Escape strategies of mice in the watermaze: a meta-analytical dissection

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Hippocampal lesions in rats selectively disrupt place navigation in the Morris swim navigation task. Based on this observation, variants of this test are widely used to assess spatial learning and memory in genetically modified mice. However, careful observation of performing mice reveals that multiple forms of learning and a variety of escape strategies are involved. Spatial navigation is only a final step in a complex learning process. Mutations affecting procedural components of learning, behavioral flexibility or motivation may interrupt the process at early stages, long before spatial navigation abilities become a limiting factor. We have used a standardized watermaze procedure for most of our strain comparisons and studies of genetically modified mice conducted during the past 15 years. In this procedure, mice are first trained for a fixed goal during three days and then have to learn a new position during the following two days. Using principal component analysis (PCA) and 120000 video-tracked swim paths from 4000 mice we have now evaluated a large set of parameters across different strains and mutations, and have grouped them according to their ability to quantify particular escape strategies. We find that escape performance during training is mainly determined by non cognitive factors. Measures of escape performance have little predictive value for the precision and intensity of searching during a later probe trial, which are commonly taken as measures of spatial memory. On the other hand, PCA suggests that a mere quantification of searching behavior during a probe trial may underestimate the degree of spatial learning in many mice. In conclusion, watermaze experiments provide more information about the behavioral abilities of mice than commonly assumed. However, careful analysis and combination with suitable control experiments are needed to avoid misinterpretations and fully exploit this information.

Support:
NCCR Neurosciences Zurich, SNF 31-54184.98 & 31.57139.99, Roche Res. Foundation, Hartmann-Müller Foundation

Key words:
spatial learning, spatial memory, navigation, thigmotaxis, floating, principal component analysis