Flashback: Nothing new in science?

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*During my flyfishing vacation last year, pretty much nothing was happening on this blog. Now that I've migrated the blog to WordPress, I can actually schedule posts to appear when in fact I'm not even at the computer. I'm using this functionality to re-blog a few posts from the archives during the month of august while I'm away. This post is from February 9, 2011:
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In this week's journal club, we talked about an old paper from 1918! "The reactions to light and to gravity in Drosophila and its mutants" by Robert McEwen, in the *Journal of Experimental Zoology*.

As the title says, the author studied how the fruit fly *Drosophila* responds to light and gravity. He tested this in walking flies and compared flies both with intact wings and clipped wings, wing mutations, clipped antennae, glued wings or clipped middle legs. He discovered that flies without wings or with mutated wing shape, show less movement towards light (i.e., less phototaxis). This finding was later confirmed by one of the founders of modern neurogenetics, Seymour Benzer (1967) and we also find this in our experiments. We have now set out to find out which neuronal mechanisms are involved in this drastic change in behavior.

In order to get the flies to show phototaxis, McEwen developed a machine to gently tap the tube in which the flies were placed, to get them to walk. He described the necessity for flies to be active in order to show a consistent orientation towards a light source: without walking behavior being either initiated spontaneously or by the tapping machine, flies would not walk towards the light themselves. If the flies were at rest, light was not an orienting stimulus for them. This key insight was formulated by McEwen at the very end of the paper:

> *Lastly, it may be well to emphasize the peculiar relation which exists in Drosophila between general activity and phototropism. This phenomenon has been clearly recognized by Carpenter and in general I agree with this author's conclusions. The fact seems to be that this insect is not phototropic unless it is in a certain physiological state brought on by, or at least accompanied by, activity. When the fly reaches a certain degree of activity, induced by various means, it suddenly becomes phototropic. When it quiets down, however, it may still crawl about but ceases to be phototropic. Thus, when an insect has been exposed to constant illumination for some time, it no longer orients to light but wanders aimlessly up and down the tube. Eventually such an animal may even come to rest with its head away from the source of light.*

The technique described mimics what other colleagues have later developed in other fly paradigms based on vision and walking, such as the "fly-stampede" paradigm. But the insight reaches much further than that. More recent research has shown that the state of the animal has minute control over how the environment is processed. For instance, leeches respond with various behaviors to local mechanosensory stimulation (i.e., touch). However, when they feed, the biogenic amine serotonin is released and prevents the mechanosensory neurons from transmitting the stimuli – the animal becomes unresponsive when it feeds (Gaudry & Kristan, 2009). Another study showed that motion-sensitive neurons in the optic lobes of the fly brain increase their gain when the fly is flying, as opposed to when it is not flying (Maimon et al., 2010). Analogous results were obtained when walking vs. sitting flies were compared (Chiappe et al. 2010). In another, also very sophisticated study, Haag et al. (2010) showed how an identified motor neuron responds more strongly to visual input when the animal is flying than when it is at rest. Finally, Tang and Juusola (2010) report evidence that the direction in which a fly attempts to turn changes the way in which the optic lobes process the visual information on the side towards the fly attempts to turn, compared to the contralateral side.

All these groups have, largely independently of each other, discovered the biological mechanisms for something that already McEwen (and Carpenter, cited there) had understood: animals don't just respond to stimuli in always the same, stereotypical way: all animals have many different ways to treat and evaluate the incoming sensory stream, depending on what they are doing at the moment. The decisive factor for understanding animal behavior is not the environment, or the sensory organs, it is the animal itself. Apparently, this profound insight was known long ago and we're just rediscovering it now, in various places, all over the world.

Something *was* new in all the recent studies, though: they all provide first mechanistic insight into how brains balance internal and external processing. All these studies show that there seems to be a smooth gradient between decision-making and attention-like processing, even in invertebrates: Gaudry and Kristan call it decision-making, when their leeches 'decide' to ignore stimuli while they feed, even though the incoming sensory stimuli are blocked already at the very first synapse. Chiappe et al., on the other hand, relate their phenomenon to attention and Haag et al. also mention attention in their paper, with their effects being observed many synapses downstream of the sensory neurons – the word 'decision' does not occur in either of the two papers. It appears as if future neurophysiological research is bound to show that the distinction between attention-like mechanisms and decision-making, which seems so intuitive and clear-cut, may dissolve when we start to unravel how brains actually do it. Now when will we come accross the ancient text that already pre-empts that insight? 😐

References:

McEwen, R. (1918). The reactions to light and to gravity in Drosophila and its mutants Journal of Experimental Zoology, 25 (1), 49-106 DOI: 10.1002/jez.1400250103
Zhu, Y., & Frye, M. (2009). Neurogenetics and the "fly-stampede": dissecting neural circuits involved in visual behaviors Fly, 3 (3), 209-211 DOI: 10.4161/fly.3.3.9139
Gaudry, Q., & Kristan, W. (2009). Behavioral choice by presynaptic inhibition of tactile sensory terminals Nature Neuroscience, 12 (11), 1450-1457 DOI: 10.1038/nn.2400
Maimon, G., Straw, A., & Dickinson, M. (2010). Active flight increases the gain of visual motion processing in Drosophila Nature Neuroscience, 13 (3), 393-399 DOI: 10.1038/nn.2492
Chiappe, M., Seelig, J., Reiser, M., & Jayaraman, V. (2010). Walking Modulates Speed Sensitivity in Drosophila Motion Vision Current Biology, 20 (16), 1470-1475 DOI: 10.1016/j.cub.2010.06.072
Haag, J., Wertz, A., & Borst, A. (2010). Central gating of fly optomotor response Proceedings of the National Academy of Sciences, 107 (46), 20104-20109 DOI: 10.1073/pnas.1009381107

Tang, S., & Juusola, M. (2010). Intrinsic Activity in the Fly Brain Gates Visual Information during Behavioral Choices PLoS ONE, 5 (12) DOI: 10.1371/journal.pone.0014455