SUPPLEMENTAL MATERIAL D (Psychophysics)

How can we relate psychological (perceptual) representations - like brightness, loudness, sweetness - to the physical stimuli - light, air pressure vibrations, sugar molecules - that create them? This is part of what philosopher's refer to as the 'mind/body problem'. **Fechner** (mid 1800's) thought he knew how to link the two. He was a **dualist** (dualists think that the physical realm and the psychological realm are distinct and fundamentally different) and a **panpsychist** (panpsychists think that everything has a mind, even plants and rocks). He had a background in math and physics so he was confident he could use those tools to study perception. (He also liked to stare at the sun - a bit too much - he stared at it so long and so often that it blinded him for years.) In short, he thought he could bridge between the psychological realm and the psychological realm with mathematics. To do that he would have to establish a new field of science. He called it **Psychophysics**.

***Psychophysics** is the study of the (mathematical) relationship between physical stimuli (like light, sugar molecules, air vibrations, etc.) and psychological representations (like brightness, sweetness, and loudness, respectively).*

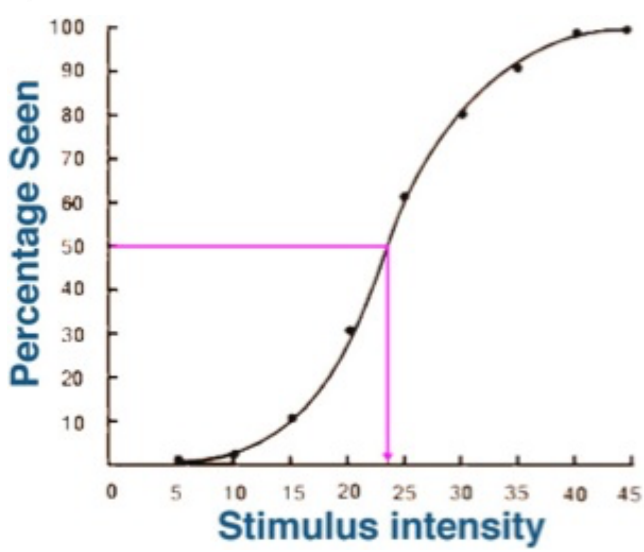
To see how psychophysics works, we can take a concrete example. Let's say you are interested in figuring out the smallest amount of a stimulus a person can just barely notice: for instance, the dimmest light, the quietest sound, the smallest concentration of sugar mixed with water, or the lightest touch. This is what's called the **Absolute Threshold** (the smallest amount of stimulation that can be detected). To get an idea how low these threshold are, here is a table with some '**commonsense' absolute thresholds.**

TABLE 1.1 Some commonsense absolute thresholds

Sense	Threshold
Vision	Stars at night, or a candle flame 30 miles away on a dark, clear night
Hearing	A ticking watch 20 feet away, with no other noises
Taste	A teaspoon of sugar in 2 gallons of water
Smell	A drop of perfume in three rooms
Touch	The wing of a fly falling on your cheek from a height of 3 inches

Source: From Galanter, 1962.

These commonsense absolute thresholds are kind of like fun facts about perception, but psychophysics wants to measure the Absolute Thresholds in a more formal and general way (i.e. to state thresholds with actual numbers: how many lumens of light can a person just barely see? how many dB of air pressure can they just barely hear?; what concentration of sugar molecules is needed in water to just barely taste sweet? etc.).



So, let's say it is your goal to measure the absolute threshold for vision: the dimmest light that a person can just barely see. You might imagine that you could set up such an experiment by showing a person lights of various brightnesses (all of them quite dim, though) and asking the person "Can you see this light?". This is like the visual equivalent of a hearing test. For the very, very dim lights, the person would probably say "no, I don't see the light". And for the brightest of the dim lights, the person would always say, 'yes, I see it'. For the ones in between, sometimes the person would be able to see it and sometimes not, so you'd get some kind of mixture of yes's and no's. From all this data, you can make a graph of 'Stimulus intensity' (a physical measure of how bright the light is) versus 'Percentage seen' (that's a psychological measure of how good you are at seeing the light). What we just described was a psychophysical experiment, and the characteristic S-shaped curve that we graphed (see above) is called a **Psychometric function** - a mathematical mapping between the physical and psychological worlds. That point on the graph where you can just barely see the light, basically where you have a 50/50 shot of seeing it, is considered to be your 'absolute threshold', that is, the smallest amount of a physical stimulus (in this example, light) that you can detect. You can easily redo this experiment and produce another psychometric function (and figure out the threshold) for the other senses by using different physical stimuli, e.g. decibels of sound, grams of sugar, lbs/sq_inch of pressure, instead of lumens of light. And the exact shape, and the threshold for whatever psychometric function you create will differ between individuals, and definitely differ between organisms (the absolute threshold for vision will be much lower in cats than humans; cats have much better night (low-light) vision than a typical human).

Fechner also wanted to find a psychological "unit". For physical stimuli, we already have agreed-upon units. For example, for weight, a unit is pounds. For length, a unit is inches. For light a unit is lumens. For temperature, a unit is degrees. But what could be a unit of perception? What is a unit for brightness, or loudness, or roughness, or pain? He thought he found the answer in the experiments of Ernst Weber. **Weber** (mid 1800's) was studying Difference Thresholds. **A Difference Threshold is** the amount of <u>change</u> (increase or decrease) a stimulus needs for someone to notice it has changed. (Remember, an *Absolute* Threshold is how much of a stimulus someone needs to notice that it is there at all. But, once the stimulus is detected, how much of a difference (increase or decrease) is required to notice that it has changed, for instance, gotten louder, softer, brighter, sweeter, rougher, or heavier?). Weber called this amount of change, by another name, the **"Just Noticeable Difference (JND)". Fechner** liked this concept, and decided that the JND, was the psychological "unit" he was looking for. A weight may increase in pounds, but it is only when that increase is at least one JND that a person will notice.

Weber did his early experiments with the perception of weight. He noticed that the 'bigger' the stimulus, then the bigger any difference had to be in order for a person to notice it. This is true for lots of everyday things too: for instance, with money, the bigger the base price of something, the

I	ΔI (<u>JND</u>)	ratio	K (weber fraction)	*Just barely heavier weight*
1 gram	0.02	0.02/1	0.02 (2%)	1.02 g
10 grams	0.2	0.2/10	0.02 (2%)	10.2 g
100 grams	2	2/100	0.02 (2%)	102 g
1000 grams	20	20/1000	0.02 (2%)	1020 g

Weber's Law

- The amount of change that is necessary to be noticed is systematically related to the intensity of the original stimulus
- The stronger the initial stimulus, the greater a change must be for it to be noticed.
- Mathematically:

$$K = \frac{\Delta i}{I}$$

  - *K = A constant (varies across senses)*
  - *Δi = The minimal change in the intensity required to produce j.n.d.*
  - *I = the intensity of the stimulus where the change occurs*

more the difference has to be in price between two products for you to notice. So, you may 'notice' (care about) a price difference of a dollar if you are choosing between two energy drinks, but you probably won't notice (care about) a price difference of a dollar if you are shopping between two used cars. In that case, you might just barely notice a difference of even, say, $10 or $100. Or, just let this guy help explain! (https://www.youtube.com/watch?v=wVhiezByMSU). Or this one is specifically about Weber (https://www.youtube.com/watch?v=-1e0uIS5j2Q)

Weber put all his observations together into something we call **Weber's Law:** *the size of the JND (sometimes written as is a constant proportion (K) of the original stimulus ("I").* Often the stimulus intensity is written as "I" and the JND is written as "ΔI" (*delta* I), and the constant proportion is written as "K" (Weber fraction).

For instance, let's say you are judging weights, and you determine that your JND (ΔI) for a 10 gram weight (I) is 2 grams, so that you can just barely notice that an 12 gram weight is heavier than a 10 gram one. That's a 0.2, or 2% (K), increase. According to Weber's Law, that means your difference threshold for a 100 gram weight will also be 2%, so you'll need a 102 gram weight to just notice that it's heavier. For other dimensions (brightness, sound intensity), you will have different values for K. And, different individuals, or organisms, will have different K values. Below are some examples of the Weber fractions for various perceptual dimensions. Notice that a typical human is more sensitive (can notice smaller changes) to shocks than salt.

Table 1.3 *Weber fractions for a number of different sensory dimensions*

	K	
Electric shock	0.01	(1%)
Lifted weight	0.02	(2%)
Sound intensity	0.04	(4%)
Light intensity	0.08	(8%)
Taste (salty)	0.08	(8%)

Source: From Teghtsoonian (1971).