The modeling of state-dependent memory with artificial intelligence approaches

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Introduction: State-dependent memory (SDM) is the term that explains recalling particular information occurs most accurately when a subject (humans or animals) is in the same physiological state of consciousness as it was at the time of memory formation. The present study was defined to construct an accurate model that predicts memory formation under drug abuse. The model assists scientists in the field to appraise their new hypotheses and inspire for further experiment-design without neither animal usage nor colossal amount of time and money consumption.

Methods: The primary dataset for the present modeling was generated by combining the data extracted from five pieces of our previous researches (published in neuroscience journals) that elucidated the influences of various states of consciousness in memory retrieval. Throughout these studies, multiple drugs including morphine, nicotine, MDMA, ethanol, mecamylamine, S-WAY100135 (an 5-HT1A receptor antagonist), ACPA/AM251 (cannabinoid CB1 receptor agonist/antagonist), WIN 55,212-2 (a cannabinoid CB1/CB2 receptor agonist) and dextromethorphan were injected into the different brain sites during post-training and/or pre-test phases of passive avoidance learning task to measure memory consolidation or retrieval in male Wistar rats. Each row in the data-set represented a single experiment on an animal that a combination of drugs with specific doses was administered via systemic or intracerebral injections. The last column of each row was the latency of the passive avoidance task in the range of 0 - 300 seconds to assess memory retrieval based on injections' combination. Trials were randomly split into train-set and test-set with a portion of 0.8-0.2; correspondingly, the models were fed with the train-set. Various machine-learning algorithms, including Linear Regression, Support-Vector Machine, Decision Tree, Random Forrest, K Nearest Neighbor, and Neural Networks were applied to establish the most accurate model to predict the latency of the passive avoidance task. The hyper-parameters of every utilized algorithm were tuned by using grid-search functions and illustrative plots.

Result: The best performance of a model was observed in a compound voting model that returned the mean value of latency output from "Support-Vector," "Decision Tree," "Random Forrest," and "K-Nearest Neighbor" regressors. The voting model attained the R2 score of 0.803 on the train-set and 0.781 on the test-set. Moreover, the model reached the Root-Mean-Squared-Error of 49.36 on the train-set and 55.39 on the test-set for predicting the latency of passive-avoidance learning task.

Conclusion: Since the latency numbers can be inferred as a binary conclusion of amnesia or solid memory, and by assuming that latency of 150 seconds or less is referring to amnesia, the model has an accuracy of 93% in predicting amnesia or memory based on injections' doses. Even though the data-set included diverse states of consciousness, additional data from other related articles can lead the model to an even more complex model that appreciates the interactions between added states more precisely to assist scientists multifacetedly.

Keywords: Memory formation, Cognitive neuroscience modeling, Artificial intelligence, Machine learning