

Research Article

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Aging Might Increase Efficiency in Behavioral Performance for Risk Situations



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Abstract

There are many examples in the scientific literature about the changes and deterioration of memory through ages in humans. However, very little is written about the possible improvements of behavioral outputs with aging by a better discerning use of alerting attentional resources. In this brief report we have shown how attentional skills and abilities to solve unknown situations might be different between ages: using domestic rodents and Morris maze tests, the performance of two age cohorts (4 months vs 1 months of age) were significantly different for the first trials. Anxiety, rapidity of uncoordinated movements and thigmotaxis were predominant in the junior group, although they quickly learned how to escape and reach the adult level soon. Some research about human attentional skills and amygdala selection of external stimuli during lifespan are discussed.

Keywords: Morris Maze; Memory; Stages; Cognitive Mapping; Arousal; Learning; Evocation; Hippocampus; Escape

Introduction

Efficiency is the extent to which time or effort is well used for the intended task or purpose. In network sciences efficiency is a measure which indicates how efficiently a network exchanges information, but in statistics, it also represents a measure of quality of an estimator, experiment or text. In terms of energy, efficiency is the ratio of power consumed to useful power output. Useful, good use of power, proper links, quality, etc. they all seem to be positive values for pursuit of efficiency. There are many examples in the Scientific literature about the changes and deterioration of memory through ages in humans. However, very little is written about the possible improvements of behavioral outputs with aging by better discerning use of alerting attentional resources. Semantic memory and short-term memory are well preserved most of the adult lifespan, but some changes might happen very late in life. On the contrary, autobiographical memory, emotional memory and implicit memory are certainly unaffected by aging [1]. Some authors have mentioned changes in specific but not general attention skills with aging. In this line, alertness and working memory abilities might improve and some research is defining how to prevent the specific decline [2]. The amygdala might be relevant for this purpose,

since it is constantly monitoring and regulating the environment for stimuli to signal a threat to the organism like the "brain's lighthouse" [3].

The use we have given to our brains and the external stimulation we might have received seem to be relevant for the attentional skills during life. One study pointed out how bilingualism provided advantages in cognitive control abilities such as alerting: adult bilinguals showed an increase in neurofunctional activity in the frontal and parietal areas when compared to young bilinguals (French-English) [4]. For establishing the state of alertness of the incoming stimuli, the alerting ability is improved in those bilingual people. Extra brain networks (stronger functional connectivity between anterior to posterior brain areas and frontoparietal cortex) during development might improve the efficiency of the alertness criteria [4]. We have checked, with a Morris maze test and using domestic rodents, how the first reaction to an aversive stimuli such as water was completely different in two groups of ages. Comparing junior and adult animals (few "human months" of differences) the junior group were more anxious, visible with the naked eye, and unable to control the situation during the first trials. After training they learned as the adult group, different

strategies of approaching the platform in the Morris Maze, according to their search swimming strategies, from less to more focus on the goal of platform: thigmotaxis, random, scanning, chaining, focal, directed and direct [5]. Thigmotaxis defines the behavior of the animal which swims in reaction to the feelings of the water but with not a clear goal. The random style defines the haphazard movements of the animal in the water without conscious choice. The next manner of behavior in the water is the Scanning strategy that refers to the recursive and repetitive circles that an animal does in the same area and Chaining performance is the same as Scanning but happening in several different areas. Focal performance for swimming happens when the animal's behavior is clearly aimed to escape from there, but with no defined direction. However, Directed and Direct behaviors occur when, the platform is the main goal where the animal straightens all the movements toward. That means, the attention of the animal flows from the direct physical sensations (water, unstable and uninhabitable medium) to understanding for defining and finding the platform (behavior to escape).

Method

Two domestic mice rodents *Mus Musculus* (one male, one female) were obtained by acquisition them in an official pet store. They mated on February the 14th and subsequent offspring of that couple were used for these experiments. A total of 12 domestic *Mus Musculus*, an adult group (N = 6) of 4 months old (born 16th March) and a younger group (N = 6) of 1 month old (born 9th and 12th June) were tested with a Morris Maze test. All experiments were approved by local authorities and were in accordance with the guidelines for animal experiments of the EU (Directive 2010/63/EU). We also strictly follow the general protocols established for mice by the American Institutional Animal Care & Use Committee (IACUC) concerning the Policy on Investigation Noncompliance and Animal Welfare and the Environmental Enrichment for Animals Standard Operating Procedures (SOP). All mice were group housed per ages and sexes at 25 °C, under 12 h day/night cycle, in comfortable beds of finely ground Spanish pine sawdust, hay, straw and rodent litter changed at least once every week.

All the cages were cleaned, changed and dewormed using antiparasitic spray at least once every week. For proper cognitive and motor stimulation (proprioception) they were housed with interconnected cardboard cylinders, rotating wheels (vertical and diagonal), creative colorful pipe tube tunnels, outside and inside spacious nests, several height levels to roam around in each cage and elastic or fixed aerial ladders made from popsicle sticks. All those stimuli have been changed, cleaned and renewed once a week to create and stimulate their roaming entropy and exploratory behavior. It has been widely suggested that an enriched environment with novelties are very important variables for cognitive learning processes, plasticity, brain neurogenesis, reducing anxiety levels and inducing individuality in behavior [6]. The food provided was carefully chosen in a healthy variety

following veterinary instructions for little rodent necessities: natural seeds without additives, nuts (pumpkin seeds, black sunflower seeds, walnuts, peanuts in shell, oatmeals etc, pasta (raw macaroni), toasted bread crumbs or bread peaks, fresh and dry proteins (healthy live tenebrio molitor coleoptera, unpoisoned cockroaches and boiled snails, boiled eggs and dry cat food), fresh lettuce, mineral stone for rodents and clean fresh water ad libitum.

Experimental Design: Morris Water Maze Task

In brief, a circular water tank (color: black, height: 31 cm, diameter: 53 cm, and 167 cm of perimeter) was located 35 cm away from the floor. The color of the water tank was transparent, and the color of the plexiglass-platform was black as well, no additional color was added into the water. This circular platform (height: 11,5 cm, and diameter: 8,5 cm) was fixed at a particular location during each trial and it changed every time. Additionally, the platform was submerged to a depth of 0,5-1 cm above the water surface, but always depending on the size of the animal's paws (water above the platform has to be the same to half the length of the rodent lower extremities). The recorder was done from a fixed place, located in the distance, providing a good view of the animal behavior, but with one blind spot, that was a traffic area. The recorder was stopped as soon as a mouse sat on a hidden platform or if the mouse swam for a maximum of 60 s per trial without finding the platform. Mice had to learn to find a hidden platform using distal spatial cues because it was assumed they were able to distinguish the clues in the surrounding environment by seeing and all of them were able to swim acceptably [8, 7].

Two groups of male mice of different ages (N = 12) were compared. Two dependent variables were registered: 1) latency in water till finding the platform (seconds) and 2) track length of the swimming (centimeters). Both groups of ages were previously to the test highly externally stimulated, cognitive and motor (see material and methods) but during different periods of time according to their ages. They swam in a session of 6 trials, in consecutive days, at the same time (around 7pm, when sunsets and their biorhythms start to be more active). This testing environment of water reduces odor trial interferences Bromley-[8]. Clean water was changed every three trials. Statistical analysis, graphs, tables and figures were made with IBM SPSS Statistic version 29.0.2.0, with JMP Statistical Discovery [Trial 18.0.1 (766619)] and with PowerPoint for Windows. For inter-group comparisons the unilateral analysis of variance, with non parametric Kruskal-Wallis and U-Mann Whitney were performed.

Results

Comparing adult vs junior performances, we found clear statistical group differences for the first trial time [F (1,13) = 8.609, p = 0.003], first trial distance [F (1,13) = 8.308, p = 0.004] and the second trial (distance [F (1,13) = 3.692, p = 0.05]), having the junior group the longer marks (Figure 1 & Figure 2). The adult group showed a more efficient and practical behavior in finding the platform during the first trials (Figure 3 & Figure 4).

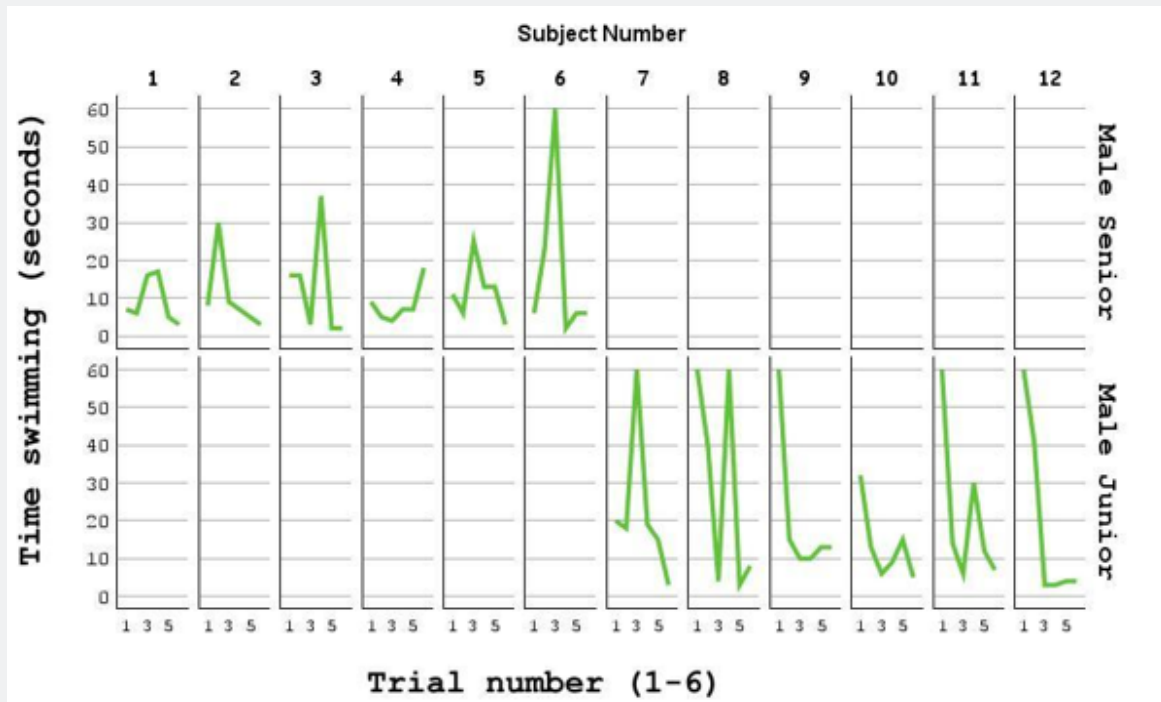


Figure 1: The graph is showing the individual performance in time of each animal of both groups during swimming tests. It is noticeable how the younger subjects of the junior group (from 7 to 12, lower lines) spent longer times in the swimming pool before finding the escape (platform). There was statistical group significance for the first trial between junior and adult or senior groups, being the adult group faster and more efficient. * $p < 0.003$ in trial 1.

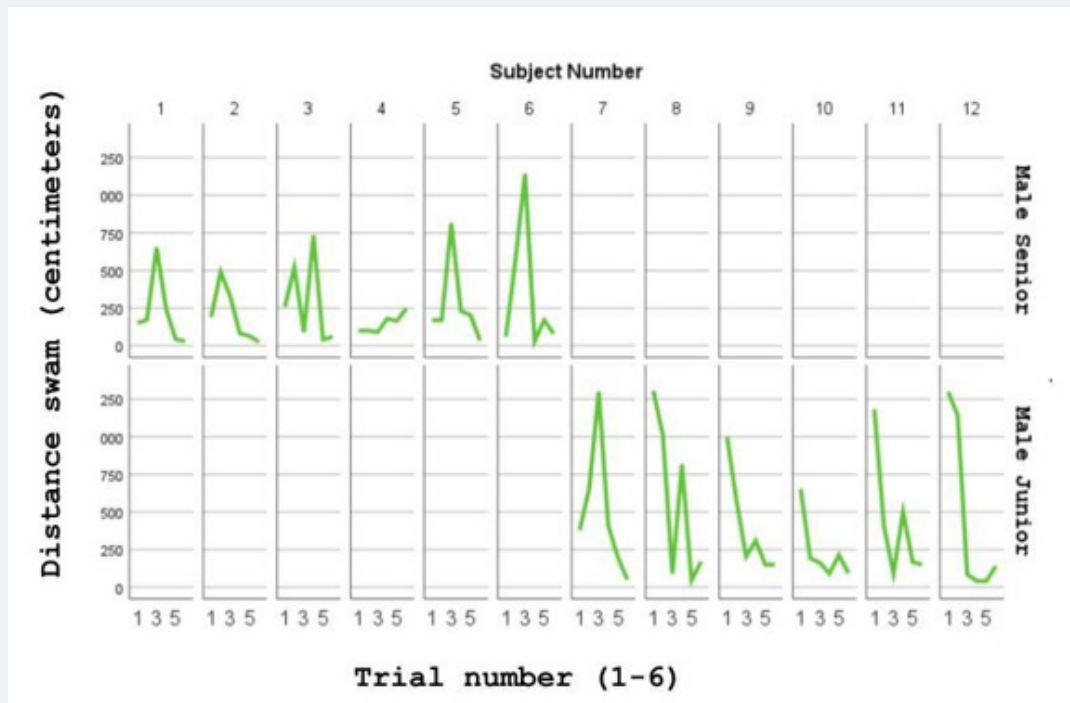


Figure 2: The graph is showing the individual performance in distance of each animal of both groups during swimming tests. Again, it is visible how the younger subjects (from 7 to 12) traveled longer distances before finding the platform. There were statistical group significance for the first and second trials, being the adult or senior group faster and more efficient. ($p < 0.004$ in trial 1 and $p < 0.05$ in trial 2).



Figure 3: The graph is visually showing the bigger amount of the younger group made during six trials (clear blue), specially in the first trials (outsider circles), compared to the adult group (dark blue).

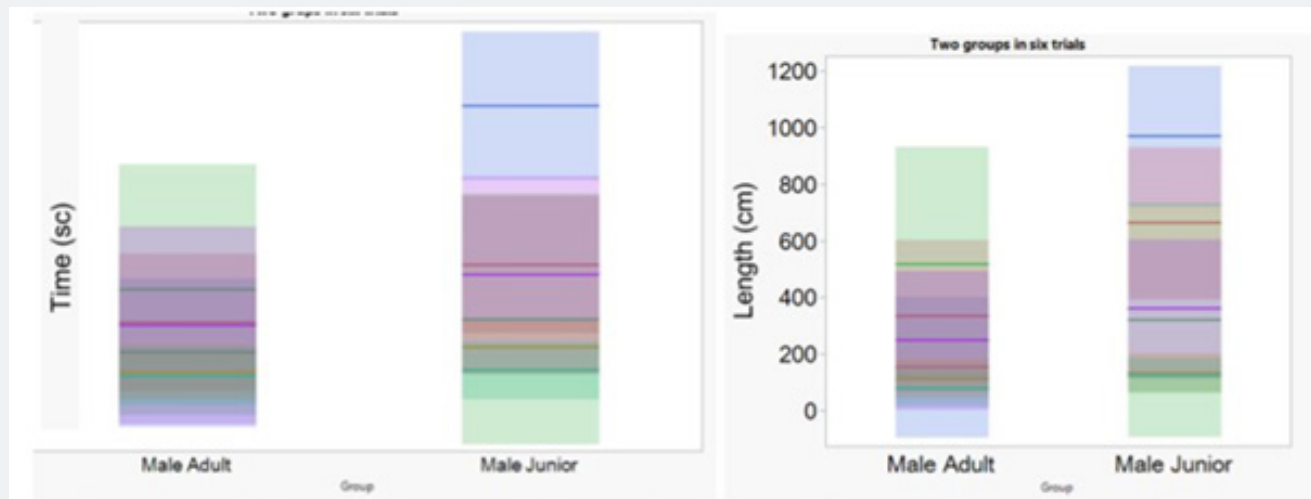


Figure 4: Graphs showing differences between groups for the time and length swam. Male junior group presents the longer bar for all consecutive trials, although they improved their performance with practice.

Discussion

In this paper we show how different aged mice react statistically differently to the same stimuli (Water Maze), proving their attentional skills and abilities to solve unknown situations are different throughout lifetime. The adult group was able to

reduce costs and maximize benefits earlier than the junior group, which reacted at the beginning following signals of risks and danger instead of searching for escape. In humans we have seen this age difference does appear in bilingual persons [4]: there is an age difference in human alerting that might be depending on the presentation, duration or persistence of the warning cue

Jennings, et al. [9]. The term naive means inexperienced or immature. This is also happening for their brains and most likely to their amygdala network for the selective attention and reaction toward dangerous stimuli [3]. This inexperienced Amygdala might be costing extra energy and inefficiency in finding the escape quickly. The decreases in local efficiency during tasks were associated with better working memory performance in both age cohorts, while the older participants had an increase in global efficiency because of a slight decrease in predicted working memory performance [10]. Researching with domestic mice has some particularities. These animals, in genes, behavior, brain material, etc. are exactly the same as experimental animals in an animal house of a lab (*Mus Musculus*). However, they are allowed to have a different treatment, more affectionate, by the researcher or caregivers, because they are like pets. Mice of pet store *Mus Musculus* have an unknown genetic background, but they are usually sold to become pets or to be food for captive reptiles, when they are certainly good specimens for obtaining scientific behavioral and experimental data to provide information to the Scientific community

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