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Ethics and radiation protection

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Abstract

Some of the major problems in radiation protection are closely connected to issues that have a long, independent tradition in moral philosophy. This contribution focuses on two of these issues. One is the relationship between the protection of individuals and optimisation on the collective level, and the other is the relative valuation of future versus immediate damage. Some of the intellectual tools that have been developed by philosophers can be useful in radiation protection. On the other hand, philosophers have much to learn from radiation protectors, not least when it comes to finding pragmatic solutions to problems that may be intractable in principle.

1. Introduction

Radiological protection and moral philosophy differ in many respects. Radiological protection is based on physics and biology, and it has the clear practical aim of protecting human beings and the environment from specific types of damage. Moral philosophy is a much more abstract discipline, dealing with what is right and wrong, praiseworthy and blameworthy, in principle. It turns out, however, that some of the major problems in radiation protection are strongly connected with those that moral philosophers have worked with since antiquity. This applies in particular to the problem of combining respect for individual rights with the furthering of collective interests. Since moral philosophy is about 25 times older than radiation protection, it might then be hoped that moral philosophy should have ready-made solutions that can be taken over and applied by radiation protectors. This is not the case, but some thought patterns and modes of reasoning that have been developed in moral philosophy may be useful in radiation protection. On the other hand, moral philosophers have much to learn from radiation protectors, not least when it comes to finding pragmatic solutions to problems that may be intractable in principle.

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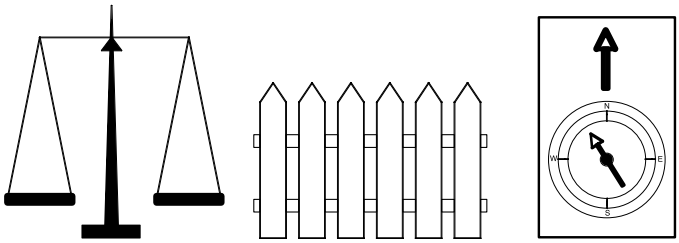

Figure 1. Three thought patterns in moral philosophy.

It is the purpose of the present contribution to introduce some of the interconnections between moral philosophy and radiation protection, with the hope of furthering increased connections between the two disciplines. In section 2, three major traditions in moral philosophy are introduced, and it is shown how they relate to current discussions in radiation protection. Section 3 is devoted to the choice between individual and collective risk-weighing, and section 4 to different ways of combining individual dose limits with minimisation of collective dose. Section 5 discusses how future exposures should be evaluated, and section 6 introduces some further issues that should be treated in future discussions on the ethics of radiation protection.

2. Three ethical thought patterns

There are many ways in which we can think about ethics and about the ethical requirements for our own actions and decisions. Moral philosophy is dominated by three thought patterns, each of which has been distilled into a type of moral theory. I would like to summarise them with the help of three metaphors, as illustrated in figure 1.

The first metaphor is that of *weighing*, as represented by the balance. Whenever there are several actions that one can choose between, it would seem sensible to specify the advantages and disadvantages associated with each of the alternatives, and then choose the alternative that has the largest net advantage (sum of advantages minus sum of disadvantages). In moral philosophy, this way of thinking is associated with *utilitarianism*. According to utilitarian philosophers such as Jeremy Bentham (1748–1832) and John Stuart Mill (1806–1873), morality requires that we choose the actions that maximise utility. Classically, utility was defined as the total amount of happiness produced by an action, minus the total amount of unhappiness that it produces. In modern moral philosophy other definitions of utility have been used, such as the total amount of preference satisfaction. However, the thought pattern is the same. Utilitarians want us to choose between actions by weighing their positive and negative effects against each other.

The second metaphor is that of a *limit*, represented in the figure by a fence. When we teach children ethical behaviour, we tell them that there are certain limits to what they may do. 'You may tell you sister that you are angry with her, but you may not beat her.' Moral philosophers have developed this mode of thinking into *deontological ethics*, also called duty ethics. The most famous deontologist was Immanuel Kant (1724–1804), who emphasised the strictness of moral limits. According to Kant, it is morally wrong to lie, and this applies even in cases when telling the truth can cause great harm. Other philosophers, most notably W D Ross (1877–1971), have developed less absolute variants of deontology, in which it is possible for a duty to be outweighed by other moral considerations. A closely related group of moral theories are *rights-based ethics*, in which the limits to our actions are constituted by the rights of other people.

The third metaphor is that of *orientation*, as represented here by the compass. Being ethical means more than being able to follow precepts of weighing or staying within given limits. An ethical person should have an inner sense of moral orientation. This means to be a virtuous person. *Virtue ethics*, the oldest well-developed form of ethical theory, focuses on the personality traits that one needs to develop in order to have a sound moral orientation. Aristotle's (384–322 BC) formulation of virtue ethics is still the most influential one. Virtue ethics declined in the twentieth century, but it has recently been revitalised, both in general moral philosophy and in some applied areas, notably nursing ethics.

In the current basic principles of the ICRP (1991, p 71), the foundations of radiation protection are summarised in terms of three principles: justification, optimisation and individual dose limits. This strikes me as an excellent confirmation of the close connections between moral philosophy and radiation protection. There is a rather obvious relationship between these three principles and the three thought patterns in moral philosophy that I have just introduced. Optimisation corresponds to weighing and utilitarianism, and dose limits equally obviously to the fence metaphor and deontology. Justification concerns acting with the right reasons and motives, which corresponds to the orientation metaphor and virtue ethics. (However, justification is an overarching principle. As was pointed out to me by an anonymous referee, the 1977 Recommendations of the ICRP described justification in terms akin to those in which optimisation was described. On this interpretation, justification could also be seen as a utilitarian principle.)

However, there is also an interesting difference. Philosophers typically identify themselves with one of the three thought patterns. At a conference on moral philosophy you will find utilitarians who argue that deontology is a misconceived form of moral philosophy, deontologists who say the same about utilitarianism, and virtue ethicists who claim that both utilitarians and deontologists ask the wrong questions in the first place. At a conference on radiation protection you will have a hard time finding optimisers who consider dose limits useless, dose limit proponents who claim that optimisation is irrelevant, or justification enthusiasts who regard optimisation and dose limits as mistaken approaches. Instead you will find radiation protectors who try to combine the three principles. However, this is no easy task, since the principles often conflict, or at least seem to do so. The conflicts are particularly sharp between the principles of weighing and limit-setting, i.e. between optimisation and dose limits. Similarly, in moral philosophy there are conflicts between utilitarian and deontological thinking. But where moral philosophers tend to choose one of the conflicting principles and defend it against the other, radiation protectors look for ways to combine the principles. Since both weighing and limit-setting have strong support from our moral intuitions, which are the ultimate source of any reasonable moral standpoint, this is in my view the better approach. Moral philosophers have something to learn from radiation protectors in this respect.

3. Two ways to weigh

Before investigating the conflict—or combination—between weighing and limit-setting, I propose that we have a closer look at the weighing principle. There is more than one way in which we can weigh the advantages and disadvantages of options against each other. I will leave aside the issue of exactly what these advantages and disadvantages consist of, since that is specific to context and subject-matter. (In the context of radiation protection, the disadvantages are doses of radiation, and the advantages are economic, medical and social advantages of the activities that give rise to these doses.) Instead I will focus on the distinction between two ways to weigh advantages and disadvantages that concern several persons.

Table 1. The prevalence in different social practices of individual and collective weighing of advantages and disadvantages.

Individual	*Collective*
Deontological moral theory	Utilitarian moral theory
Modern economic theory	The old school of welfare economics
Medical ethics	Risk analysis
Dietary advice	
Mixed	
Everyday moral reasoning	
Radiation protection	

The most common method is to weigh all advantages and disadvantages, irrespective of whom they pertain to, against one another in one single calculation. This we may call collective weighing. The major alternative is to treat each individual as a separate moral unit. Then advantages and disadvantages pertaining to each concerned person are weighed against each other in a separate act of weighing. A balance is thus struck separately for each individual. The most obvious way to make social decisions based on such individual weighing is to require a positive balance for each individual.

The crucial issue in choosing between the two types of weighing is whether or not there is interindividual compensability of goods, i.e. whether or not a disadvantage for one person can be outweighed by a (larger) advantage for another person. If we allow for interindividual compensation, then collective weighing appears more reasonable. If not, then individual weighing is the obvious choice.

There are many branches of social decision-making in which we have to choose between collective and individual weighing of advantages and disadvantages that affect different individuals. Interestingly enough, different choices have been made in different social areas and different intellectual traditions (Hansson 2004). See table 1.

In *moral theory*, weighing is primarily associated with utilitarianism. In utilitarianism, weighing is always collective. This means that individuals have no other role than as carriers of utilities and disutilities, the values of which are independent of whom they are carried by. Deontological theories are very different in this respect, since they put the focus on the individual. To the extent that weighing has a role at all in classical deontological theories, it is decidedly weighing of the individual type.

Everyday moral reasoning differs from both utilitarianism and deontology in being less clear-cut in this respect. In the informal moral argumentation that we all perform without reference to moral theories, we tend to allow interindividual compensation in some but not in all cases. Some issues of interindividual compensation are quite contentious, such as whether raised taxes for the wealthy can be justified by improved healthcare and welfare for lower-income groups.

In *economic theory*, the issue of collective or individual weighing is in fact the dividing line between the 'old' and 'new' schools of welfare economics. Full interindividual comparability prevailed in Pigou's (1920) so-called old welfare economics. In the so-called new school in welfare economics it was replaced by individual weighing. The latter school has dominated mainstream economics since the 1930s, when Robbins (1932, 1938) showed how economic analysis can dispense with interpersonal comparability. A central concept here is that of Pareto optimality. A state of the economy is Pareto optimal if and only if there is no other state that is better for one individual without being worse for at least one other individual. Modern theory of the market is based on Pareto optimality and thus on individual weighing.

Risk analysis developed in the 1970s out of attempts to deal with technological risks that were subject to significant public opposition. Today, risk analysis is methodologically dominated by probabilistic risk analysis (PRA). This means that uncertain outcomes are weighed according to their probabilities, so that for instance a risk of 1 in 50 that a person will die is counted as the death of 0.02 persons. In other words, risks are assessed according to their statistical expectation values (Hansson 1993). Expectation values that refer to risks for different persons are added in a calculation of the 'total risk' from an activity. Thus, risk analysis adheres to collectivist risk-weighing. Such calculations exclude from consideration many moral aspects of risk that have considerable intuitive appeal, such as the distinction between taking and being exposed to a risk, voluntary versus involuntary risk exposure, and fairness in the distribution of risks and benefits (Hansson 2003).

In *medical ethics*, the tradition is different. Medical ethics has a strong emphasis on the patient–physician relationship, according to which the physician is required to act in the interest of the individual patient. Therefore, when physicians talk about weighing risks against benefits they normally refer to the balance between risks and benefits for the individual patient. An interesting example of this is the ethical appraisal of clinical trials. It is an almost universally accepted principle in research ethics that a patient should not be included in a clinical trial unless there is genuine uncertainty on whether or not participation in the trial is better for her than the standard treatment that she would otherwise receive. That her participation is beneficial for others (such as future patients) cannot outweigh a negative net effect on her own health; in other words her participation has to be supported by an appraisal that is restricted to risks and benefits for herself (London 2001, Hansson 2006). It should be remembered that modern medical research ethics largely originated as a 'protest movement' against dangerous experiments that physicians had performed on their patients, justifying them with expected benefits for future patients. Hence, collectivist risk-weighing—letting one person's advantage outweigh another person's disadvantage—that is regarded as a standard of rationality in risk analysis is regarded as unethical in the medical context.

Dietary advice is very close to clinical medicine in the way in which it weighs risks and benefits. As an example of this, although fish is generally speaking healthy food, contaminants in fish caught in certain waters give reason to recommend limits in consumption. Such recommendations are based on the positive and negative health effects on the individual (and in the case of pregnant or breast-feeding women, on corresponding effects on the child) (Knuth *et al* 2003). It would be regarded as inappropriate to include other factors in these deliberations, such as the effects of diminished fish consumption on employment in the fishing industry or on regional economics.

Hence, when contamination comes with the food we tend to apply individual risk-weighing, adopted from medical thinking. In contrast, when contamination comes with the air, risks are more often appraised with collective risk-weighing, adapted from the standards of risk analysis. It is not obvious if and, in that case, how this difference can be justified in a principled way. Since radiation can come with both food and air, this discrepancy is important for radiation protection.

Finally, how can we describe the approach taken in *radiation protection*? Do radiation protectors apply individual or collective risk-weighing? As far as I can see, the picture is mixed. When radiation protectors discuss collective doses, or the contributions of different sources to total radiation exposure, the approach is mainly that of collective weighing. On the other hand, in discussions on dose limits and therapeutic or diagnostic exposures, individual weighing seems to be the norm. This mixed picture is no surprise. Radiation protection operates in a wide range of social contexts. In some of these contexts individual weighing is the norm and in others collective weighing. These differences seem to have arisen out of

differences in traditions rather than out of well-motivated principles. The unprincipled social mixture between individual and collective weighing is a problem for radiation protection to the extent that it strives to be consistent across sectors.

4. Combining the balance and the fence

As I mentioned in section 2, radiation protection tries to combine the two basic thought patterns of weighing and setting limits. In doing this it concurs with everyday moral reasoning, rather than with conventional moral theorising that instead tries to make a definite choice between the two approaches. Strivings to combine the two modes of moral thought have support in our moral intuitions, which strongly support both of them, but it is difficult to combine them in an intellectually fully satisfactory way.

One obvious way to combine the two principles in radiation protection is through what is called in decision theory a lexicographic ordering of the two principles. Two principles are lexicographically ordered if one of them has absolute priority over the other. Judging by recent discussions, it seems to be a common view among radiation protectors that compliance with individual dose limits should be given priority, in this sense, over reductions in collective dose. I hope that I do not simplify too much when I summarise this standpoint as follows: 'First, see to it that no individual dose limits are exceeded. After that, minimise collective doses'. (The minimisation referred to here will of course be restrained by technological and economic feasibility.)

This way to combine the two principles has the advantage of being simple, but it also has the disadvantage that in some situations we may have to pay high 'marginal costs' in terms of collective doses for some reductions in individual doses. This is best seen from a somewhat extreme hypothetical example. Suppose that we have the individual dose limit 10 (in some unit) that we adhere to very strictly and always give priority to over the reduction of collective doses. Furthermore, suppose that we have to choose between two alternative ways to conduct a specific work task. Five persons are involved. According to alternative A, one of these persons will receive the dose 11 and the others the dose 0, i.e. the exposure pattern will be $\langle 11, 0, 0, 0, 0\rangle$. According to alternative B, the dose pattern will be $\langle 9, 9, 9, 9, 9\rangle$. According to the lexicographic approach we should prefer B to A. This means that we 'buy' a reduction of 2 units for one person at the price of increases of in total 36 units for other persons. A more realistic example illustrating the same issue would be a choice between $\langle 11, 8, 7, 7, 7\rangle$ and $\langle 9, 9, 9, 9, 9\rangle$. (An anonymous referee pointed out that in this form, the choice between reductions in collective doses and in extreme individual doses is a conundrum well-known from annual revisions at nuclear installations.)

Of course, any radiation protector will react to examples like this by saying that this is not how we work in practice. We do not apply the lexicographic principle as strictly as that. And this is exactly what I want to show with this rather extreme example. The lexicographic principle does not seem to capture our considered opinions on radiation protection. Can we find a model that captures them better?

When looking for such a model we should consider the principles of distributive justice that have been developed in welfare economics and political philosophy. Theories of distributive justice are mostly concerned with the fair distribution of goods and social advantages among a population. In radiation protection, much of the same reasoning can be used, but we have to 'add a minus sign' in the right places since it is the disadvantage of radiation exposure rather than the advantages of valuable goods that we are concerned with distributing.

In welfare theory, a distinction can be drawn between two types of strivings for distributive justice, namely egalitarianism and prioritarianism. Egalitarianism is a view according to which

it is better that advantages (or disadvantages) are equally, rather than unequally, distributed in a group of persons. Different versions of egalitarianism emanate from different views of what the (dis)advantages are that should be distributed equally (Hansson 2001), but that need not concern us here since our focus is already set on the distribution of radiation doses. It should be emphasised that no egalitarian is concerned only with equality and not at all with the general level of advantages (or disadvantages). The political egalitarian who is just as satisfied if everybody is equally destitute as if everybody is equally rich is just a figment of the anti-egalitarian's imagination. Similarly, no sensible person would take equality as the only criterion for judging dose patterns. Hence, an egalitarian is not someone who is indifferent between the dose patterns $\langle 1, 1, 1, 1, 1\rangle$ and $\langle 5, 5, 5, 5, 5\rangle$. It is, however, someone who prefers the dose pattern $\langle 1, 1, 1, 1, 1\rangle$ to the pattern $\langle 5, 0, 0, 0, 0\rangle$.

Prioritarians agree with egalitarians that an improvement for a disadvantaged person is of more worth than an improvement of the same size for someone who is well off. However, according to prioritarians, 'that is only because these people are at a lower absolute level. It is irrelevant that these people are worse off than others' (Parfit 1997).

Hence, a prioritarian who considers radiation levels below 10 as fully acceptable may be indifferent between the patterns $\langle 1, 1, 1, 1, 1\rangle$ and $\langle 5, 0, 0, 0, 0\rangle$ (whereas the egalitarian prefers the former). On the other hand, the prioritarian will agree with egalitarians in preferring $\langle 9, 9, 9, 9, 9\rangle$ to $\langle 18, 7, 7, 7, 6\rangle$ since in the latter case one individual receives too high a dose.

Which is the most plausible approach, egalitarianism or prioritarianism? In issues of general social distribution there has been a long debate on this, usually couched in terms of 'relative' and 'absolute' poverty or deprivation. As far as I can see, the strongest argument in favour of egalitarianism, in contrast with prioritarianism, is the argument of positional goods.

A person's well-being depends not only on her own material conditions but also on how these conditions compare to those of others who live in the same society. In the terminology introduced by Hirsch (1976), some goods are 'positional', i.e. they give their owner a place in the social hierarchy. Having a colour TV at the time when this was a new and exciting technology contributed positively to the owner's social status. This effect decreased in importance as colour TVs became common. Access to a particular type of positional good typically increases with economic growth, and it can then lose its positional value and be replaced by other, newer objects, as markers of social status. Therefore, a standard of living that was quite acceptable in a Western European country 50 years ago may today be stigmatising in the same country. The relative position is important, and this is an argument in favour of egalitarianism as contrasted with prioritarianism.

This being said, it should also be emphasised that there are different political views on the relevance of positional goods for social justice in general. For our present purposes, this is not something that we need to penetrate further. Instead, the crucial issue is whether or not the argument for egalitarianism just referred to can be transferred to radiation protection. In other words, are radiation doses 'positional goods'? As far as I can see, it is quite clear, under present social conditions, that they are not. This can be used as an argument in favour of a prioritarian approach to dose distributions in radiation protection.

A prioritarian approach can be operationalised by a mechanism that ensures that in the overall calculation of doses, doses that exceed a certain limit are given more weight. For a simple illustration, consider a rule saying that doses in excess of 10 units should be given three times higher weight than lower doses. With this approach, the dose pattern $\langle 18, 7, 7, 7, 6\rangle$ will have the disvalue 61, and is thus much worse than the dose pattern $\langle 9, 9, 9, 9, 9\rangle$ that has the disvalue 45, whereas the dose patterns $\langle 1, 1, 1, 1, 1\rangle$ and $\langle 5, 0, 0, 0, 0\rangle$ both have the disvalue 5 and are thus treated equally. Furthermore, the dose pattern $\langle 11, 0, 0, 0, 0\rangle$ has the disvalue 13 and is thus much preferable to $\langle 9, 9, 9, 9, 9\rangle$. Such a prioritarian approach has the effect of

Table 2. A mathematical account of some approaches to dose limitation. $\langle x_1, \ldots x_n \rangle$ is a dose pattern representing the doses to which n persons are exposed. m is a measure of inequality such as the Gini coefficient (or a statistical variance measure such as standard deviation). f is a continuous non-decreasing function. The following are three severity measures:

Based on collective dose	$S_{CD}(\langle x_1, \ldots x_n \rangle) = \sum_{1 \leqslant k \leqslant n} x_k$
Based on egalitarian principles	$S_E(\langle x_1, \ldots x_n \rangle) = (\sum_{1 \leqslant k \leqslant n} x_k) + m(\langle x_1, \ldots x_n \rangle)$
Based on prioritaranism	$S_P(\langle x_1, \ldots x_n \rangle) = \sum_{1 \leqslant k \leqslant n} f(x_k)$

making the dose limit 'softer' than with a lexicographic approach. I propose that the prioritarian approach is closer to the intuitions that many of us have about dose distributions in radiation protection.

For the mathematically minded, the argument in this section is summarised in table 2 in a few simple formulas. For a more detailed mathematical treatment, see Wikman-Svahn *et al* (2006).

5. Valuing future effects

One of the major complications in radiation protection is the need to take future damage into account. Often, radiation protectors have turned to economic analysis for the evaluation of future effects. Almost equally often, they have been dissatisfied with the outcome of economic analyses of this problem.

The standard approach in economic analysis to future advantages and disadvantages is a bifactorial model. The value of a future good is assumed to be equal to the product of two factors. One of these is a time-independent evaluation of the good in question, i.e. the value of obtaining it immediately. The other factor represents the subject's 'pure time preferences'. It is a function of the length of the delay, and is the same for all types of goods. The most common model of time preferences sets the present value at $\frac{u}{(1+r)^t}$, where u is the time-independent value, r is a discount rate and t the duration of the delay. This is the discounted utility model, proposed by Samuelson (1937), that still dominates in economic analysis. (r refers to real value, i.e. the inflationary component is excluded.)

The application of this approach to radiation protection will lead to drastic reductions in the disvalue of future effects. Hence, if we use the common discount rate $r = 0.03$, and assume that the world's population will be 10 000 000 000 in the year 2800, then the disvalue of an action in the year 2020 that will kill every living person in the year 2800 is smaller than that of an action in the year 2020 that will kill one single person immediately.

We have good reasons to ask, therefore, if this approach—the discount rate approach—is at all applicable to radiation protection. In my view, calculations such as the one I just made go beyond the range of admissible application for the discount rate method. Its legitimate range is limited to money, and goods that can meaningfully be valued in monetary terms, for as far into the future as we can reasonably predict that there will be an economy with rents and loans that works in similar fashion to the economy we have today. (Since r reflects an increase in real wealth, the model implies an economy that grows continuously, which is of course a contestable assumption.)

Obviously, human lives cannot be valued in money. The conversions between lives and money that are made in cost–benefit analysis are—or at least should be—of a much more guarded nature. A cost–benefit analyst who assigns a monetary value to the loss of a human life does not thereby imply that someone can buy another person, or the right to kill her, for that price. Essentially, lives and money are incommensurable, and any value of lives that is included

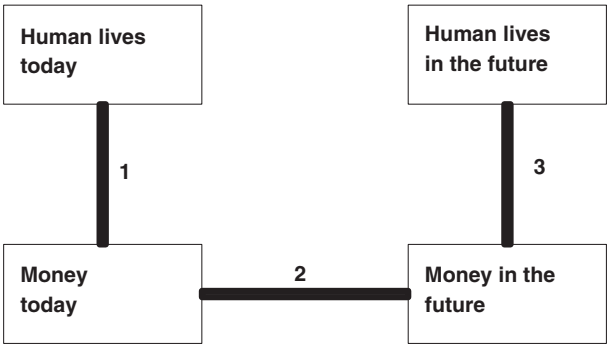

Figure 2. The three implicit conversions in the discount rate model for the valuation of future fatalities.

in an economic analysis should be for calculation purposes only. The values of life that are used in economic analysis reflect either actual practices today in terms of what we pay for saving a life or some kind of ideal for what we should be prepared to pay for this. These values do not represent a 'value of life' that is timeless or independent of today's social conventions and practices (Hansson 2007). (It should also be noted that these values refer to statistical lives, not to lives of identified persons.)

The economic argument for discounting future losses in lives presupposes a series of conversions that are summarised in figure 2. We do not convert human lives today directly into human lives in the future—there is no ground whatsoever for doing that. Instead, this is done through three conversions:

(1) From human lives today to money today.
(2) From money today to money in the future.
(3) From money at some future point in time to lives at that same future point in time.

As I just said, the first of these conversions can be performed, but only as a report on the trade-offs that we make, or wish to make, today. The second conversion is a standard economic procedure. In the time-spans that economists usually work with, it is a highly useful tool of analysis. In the longer time-spans that we discuss in radiation protection, its value is more uncertain since we cannot take for granted that the economy will function in the same way as today thousands of years ahead. However, it is in the third step that the whole conversion breaks down. There is no ground whatsoever for projecting the trade-offs that we make today between human lives today and money today far off into the future.

The other major standpoint on future (dis)advantages is that they should be given the same weights as the same (dis)advantages today. Prominent philosophers such as Hobbes (1642, p 48), Sidgwick (1907, p 381) and Rawls (1971, p 95) have endorsed this view, claiming that it is irrational to prefer an advantage at present to an equal advantage to be obtained (with the same certainty) at some future point in time. Utilitarians claim that utilities that accrue to different persons are fully exchangeable, and this includes all future persons at all future points in time. Many non-utilitarians come to a similar conclusion but via a quite different argument: the moral separateness of persons blocks the continuation into the distant future of the discounting that we may choose to apply to later parts of our own lives (Ziff 1990). In recent discussions, arguments for treating future damage as equally serious to immediate damage have been expressed in terms of the requirement of sustainable development (World Commission 1987).

Are there then no arguments that can be made in favour of treating future radiation doses differently from doses to which people are exposed today? As far as I can see, there is one class of arguments that can validly be used, namely arguments referring to uncertainty about future effects. We do not know if future radiation doses will have the same effects as the same doses today. Future technology may enable us to decrease the harm associated with exposure. Hence, if we have reason to believe that future generations will suffer less from the same dose than we do, then this is an argument for giving lower weight to future doses. However, the problem with such uncertainty-based arguments on future doses is that they can work both ways. It is not difficult to construct scenarios in which our capability to cope with radiation exposure will deteriorate rather than increase.

6. Conclusion

I have devoted this contribution to a couple of problems in radiation protection that have surprisingly close, and largely unexplored, connections with moral philosophy. Of course, there are many other moral issues that should be of concern to radiation protectors. In particular, I have focused here on moral issues that relate to the outcome of radiation protection in terms of exposures and dose levels. It is equally important to consider procedural issues such as how and by whom the various decisions that influence exposures should be made, and what information the persons who are affected by these decisions should receive. The ethics of radiation protection is a new field of applied ethics. It is a highly promising one, both from a theoretical and a practical perspective.

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