FOUR LEG NEWS

Introduction - Exercise and The Brain

This newsletter was inspired by a talk I went to at the 2016 Orthopaedic Division Symposium. There was a very interesting speaker who spoke about exercise and learning. Essentially, he stated that aerobic exercise improves motor learning, neuroplasticity, memory, cognitive function, attention, and brain health. He told the crowd that exercise increases the volume of the hippocampus in the brain, and reduces cerebellar inhibition which thereby creates an optimal neural environment for neuroplastic changes to occur. This reduction in inhibition is important for rapid plasticity and motor learning (and recovery from stroke!) The speaker's 'physiotherapy-suggested-use' of this information was to use exercise bouts in order to help the CNS ready itself for motor learning, then to practice motor skills which is, in part, what physiotherapy targets. All in all, it was enough to stimulate my brain to want to do a newsletter on Exercise and The Brain (Canine-Specific). The bonus for you is that I also found articles in regards to brain-aging and exercise. Enjoy this issue everyone! Cheers! ~*Laurie*

Pleasant arousal post-learning has similar effects on enhancing memory in dogs as it does in humans

Affenzeller N., Palme R., Zulch A.* Playful activity post-learning improves training performance in Labrador Retriever dogs (Canis lupus familiars). *Psychology & Behaviour 168 (2016): 62-73.

Objective:
This study was designed to investigate what effect playful & fun activities (provided immediately after learning/training) has on dogs engaged in memory specific tasks. Specifically, to see if the experience of a positive, arousing stimulus improved the memory of learning in these dogs.

Methods:
16 Labrador Retrievers aged 1-9 years were selected for a pseudo randomized, counterbalanced between subject study. Factors such as age, sex, previous training experience and trials to criterion were subjected to a multiple factor/covariate General Linear Model analysis.
The dogs were trained in a 2-choice discrimination paradigm and were exposed to either a rest period (N=8) or a playful activity intervention (N=8) for the 30 minutes immediately following task acquisition.
Dogs in the resting group were settled on a mat next to the owner or assistant and remained responsive while the owner/assistant engaged in conversation with the researcher. Dogs in the play group engaged in one on one play with the researcher.

Results/Conclusions:
Results show that playful activity post-learning improved training performance evidenced by fewer trials needed to re-learn the task 24-hours after initial acquisition. (Play group M 26 SD 6; resting group M 43 SD 9; effect size 1.2). Notably, the dogs in the play group recorded elevated heart rates (143 bpm, SD 16) as compared to the rest group (86 ppm, SD 19). Salivary cortisol levels did not differ significantly between groups during the training task, but there was a significant decrease in the salivary cortisol levels in the play group after the 30 minutes of playful activity.

The significant difference suggests, as it does in people, an improvement in long-term memory. The importance of a high, compared to a low, heart rate when experiencing a stressful stimulus and its positive effect on memory has recently been evaluated in humans and it has been recorded that low level exercise leads to a reduction of circulation cortisol levels. While a better understanding of the roll of amygdala activation during these scenarios should be sought, this is potentially the first evidence that post-training positive-arousal-type activity may influence overall training performance in dogs.

Commentary/Relevance to Rehab… Laurie's thoughts:
This study is great for those of us involved in the treatment of sporting dogs specifically (or perhaps service dogs, working dogs, sniffing dogs, etc..). It's also something important to pass along to dog

trainers. Essentially after a dog is trained to do something new, anything new, anything you want the dog to retain… then play with him or her. Maybe this would also be true for 'potty training' a puppy! In these scenarios it would make we, the rehab professionals, the purveyor of information. However, what if 'learning to use a limb again' after surgery or injury was followed by some fun form of 'safe' activity! (There's a head scratcher! How do you get a dog to increase his heart rate when you are protecting a limb from too much activity? Hmmm, I may need to think on that subject a little longer… or perhaps it is just that the exercise we are ALREADY DOING IN rehab is part of the brain building, memory forming that will help the dog to use his/her leg or body properly again. In which case, it justifies rehab from yet another perspective! YES! I like this thought!)

Luminosity for dogs?

King C.* Canine Neurobics: A Curriculum to Improve Brain Health. *International Association of Animal Behaviour Consultants Journal, October 1 (2016)

Behaviourist Camille King developed a curriculum for a group dog-training class designed specifically for dogs with behavioural issues related to anxiety, impulse control, and boredom. Described as a 'group therapy' class and given the name Canine Neurobics the course was essentially a version of brain games for dogs using tasks that targeted a different sense each week to provide calm, focus, and the opportunity for new learning.

The course is broken down into 5 weekly, one hour long classes. Each week different learning and cognition tasks were introduced that were divided into sense specific learning categories.
Week one: tactile learning, week two: visual learning, week three: olfactory and auditory learning, week four: gustatory (taste) learning, and week five: cognitive learning.

The course was run for 3 years with multiple groups of dogs and owners. Owners reported anecdotally that anxious dogs grew more confident, hyper-aroused and impulsive dogs grew more focused, and hyper-active or bored dogs settled and rested well after classes. Owners reported improved relationships with their dogs. While the actual effect of the brain function of the participants can't be objectively measured the classes are a fascinating idea that go beyond the simple learning of new behaviours to involve and target specific senses and areas of the brain. Essentially it's brain-training for dogs!

"It's never easy. The trick is to make it look easy."

Exercise and the aging brain

Snigdha S., De Rivera C., Milgram N.W., & Cotman C.W.* Exercise enhances memory consolidation in the aging brain. *Frontiers in Aging Neuroscience, 6, 3. (2014).

Previous studies using the canine model of aging show that there is a significant improvement in cognitive ability in dogs housed in a cognitive and exercise enriched environment. This study sought to further the investigation into the relationship between acute posting-learning exercise and it's possible role in memory consolidation in aging dogs.

Methods

Eight male and fourteen female beagles aged 10 to 11 years with similar training histories and experience with cognitive training were selected for the two year study and cleared prior to participation of any visual, auditory, or motor impairment. Since memory consolidation is thought to involve the hippocampus early on in the process, and then task-relevant cortical areas later in the consolidation process the animals were tested both immediately following the post-training exercise session, 1 hour following the session, and again 24 hours after the exercise. To specify where in the brain that exercise was having an effect on memory consolidation tasks were broken down into brain area specific tasks.

Object location memory (OLM) and novel object recognition (NOR) tasks were used to test the effects on the medial temporal lobe (hippocampus, perirhinal, entorhinal, and parahippcampal cortices, all particularly susceptible to aging). A reversal learning task targeted the frontal lobe to test for loss of inhibitory control as affected by aging. All animals were taught to run on a treadmill and were then divided into an exercise group, who would run on the treadmill following the training session for 10 minutes, while control group dogs were placed in a small crate for 10 minutes of reinforced inactivity.

The concurrent discrimination task was tested immediately after the exercise/rest, the OLM and NOR tasks were tested both one hour and 24 hours after the exercise/rest session.

Results

Statistical analysis of the collected data reveals that a single session of post-learning exercise improves memory performance in a medial temporal lobe dependent task (Concurrent discrimination), and notably the performance is significantly improved at the 24 hour post exercise mark and therefore has a positive effect on memory consolidation. The OLM task showed measurable improvements only after the 24 hour period. In contrast the NOR task did not show improvement in either group. (It is interesting to note that the NOR task is not dependent on the hippocampus as it does not involve spatial learning, while the other tasks did. Several factors might account for the lack of results here i.e. the perirhinal cortex may not be greatly affected by aging, or a ceiling effect in the groups might be present).

The improvements noted only at the 24 hour period suggest that exercises did not have an effect on learning a task (which would have shown in the immediate and the 1 hour post exercise testing) but rather an effect on consolidation of memory, specifically in hippocampal dependent learning.

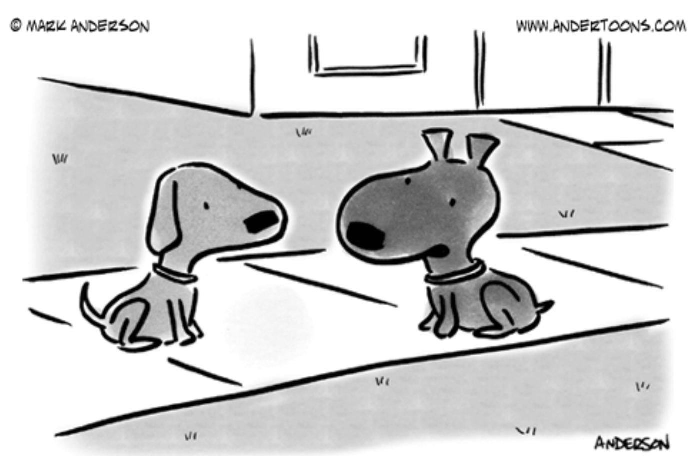
Further results also showed that exercise has a lasting effect, showing task improvement for as long as 48-72 hours after the last exercise session, supporting the idea that increased physical activity has a cognitive benefit and that the improvement is not in task acquisition but in the consolidation and retrieval of task specific memory.

The results on the frontal lobe specific task, that required the dog to inhibit a previously learned behaviour due to a change in criteria showed that while initial learning of the criteria was not affected by the exercise, the exercise group did show significant improvement in learning the inhibition of the previously learned behaviour. In short, the exercise did not affect the learning portion of the first part of the task, but the cognitive flexibility to unlearn, break the habit, and inhibit the learned response.

In all cases the improvements occurred whether the exercise was chronic or acute.

Lifestyle Interventions

Snigdha S., Astarita G., Piomelli D., & Cotman C.W.* Effects of diet & behavioural enrichment on free fatty acids in the aged canine brain. *Neuroscience, 202 (2012) pp. 326-333.



"I'm at the age where not only can I not learn new tricks, I can't even remember my old ones."

Recent studies suggest a relationship between brain lipid abnormalities and mechanisms of aging in the brain (including Alzheimer's disease) by affecting the cellular structure of membranes and protein-membrane interaction. Lipids also serve a role in cell to cell signalling and communication. Increased levels of stearoyl-CoA desaturase (SCD) and in free fatty acids have been associated with cognitive deficits due to aging and Alzheimer's disease.

Objective

The researchers had previously established a relationship between cognitive improvements from the provision of an enriched environment and an enriched diet. The goal of this study was to further investigate the relationship between lipid changes and levels, and cognitive function.

Method

12 male and 12 female beagles aged 8-12 years were selected for the study and received baseline cognitive function testing. Animals were ranked in order of cognitive ability and based on that ranking were divided into four groups containing dogs of all skill levels. C/C - control environment/control diet. E/A - enriched environment/antioxidant diet, C/A - control environment/antioxidant diet, and C/E - control diet/enriched environment. The enriched environment consisted of social housing (pairs), weekly exercise (two 20 minute outdoor walks per week), continuous cognitive testing. The antioxidant diet was identical to the control diet save the inclusion of a broad based antioxidant and mitochondrial cofactor supplement. Omega 3 fatty acid supplementation was excluded from both diet groups.

Animals were evaluated yearly for cognitive changes, and were sacrificed short of the two year mark at the age range of 12-15 years. Theirs brains were dissected and appropriately prepared or stored for study. Frontal cortical samples from the right hemisphere were used for lipid analysis and fatty acids were extracted and quantified. The results of the cognitive tests that specifically recruit use of the frontal lobe were used as the measure of cognitive function.

Results

Dietary supplementation, an enriched environment, and the combination of the two factors improved cognitive function of subjects in comparison to the control group.
Examination of the lipid samples from the brain tissue indicate a reduction in palmitoleic acid and nervonic acids in the dietary intervention groups as compared to the control group and the C/E group, indicating a decrease in SCD. An inflammation marker, arachindonic acid, was also significantly decreased in the C/A group (but not in the combined group). Alone, environmental enrichment had no significant effect on the free fatty acid levels in the frontal cortex.

The results show that levels of detrimental free fatty acids in the brain, associated with cognitive decline, can be decreased by dietary supplementation and the resulting reduction in SCD activity.

Snigdha S., Berchtold N., AStarita G., Saing T., Piomelli D., & Cotman C.W.* Dietary and Behavioural Interventions Protect against Age Related Activation of Capase Cascades in the Canine Brain. *PLoS ONE, 6(9), e24652 (2011).

Objectives

To further investigate the mechanisms of age related cognitive decline and the effects of lifestyle (diet and environment) on those mechanisms the researchers. This study specifically searched of a reduction in of caspase-3 and ceramide accumulation, which has been linked to synaptic dysfunction in mouse models of Alzheimer's Disease.

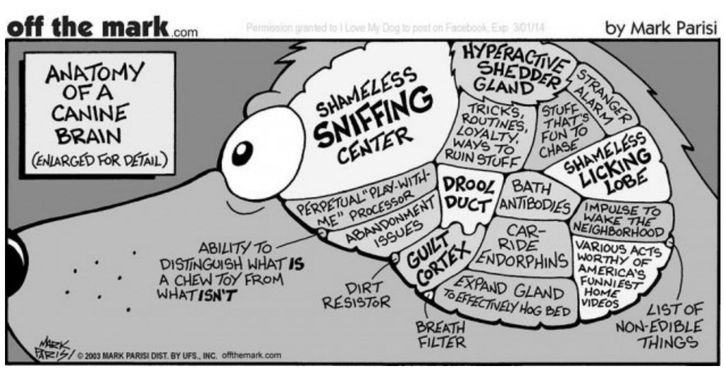
Method

Using the same subjects and brain tissue samples from the previous study caspase-3 activation in the frontal cortex was measured by counting cells with an antibody specific to the activation of caspase-3. Comparisons in number of caspase activated cells were made across the four test groups, and were also correlated with the individual animal, and their performance on the cognitive tasks. Likewise, the levels of several species of ceramides were also measured.

Results

The three intervention groups, as compared to the control group, all showed significantly fewer cells with activated caspase-3. Of the our groups, the combination group (dietary and environmental intervention) had the most significantly reduced caspase-3 activation (an 80% difference from the control group). Caspase-3 activation also correlated with cognitive function, whereas cognitive scores were highest in the animals with the fewest caspase-3 activated cells. This suggested that the interventions were successful in reducing cognitive decline by reducing caspase-3 activation. Since caspase-3 is activated by caspase-8 and -9, these were also counted, and while there was no significant decrease in caspase-8, there was a decrease observed in the presence of caspase-9, which may contribute to the downstream reduction in caspase-3 as a result of the interventions. Caspase-9 was reduced the least in the environmental enrichment only group. However, when ceramides were measured, the reduction in ceramides was noted only in the environmental enrichment only group.

The results reveal that lifestyle interventions that include diet and environmental enrichment have an effect on a range of molecular mechanisms in the brain, and decreases caspase-3 and ceramide can now be added to those ranks.



TAKE AWAY THOUGHTS:

Are you just as 'geeked-out' as I am about these studies? Maybe I'm the lone nerd!! My take home thoughts are below:

1) Light, fun exercise AFTER a learning even will help to retain new knowledge and accelerate the time to learn new tasks.
2) Exercise BEFORE learning (even 24 - 48 hours beforehand) will help memory and changes in behaviour related to learning.
3) Diet (high in antioxidants), a stimulating environment that included regular exercise will reduce brain deterioration. (Note that both are needed for best results.)

So, as rehab practitioners we should be the leaders in advocating for healthy lifestyle habits and choices. We should be the exercise-experts! We should also be reliable, reputable, and the 'go to' people for knowledge translation (i.e. digesting research and reporting out to the masses in a user friendly format). And hopefully FourLeg News helps you to do just that!

Feel free to leave this newsletter on the table in the staff room. Share it with others who will find it interesting, useful, and informative.

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