Predicting Single-Ion Exposure in Rodents through Performance Tests: A Data-Driven Approach using Support Vector Machines

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Galactic cosmic radiation is considered an inherent risk for human missions traveling beyond the magnetosphere environing Earth. Each year, an astronaut on a planned mission to Mars is likely to be exposed to approximately 13 cGy of galactic cosmic radiation.[1] Prior research conducted on rodents has suggested that exposure to approximately 25 cGy of various highly energetic charged ions (^{16}O, ^{28}Si, ^{48}Ti, ^{4}He, ^{56}Fe) could have concomitant effects on cognitive performance for rodents.[1] The attentional set-shifting (ATSET) test is designed to quantify the cognitive performance of a rodent through the use of a food reward and a series of seven tests which roughly correspond to different regions of the brain. The rodents were evaluated by Britten et al. using single beam ion exposure (^{16}O, ^{28}Si, ^{48}Ti, ^{4}He, ^{56}Fe) with dosages varying between 0, 1, 3, 5, 10, and 15 cGy.
The objective of the conducted research was to infer the effect of dose and ion on rodent performance and develop a means—by building a machine learning classifier—to accurately predict the irradiation dosages received based on performance outcomes from the tests. Demonstration of such results would, inter alia, establish a correlation between received irradiation in rodents and performance outcomes, and subsequent research could utilize these findings to inform us on the concomitant performance effects of ionizing radiation for astronauts in deep space exposed to these ions. This study presents an analysis of the experimental results based on a support vector machine (SVM) analysis. In contrast to probabilistic classifiers, SVM algorithms employ a geometric approach which can offer various insights into the way the data is dispersed and thus potentially provide clues to the correlations of effects on different parts of the brain. Our findings show that the SVM classifier can effectively predict the dosages of iron and titanium from the performance decrements. These positive results were obtained regardless of the kernel, labeling criterion, or dimensionality (2-D or 7-D) of the feature space used. Silicon, helium, and oxygen ions were inconclusive in the binary classification setting in that there was a large class imbalance which led the classifier to a majority vote. More data for testing and cross validation is essential for both model training and validation purposes.

The findings presented here suggest there is indeed a means of capturing the correlation between cognitive performance effects of ionizing radiation and the dosage using an SVM classifier. Subsequent research will further focus on validation and analyzing the effects of ion type and exposure to their combinations on performance.

[1] J.S. Jewel et al. Exposure to <15 cGy of 600 MeV/n 56Fe Particles Impairs Rule Acquisition but not Long-Term Memory in the Attentional Set-Shifting Assay (2018). *Radiation Research* 190(1), 565-575.