Topcat Metrology Ltd

"Looking behind the measurement"

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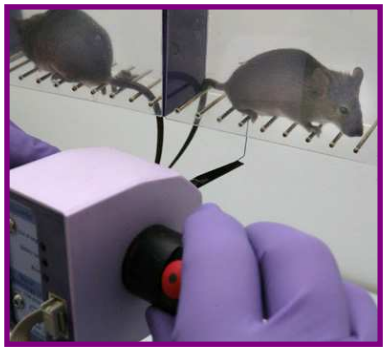
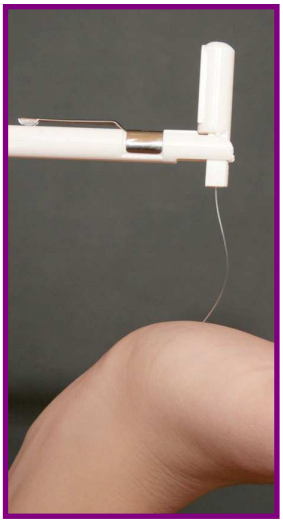
Why do von Frey filaments show a greater reduction in threshold than EVF systems?

Von Frey filaments are the accepted technique for the measurement of mechanical thresholds in rats and mice. Several manufacturers, including ourselves, have produced “Electronic Von Frey” systems which seek to replace the series of discrete measurements made with filaments (followed by analysis by the up-down or % response algorithms), with a single analogue measurement of threshold force.

A trend has emerged in the data; following treatment which invokes hypersensitivity, the reduction in threshold measured using electronic systems is not as great as that measured with filaments.

We have investigated this while validating our MouseMet and RatMet EVFsystems and present here an explanation for the difference:





The effect of probe diameter on threshold:

As the filament or probe is applied, the force produces pressure on the paw tissues, providing the stimulus which activates the nociceptors. Assuming the contact end to be circular and flat-ended, a doubling of the contact area will require a doubling of the force to maintain the same surface pressure (as pressure = force/area). In this case, one might expect the stimulus intensity, and therefore the mechanical threshold force (MT), to remain unchanged. This is not the case: larger diameter probes lead to a lower MT than expected. Several researchers have demonstrated that the MT is proportional to the diameter (and also circumference) of the probe (both linear relationships) and not to its area (a square law).

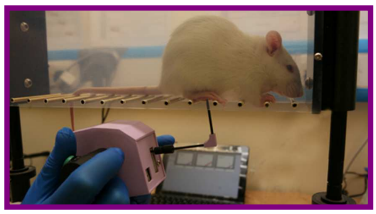
Each von Frey filament is an elastic column in compression which buckles at its rated force. The filaments in a commercially available set are all the same length, which means that the diameter must increase to increase the force rating.

The 0.07g filament, for example has a diameter of 0.15mm, while the 2g filament has a diameter of 0.3mm and the 26g filament a diameter of 0.6mm. It is clear that doubling the diameter considerably more than doubles the force.

This variation in diameter distorts filament MT data:

- Take an example mouse (untreated) which just responds to the 2g filament (diameter 0.3mm). MT is 2g.
- If we were to take a 1g filament (0.27mm diameter) and reduce its tip diameter to 0.15mm then our mouse should still (just) respond as the stimulus has not changed (half the force but half the diameter). This hypothetical filament would give the same mouse a recorded MT of 1g.
- But for real filaments, it is the 0.07g filament that has a diameter of 0.15mm. From the above we know that this reduction in diameter already halves the force needed to produce the same stimulus (versus our starting point, the real 2g filament).
- So the reduction in stimulus in going from the 2g to the 0.07g is not 0.07 versus 2 (a factor of 28), it is 0.07 versus 1 (a factor of 14), because the reduction in area already provides a factor of 2.
- A decrease in recorded MT from a baseline of 2g to a treated of 0.07g reflects not, therefore, a reduction to 3.5% of the baseline, but only to 7% (which would be a recorded MT of 0.14g)
- We suggest, therefore, that the variation in stimulus intensity from filaments is smaller than the variation in their rated forces. This is why filaments appear to measure a greater reduction in MT after treatments causing hypersensitivity than EVF systems where the probe is a constant diameter.

Finally: In order to compare filaments with an EVF system, the point at which the two methods provide an equal stimulus must be established. One could pick the filament with the same diameter as that of the EVF probe but this is an over-simplification as the effective circumference of the filament reduces (halves?) as it buckles. This can only increase the effect described, but the magnitude is difficult to predict. We are working on it.



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