to be remembered. When asked to picture a scientist we may use the 'Einstein' figure as a model due to the place he occupies in popular culture. Yet, equally important to the same period of physics is Niels Bohr, Werner Heisenberg or Paul Dirac. Ask anyone over a certain age where they were when the moon-landings happened, and more often than not they can tell you. This is because it was a dramatic and exciting event. Ask them what they had for lunch two days ago and they might struggle to remember. This idea is used to explain our inability to estimate risk and probabilities, as we tend to think in bold, striking examples. Yet sometimes it is preferred that this were the case. Take for example the firing of UK government drugs advisor Professor Nutt. The popular image is that 'drugs' are a gateway into crime and are extremely dangerous. Yet his reporting that alcohol or horse riding were statistically more harmful than ecstasy clashed with the emotional message the Government wanted to put forward (Monaghan 2011, p.1). Yet the ecstasy victim is still more likely to make the news that someone dying of liver failure due to the political and sensationalist weight the image carries. The availability heuristic leads people to overestimate the probability of smaller frequency events and, underestimate the probability of larger frequency ones. This tendency can be amplified when coupled with a powerful emotion such as fear (Slovic et al. 1979).

So how does this fit with our perceptions of science? We could maybe refer to Kuhn's distinction between 'normal' and 'revolutionary' science as representative of what we imagine scientists are doing. Kuhn accused Popper of conflating these two terms in pushing the virtues of bold conjectures, paradigm testing and falsification (Kuhn 1970, p.5-6). The same may be true of PUoS where 'normal' science is presented in the guise of 'revolutionary' science. If the image of science as 'falsification' is too available it is all too easy to slide into meta-inductive pessimism. The things that were believed to be true in the past are now known to be false; therefore, who is to say what we believe now is not also false? (Putnam 1978; Laudan 1984). Other practices that do not trade on falsification do not offer this infinite spiral of pessimism and doubt. If science is always getting things wrong and finding out new information, maybe it just lags behind what ancient mystics have known for millennia and needs to catch up. So if science is just falsification it gives more justified cause to those that believe in yet scientifically unproven ideas.

Something that is dramatic or emotional is much easier to recall than a mundane event. Take a case of miracle verses medical incompetence. Given the scenario that a child has been diagnosed with terminal cancer and given 6 months to live, the child's parents may well take to 'alternative' measures in a desperate bid to cure them. Let's say they go to a spiritual healer who recommends 4 sessions of visualization and energy channelling a week. We find to our amazement that after 2 months not only is the patient feeling better but also is given a clean bill of health by doctors. Is this not the most dramatic example of a miracle and demonstration of what modern science cannot explain? For the parents and child most definitely and they will possibility go on and extol the virtues of spiritual healing over the inadequacy of modern medicine. The fact that cancers do randomly go into remission (albeit not well understood) and doctors do misdiagnose is not seen as a viable option. Which are the more potent to last in the memory, simple human error or divine intervention and miracle?

Representativeness

This refers to the tendency to judge the probability that a stimulus belongs to a particular class on the basis of how typical of that class it appears to be, with minor regard for the (objective) base-rate probability of a stimulus belonging to that class (Kahneman & Tversky 1972). Sensitivity to things like prior probability, base-rate frequency, and sample size, will be shaped by one's worldview. This heuristic is present in forming stereotypes such that we draw strong inferences from a very limited supply of information. So, for example, with the 'Gambler's Fallacy' if one knows a sequence of events is randomly generated one would expect the sequence to 'look' random. So a series of coin tosses that produces the sequence HTHHTHTH seems more probable and more random than the sequence HHHHHHHH. Since the first sequence is more 'representative' of what we think randomness is like it is judged more probable than sequence two. Another mistake is to then ask what the likelihood of getting that sequence was. This is to calculate 'after-the-fact' rather than work from prior probability. In the example given the likelihood of getting a head on a single coin toss is ½ each time. But to ask what is the likelihood of getting a consecutive series of eight heads over eight tosses the probability then becomes ½ x ½ x ½ x ½ x ½ x ½ x ½ = 1/256. As a finite sequence, stated ahead of time, a mixture of heads and tails is more likely than only heads or tails but as storytellers and people who seek meaning we tend to ask retrospectively after an event or series of events what the likelihood was. This tends to be the case with surviving accidents or asking about the probability of life on earth. Here we form 'stereotypes' of scientific concepts.

How orderly or random someone's world is will reflect in what 'science' they follow. These are more than just mathematical terms where 'order' and 'non-order' are loaded with symbolism and cultural significance. In a culture that is saturated by Judaeo-Christian metaphysics orderliness and chaos are two massive opposing forces that date back to the first creation myths. We might say 'order' is representative of meaning, patterns or mind which can be gained from events. The opposite can be said of 'randomness' or 'chaos' standing for meaninglessness or indifference towards us. So how do our representations of these terms influence our decisions on science? At the one end with 'scientism' we accept that the universe and evolution are indifferent to whether humans live or die, there is no inherent morality or universal order that makes humans special. 'Scientism' is a broad church but typically it holds the methodological conception of science to be primary. Examples of this type of scientism can be found in the new fashion of accounting for all facets of the human condition from an evolutionary standpoint (Rose & Rose 2001). Another example is Harris (2010) who argues that science can determine what values people should live by. Some find this desirable as it appears to be the antidote to religious fervour, yet in its quest to rule certain ways of talking out it also traps itself. When science tries to account for itself via its own methodological prescriptions it begins to deconstruct itself (Fuller & Collier 2004).

Going the other way we may give overdue significance to random events or the withholding of conclusions based on uncertain information. Everyday a billion highly improbable events happen in an order that is inestimable as a predetermined sequence. Just this fact may give us a sense of wonder or anthropic benevolence to the universe. This cognitive balance is a fine one as giving too much significance to events can be a symptom of manic or schizophrenic paranoia. Here everything becomes overly significant where accidents are not accidents. Less manic but still strange sounding was Jung's acausal connecting principle 'synchronicity' (Jung 2006). Yet, representativeness can be subtle. Take the placebo effect. Where our prior expectations and representations of how we think science works affect the efficacy of a treatment. For example, from our cultural knowledge we know that two pills are better than one pill, an injection is a greater treatment than a pill, and a minor surgery is even more effective than either (Goldacre 2009, p.63-84). For certain people the over-representing of the significance of medical procedures are enough for pains and illnesses to cure themselves and it is possibly this same over-representativness that prevents us from attributing 'miraculous' cures to human error rather than divine intervention.

To give a commercial example, when the Apple 'iPod' was launched there were complaints about the apparent lack of randomness in the shuffle function. People were hearing songs repeated in close proximity to one another. This was viewed as non-representative of what 'random' shuffling should be. I should not hear songs from the same album more than twice within a short period of time. Statistically, if you have 300 albums and randomly pick 17, there is a 50-50 chance that at least two of them will belong to the same album. The formula in this case is the square root of (300) = 17 (approx). Apple thus solved the problem by making the algorithm that simulates randomness *less* random. So patterns which would be more representative of our cultural conception of randomness would be more explicit within the shuffle function (Bellos 2010, p.324). This may seem like harmless commerce but it also reinforces a cultural preconception of a statistical/mathematical idea that is wrong. This is even more harmful when you consider Government's sacking special advisors when the numbers to not reflect the message.

Conclusion

My argument has been for a new approach to the PUoS, in that it must include a space for our cultural expectations about science. This does not consist in a simple telling of the history of science but recognition that as culturally and historically centred people we always view science 'as' something. My suggestion has been through the market research model of RDE in which it is not used as a tool to appeal to a demographic but reveal why certain ideas and understandings are more appealing than others. Here we treat science as a cultural product that has qualities and properties like any service or product we might buy. Our 'buying' in this context is willingness to give up belief or disbelief in the efficacy of a science. If we look at it in this way, in that, we select a 'brand' of science that compliments our worldview we do so through a number of cognitive heuristics. If this can be made explicit, it not only gives a sound account as to why bad science exists but it does not place blame on the part of the person who endorses an alternative practice as mere intellectual deficiency. We are all interpreters and it is in keeping the cultural proclivity to always have a worldview that is culturally-historically dependent that means we can acknowledge our bias.

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