NEUROBIOLOGICAL BASIS of sex-specific behaviours

by Carolina Rezaval

Drosophila melanogaster female. Artwork by Joane C. Carvalho, Evolutionary and Developmental Biologist, Portugal

Sex-specific behaviours are prevalent across the animal kingdom, particularly in activities related to reproduction, such as mate selection and offspring care. There are a number of beautiful examples of gender-specific mating rituals in nature, including sophisticated dances and ornamental displays. In some species of frogs, songbirds and crocodiles, males produce a courtship song that is thought to attract females by advertising desirable attributes. Whereas in some species of spiders, males use gifts of food to entice females. It is thought that females use these male courtship displays to evaluate the fitness of potential mates and decide whether to copulate or not. This variation in behaviour between sexes is essential for reproductive success, and the intriguing question here is to understand how these differences in behaviour arise.

Sex-specific behaviours are usually innate and are believed to reflect gender differences in the nervous system. It is possible that, in the most extreme case, an entire neural circuit unique to one sex might generate a sex-specific behaviour. Alternatively, sex differences may reside in sensory or motor neurons that are connected to shared neural circuitry. However, given that many non-reproductive behaviours are common to both sexes, these pathways are likely to be similar between males and females, and sex differences may instead arise from intermediate neurons in the brain. Knowledge of this underlying neural circuitry will help further our understanding of the cellular basis of sex-specific behaviours.

The fruit fly Drosophila melanogaster has proved an ideal model for studying the neuronal bases of sexually dimorphic innate behaviours, as their sexual behaviours are robust and highly stereotypical. During courtship, the male chases the female while vibrating one wing in order to perform a species-specific song, whereas females do not court.

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As a result of available sophisticated genetic tools, we have gained insight into the genes and neurons that control sex-specific behaviours in fruit flies. Previous work has indicated that the neuronal circuitry expressing the sex determination genes doublesex (dsx) and fruitless (fru) controls all aspects of male courtship (1). Notably, activation of male-specific dsx/fru+ neurons has been shown to initiate courtship behaviour in males. Therefore, it has been proposed that the presence of these male-specific neurons could explain why males court and females do not. However, other studies have challenged this notion. For example, direct stimulation of fru+ neurons in the thorax has been shown to elicit singing in female flies (2), demonstrating that neurons capable of male-like song generation are indeed present in the female. These observations led to the hypothesis that females do not normally sing because 'command' neurons in the brain, normally required to activate the song pattern generator, are either missing or inactive. Additionally, it has recently been shown that activation of dsx+ neurons in the brain induces female flies to exhibit male-like behaviour, such as courtship song.

This finding shows that key components of the neuronal circuitry for 'male' behaviours exist in the female fly brain but remain dormant (3). Thus, sex differences in behaviour may not stem from the presence or absence of key neural circuits, but rather from how their activity is modulated. Interestingly, the female mouse brain has also been shown to contain latent circuits driving male-specific behaviours (4). Therefore, the presence of male and female-specific circuits in the brain might be a conserved feature of the nervous system.

These findings are not only fascinating, but they also remind us of the importance of taking a comparative approach to further understand brain organisation and function. Future work is likely to focus on understanding how behaviours of the opposite sex are repressed in functionally bisexual brains. Needless to say, exciting times lie ahead in this interesting field of research!

References

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Dr Carolina Rezaval, School of Biosciences, University of Birmingham