Cultural diversity in nanotechnology ethics

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Along with the rapid worldwide advance of nanotechnology, debates on associated ethical issues have spread from local to international levels. However, unlike science and engineering issues, international perceptions of ethical issues are very diverse. This paper provides an analysis of how sociocultural factors such as language, cultural heritage, economics and politics can affect how people perceive ethical issues of nanotechnology. By attempting to clarify the significance of sociocultural issues in ethical considerations my aim is to support the ongoing international dialogue on nanotechnology. At the same time I pose the general question of ethical relativism in engineering ethics, that is to say whether or not different ethical views are irreconcilable on a fundamental level.

Within the space of less than a decade, nanotechnology has emerged as a major technological theme not only across most of the science and engineering disciplines, but also across most of the world, including in many developing countries in Asia, South America and Africa. Because they have identified great economic potential, or simply because they have not wanted to lag behind, governments around the globe have launched nanotechnology programmes and initiatives and promoted nanobusiness alliances to harvest the fruits of the 'next industrial revolution'. This perhaps unprecedented global technological movement has been fostered by exaggerated promises that nanotechnology will fundamentally change society, that it will bring the wealth, health, clean environment and security of which we have all dreamt. At the same time, however, warning voices have argued that such a powerful technology could also bring about unparalleled harm to the world, from environmental hazards to the destruction of all life. And so the ethicists and philosophers have been called in.

My involvement in discussions of the ethical and societal implications of nanotechnology has developed since 2002, through attending and organising conferences that have grown rapidly from small-scale meetings to large international events, and through sitting on boards and expert groups to advise others on these matters. There is little doubt that ethical reflection has been unable to keep up with the pace of globalisation of the nanotechnology movement. Unlike research in nanotechnology, perception of ethical issues surrounding nanotechnology is influenced by the specificities of cultural background, to the extent that, for instance, some countries heavily involved in research do not see any such issues at all. All this causes misunderstandings and contributes to the reinforcement of cultural clichés, which need to be overcome by in-depth discussion. As nanotechnology turns global, with prospective global impacts, both positive and negative, the globalisation of the ethical debate around nanotechnology becomes ever more important.

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In order to facilitate such debate I try here to bring into systematic form my own personal experience, from numerous international discussions, of the cultural diversity of perceptions of ethical issues related to nanotechnology. Rather than providing personal anecdotes or hermeneutical studies of this or that culture, I investigate various ways in which perception of ethical issues can differ. Such a philosophical approach requires that concepts are both broad enough to embrace the cultural diversity, and clear enough for conclusions to be drawn. Thus, by 'perception of ethical issues of technology' I mean perception of conflicts with one's individual moral intuition or with the moral order of one's society that might be caused by a given technology in the present, past or future. (Note that this is different from the much-discussed perception of risks.) Furthermore, by 'technology' I mean not only actual or possible technological products, but also associated technological knowledge, manufacturing processes from laboratory to industrial scale, and research and development activities (R&D) including the control mechanisms that govern them.

As with any philosophical analysis, my analysis of cultural conditions takes apart what is in reality interwoven in any given culture. Indeed, I will analyse separately five dimensions of sociocultural conditions, namely language, cultural heritage, economy, politics and ethics. For the purpose of my main argument the analytical distinction does not matter, however, because my aim is to illustrate and to help understand the rich diversity of ethical issues that can be perceived, depending on one's cultural background. Ultimately, cultural diversity poses the question of ethical relativism in engineering ethics, in other words whether different ethical standpoints are irreconcilable on a fundamental level, a position I will finally reject.

LINGUISTIC CONDITIONS: DEFINITIONS OF NANOTECHNOLOGY

As with most ethical issues, the perception of ethical issues surrounding nanotechnology has an essential dependence on the definition of crucial concepts. While some concepts may be defined on a cross-cultural scientific basis with high precision, for example concepts related to scientific measurement, others resist such an approach, remaining unfocused and context-dependent, such that cross-cultural translation becomes virtually impossible. Despite using the same, or a literally translated, term, people from different cultures read in different meanings that may result in different perceptions of ethical issues.

In the present context, the most problematic term is 'nanotechnology' itself. Definitions are vague, and there is no general agreement on what nanotechnology is. Different communities, disciplines and countries use different concepts, which are in turn under continuous revision. Note that the mere fact of a vaguely defined technology, which is at the same time said to have huge impacts on society, may already shape the perception of ethical issues, as it allows space for projecting personal fears, suspicions and hopes onto the unknown.

Among current definitional approaches, three types prevail. First, there are what philosophers call 'nominal' definitions, i.e. defining a term against necessary and sufficient conditions. The most common of these define nanotechnology as the investigation and manipulation of material objects in the 1–100 nanometre range, in order to explore novel properties and to develop new devices and functionalities that essentially depend on that

1–100 nanometre range. Whether intentionally or not, this definition covers all classical natural science and engineering disciplines that investigate and manipulate material objects, including chemistry, materials science, solid state physics, pharmacology, molecular biology and chemical, mechanical and electrical engineering. This is because almost any material is structured in the 1–100 nanometre range in such a way that its structure in this range determines properties and (technologically speaking) functionalities.[1] If you stick to such a definition, you will perceive no new ethical issues simply because there is nothing new about nanotechnology other than the term. It is according to this definition that researchers from across the board of science and engineering disciplines are currently relabelling their research 'nano', because it helps them raise funding, and rightly so.

The second definitional approach, also known as 'real' definition, refers to a list of particular cases of current research topics. Such lists typically include scanning probe microscopy, nanoparticle research, nanostructured materials, polymers and composites, ultra-thin coatings, heterogeneous catalysis, supramolecular chemistry, molecular electronics, molecular modelling, lithography for the production of integrated circuits, semiconductor research and quantum dots, quantum computing, MEMS (micro-electro-mechanical systems), liquid crystals, small LEDs, solar cells, hydrogen storage systems, biochemical sensors, targeted drug delivery, molecular biotechnology, genetic engineering, neurophysiology, tissue engineering, and so on. Unrelated as these research topics are, apart from their common topicality, it would be more appropriate to speak of 'nanotechnologies' (plural) than of a single 'nanotechnology', particularly because there is, contrary to many claims and hopes, no particular interdisciplinary collaboration.[2] From an ethical perspective, it is difficult to identify any one possible issue that would equally apply to all these research fields. So sticking to this second type of definition, one's perception of ethical issues of nanotechnology essentially depends on what is included in the list. Since the list varies from country to country, even from research community to research community, and since it changes over time, perceptions of ethical issues are bound to change accordingly. Moreover, because this type of definition lumps together what are otherwise unrelated fields, personal fears and hopes about one technology may spread over and contaminate all other 'nanotechnologies' without reason.

The third definitional approach, 'teleological' definition, defines nanotechnology in terms of future goals. To be specific, one needs to provide more than just generic values, such as health, wealth, security and so on, and more than just relative attributes like smaller, faster, harder, cheaper. Since their introduction by Eric Drexler twenty years ago, teleological definitions of nanotechnology have developed into visions of a futuristic technology that will radically change everything, from industrial production to the somatic, psychological and social conditions of human life.[3] According to this approach, current research belongs to nanotechnology if it helps realise a nanotechnological future in which these prospective goals will be achieved. Numerous such visions are in circulation, particularly in the US but more recently also in Europe. Besides Drexler and many other software engineers, who dominate the popular book market on nanotechnology with their fantastic visions of nanorobots that can do anything, from gaining immortality to totally destroying intelligent life, there is a proliferating nano-science fiction field that essentially inspires them.[4] In addition, the US administration has assumed its own nanotechnological visions, from the Drexler-like 'shaping the world atom by atom'[5] to transhumanist visions of the 'convergence of nanotechnology with biotechnology, information technology, and cognitive science' for the enhancement of human intelligence and physical performance.[6]

If you stick to teleological definitions, ethical issues of nanotechnology immediately arise. Because goals are normative concepts, i.e. they prescribe what kind of technology should be developed, the entire discussion about nanotechnology in terms of teleological definitions is actually a hidden normative debate about norms and values that are frequently expressed in the form of hopes and fears. Moreover, if one believes that normative debates should be conducted explicitly and deliberately in public discourse, the teleological approach to defining nanotechnology taken by governments and others is already an ethical issue because it smuggles in values in the disguise of definitions or forecasts of allegedly deterministic technological developments, which are kept apart from normative debates.

However one defines or avoids defining nanotechnology fundamentally shapes one's perception of related ethical issues. The scope of ethical perceptions ranges from vague fears and hopes, to no new ethical issues at all, to very particular ethical issues and basic questions about technology governance.

The definitional conditions of perceiving ethical issues of nanotechnology discussed thus far go beyond the level of cultural distinctions and may readily apply to the views of different individuals from the same culture. There is some evidence, however, that certain countries favour different definitional approaches and different definitions from others. For instance, in the US the teleological approach along with a vague nominal definition has become prevalent in public discourse, because it resonates with the religious tradition (see below), is easier to communicate to a broader public without much scientific literacy, and avoids an explicit discourse about norms and values of technology. In Japan, where nanotechnology started with the Atom Technology Project in the 1990s as an effort to fund so-called fundamental research, and where critical public attitudes towards technology are rare, the real definitional approach seems more significant, with a list of research topics that has been continuously revised and that differs from the nanotechnology funding lists of other countries.[7] In general, since 'nanotechnology' does not denote an established research field but is rather a term used by governments to describe their research funding priorities, definitions may be tailored so as to cope with the ethical sensitivities of their publics, which itself may already be perceived as an ethical issue.

At this point one might become doubtful of the sense of discussing ethical issues related to nanotechnology at all. On the one hand, discussion of such issues requires clarification of the term's meaning to ensure that we are speaking about the same thing; on the other, any such definitional clarification already shapes the perception of ethical issues almost at will. There seems to be no way to escape this circle other than giving up the idea that 'nanotechnology' (singular) can be defined in a meaningful way to discuss specific ethical issues of that technology. It would be more reasonable to identify ethical issues by scrutinising each of the individual technologies that are more or less loosely associated with nanotechnology.[8]

However, the perception of ethical issues related to an individual technology may be affected even by its loose association with 'nanotechnology', since many issues of public concern are related to the novelty of technological products that provokes uncertainty and fear of risks. If nanotechnology is propagated through its novelty, as being 'the next industrial revolution' as the US National Nanotechnology Initiative has claimed since its launch in 2000,[9] any technological product associated with nanotechnology may be supposed to bear new kinds of risks and to require new regimes of evaluation. If, on the other hand, nanotechnology is (according to the nominal definition) considered to be simply a new term for received technologies, then any new technological product associated with nanotechnology may be considered the result of continuous development, and likely to be well covered by existing regulatory regimes. Mere association with 'nanotechnology' thus affects evaluation of the novelty of a product, and thereby the decision whether old or new evaluation regimes need to be applied.

A good case in point are nanoparticles. It has been known empirically for centuries, and understood to a degree by quantum mechanics, that the electromagnetic, chemical and catalytic properties of nanoparticles of the same composition can vary with the size and shape of particles in the nanometre scale. In this regard, recently burgeoning research in nanoparticles belongs to a continuing tradition. What is new, however, is the systematic development and large-scale industrial production of nanoparticles (and nanostructured materials with nanoparticle abrasion) for specific uses. Increased exposure to manufactured nanoparticles poses new health and environmental risks, because their size-dependent properties and potential toxicity are unknown, and because below a certain size they can permeate biological membranes. Thus far no country worldwide has a regulatory regime for nanoparticles, but instead use of materials continues to be controlled only according to their composition, thus expressly disregarding particle size. Therefore, emphasising the novelty of nanoparticles through the novelty of nanotechnology not only brings greater awareness of risks. It also raises ethical concerns that current regulations are insufficient and that we need to develop a new regime for nanoparticles.

CULTURAL HERITAGE

Perception of the ethical implications of nanotechnology, or of any technology for that matter, also depends on culturally embedded sensitivities, symbolic meanings, and religious or literary myths specific to a particular culture. Depending on how the new technology is framed (see above), it may trigger memories of past issues and myths and provoke judgement by analogy or stereotype. Unlike the ideal of philosophical ethics, public perception and debate around ethical issues is dominated by such culture-specific responses. While examples from nanotechnology abound, I will focus specifically on a comparison of Western European and US perspectives.

In Western Europe, for example, the Christian idea of an artisan-like creator-God has always provoked stereotypical criticism of technology. As soon as nanotechnology is framed in terms of 'reshaping nature atom by atom', it can readily be accused of hubris (playing God) and destroying nature (changing God's creation against God's will), two concerns that have accompanied chemical craft and science since antiquity and eventually inspired the literary motif of the 'mad scientist'.[10] In the US, where Christian religion is much more focused on the 'end times', nanotechnology is rather viewed as the dawn of the 'Golden Age', the 'Apocalyptic destruction', or both.[11] If even Europeans and US-Americans, despite their common religious roots, differ considerably in their religion-based perception of ethical issues of nanotechnology, the cultural diversity worldwide is likely to be substantial.

Apart from religion, cultural traditions and particular events in the more recent history of a culture can inform specific sensitivities. For instance, as a result of their Nazi legacy, Germans are particularly sensitive to any approach that could be used or abused for eugenic purposes. From this point of view, the mere notion of 'human enhancement', which the US government has made one of its primary goals for nanobiotechnology and in which the military has a vested interest, is not only suspicious but also strongly abhorrent. Similarly, from a pacifist point of view, which still pervades countries that experienced two world wars on their own territory, any nanotechnological research for weapons development appears morally questionable, because weapons are made for destructive purposes and/or may cause another arms race. In the US, on the other hand, where a large part of the federal budget for nanotechnology R&D has gone to the Department of Defense, the vast majority of people take great pride in the strength of the military and thus support weapons research. Support has even increased since the 9/11 terrorist attacks, so long as such research is said to strengthen 'homeland security'. However, the same event has also caused tremendous fear of any terrorist abuse of technology, which has become a main focus in the American perception of ethical issues surrounding nanotechnology and which is additionally inspired by the proliferating nano-science fiction field.

Societies also differ greatly in their normative ideas about human identity and integrity, putting different weight on different aspects of human existence, and accordingly their perceptions of ethical issues of nanotechnology differ. For instance, US policy-makers foresee particular societal concerns in the 'use of nanotechnology in enhancing human intelligence and in developing artificial intelligence which exceeds human capacity'.[12] The underlying assumption here seems to be that US-Americans, perhaps more so than Europeans, identify themselves with machine-like 'intelligence' operations of their brains that can be enhanced by IT. Any improvement of that operational capacity would change the identity and thus affect the integrity of human beings. Moreover, a machine that is better at these operations than human beings could undermine human self-esteem, if not dignity, and cause fears of loss of control. On the other hand, if one considers such operational capacities only an instrumental rather than an integral part of human beings, and bases human identity and integrity instead on moral, social and other mental capacities (such as free will), as European philosophers of the Enlightenment did, these concerns are less important.

Another normative idea concerning the integrity of human beings is individual privacy, according to which a private sphere needs to be protected from public access. In any society, privacy is codified in laws and taboos, but the differences are surprisingly large even among European countries. For instance, Germans treat their salary like a private secret, whereas in Scandinavian countries the complete tax return of every citizen is displayed in public libraries. By contrast, both in Germany and Scandinavian countries, public nudity on nudist beaches is commonly accepted, whereas this would seriously breach a privacy taboo in many other European countries, like, for instance, England. England, in turn, stands out for first introducing surveillance cameras in public spaces, which in other European countries would be considered a violation of privacy rights. These examples illustrate that, although each culture clearly has a normative idea of privacy, the specific aspects of the private sphere that need to be protected vary enormously even within Europe, and much more so worldwide.

One of the current promises of nanotechnology is that it will provide ultra-small sensors, computing and signal transmission devices. This puts the current privacy debate about macroscale radio-frequency identification devices (RFIDs) and ubiquitous computing on a new level, because the devices might be too small to be detected by the naked eye and thus invade private spheres much more easily than before. Because of the wide cultural diversity in notions of privacy, perception of privacy issues around nanotechnology may also be expected to be culturally very diverse.

Finally, owing to the vagueness of definitions, nanotechnology is an excellent candidate for loading with culture-specific symbolic values, such that it stands for something else that is considered intrinsically good or bad. Examples of objects loaded with culture-specific symbolic values are social prestige objects that stand for social status and are thus highly valued independent of their instrumental value. Indeed, like the Apollo programme and other technological prestige projects during the Cold War, the US government has already symbolically loaded nanotechnology. Whatever it is, nanotechnology is something in which the US must have 'global leadership'.[13] Once nanotechnology is made a national prestige object, the perception of ethical issues changes because it stands for something that is considered intrinsically good, such that any criticism would seem to undermine the cultural basis of values. There is some evidence that nanotechnology is also becoming a national prestige object in other countries, including fast developing ones like South Korea and China, where efforts in nanotechnology R&D are intended to catch up with the West.[14] A likely problem for rapidly developing countries is that nanotechnology may become a symbol of (Western) modernism, and thus a symbolic target for traditionalist critiques. If nanotechnology, as so many other technologies before, becomes a proxy on which the modernism/traditionalism conflict is debated in developing countries, that will radically affect the perception of ethical issues of nanotechnology there.

ECONOMIC CONDITIONS

The perception of the ethical implications of nanotechnology also depends on the economic situation of a given country. If nanotechnology is considered as enabling 'the next industrial revolution', i.e. as providing a unique opportunity for huge economic improvement, no country wants to lag behind, naturally. Thus the economic promise puts enormous pressure on suppressing or at least outweighing ethical issues, both in developing and developed countries. However, there are some important differences between these two situations.

In many developed countries, a large part of private investment in R&D for new technologies comes from venture capital, i.e. from individuals or investment funds that seek potentially very high interest rates in risky investments. If the venture capital market also allows for bets on losses, i.e. if money can be made from falling prices, fluctuations tend to be very high. The two recent examples of venture-capital sponsored technologies, internet technology and biotechnology, illustrate that the venture capital market, with its associated media, is prone to extreme exaggeration of both positive and negative prospects for new technologies in two separate phases. In the first phase, the 'bull market' or 'bubble creation', the new technology is promised to enable 'the next industrial revolution', leading to astronomical growth rates. In this phase any negative information, including ethical concerns, is largely suppressed. As a result of any incident, the first phase can abruptly turn into the second phase, the 'bear market' or the 'burst bubble', in which prices immediately drop and in which any negative news, including ethical concerns, is eagerly embraced and exaggerated in the media. For venture capitalists, nanotechnology is currently in the first phase. And because information about nanotechnology is drawn mostly from business magazines and newspaper business sections, the public perception of ethical issues of technology in developed countries is strongly influenced by the interests of the venture capital market.[15]

For developing countries, being part of 'the next industrial revolution' from the outset offers a unique opportunity to catch up economically. It is much easier to start out in a new market than to compete in traditional industrial markets where the R&D gap is big and where global companies are already established and have protected their research and products by broad patenting strategies. Because of the supposedly unique situation, it is likely that developing countries will tend to neglect ethical issues of nanotechnology, on the basis that they will be outweighed by the extraordinary economic benefit of an early and unhindered R&D effort.

There are at least two ethical issues related to nanotechnology, however, that might be more readily perceived in developing than in developed countries, because they reflect issues of equity in a globalised market. First, the rise in fortunes of all the research fields mentioned above in discussing the 'real' definition of nanotechnology began at a time when patent policies drastically changed in the Western world, first in the US with the 1980 Bayh-Dole Act and more recently in Europe. Since universities have been allowed to file and market their own patents, much of the kind of knowledge that was formerly in the public domain, including basic engineering knowledge, is now protected by patents. The large-scale shift from public to private knowledge considerably increases the costs of industrial R&D that builds on existing knowledge, which must now often be bought through licences. While this of course affects industrial research in any country, it particularly increases the knowledge gap between rich countries and poorer ones that cannot afford the licence fees. Because R&D expenditures are usually much higher in richer countries, nanotechnology (under the real definition) may be expected to increase the economic gap between rich and poor countries much more than any previous technology.

The second issue is even less obvious because we tend to associate nanotechnology with small things. On an industrial world market scale, however, small things easily sum up to hundreds or thousands of metric tons of materials per year, with materials prices of millions to billions of dollars. Since raw material resources that need to be mined, particularly metals, happen to lie mostly in developing countries, any change in materials demand on the world market would have its most pronounced effects on the economies of these countries. Many of the research fields listed in real definitions of nanotechnology have the potential to change world metals markets. For instance, catalysis research could, and deliberately should, lead to substitutes for platinum and palladium that are almost entirely mined and produced in South Africa at a value of several billion dollars per year. Nanostructured ceramics are about to replace much of the current tungsten (nitride), mainly produced in China at three hundred and fifty million dollars per year. Organic semiconductors could replace many of the classical semiconductor elements such as gallium, germanium, selenium, cadmium, etc. There are many more examples which suggest that much of current nanotechnology, particularly nanostructured materials, could continue a long-term trend in making industrialised countries independent of the resources of developing countries, thus increasing the economic gap. In countries whose economies depend on the export of raw materials, people are more likely to perceive this as an ethical issue of nanotechnology.

POLITICAL CONDITIONS

Because politics is a very complex field, I focus here on only two aspects of how the political conditions in a country can influence the perception of ethical issues of nanotechnology by its citizens: the form of technology governance, and its relation to the general political system. Technology governance is the political control of technological development, including the whole sphere of political instruments from governmental R&D programmes and institutes, to subsidised industries, to restrictive regulation. With some simplification, we can distinguish between three models of technology governance according to different kinds of citizen involvement.

In the *autocratic* model, decisions on technology governance are made autocratically, either by governments (political leaders or bureaucratic administrations) or by corporations, without provision of public information about the technology and its positive and negative impacts on society. In such cases the perception of ethical issues tends to be low, owing to the lack of information, and stereotypical according to general attitudes. The perception is different, however, if the autocratic model applies only to a subset of R&D activities that are intentionally kept secret in the name of the national interest. This includes R&D that is said to serve the military, intelligence agencies, 'homeland security' or other political institutions that are excluded from the usual public checks and balances. Because secrecy raises suspicion and mistrust, it inspires the imagination and encourages rumours about fantastically powerful technologies of the greatest ethical concern.

In the *information-plus-debate* model, public information, including educational programmes and public spaces for debate, are provided on all R&D activities. This certainly helps avoid the suspicion and concerns raised by secret R&D. However, as many studies in the public understanding of science have demonstrated, information about science and technology does not simply dispel ethical concerns, at least in democratic countries. Instead, information helps concerns to be formulated more specifically and public debates help sharpen the arguments, while general attitudes towards technology continue to determine the degree of concern and criticism. Confronted with new technologies on the market, critical citizens can protest only by refusing to buy or consume their products.

The *democratic* model involves citizens from the very beginning in the political decision-making processes that shape future technologies. This model has learnt the lesson that people who perceive ethical issues around new technologies are more likely to accept them if they see themselves as part of the technology governance process. The step from being informed and discussing the issues to being involved in the political decision-making procedure moves individuals from a passive to an active role which implies three important changes. Being able to make a decision requires, first, that there are real options to decide between, which may include various forms or variations of the technology in question, beyond a mere yes or no – thus the citizen decision-maker actually helps form an acceptable technology and so has little reason to mistrust technology governance. Second, it requires that for each option the various pros and cons are compared, putting specific ethical concerns in a wider context of ethical and political deliberations. Third, it requires responsibility towards society, such that in time critical questions can be answered and decisions defended. In sum, a political system that allows citizens in one way or another to participate actively in technology governance does not dispel ethical issues of new technologies, but rather incorporates them into the shaping of technologies. The perception of ethical issues thus becomes part of a politically responsible activity.

If one considers the extent of secret military and corporate research in nanotechnology, most countries in fact have some mix of the autocratic model and the information-plus-debate model, and differ only in the degree of public information and debate. Indeed, many Western countries have established governmental technology assessment bureaus that, in addition to advising governments and administrations, try to inform the public about new or recent technologies. All in all, however, political conditions within the scope of the two models seem to affect the perception of ethical issues of nanotechnology only to the extent that concerns are more or less specific and supported by argument, depending on the level of public information and debate on nanotechnology, which is still low in all countries.

There is one other political dimension that affects the perception of ethical issues of nanotechnology. Countries differ in their general political cultures and systems. Provided that citizens trust their general political system, any form of technology governance that does not fit the general political system may cause mistrust. Thus, citizens in a strongly democratic system would mistrust the autocratic model of technology governance, and vice versa. Moreover, societies differ in the degree of desired political regulation. Some countries prefer less political control and planning, relying more on free market control. For such countries both autocratic and democratic models of technology governance would be foreign, whereas the information-plus-debate model that educates informed consumers would appear more suitable. Other countries trust more in the efficacy of political control and advance planning, for which the autocratic or democratic models of technology governance would be more suitable than the information-plus-debate model.

In every country I know of, nanotechnology programmes have been launched by government decree, with little prior public involvement or debate on the utility of such a programme and of nanotechnology in general. In the US, where the launch of huge research programmes has a long tradition dating back to the Manhattan Project, the parallel start of an information-plus-debate programme meets general political expectations by preparing the way for the preferred free-market control by informed consumers. In many Western European countries with less trust in free-market control, the autocratic launch plus the information-plus-debate model cannot substitute for the democratic model of technology governance. Indeed, democratic models of citizen involvement from the earliest stage on have been developed in various European countries, for example 'consensus conferences', 'constructive technology assessment' and 'upstream technology assessment'.[16] Thus, for many Europeans, particularly for political ethicists, the undemocratic governance of nanotechnology is a big ethical issue because it fails to fit with their general ideas of a just political system.

ETHICAL FRAMEWORK

Of course it is tautological that one's ethical standpoint influences one's perception of ethical issues. From that one might readily find support for ethical relativism. However, as promised in the introduction, I will not defend radical ethical relativism. Instead I will argue that small differences, both in definitions of ethically relevant concepts and in relative weighting of values, may be sufficient to generate widely differing perceptions of ethical issues of nanotechnology.

Basic ethical concepts that impact on the perception of ethical issues are normative concepts, such as human integrity and privacy discussed above. The most general, however, is the concept of a good life. I assume all cultures have such a concept, though they may differ in the detail of what it involves. For instance, they may all include some ideas about physical, mental and social wellbeing and health, but differ with regard to the relative weights given to these three components. While traditional cultures put more weight on social wellbeing, modern individualist cultures tend to neglect that in favour of physical and mental health. Moreover, each of the three components may have slightly different meanings in different cultures. For instance the notion of mental health and wellbeing may cover various mental capacities, for example intellectual, emotional, aesthetic, social and moral. Again, cultures differ in the emphasis they lay on each of these components. While one culture might define mental health primarily in terms of intellectual performance, another will put more weight on social and emotional capacities, and so on.

If nanotechnology is, like other technologies, a means of improving conditions for a good life, then it does so only with regard to specific aspects of the concept of a good life. These aspects may be valued per se in every culture, but since different cultures put different relative weights upon them, what is considered a major improvement in one culture will be less important in another. Moreover, an improvement in one aspect could be at the expense of other aspects. For instance, improving physical health to the extent of prolonging life by nanobiotechnology could simply increase the rate of mental disorder through the dementia of life-prolonged patients; it could also undermine traditional strategies for social wellbeing, from social relationships between generations to systems of social insurance. Or, improving intellectual performance through nanotechnological devices could go at the expense of other mental capacities. Thus, what might be considered an improvement in one culture could in another raise concerns and be perceived as an ethical issue of nanotechnology, because of different underlying concepts of a good life.

The general issue here is that, even if all cultures hold the same values, they may put different relative weights upon these values and thus draw different ethical conclusions. Some values are antagonistic to one another in the sense that pursuing one usually has a negative effect with regard to the other. For instance, security and liberty are antagonistic because increasing the security of citizens usually restricts their liberty, and increasing liberty weakens security. As a result, each culture needs to find a balance between security and liberty that depends on the relative weight put on these values. If nanotechnology will help increase security, say by new surveillance and control systems or by portable medical systems that monitor and control health, it will at the same time weaken liberty. Some cultures might embrace these developments, others will not.

Some values are not strictly antagonistic but can nevertheless be in conflict. Increasing wealth as a means of improving conditions of life has environmental costs if it is achieved by industrial production that consumes resources, generates pollution, and accumulates waste – and here of course industrial nanotechnology production will be no exception. Depending on how much the natural environment is valued in a culture, and on what the other options to nanotechnology production are, this might be perceived as an important ethical issue or not.[17]

Similarly, the values of utility and (distributive) justice can easily come into conflict through new technologies.[18] A technology that unquestionably improves the conditions of life of individuals could at the same time increase inequality among the general population, because for various reasons the benefits are not justly distributed. For instance, a nanobiotechnology-based medical treatment could be so expensive that only the economic elite can afford it; or the beneficial use of a nanotechnology-based device may require considerable knowledge skills so that in practice only the educational elite can benefit from it. Cultures that value justice over utility will certainly raise ethical concerns about the injustice induced by the new technology. Others that put a lower value on justice, or have a different concept of justice, will embrace the technology without much hesitation. Cultures with a still lower evaluation of justice would perhaps accept the technology even if it posed unequally distributed risks, such that it benefited a fraction of society and harmed another fraction, so long as the benefits overall outweighed the harms.

CONCLUSION: CULTURAL DIVERSITY WITHOUT ETHICAL RELATIVISM

Each of the five dimensions of sociocultural conditions discussed in this paper (language, cultural heritage, economy, politics, ethics) entails a large variety of different perceptions of ethical issues. Overall, the scope ranges from no issue at all, to very specific issues, to general concerns and hysteria. In discussions about nanotechnology over the past four years I have met all these views, and many more that I omit for reasons of brevity. Although the five-dimensional scheme allows the dominant perceptions to be located in various cultures, there may be a great variety of perspectives even within one country. Whether or not this is a result of globalisation or the trend towards multicultural societies, it does allow for improved ethical understanding of the other because probably no one view is entirely foreign to any given society.

Since my five-dimensional scheme points to cultural differences rather than to the common grounding of ethical views, I may appear to be arguing for ethical relativism. In the common-sense understanding, 'ethical relativism' means that individuals and/or cultures differ in their ethical views such that they make different moral statements on particular cases. This is trivially true, because it is in fact the case – otherwise there would be no moral debate. In philosophy, however, 'ethical relativism' implies that individuals and/or cultures differ in their *fundamental* ethical views, such that even perfect information about all details of a case and a uniform understanding of all concepts involved cannot settle their moral conflict. Because only few of the cultural conditions I have analysed refer to differences in information and conceptual understanding, it seems that this paper has made a case for that kind of ethical relativism.

In cross-cultural ethical debates, ethical relativism is a frustrating dead end. All one is left to do is analyse a conflict down to the 'fundamental' level, and then point out the irreconcilable differences. Numerous debates on human rights and in medical ethics have finished like that, and I have no desire to repeat that experience in engineering ethics in the face of increasingly globalised technologies. Beyond being practically fruitless, the philosophical idea of ethical relativism is also a misleading concept because it is based on four problematic assumptions about the ethical views of human beings, as follows.

First, ethical relativism assumes that our ethical views are organised in an axiomatic manner such that they are all based on fixed sets of 'fundamental ethical views' on which people can differ. While the axiomatic ideal of ethics might be appealing to mathematical reasoning, it has little evidence in support and has therefore been criticised by philosophers ever since Aristotle. In this paper, I have argued for an entirely different view. Instead of an axiomatic order, there are various dimensions of cultural conditions that shape our ethical views. These dimensions are to some degree independent of each other, and we do not even know how they interact to form ethical views. Second, even if we take the values discussed above as ethical 'fundamentals', differences arise not because people hold different values, but because they weigh these values differently; and the balance of values may change not only from culture to culture, but also from time to time and from case to case, depending on other factors involved. Third, the clear-cut distinction between ethical views and descriptive information and concepts which underlies the idea of ethical relativism is questionable. Concepts are normatively loaded in subtle ways, as I have illustrated in several examples, and thus are an integral part of our ethical views. Finally, and most importantly, human beings are not as static as ethical systems in philosophy, which ethical relativism presupposes. Their ethical views can change and grow. Understanding the cultural conditions of my own ethical views can help me develop a more reflective view. Discussing ethical issues with people from different cultures not only provides information. It can also help me see new normative aspects or let me value some normative aspects differently.

International discussion of ethical issues of nanotechnology is an excellent and important exercise, not only because views on nanotechnology are so diverse, but also because nanotechnology is frequently attached to a particularly strong and naive attitude of 'improving the world'. International discussions can help us understand that our notions of both 'improvement' and 'the world' are very complex, culturally diverse and under continuous revision. If such discussions do not reach perfect agreement, we need not resort to ethical relativism, but recognise that people put different weight on different factors. And since nanotechnology is not monolithic, but a bunch of very diverse technologies in the making, societies still have a chance to shape its development according to their own specific societal needs and ethical views.[19]

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NOTES

1. J. Schummer: 'Interdisciplinary issues of nanoscale research', in *Discovering the Nanoscale*, (ed. D. Baird, A. Nordmann and J. Schummer), 9–20; 2004, Amsterdam, IOS Press.
2. J. Schummer: 'Multidisciplinarity, interdisciplinarity, and patterns of research collaboration in nanoscience and nanotechnology', *Scientometrics*, 2004, **59**, 425–465.
3. K. E. Drexler: *Engines of Creation: The Coming Era of Nanotechnology*; 1986, New York, NY, Anchor Press.
4. J. Schummer: 'Reading nano: the public interest in nanotechnology as reflected in book purchase patterns', *Public Understanding of Science*, 2005, **14**, 163–183.

5. *Nanotechnology: Shaping the World Atom by Atom*; 1999, Washington, DC, National Science Technology Council. For an analysis of the underlying worldview, see A. Nordmann: 'Nanotechnology's worldview: new space for old cosmologies', *IEEE Technology and Society Magazine*, 2004, **23**, (Winter), 48–54.
6. M. C. Roco and W. S. Bainbridge (ed.): *Converging Technologies for Improving Human Performance: Nanotechnology, Biotechnology, Information Technology and Cognitive Science*; 2002, Arlington, VA, NSF.
7. Y. Fujita: 'Heterogeneous scientists meet in the national lab: the Atom Technology Project in 1990s Japan', unpublished paper presented at the conference *Nano Before There Was Nano: Historical Perspectives on the Constituent Communities of Nanotechnology*, Chemical Heritage Foundation, Philadelphia, PA, March 2005.
8. J. H. Moor and J. Weckert: 'Nanoethics: assessing the nanoscale from an ethical point of view', in *Discovering the Nanoscale*, pp. 301–310 (see Note 1); B. Gordijn: 'Nanoethics: from apocalyptic nightmares and utopian dreams towards a more balanced view', *Science and Engineering Ethics*, 2005, **11**, 521–533; J. Schummer: 'Identifying ethical issues of nanotechnologies amidst the nano hype', in *Nanotechnology: Science, Ethics and Policy Issues*, (ed. H. ten Have); 2006, Paris, UNESCO.
9. White House, Office of the Press Secretary: 'National nanotechnology initiative: leading to the next industrial revolution', press release, 21 January 2000, Washington, DC.
10. J. Schummer: 'The notion of nature in chemistry', *Studies in History and Philosophy of Science*, 2003, **34**, 705–736; W. R. Newman: *Promethean Ambitions: Alchemy and the Quest to Perfect Nature*; 2004, Chicago, IL, University of Chicago Press; J. Schummer: 'Historical roots of the "mad scientist": chemists in 19th-century literature', *Ambix*, 2006, **53**, (2), forthcoming.
11. J. Schummer: 'Nano-Erlösung oder Nano-Armageddon? – Technikethik im christlichen Fundamentalismus', in *Nanotechnologien im Kontext: Philosophische, ethische und gesellschaftliche Perspektiven*, (ed. A. Nordmann, J. Schummer and A. Schwarz), 263–276; 2006, Berlin, Akademische Verlagsgesellschaft.
12. *21st Century Nanotechnology Research and Development Act*, Washington, DC, December 2003, Sec. 2, b.10.
13. From the launch of the US National Nanotechnology Initiative to the *21st Century Nanotechnology Research and Development Act* (Sec. 2), 'ensuring United States global leadership' has been a primary concern.
14. For a quantitative study of research outputs, see R. N. Kostoff, J. A. Stump, D. Johnson, J. S. Murday, C. G. Y. Lau and W. M. Tolles: 'The structure and infrastructure of the global nanotechnology literature', *Journal of Nanoparticle Research*, 2006, **8**, forthcoming.
15. J. Schummer: '"Societal and ethical implications of nanotechnology": meanings, interest groups, and social dynamics', *Techné: Research in Philosophy and Technology*, 2004, **8**, (2), 56–87 (reprinted in J. Schummer and D. Baird (ed.): *Nanotechnology Challenges*, 413–449; 2006, Singapore, World Scientific).
16. S. Joss and J. Durant (ed.): *Public Participation in Science: The Role of Consensus Conferences in Europe*; 1995, London, Science Museum; A. Rip and T. J. Misa (ed.): *Managing Technology in Society: The Approach of Constructive Technology Assessment*; 1995, London, Pinter; J. Wilsdon and R. Willis: *See-Through Science: Why Public Engagement Needs to Move Upstream*; 2004, London, Demos.
17. C. J. Preston: 'The promise and threat of nanotechnology: can environmental ethics guide us?', *Hyle: International Journal of Philosophy of Chemistry*, 2004, **10**, 19–44 (reprinted in J. Schummer and D. Baird (ed.): *Nanotechnology Challenges*, 217–248; 2006, Singapore, World Scientific).
18. B. V. Lewenstein: 'What counts as a "social and ethical issue" in nanotechnology?', *Hyle: International Journal of Philosophy of Chemistry*, 2004, **10**, 5–18 (reprinted in J. Schummer and D. Baird (ed.): *Nanotechnology Challenges*, 201–206; 2006, Singapore, World Scientific).
19. For such an approach tailored to the needs of developing countries, see F. Salamanca-Buentello *et al.*: 'Nanotechnology and the developing world', *PLoS Medicine*, 2005, **2**, (5), 100–103.

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