Topic Summary

Exploratory Behaviour in Mice from a Neurodevelopment Perspective

It is well-established that mice have an innate exploratory nature, closely tied to the concept of novelty (defined as a new or a never-before-experienced quality or environment) (Crusio, 2001; Thompson et al, 2018). This exploratory behaviour of mice has been theorized by scientists as emerging from a likelihood of finding food, shelter or other necessities and is an evolved behaviour for mice to acquire information about their surroundings (Crusio, 2001). Therefore, mouse exploratory behaviour is defined as acts or postures that facilitate the collection of information about unfamiliar objects or territories (Van Daal et al., 1987). Several papers, such as the work of Archer (1973), have examined the influence of psychological state (stress, fear or anxiety) on mouse exploratory behaviour through a number of tests. These tests include placing mice in several different novel environments (meant to instill fear or stress) and observing the likelihood for them to emerge from shelter (Archer, 1973; Crawley, 1985). However, the genetic and neurobiological underpinnings of mouse exploratory behaviour have only recently gained attention and reveal a different set of methodologies.

In effort to understand the neurobiological basis of mouse exploration, scientists will subject mice to an open-field analysis (OFA), a widely use methodology in behavioural neuroscience for its simple design and rapid measurement of exploratory behaviour (Walsh & Cummins, 1976; Tanaka et al., 2012). In an OFA, mice are placed in a novel environment and several components of their behaviour (such as locomotion etc.), are recorded by a tracking system (Rosin et al., 2015). This is used in the field of neurodevelopment as experimental groups (mice with variation in brain structure/size) are compared to control groups, with discrepancies between the two groups scrutinized. For example, recent studies have attempted to determine the implication of the cerebellum and hippocampus in mouse exploratory behaviour using the OFA (Caston et al., 1998; Laghmouch et al., 1997). In such studies, the performance of wild-type mice in the open field is compared to mice with variations in cerebellar or hippocampal structure. Indeed, both regions of the brain are involved in exploratory behaviour, with the hippocampus playing a role in permitting exploration and the cerebellum involved in the motivation to explore (Caston et al., 1998; Laghmouch et al., 1997). Moreover, both structures of the brain are hypothesized to play a role in the habituation of such behaviour, as hippocampal lesioned or cerebellectomized mice show no sign of habituating to a novel open environment (Caston et al., 1998; Laghmouch et al., 1997; Walsh et al., 2012). However, the influence of neurodevelopment on mouse exploratory behaviour has evolutionary origins and ultimately, genetic influences that underlie such behaviour (Crusio & van Abeelen, 1986).

As stated, the natural tendency for mice to explore has been adapted for survival (Crusio, 2001). Upon performing several diallel crosses (a mating scheme to investigate the genes involved in quantitative traits), and examining the genes of the progeny, researchers have determined that natural selection has influenced the genetic architecture underlying mouse exploration (Crusio, Schwegler & van Abeelen, 1989; 1991; Van Daal et al., 1991). For example, with exploration comes an increased likelihood of encountering predators and therefore, the evolutionary history of mouse exploration resembles that of stabilizing selection (favouring an intermediary phenotype), with multiple genes contributing to this behaviour (Crusio, Schwegler & van Abeelen, 1989). When examined holistically, this begs the question of whether mouse exploratory behaviour is influenced by both genetics and neurobiology. For example, in the study by Rosin et al., mice lacking an important developmental gene known as *Shox2* were subjected to an OFA, where mutant mice spent more time immobile and explored 1.4-fold slower than controls. Furthermore, upon investigating the brains of both wild-type and mutant mice, a reduction in the overall size of the cerebellum was observed (Rosin et al., 2015). Therein lies the question of whether exploratory behaviour is influenced by important genes implicated in neurodevelopment and passed down through natural selection. Future studies that seek to understand the role of discrete brain structures in mouse exploratory behaviour would expand the field of behavioural neuroscience. More specifically, determining if other parts of the brain beyond those mentioned influence mouse exploration, and whether the open-field analysis can help to characterize this relationship.

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