**Communicating Uncertainty**

**Introduction**

Science is a discipline that must regularly deal with uncertainty, which means it is very important that you learn how to communicate such uncertainty in a way that people can understand and relate to. There is a lot of uncertainty in science for three main reasons:

1. Science is a very creative discipline, which means there are many different ways of approaching any research question, conducting experiments, and interpreting data/results. Even when two scientists view the same results, they might not interpret them the same way.
2. Like the universe, scientific knowledge is always expanding. This is because we gain new insights with more research into specific topics, and because new technology allows us to approach research questions in different ways than scientists did in years gone by. What was commonly held to be ‘true’ as little as five years ago might not be now.
3. Scientific research relies on objective, statistical analysis of results. However, we form conclusions based on the probability/likelihood of an explanation for what causes the results being the correct one. Science is **virtually never** certain, which means it is important to indicate the degree of confidence you have in a particular result (e.g. your new drug might have resulted in a statistically significant reduced chance of getting sick, but that does not mean that it will be 100% effective for everyone that takes it…).

There are five tips that you can put into practice when communicating uncertainty to boost the chances of your reader(s) understanding the level of uncertainty. You can:

1. Make any numbers (and statistical analyses) easy to interpret.
2. Contextualize these with an everyday comparison.
3. Choose descriptive language very carefully.
4. Use figures and images as well as words and numbers.
5. Communicate timelines (when might new data be available?).

**Making Numbers (and Statistical Analyses) Easy to Interpret**

When dealing with very large or very small numbers, it is a good idea to round these up/down to make it easier for people to picture.

**An Example**

If something has a 4,427-1 chance of happening, it’s fine to tell people that there is ‘*roughly a 4,500-1 chance.*’ However, if something has an 8.3/1 chance of happening, telling someone that there is ‘*roughly a 10/1 chance,*’ is misleading because there is actually a reasonably large difference between the two.

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Watch out for related contingencies (e.g. when one thing affects another, make sure you state the chance based on the combined likelihood, as well as the individual ones). For example, if I have a 10% chance of winning a regional award based on my grades, and then a 20% chance of winning a national award, it should be made clear that I only have a 2% chance of winning the national one (0.1 x 0.2 = 0.02).

It is also important to avoid **framing bias** when working with numbers. Framing bias can cause people to home in on the wrong message, and is often linked to your choice of wording, or even in the order that you introduce things.

**An Example**

Suppose there is a 10/1 chance that people will have a reaction to a new immunization that will make you feel very poorly for a few days, but that it is important to have the jab as catching the disease without immunization could be much worse.

If you tell people that ‘*anyone having a reaction will feel very poorly and 1 in 11 of you will have this reaction,”* you are focusing on the negative possibility and could dissuade people from having the immunization.

You should instead say something like ‘*being able to protect ourselves from this disease is very important, so although there is a 10% chance that you might have a reaction that could make you feel poorly for a few days, medical staff are recommending this jab.’*

**Contextualizing Numbers with Everyday Comparisons**

This is not always appropriate, but it can help to put things into context and make people understand the likelihood of something happening more easily. Pay special attention to your audience and try to tailor a comparison to them.

**An Example**

If you are speaking to members of a poker society, and want to communicate that there is an approximate 2% chance of another immunization making people feel poorly for a few days, you could try to relate this to an everyday example they will understand by saying something like ‘*The chance of having a reaction to the jab and feeling poorly is very similar to your chances of drawing the Ace of hearts from a standard deck of cards with only one go.’* This works because there are 52 cards in a deck (and only one ace of hearts, which means the chances of drawing it are 1.92%).

**Choosing Appropriate Descriptive Language**

This links in fairly closely to the idea of avoiding **framing bias**; if you tell people that ‘*the reaction to this jab that some people have is horrifying; you’ll feel gross for days,’* they will be more likely to focus on this and ignore the probability of actually being affected. People will also interpret *horrifying* and *gross* very differently, and this is the key to choosing appropriate descriptive language. Be very careful when using adjectives that imply a quantitative element to what you are saying.

**An Example**

If you said the chance of having a reaction to the second immunization was *pretty unlikely*, your readers would likely interpret this very differently. What does ‘*pretty unlikely*’ mean? One person might assume there is a 20-30% chance of something ‘*pretty unlikely*’ happening, whereas another might think this means there is only a 2-5% chance of it happening.

For this reason, it is always a good idea to use objective adjectives where possible, and to accompany them with a distinct number (e.g. ‘*There is a 2% chance that you will have a reaction to this immunization, so it’s pretty unlikely*.’).

**Using Figures and Images (as well as Words and Numbers)**

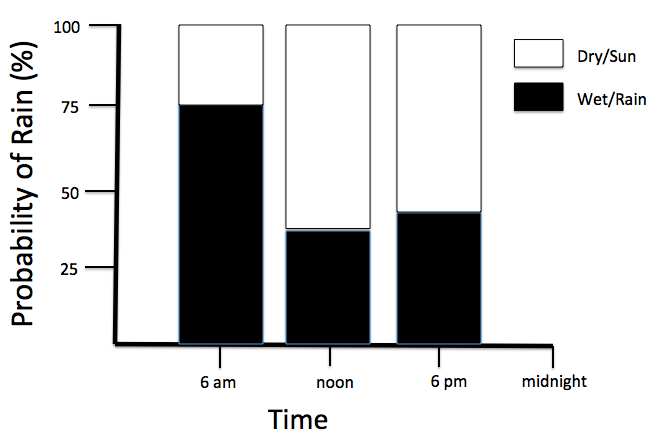
Some people find it easier to visualize and interpret patterns when they see them in figures and images instead of reading about them in print. The great advantage that figures have over words and numbers is that they can be more effective in highlighting magnitudes of differences between comparisons.

There are a few tips that you should put into practice when producing effective figures (such as keeping them simple, avoiding white space, and using bar graphs where possible – these are easier to interpret than pie charts and scatter plots). These tips and more information can be found by visiting our resource on ‘Producing Effective Figures’.

**An Example**

If you write that there is a 75% chance of rain at 6 am on a particular day, then a 35% chance of rain at noon, and a 40% chance at 6 pm, it is not easy to quickly relate to the relative uncertainty of these estimates; how much of a difference is there in these estimates?

The figure below makes this much easier to visualize, and might help you make a more informed decision as to whether you would risk going out without a rain jacket at certain points of the day.



**Figure 1: Probability of rain at different times on a particular day.**

**Communicating Timelines**

Because scientific knowledge is constantly evolving, it is a good idea to mention whether there will be an update in the coming weeks/months/years that might change the information you are currently presenting.

It is also a good idea to inform people when they can expect to hear more information in the midst of a crisis. For example, if there is an outbreak of mumps at school, it is better to tell people that you are unsure of the risk their children have of catching it if you don’t know, but that you are working with health specialists and will have information on this for them in the next five days. Telling them that ‘we don’t know’, but not giving them an indication of when you will know more is only going to cause worry and anger.

**An Example**

You might have completed Stage One of a research project that shows there is a 1 in 2,000 chance that your town will be hit by an earthquake in the next 10 years. However, if Stage Two is currently under way and you will have additional data to provide a more accurate estimate in three months, you should tell people that; not only are you underling the point that your estimate at present is just that – an estimate – but you are also giving them a timeline as to when they can expect to get a more fine-grained one.

**Communicating Uncertainty Quick Quiz**

**1)** Read the following summary of some research in which you must communicate the degree of uncertainty in your results.

*We have assessed the risk of a serious volcanic eruption affecting people living in the nearest town and believe there is a 1 in 151,091 chance that such an eruption will occur in the next week, a 1 in 106 chance in the next 10 years and is a 1 in 12 chance that it will happen in the next 50 years.*

**a)** Decide whether you cansimplify the three numbers without affecting their accuracy too much, to make this easier for people to interpret, and then make these simplifications if you think it is possible to do so (**1 mark** for each decision, **3 marks total**).

**b)** Read the following descriptions of the risk facing town residents, and rank these in order from best to worst, remembering the importance of avoiding framing bias (**4 marks**):

**A:** Realistically, there is no chance that the volcano will erupt in the next week.

**B:** It is a bit more likely that the volcano will erupt by 2065 than by 2025.

**C:** It is very unlikely that the volcano will erupt in the next 50 years.

**D:** There is an absolutely tiny chance that the volcano will erupt in the next week.

**2)** Read the three short descriptions below that all deal with scientific uncertainty in some way. Try to suggest what the potential problems are with each one and then re-write them to remove these problems **(3 marks).**

**i)** If the pest outbreak spreads to the city, there is a 1.3% chance that all the maple trees will die. Scientists think there is approximately a 14% chance that it will reach the city.

**ii)** Statistics show thatcyclists involved in traffic accidents have a 45% chance of missing at least two weeks of work to recover from injuries. Car drivers have only a 15% chance, but on average they are involved in six times as many accidents.

**iii)** Every single one of our 150 test subjects improved their performance in biology exams following our instructional course, so there is no chance that you would pay for it and not see an improved result at the end of term.

**Quick Quiz Answer Key**

To check your answers and see whether you are now a wizard at communicating uncertainty effectively in your science writing, you should access the answer key **here.**

**1)** Read the following summary of some research in which you must communicate the degree of uncertainty in your results.

**a)** Decide whether you cansimplify the three numbers without affecting their accuracy too much, to make this easier for people to interpret, and then make these simplifications if you think it is possible to do so (**1 mark** for each decision, **3 marks total**).

Simplifications, where possible, appear in **bold** font below:

*We have assessed the risk of a serious volcanic eruption affecting people living in the nearest town and believe there is* ***approximately a******1 in******150,000*** *chance that such an eruption will occur in the next week,* ***approximately a 1 in 100*** *chance in the next 10 years and a 1 in 12 chance that it will happen in the next 50 years.*

**b)** Read the following descriptions of the risk facing town residents, and rank these in order from best to worst, remembering the importance of avoiding framing bias (**4 marks**):

**BEST = D:** There is an absolutely tiny chance that the volcano will erupt in the next week. [**This is accurate – there is a chance, but is it incredibly small**]

**SECOND-BEST = B:** It is a bit more likely that the volcano will erupt by 2065 than by 2025. [**It is more likely, but more than a bit**]

**SECOND-WORST = C:** It is very unlikely that the volcano will erupt in the next 50 years. [**This is potentially misleading – what does ‘very unlikely’ mean? 1 in 12 is not ‘very unlikely’ to most people; perhaps ‘unlikely’ would acceptable**]

**WORST = A:** Realistically, there is no chance that the volcano will erupt in the next week. [**This is wrong; there is a chance**]

**2)** Read the three short descriptions below that all deal with scientific uncertainty in some way. Try to suggest what the potential problems are with each one and then re-write them to remove these problems **(3 marks).**

Problems and re-written versions appear in **bold** font below:

**i)** If the pest outbreak spreads to the city, there is a 1.3% chance that all the maple trees will die. Scientists think there is approximately a 14% chance that it will reach the city.

**Problem: Two sets of probabilities should be combined into one, because on their own they imply a greater likelihood than in reality.**

**Example re-write: There is only around a 1 in 500 chance that all the maple trees will die, because there is a 14% chance the pest outbreak will reach the city and only a 1.3% chance that it will kill all the trees if it does.**

**[*Note: 0.14 x 0.013 = 0.00182, = ~ 0.2%, or 1 in 500*]**

**ii)** Statistics show thatcyclists involved in traffic accidents have a 45% chance of missing at least two weeks of work to recover from injuries. Car drivers have only a 15% chance, but on average they are involved in six times as many accidents.

**Problem: The sentence suggests that you are more likely to miss work due to a cycling injury than a car injury, due to the framing bias of mentioning this first and not assessing the true risk based on the frequency of the accidents involving each commuter.**

**Example re-write: Car drivers are twice as likely to miss at least two weeks of work than cyclists due to traffic accidents; although cyclists involved in accidents are three times as likely to miss work for such a period, they are six times less likely to be involved in these accidents in the first place.**

**iii)** Every single one of our 150 test subjects improved their performance in biology exams following our instructional course, so there is no chance that you would pay for it and not see an improved result at the end of term.

**Problem: All 150 subjects improved their performance but that does not mean that every person on the planet would! This is just a wrap-up from a relatively small sample size.**

**Example re-write: All 150 of our test subjects improved their performance in biology exams following our instructional course, so there is an exceptionally good chance that you would pay for it and see an improved result at the end of term.**