

Nuclear Academics Meeting  
Leeds, Tue 2 Sep, 2014

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# Radiation Misconceptions and Public Fears

Julian Hamm

## A testable conjecture:

The vast majority of people have **predictable misconceptions** about radiation that lead them to overestimate the risks



# Misconceptions involve alternative models of how the world works that are at odds with scientific ones

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A type of  
unconscious  
incompetence



Predictable



Scientific  
sounding



Hard to  
replace



# Lots of research about public **attitudes** to nuclear energy but little or none about public **understanding**

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Never mind finding evidence for which messages actually work when it comes to reassuring people!



# Pilot research for the Public Understanding group of the Nuclear Industry Council – NIRAB proposal in pipeline

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## Questions

- Is there any evidence that people have predictable misconceptions?
- How effective are attempts to correct them?

## Study

- 13 admin staff at Imperial College (thanks Gerry Thomas)
- All graduates, about half science background
- 9 scenarios – but we only have time for 4 of them now
- Quantitative plus interview – about 20 mins each

# Scenario 1

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Imagine this box contained a highly radioactive substance that gave off dangerous amounts of radiation. Imagine I left it all day on the table in this room, before taking it away just before you came in.

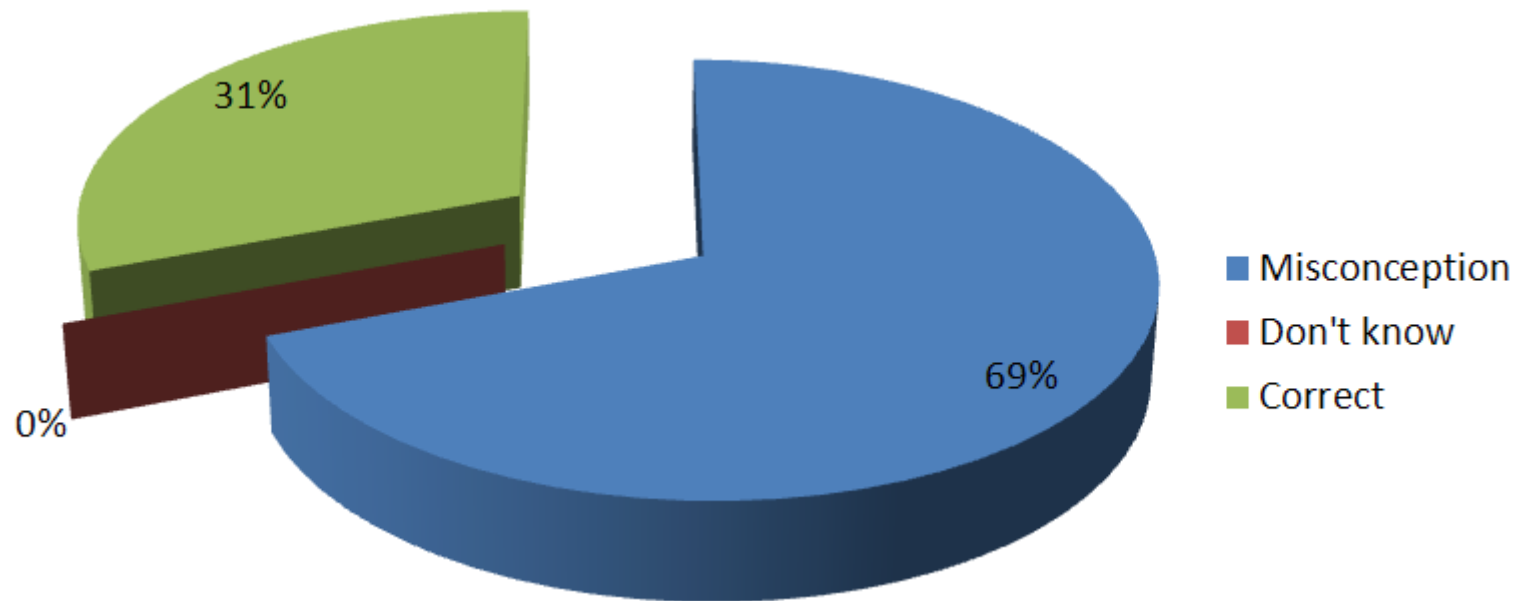
**1 a. It would be too dangerous to enter the room.**

Strongly agree | Tend to agree | Neither agree nor disagree | Tend to disagree | Strongly disagree

**1 b. The table would become radioactive.**

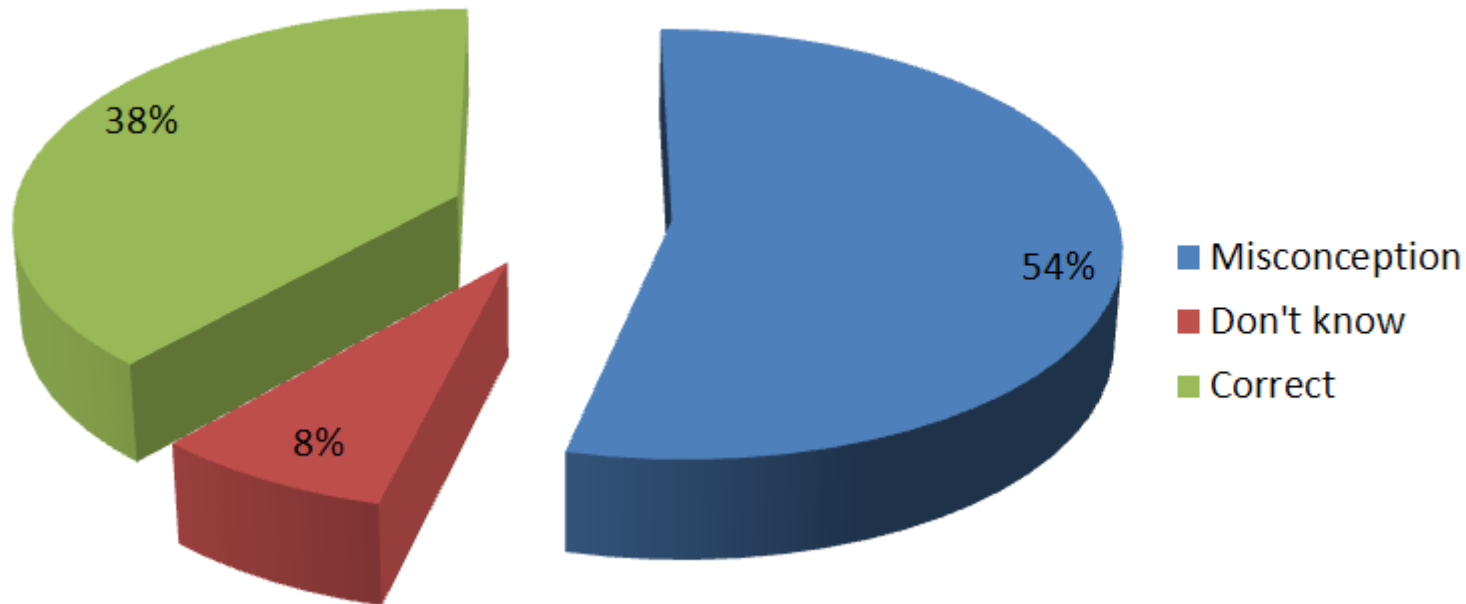
Strongly agree | Tend to agree | Neither agree nor disagree | Tend to disagree | Strongly disagree

## Misconception: Radiation persists in the environment.



“I don’t think that the residual radiation would be that strong. I don’t know how much is emitted and how much stays in the room. My gut feeling says about 20%.” *Geology graduate*

## Misconception: Radiation makes other things radioactive.



“Materials subjected to radioactivity tend to become radioactive. Materials in a nuclear reactor, concrete etc., end up as radioactive waste.” *Physics graduate*

“I remember Superman became radioactive because he was exposed to high levels of radiation [laughs] but maybe that isn’t the best way of learning something.” *Philosophy graduate*



## Scenario 2



**A: Half-life: 10 years**



**B: Half-life: 200,000 years**

Say these boxes contained the same amount of two *different* radioactive substances. Each substance gives off the same type of radiation. Substance A has a half-life of 10 years, substance B has a half-life of 200,000 years.

**2 a. To begin with both substances will give off the same amount of radiation.**

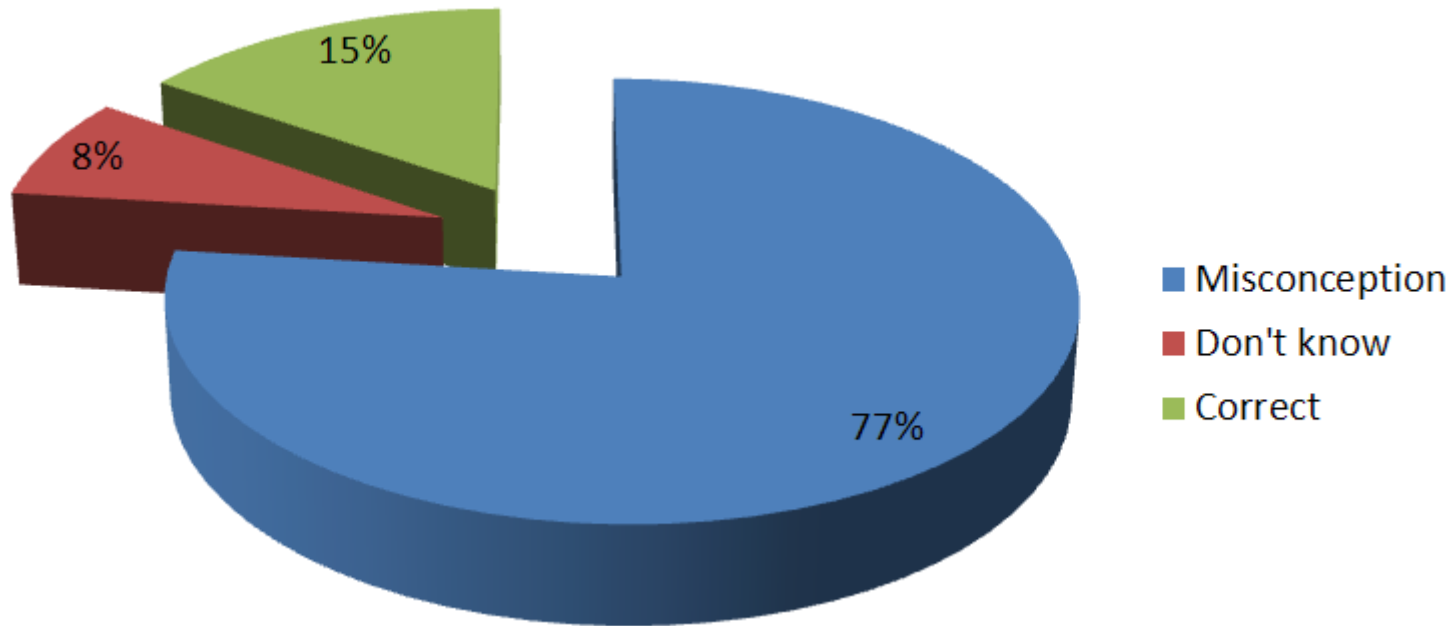
Strongly agree | Tend to agree | Neither agree nor disagree | Tend to disagree | Strongly disagree

**2 b. Substance B would be more damaging if released into the environment because it has such a long half-life.**

Strongly agree | Tend to agree | Neither agree nor disagree | Tend to disagree | Strongly disagree

## Misconception: Radioactivity is independent of half-life.

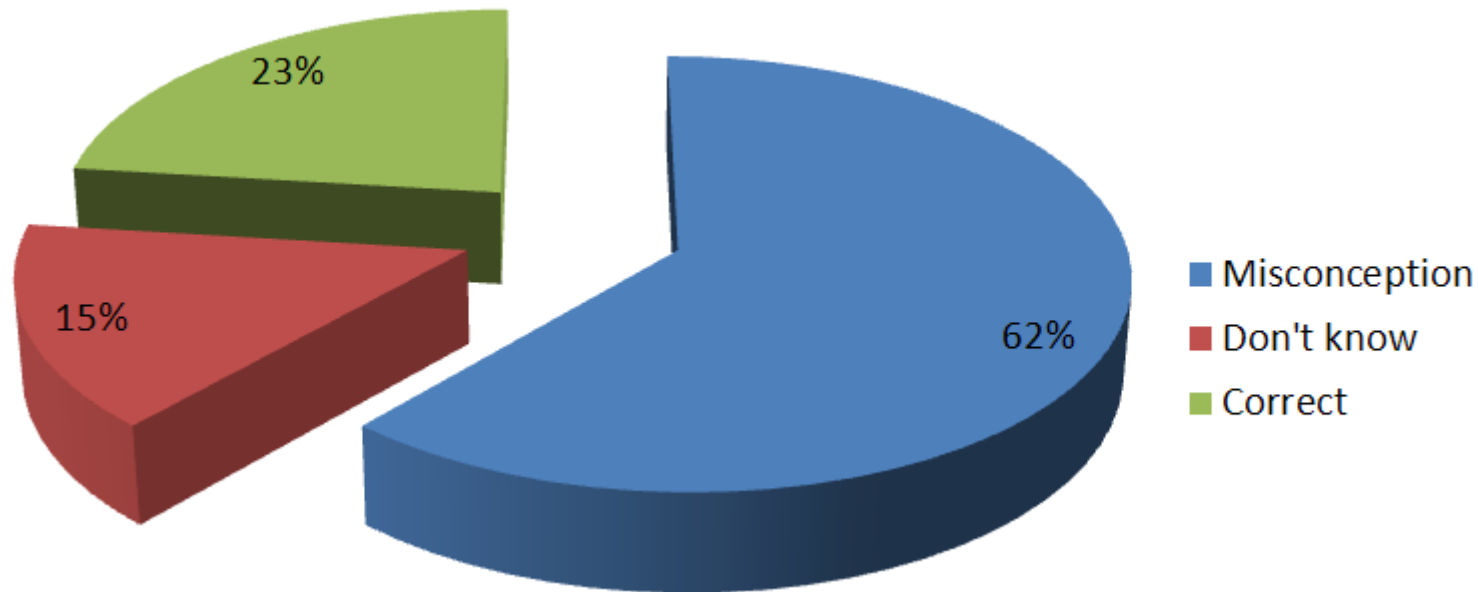
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“...the half-life is to do with how long the substance is dangerous for, how long it’s radioactive for. It’s not about the strength of the radiation.” *English graduate*

## Misconception: The longer the half-life, the more hazardous in the environment.

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“Even from a media point of view, people say it’s the half-life. I think from a kind of logical point of view, if it stays around longer it must be more dangerous. I think you’re quite accustomed to half-life.” *Physiology graduate*

## Scenario 3

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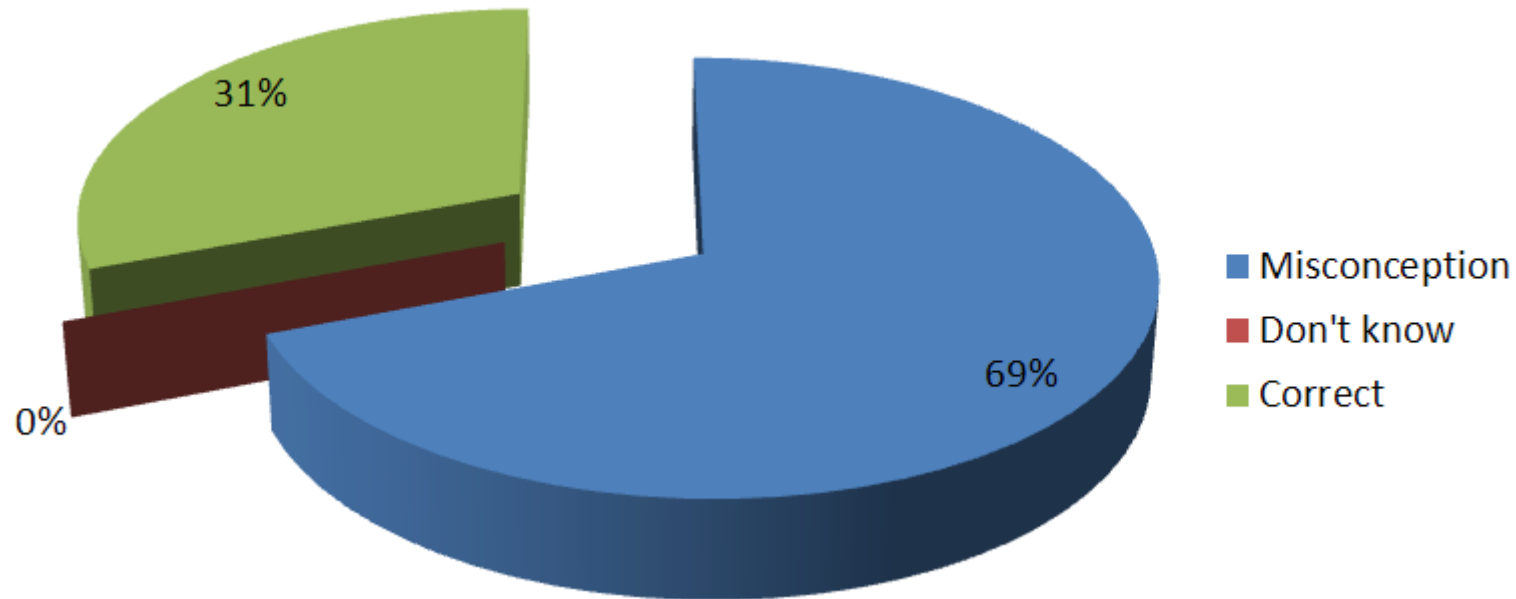
Here is a picture of a canister that is designed to contain high-level radioactive waste for disposal deep underground.

**3. If there was an earthquake and the container split, the waste would leak out.**

Strongly agree | Tend to agree | Neither agree nor disagree | Tend to disagree | Strongly disagree

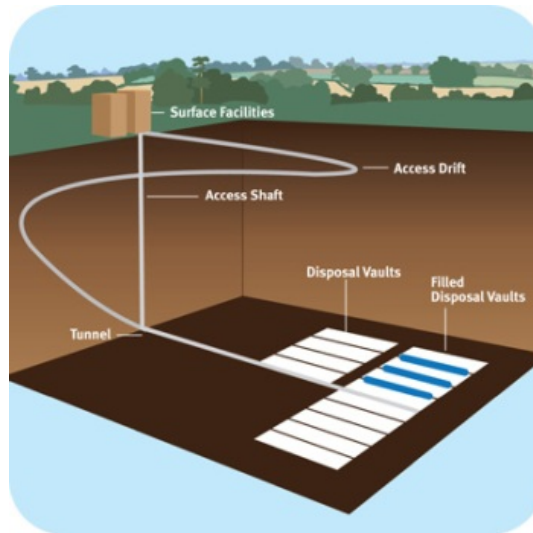
## Misconception: Waste is not always disposed of as a solid, so will leak if the container is damaged.

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“I have no way of knowing that it won’t [leak out].” *Business graduate*

## Scenario 4



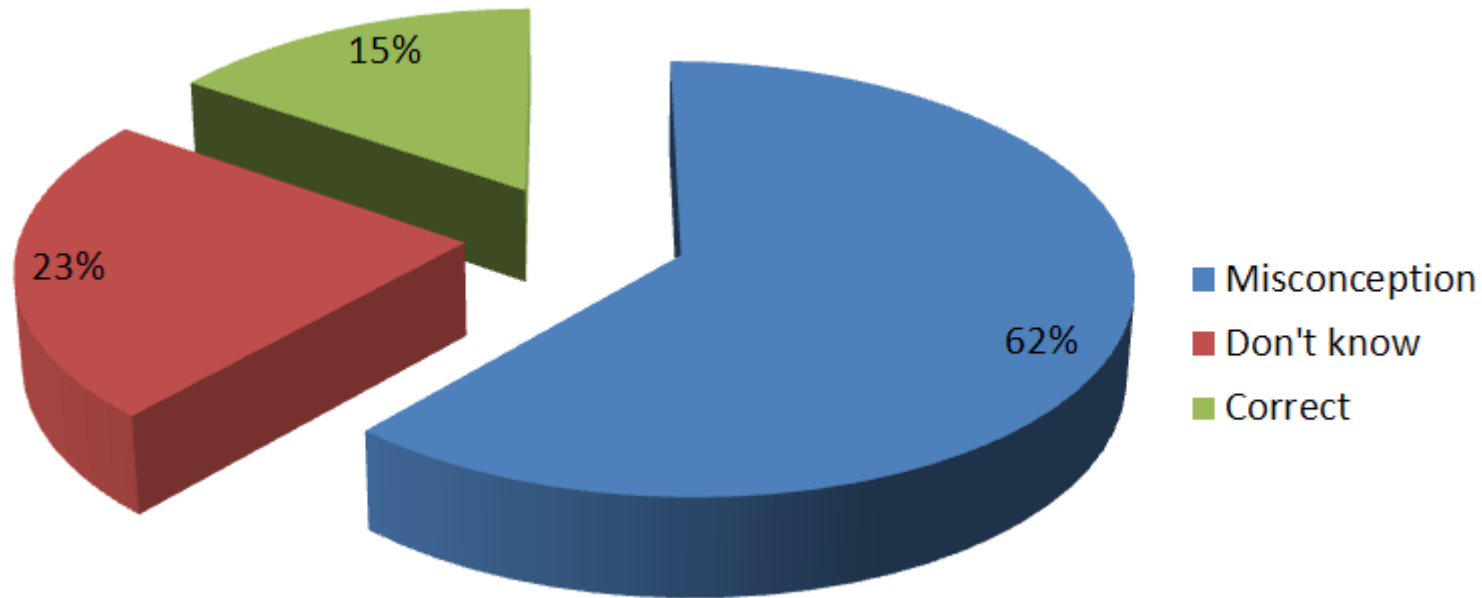
Here is a diagram of a proposed deep underground facility for disposing of high-level radioactive waste. The proposal is to place the waste up to 1000 metres underground.

**4. The waste needs to be buried 1000 meters down to stop the radiation eventually reaching the surface, even if the waste itself doesn't move.**

Strongly agree | Tend to agree | Neither agree nor disagree | Tend to disagree | Strongly disagree

## Misconception: Radiation is mobile: it will eventually reach the surface, even if the waste doesn't move.

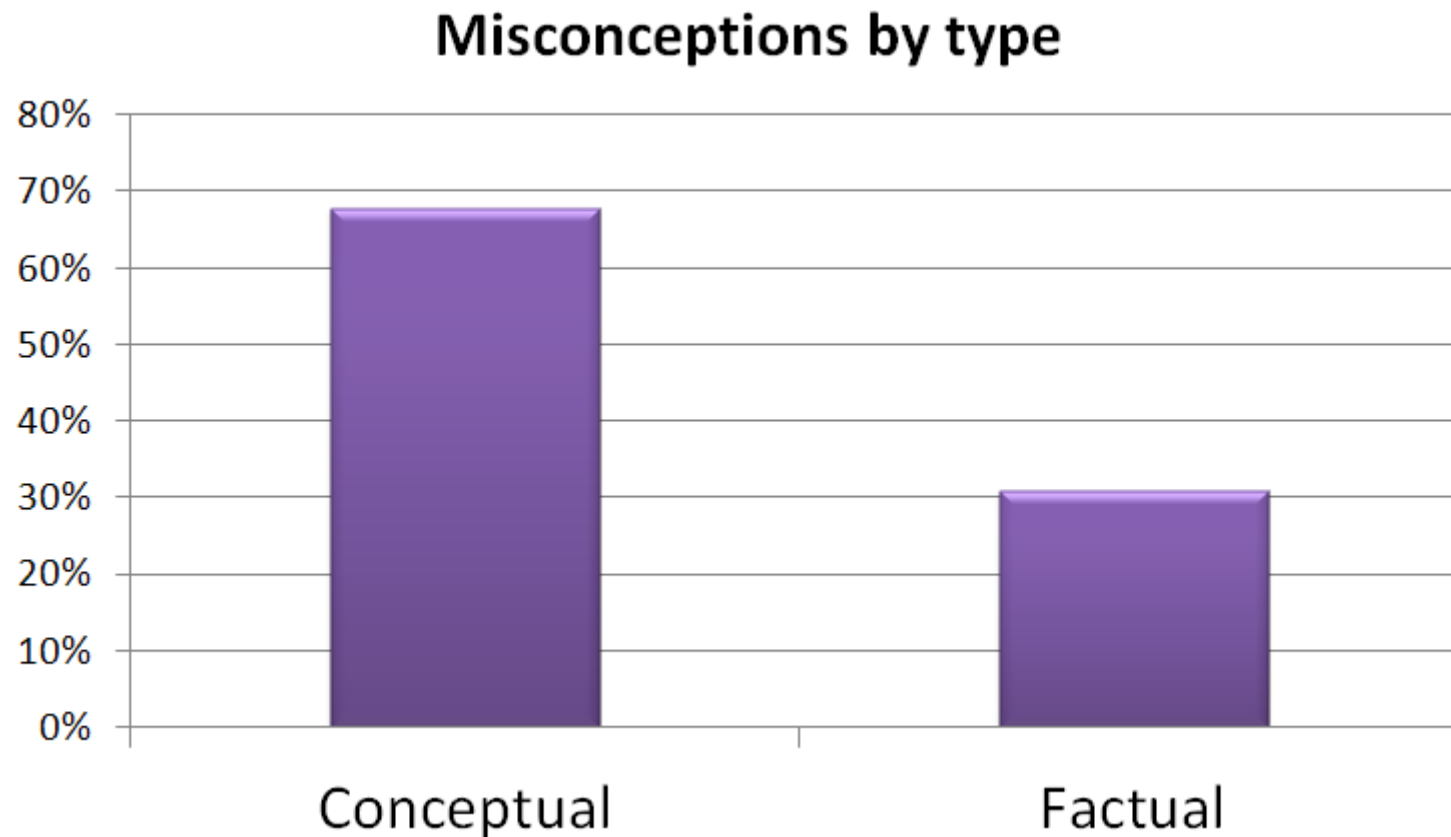
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“I think some radiation will reach the surface anyway, but it will take some time.”  
*Economics graduate*

**Conceptual misconceptions were twice as common as factual ones.**

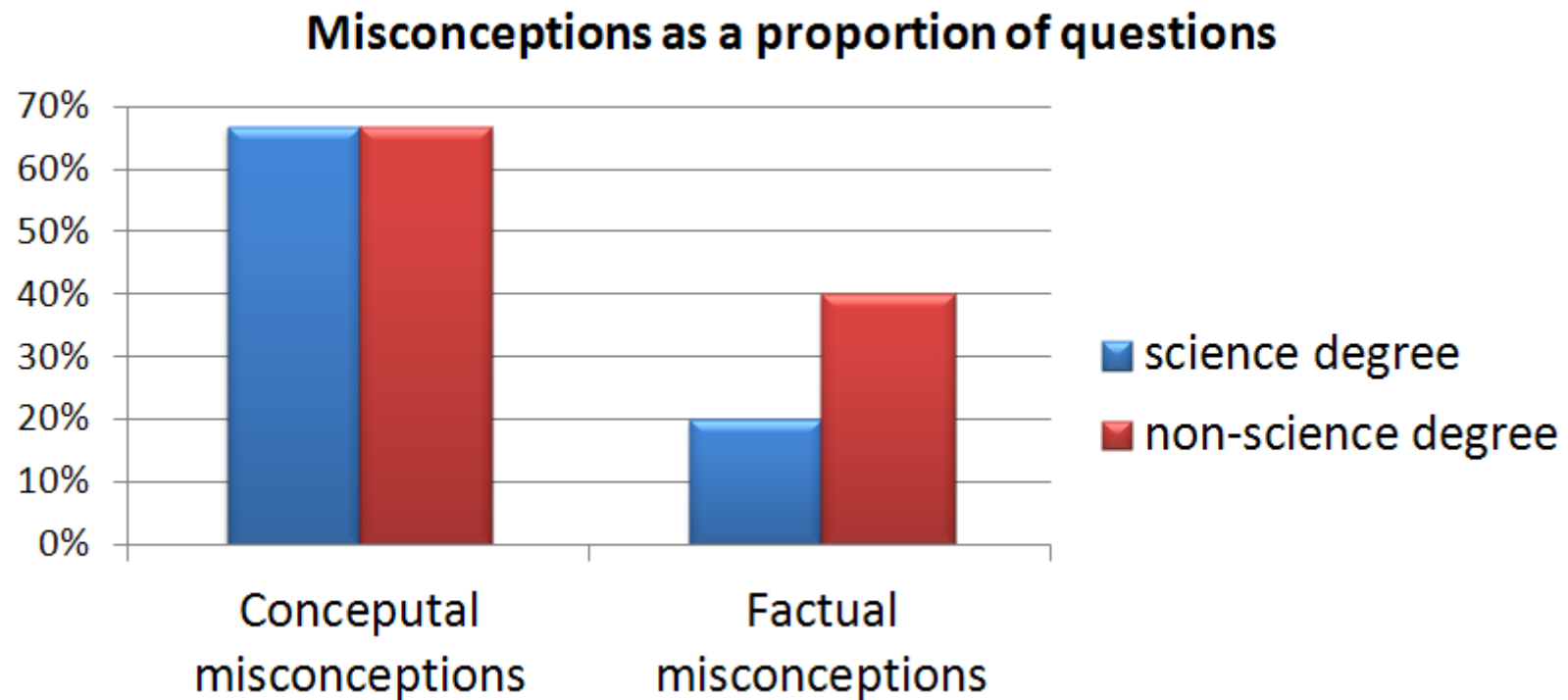
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# Scientists had fewer factual misconceptions but just as many conceptual ones.

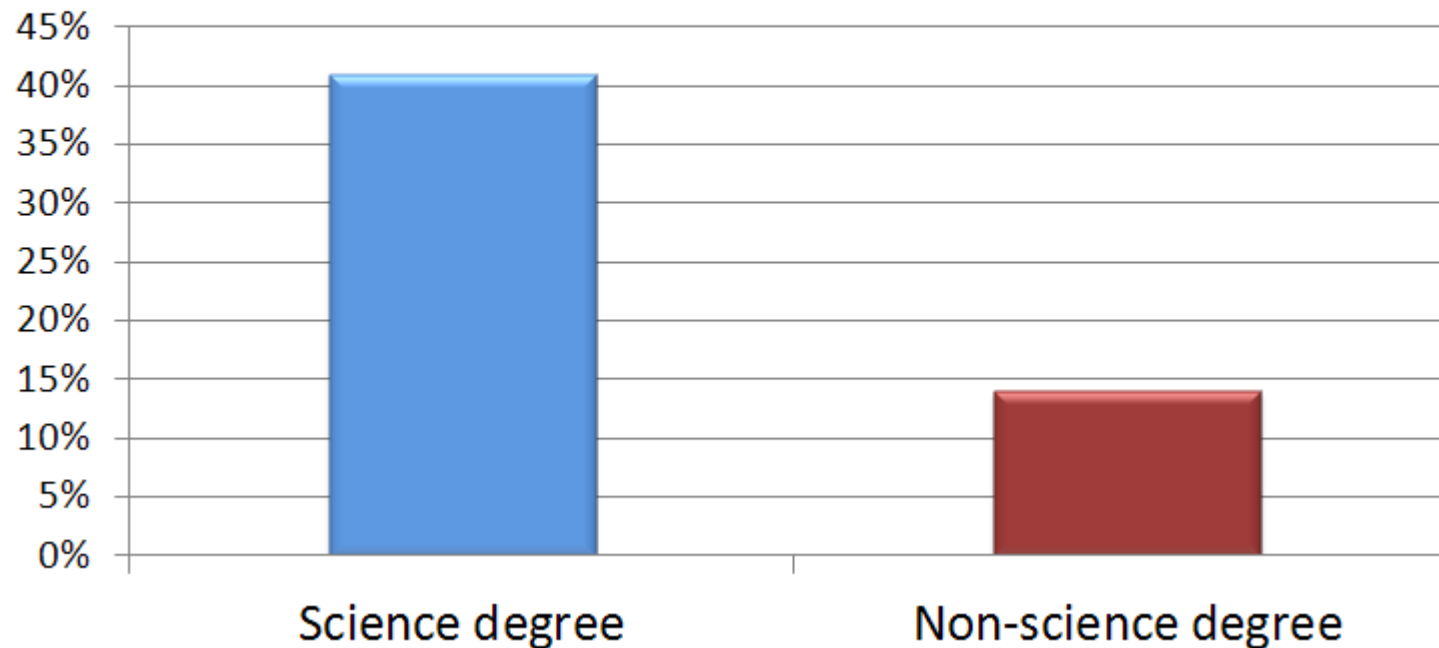
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**But scientists had a far higher degree of (misplaced!) confidence in their answers.**

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**Proportion of incorrect answers to conceptual questions with 'Strongly agree'**



# Assume the misconceptions are there – and so mention them explicitly - even if everything seems correct

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<http://www.theguardian.com/world/2011/apr/12/japan-nuclear-fukushima-radiation>

News > World news > Japan disaster

## Radiation from Fukushima spreads, but threat to rest of world is low

Amounts of radioactive contamination have been detected around the globe but not in levels dangerous to human health

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Ian Sample, science correspondent

 Follow @iansample

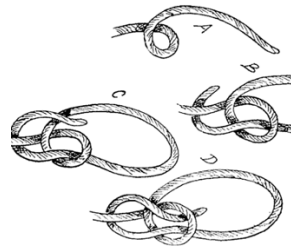
 Follow @guardian

The Guardian, Tuesday 12 April 2011 21.30 BST

# To replace misconceptions you need cognitive conflict

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Clear  
description



Comfortable



Old model +  
some new details

**Identify  
misconception**

Entire  
+ explanation of  
new model



Challenging



but can be fun

Replace old  
model

# Make sure your mental model has the best tunes!

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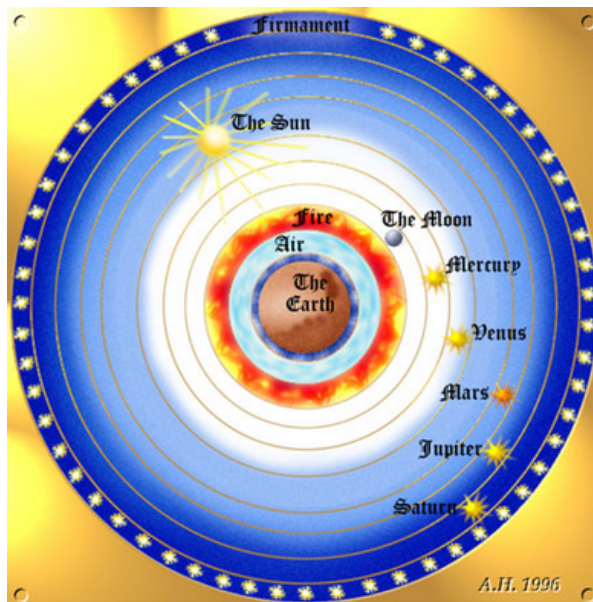
...and images and analogies and applications and multiple use of senses and emotional associations...



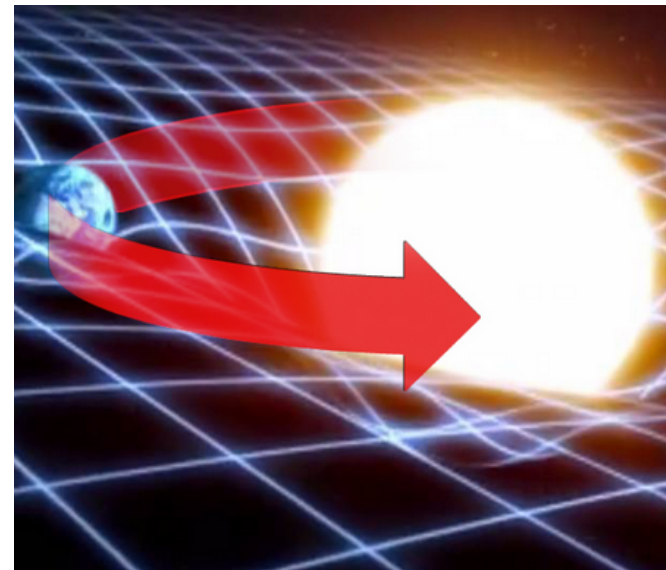
# Misconceptions are a sign of engagement. They show that people are trying to make sense of their world.

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People use sensible,  
intuitive models...



...but scientific  
theories don't.



# Make the invisible and conceptual tangible and familiar

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The sparkler analogy explains the difference between radioactive materials and the radiation they give off



# There are two major classes of conceptual misconception

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## 1. Confusing the properties of radiation with radioactive stuff, like dust

- Radiation seen as persistent, mobile and contagious
- Confusing shielding and containment
- Mixing up irradiation and contamination

## 2. Failing to understand the unbreakable link between half-life and radioactivity

- Thinking everything starts off equally radioactive but long half-life just means radioactive for longer
- Not understanding that something can only have a long half-life if it gives off very little radiation
- Thinking long half-life waste is the most problematic in the environment



# If you believe radiation is persistent, mobile and contagious then how can it be controlled?

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Dust can be swept up



Liquids can be contained

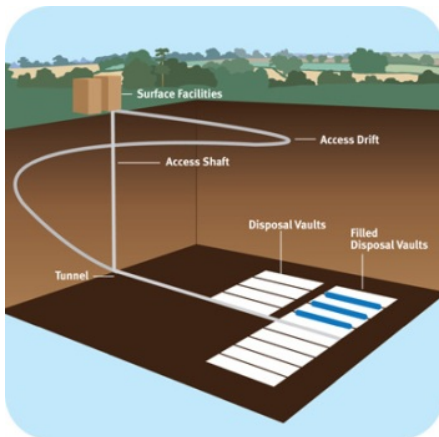


But radiation seems sinister and pervasive



# Confusing shielding with containment gives the impression that radiation is trying incredibly hard to get out

We think adding precaution on top of precaution will make people feel safer...



...but what they really hear is often this!



# Misunderstanding the purpose of this clothing makes radiation feel as dangerous as ebola

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People assume these suits protect you from radiation.



Re-spraying a car: similar clothing is worn for similar reasons



**The fact that the waste form is really hard to dissolve in water should be a key message for a GDF**

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When green glass breaks, the green doesn't leak out.

**We need to constantly reinforce that it's impossible for something to be both highly radioactive and long lived**

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**Short half-life**



**Long half-life**





# We need to stop this 'waste lethal for hundreds of thousands of years' meme

The half-life of  
plutonium-239  
is 24,000 years

just one  
small step  
to...



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This article is from the In-Depth Report [The Future of Nuclear Power](#)

## Spent Nuclear Fuel: A Trash Heap Deadly for 250,000 Years or a Renewable Energy Source?

Nuclear waste is either a millennia's worth of lethal garbage or the fuel of future nuclear reactors--or both

<http://www.scientificamerican.com/article/nuclear-waste-lethal-trash-or-renewable-energy-source/>

# And explain that the most hazardous half-lives are decades rather than millennia

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## Short half-life



**A heavy shower** – gets you wet, but avoidable

## Medium half-life



**Persistent light rain** – will get you wet, and hard to avoid

## Long half-life



**Light mist** – won't get you wet no matter how long you stay

# By focussing on basic, uncontested science we can remove the need for trust and a conversation about risk

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Nuclear energy can be very, very dangerous but don't worry, we know what we're doing. You can trust the experts to keep you safe.



## **This might be better:**

The basic ideas are very simple. You can understand them yourself and make up your own mind.





# We should explicitly introduce misconceptions in our messaging to empower people to assess risk themselves.

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Interesting



Produce cognitive  
conflict so aid  
learning



Not explicitly about  
risk acceptance



# Getting the technical messaging right will make selling the social story for geological disposal so much easier

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Which of these would you welcome as your next door neighbour?

