LECTURE NOTES: EMGT 234

RATING THE RISKS

SOURCE:

Paul Slovic, Baruch Fischhoff, and Sarah Lichtenstein
Environment, Vol 21, no. 3, pp. 14-20, 36-39, 1979

1. INTRODUCTION

- People respond to risks they perceive.
- Public risk perception is "faulty" → Regulatory efforts are perceived as misdirected.

Risk Assessment has been developed to improve Risk Management that:

- Identify hazards
- Measure their frequency
- Measure magnitude of their consequences.

Three Analysis Scenario's for Risk Assessment:

1. Extensive statistical data is readily available; e.g. frequency and severity of motor vehicle accidents.
2. Requires complex epidemiological and experimental studies; e.g. the use of alcohol and tobacco.
3. Require risk assessments based on theoretical analyses such as fault trees, rather than on direct experience. E.G. Use of nuclear power.

- All three Analysis Scenario's include expert/human judgment.
- Results must be communicated to e.g. industrialists, environmentalists, regulators, legislators, and voters.

If above pool of people do not see, understand, or believe these risk statistics then distrust, conflict, and ineffective risk management can result.

2. JUDGMENTAL BIASES

Public evaluate risks based on:

- What they remember hearing,
- What they remember observing.

Judgmental rules or heuristics:

- Reduce difficult mental tasks to simpler ones.
- Valid in some cases, but also lead to large biases.

Example Heuristics:
Availability, Overconfidence, Desire for Certainty.

2.1 Availability Heuristic

> People judge an event as likely or frequent
> if instances of it are easy to imagine or recall.

Often appropriate, but can also be affected by:

- a recent disaster,
- a vivid film as "Jaws", "Titanic".

Study: Judge the frequency of various causes of death, such as smallpox, tornadoes, and heart disease.

Study Subjects:

1. college students
2. members of the League of Women Voters.

Study Results: <u>See Figure 2 in original paper</u>.

- **Judgments are moderately accurate.**

1. Rare causes deaths: overestimated
2. Common causes of death: underestimated.

Actual death toll varied over a range of 1000000,
Judged death tolls varied only over a range of 1000.

- **Judgement show evidence of the availability bias**

3. Homicides were incorrectly judged to be more frequent than
   - Diabetes
   - Stomach Cancer
   - Strokes (Stroke deaths claims eleven times as many)

4. Accidents were judged to cause as many deaths as diseases. Diseases take 15 times more lives as accidents.

5. # deaths per year of botulism, tornadoes, and pregnancy were greatly overestimated.

General Conclusions:

- Overestimated items were dramatic and sensational.
- Underestimated items tended to be unspectacular events.

Biasing effects of memorability and imaginability may pose barrier for objective discussions on risks.

Example: Expert presenting Fault Tree

<u>**See Figure 1 in original paper.**</u>

Publics Reaction:

"I didn't realize that so many things could go wrong"

- Instead of reassuring the public with a detailed analysis, the opposite effect is achieved.

Example: Showing the risks of starting a car.

- Participants were asked to assess the proportion of "all other problems" relative to the remainder of the tree. (<u>See Figure 3 in original paper</u>).

Next, causal tree structure was reduced and

- Participants were asked to assess the proportion of "all other problems" relative to the remainder of the tree.

Study Result:
Both public and mechanics assessed same proportion.

"Out of Sight, Out of Mind"

2.2 Overconfidence Heuristic

Follow-up study on causes of death;
Respondents were asked to indicate how sure they were in judgment about which of two events had a higher annual death toll per year.

- 25% of respondent answered odds of 100: 1 or greater. Actuality: one in every eight answers was wrong.

- 30% gave odds greater than 50:1 to the incorrect assertion that homicides are more frequent than suicides.

Explanation: Strong belief in the correctness of starting assumptions (the validity of the availability heuristic).

Overconfidence indicates that we do not realize:
1. how little we know
2. how much additional information we need.

- **Failure Rate Estimation.**

Typical Task: Estimate 98% confidence bounds.
Studies showed: 20% to 50% fall outside estimated bounds.

Experts Seem As Prone To Overconfidence as Public:

- **"Internationally known" geotechnical engineers:**

Task: Estimate 50% confident bounds on the height of an embankment that would cause a clay foundation failure.
Result: Actual failure height never captured by bounds.

- **Reactor Safety Study (the "Rasmussen Report"):**

Reviewed by H. W. Lewis: Used a procedure that result in overestimated precision of the probability of a core melt.

- **1976 collapse of the Teton Dam:**

Disaster attributed to confidence of engineers that construction problems were solved.

Routine practice:
Failure probabilities are not calculated for new dams.

Data:
1 in 300 reservoirs fail when filled 1st time.

Reasons why experts misjudge pathways to disaster include:

1. Not accounting for the human.

Example: The disastrous fire at the Brown's Ferry Nuclear Plant was caused by a technician checking for an air leak with a candle, in violation of standard operating procedures.

2. Overconfidence in current scientific knowledge.

Example: The failure to recognize the harmful effects of X-rays until societal use had become widespread and largely uncontrolled.

3. Insensitivity to how a technological system functions as a whole.

Example: Respiratory risk of fossil-fueled power plants has been recognized. However, the related effects of acid rains on ecosystems were missed until recently.

4. Failure to anticipate human response to safety measures.

Example:

- Protection by dams; People feel safe. Floodplain develops. Rare Flood results in greater damage.
- "Better" highways; the death toll per vehicle mile drops, but the total number of deaths increases as people drive more.

2.3 Desire for Certainty Heuristic

Use of Technology is a Gamble:
Involves chances of benefits and chances of losses.

Public does not like to view this as a gamble. Uncertainty is often denied resulting in **overconfidence** or **pessimism**.

Examples:

- **Overconfidence:** People faced with natural hazards, often think they are "safe". Flood victims denied that floods could ever recur in their areas.

1. Some thought (incorrectly) that new dams and reservoirs in the area would contain all potential floods,
2. Others attributed previous floods to freak combinations of circumstances, unlikely to recur.

- **Pessimism:** Many people feel that risks of nuclear power cannot be ignored, no matter how small. For these people, the search for certainty is best satisfied by outlawing the risk.

Scientists and policy makers are often resented for acknowledging uncertainty.

- Corporate managers get frustrated with consultants who give them the probabilities of possible events instead of telling them exactly what will happen.

- Scientists reported 95% certainty that cyclamates do not cause cancer.

Food and Drug Administration Commissioner Alexander Schmidt said, "I'm looking for a clear bill of health, not a wishy-washy, iffy answer on cyclamates."

- Senator Edmund Muskie has called for "one-armed" scientists who do not respond "on the one hand, the evidence is so, but on the other hand ... ”.

Search for Certainty is Legitimate, but:

- High level of certainty will require high costs.
- Eliminating uncertainty completely may mean eliminating the technology and foregoing its benefits. Often some risk is inevitable.

Example: Choose between

1. An unprotected flood plain and consequences of nature.
2. Less probable, but more catastrophic hazards associated with dams.

3. ANALYZING JUDGMENTS OF RISK

Theory of Perceived Risk must explain:

1. People's extreme aversion to some hazards
2. People's indifference to other hazard,
3. The discrepancies between these reactions and experts' recommendations.

For example, why do:

- People react vigorously against a liquid natural gas terminal despite the assurances of experts that it is safe?
- People situated on flood plains and earthquake faults or below great dams show little concern for the experts' warnings?

Behavior is related to previous discussed judgmental biases.

However, is it possible that when people judge the risk inherent in a technology, they are referring to more than just the number of people it could kill?

3.1 Quantifying Perceived Risk

4 groups of people:

- 30 College Students
- 40 League of Women Voters (LOWV)
- 25 of the "Active Club
- 15 Nationwide Professional in Risk Field

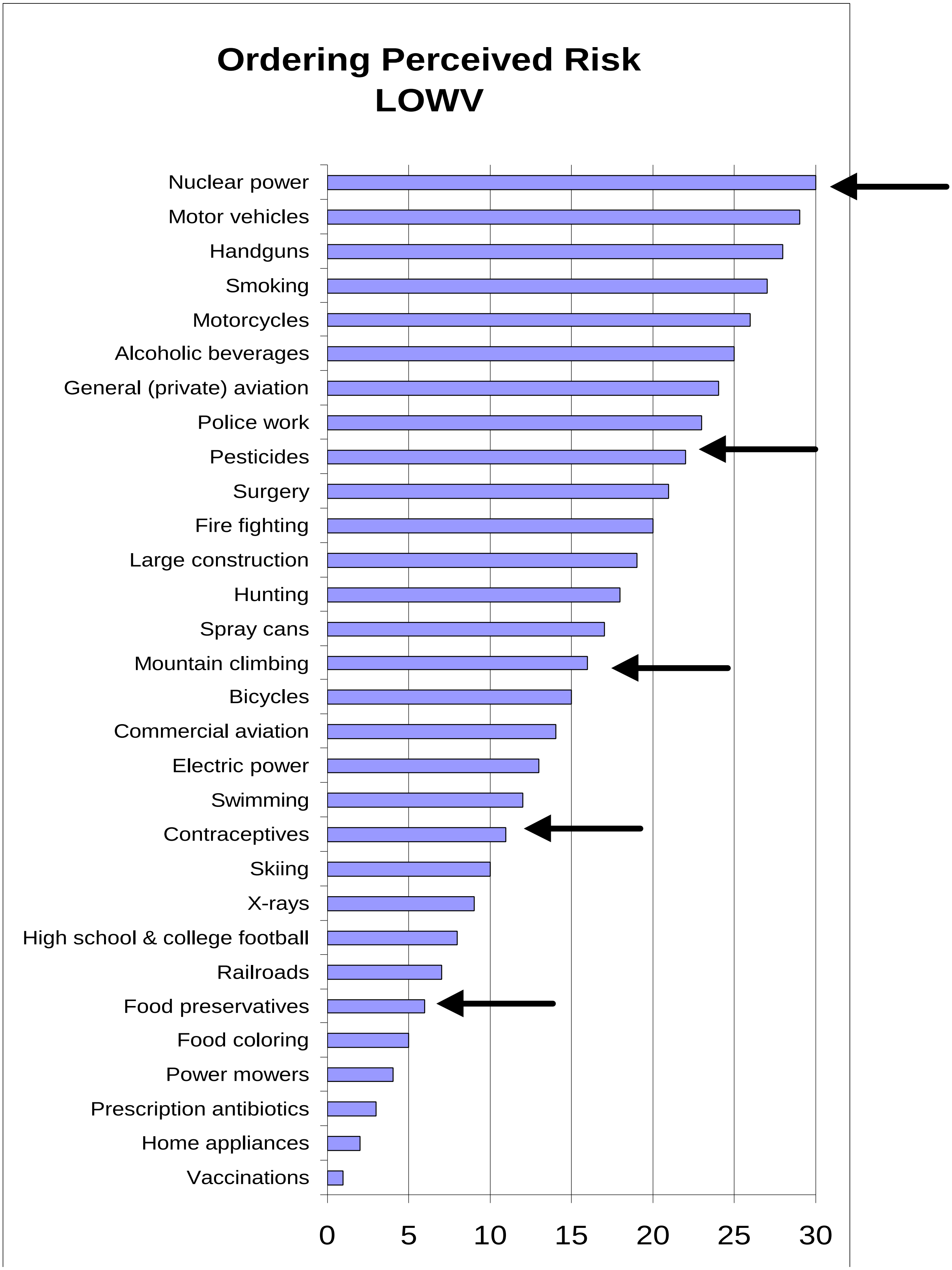
30 thirty different activities and technologies.

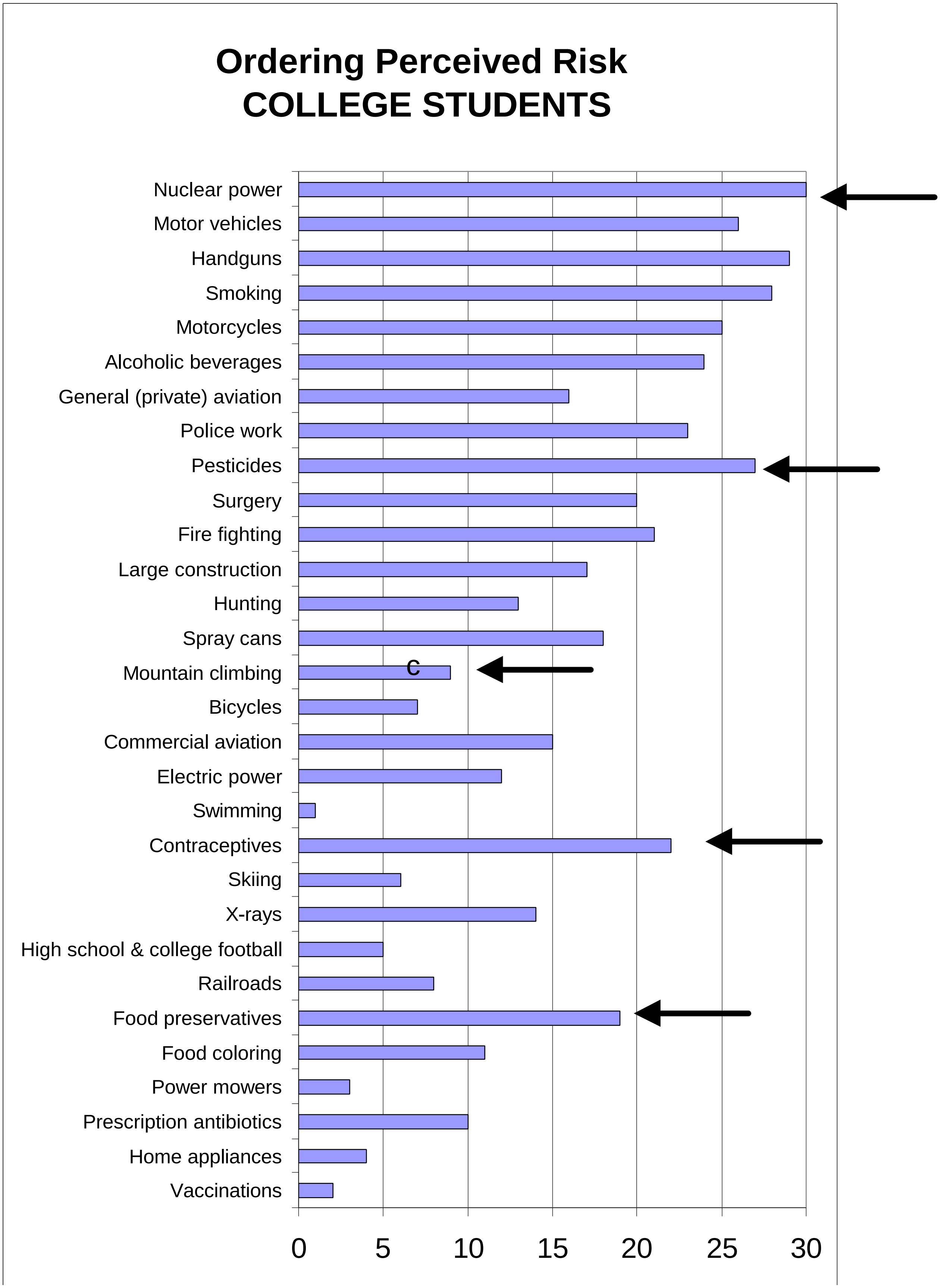
Question 1:

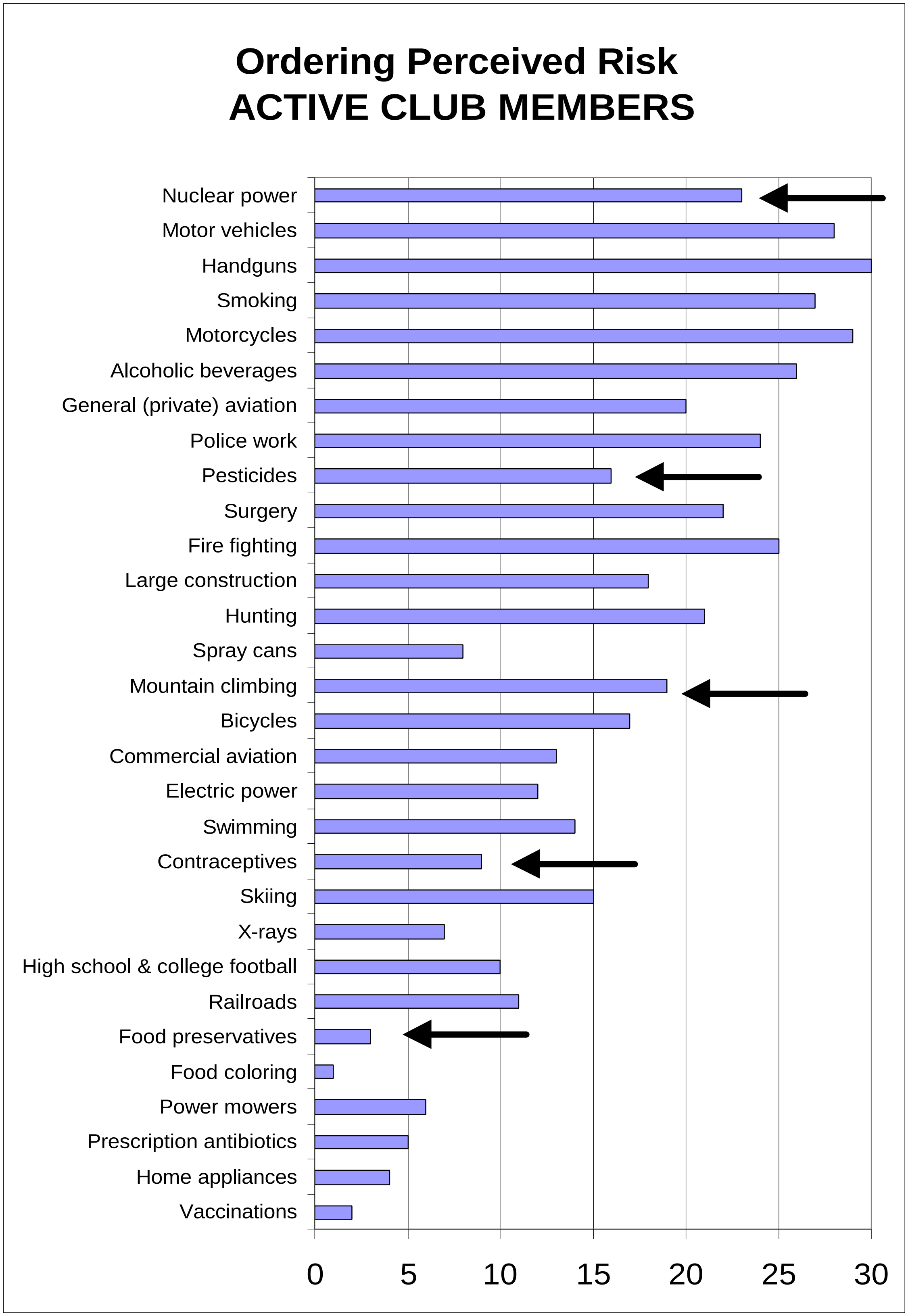
"Consider **risk of dying** in US due to one of these technologies"?.

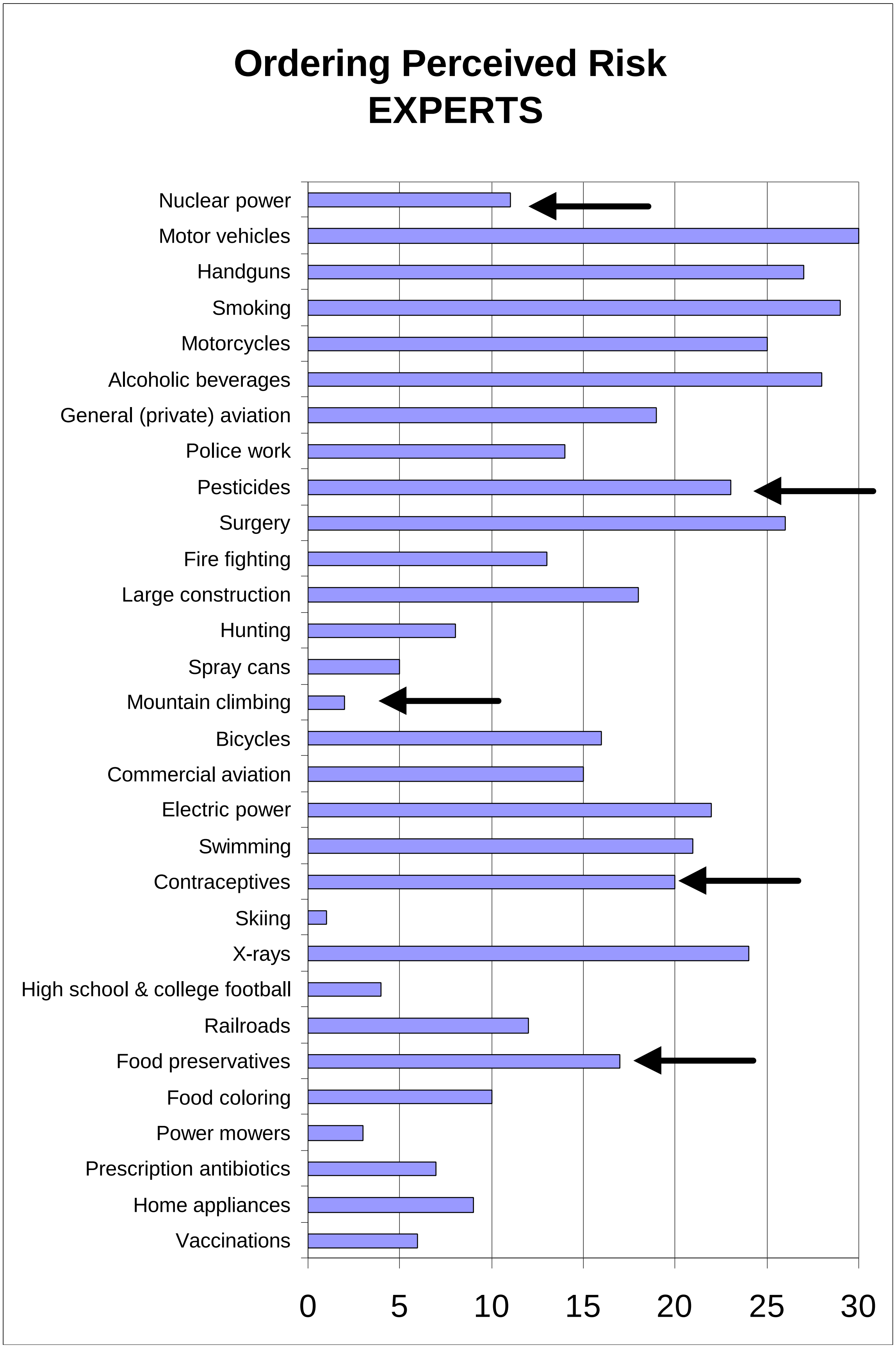
Questionnaire Process:

1. Each activity on 3" by 5" card.
2. Go through cards and think of ways of dying due to activity.
3. Order the cards according to riskyness.
4. Assign a risk value, starting with 10 to the lowest risk.


Ordering Perceived Risk
LOWV
Nuclear power
Motor vehicles
Handguns
Smoking
Motorcycles
Alcoholic beverages
General (private) aviation
Police work
Pesticides
Surgery
Fire fighting
Large construction
Hunting
Spray cans
Mountain climbing
Bicycles
Commercial aviation
Electric power
Swimming
Contraceptives
Skiing
X-rays
High school & college football
Railroads
Food preservatives
Food coloring
Power mowers
Prescription antibiotics
Home appliances
Vaccinations
0
5
10
15
20
25
30


Ordering Perceived Risk
COLLEGE STUDENTS
Nuclear power
Motor vehicles
Handguns
Smoking
Motorcycles
Alcoholic beverages
General (private) aviation
Police work
Pesticides
Surgery
Fire fighting
Large construction
Hunting
Spray cans
Mountain climbing
Bicycles
Commercial aviation
Electric power
Swimming
Contraceptives
Skiing
X-rays
High school & college football
Railroads
Food preservatives
Food coloring
Power mowers
Prescription antibiotics
Home appliances
Vaccinations
C
0
5
10
15
20
25
30


Ordering Perceived Risk
ACTIVE CLUB MEMBERS
Nuclear power
Motor vehicles
Handguns
Smoking
Motorcycles
Alcoholic beverages
General (private) aviation
Police work
Pesticides
Surgery
Fire fighting
Large construction
Hunting
Spray cans
Mountain climbing
Bicycles
Commercial aviation
Electric power
Swimming
Contraceptives
Skiing
X-rays
High school & college football
Railroads
Food preservatives
Food coloring
Power mowers
Prescription antibiotics
Home appliances
Vaccinations
0
5
10
15
20
25
30


Ordering Perceived Risk
EXPERTS
Nuclear power
Motor vehicles
Handguns
Smoking
Motorcycles
Alcoholic beverages
General (private) aviation
Police work
Pesticides
Surgery
Fire fighting
Large construction
Hunting
Spray cans
Mountain climbing
Bicycles
Commercial aviation
Electric power
Swimming
Contraceptives
Skiing
X-rays
High school & college football
Railroads
Food preservatives
Food coloring
Power mowers
Prescription antibiotics
Home appliances
Vaccinations
0
5
10
15
20
25
30

3.2 What Determines Risk Perception?

Big Research Question:
What do we people mean when they say that a technology is quite risky?

1. Comparing Perceived Risk to Frequency of Death

25 cases were compared to "reliable" technical estimates for annual frequency of death.

Results: (**See Figure 4 Original Paper**)

- Experts' judgments close to frequency of fatality.
- Lay people judgment moderately close to the frequency of fatality

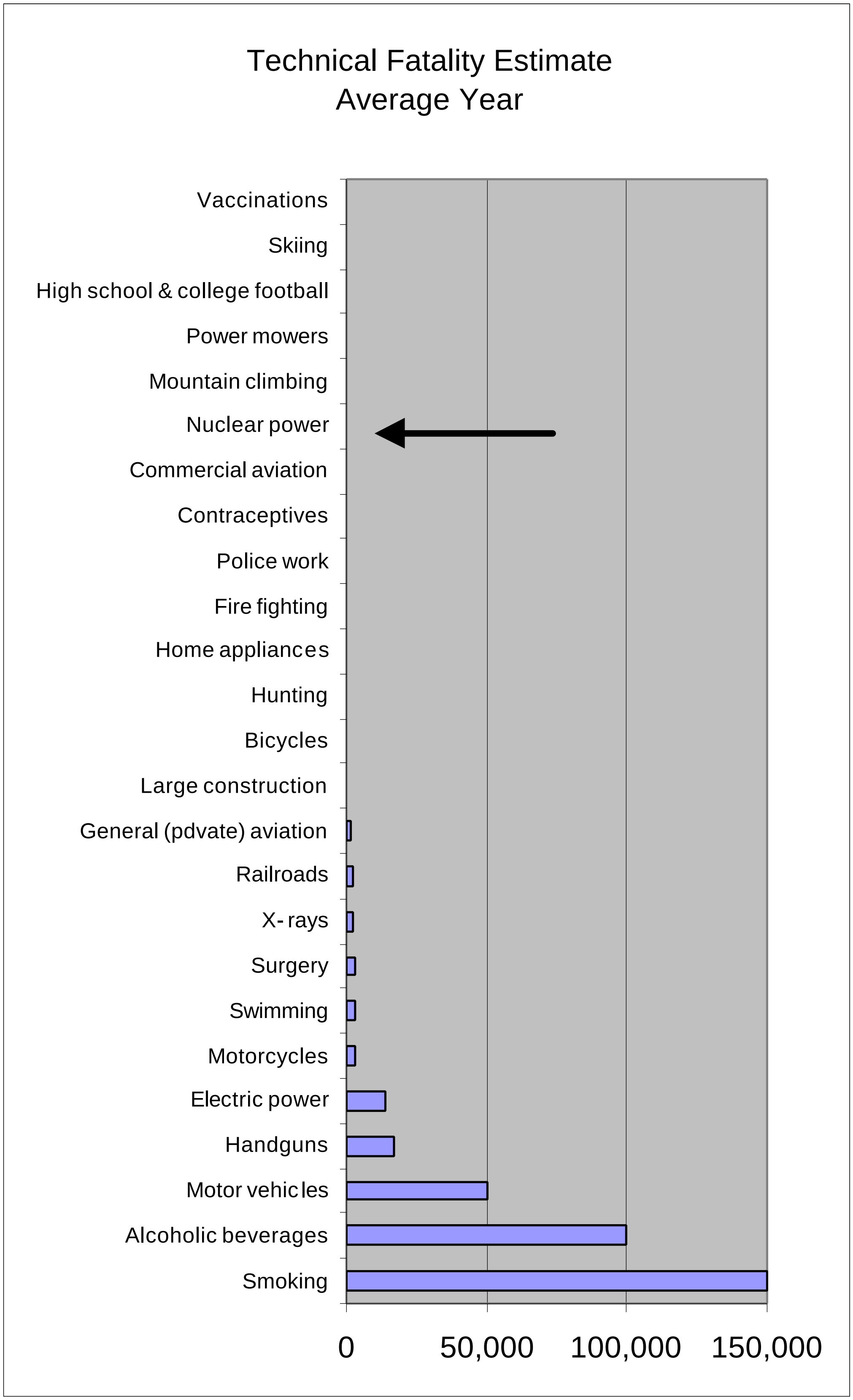
Striking Example: The perceived risk from Nuclear Power.

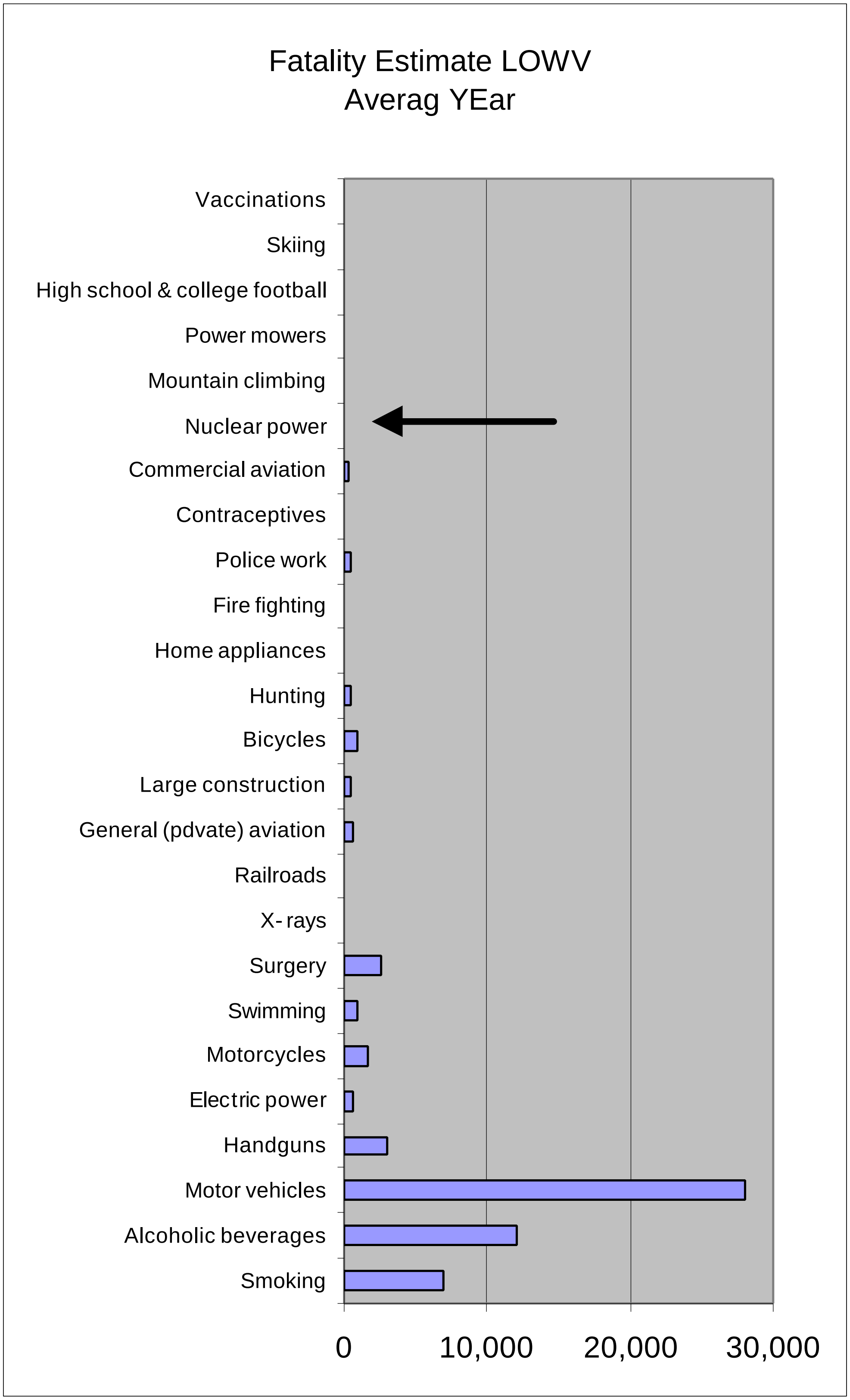
2. Explanation by Lay Fatality Estimates

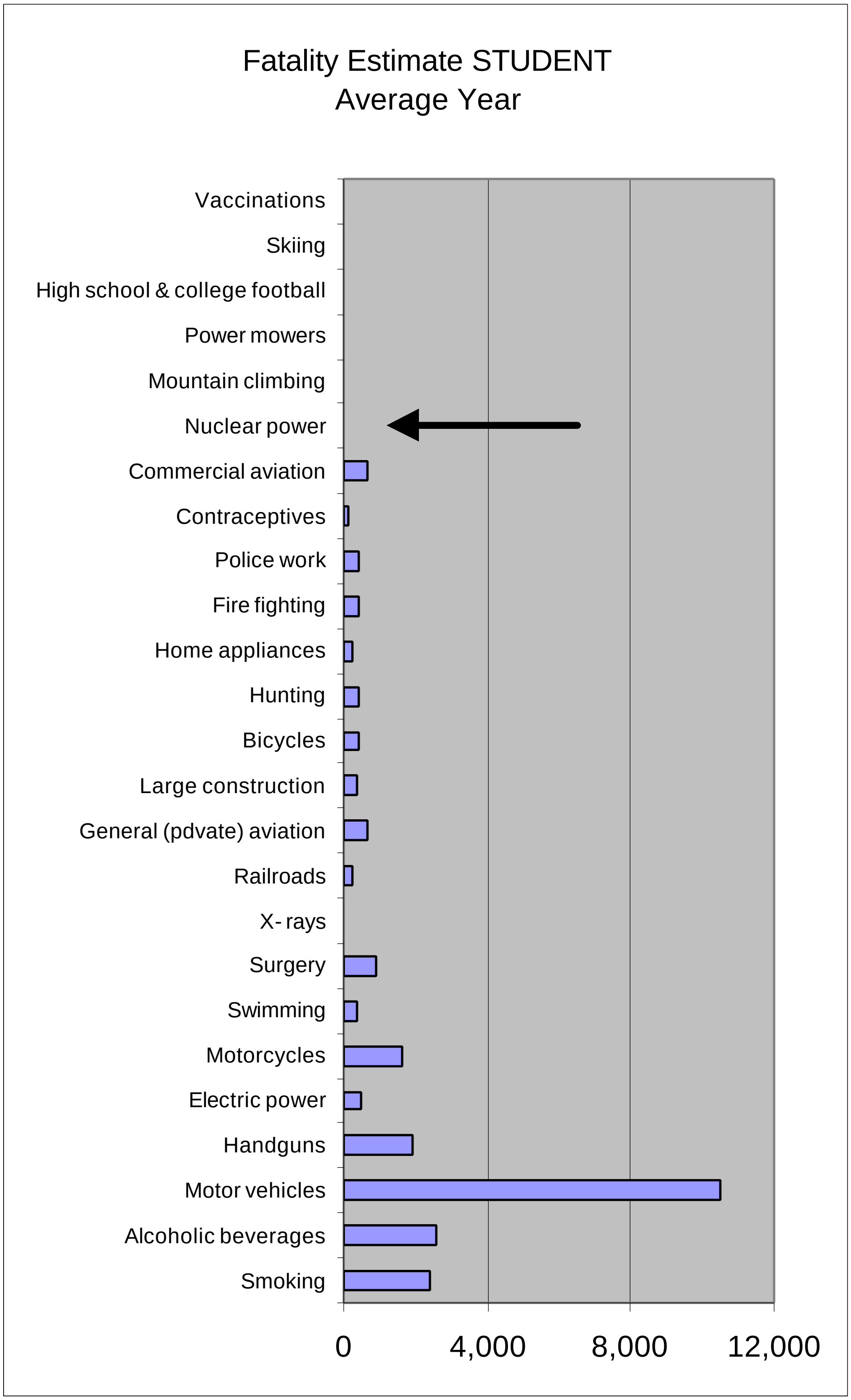
Research Question:
Is the different slope in Figure 4 for LOWV a result of inaccurate estimation, i.e. caused by the heuristics, particularly availability bias?

Question 2:

"How many people die in the US in **an average year** as a consequence of one of these technologies"?.


Technical Fatality Estimate
Average Year
Vaccinations
Skiing
High school & college football
Power mowers
Mountain climbing
Nuclear power
Commercial aviation
Contraceptives
Police work
Fire fighting
Home appliances
Hunting
Bicycles
Large construction
General (pdvate) aviation
Railroads
X- rays
Surgery
Swimming
Motorcycles
Electric power
Handguns
Motor vehic les
Alcoholic beverages
Smoking
0
50,000
100,000
150,000


Fatality Estimate LOWV
Averag YEar
Vaccinations
Skiing
High school & college football
Power mowers
Mountain climbing
Nuclear power
Commercial aviation
Contraceptives
Police work
Fire fighting
Home appliances
Hunting
Bicycles
Large construction
General (pdvate) aviation
Railroads
X- rays
Surgery
Swimming
Motorcycles
Electric power
Handguns
Motor vehicles
Alcoholic beverages
Smoking
0
10,000
20,000
30,000


Fatality Estimate STUDENT
Average Year
Vaccinations
Skiing
High school & college football
Power mowers
Mountain climbing
Nuclear power
Commercial aviation
Contraceptives
Police work
Fire fighting
Home appliances
Hunting
Bicycles
Large construction
General (pdvate) aviation
Railroads
X- rays
Surgery
Swimming
Motorcycles
Electric power
Handguns
Motor vehicles
Alcoholic beverages
Smoking
0
4,000
8,000
12,000

- Compare to Question 1 where "How Risky" was asked

Subjects:

- <u>Additional</u> Groups of Students
- <u>Additional</u> LOWV Members.

Striking Observation:
Nuclear Power had **lowest** fatality estimate
and **highest** perceived risk.

- Lay people risk perception no more closely related to their own fatality estimates as to technical estimates.

<u>See Figure 5 in Original Paper</u>

Conclusion:
Lay people do not want to equate risk to fatality rates
and differences are not due to inaccuracies in estimation.

3. Explanation by Disaster Potential

Possible Explanation:
Nuclear Power judged low death rate in average year but considered high risk because of its potential for disaster.

Question 3:

"How many people die in the U.S. in **a disastrous year** as a consequence of these thirty activities and technologies."

- Compare to Question 2 where "average year" was asked

Subjects: Same Respondents as to Question 2.

Results:
Multiplier of 2 to 3 from disastrous year to average year.

Exception: Nuclear Power had a multiplier of 107.1.

- 40% answered: > 10000 fatalities;
- 25% answered: > 100000 fatalities

Reactor Safety Study:
Maximum credible nuclear accident would cause only 3,300 prompt fatalities. Chances of accident of this magnitude 1:2,000,000.

Conclusion:
Disaster potential explains discrepancy between perceived risk and fatality rate for nuclear power.

4. Explanation by Qualitative Characteristics

Research Question:
Are there other determinants of Risk Perception besides frequency of death values?

Subjects:

1. College Students
2. LOWV Members
3. Active Club Members
4. Experts

Question 4:

Rate the 30 technologies and activities based on following Qualitative Characteristics.

Qualitative Characterisitics:

1. Voluntariness of Risk
2. Immediacy of effect
3. Is risk known to people exposed to it
4. Is risk known/understood to science
5. Control over Risk if you are exposed
6. Newness
7. Is Risk Chronic or Catastrophic
8. Is Risk Common or Dreaded
9. Severity of Consequency (Likeliness of Fatality)

See Table 4 in Original Paper.

See Figure 6 in Original Paper.

Conclusions:

- Across all 30 items, ratings of **dread** and **severity** of consequences are closely related to lay persons' perceptions of risk.
- Ratings of dread, severity, the subjective fatality estimates and the disaster multipliers predicted perceived risk almost perfectly for LOWV and students.

5. Explanation by Judged Seriousness of death

Research Question:

"Are some deaths worse than others
over the different technologies?"

Example:

- Are deaths associated with involuntary deaths worse than deaths associated with voluntary risks?
- Are deaths from dreaded hazards given a higher weight than common hazards?

Results:

- The differences were slight.
- Most serious deaths: Nuclear Power, Handguns, only 2 to 4 times worse than the least serious deaths: Alcoholic, Smoking.
- Judged seriousness not closely related to perceived risk.

3.3 Reconciling Divergent Opinions

- Experts and Lay People have different Risk Perceptions.

- Lay People risk perception does not converge to one "Appropriate View" as it relies on fallible indicators such as memorability and imaginability.

- Research indicates that people's beliefs are persistent.

1. New evidence is judged reliable if consistent with initial belief
2. Contrary evidence is dismissed as unreliable or unrepresentative.

As a Result:

1. Intense effort to reduce hazard may be interpreted as:
   - The risks are great or
   - Technologists are responsive to the public's concerns.
2. Opponents may view minor mishaps as near catastrophes and dismiss the contrary opinions of experts as biased by vested interests.
3. Convincing people that the catastrophe they fear is extremely unlikely is difficult:
   - Any mishap could be seen as proof of high risk,
   - Demonstrating safety requires a large amount of evidence.

3. THE FALLIBILITY OF JUDGMENT

Research Conclusions:

1. Cognitive limitations cause uncertainty to be denied, risks to be distorted, and statements of fact to be believed with unwarranted confidence.

2. Perceived risk is influenced by imaginability and memorability of the hazard. People may not have valid perceptions even for familiar risks.

3. Expert's risk perceptions correspond closely to statistical frequencies of death.

4. Lay people's risk perceptions are based in part upon frequencies of death. It appears qualitative aspects such as catastrophic potential, dread and the likelihood of a mishap being fatal contribute to lay people risk perception.

5. Disagreements about risk remain even in the presence of "evidence." Definitive evidence is difficult to obtain. Weaker information is likely to be interpreted as reinforcing existing beliefs.

“Treat subjective judgments with caution”