MSc Computational Cognitive Neuroscience

Advanced Quantitative Methods

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Coursework 1

Coding Assignment: Data Extraction and Statistical Analysis with Bayes Factors

The dataset contains the sequence performance tempo, measured by the mean inter-key interval (mIKI) for three groups of participants: older healthy adults (group 0), young healthy adults (group 1), and Parkinson's disease patients (group 2). The goal is to determine whether there are group effects on performance tempo during sequence learning.

The data was loaded into a pandas data frame using Python, and histograms were visualized to examine the distribution of performance tempo for each group in a Jupyter notebook. Next, a one-way ANOVA was performed in MATLAB to investigate whether there are group effects on performance tempo during sequence learning. Bayes factor analysis was also conducted to evaluate the evidence for the alternative hypothesis against the null hypothesis. To further explore the group differences, a post hoc test was carried out in MATLAB to determine which groups differed significantly from each other. The results of the analysis can be found in the source file AQM1.m.

Plots

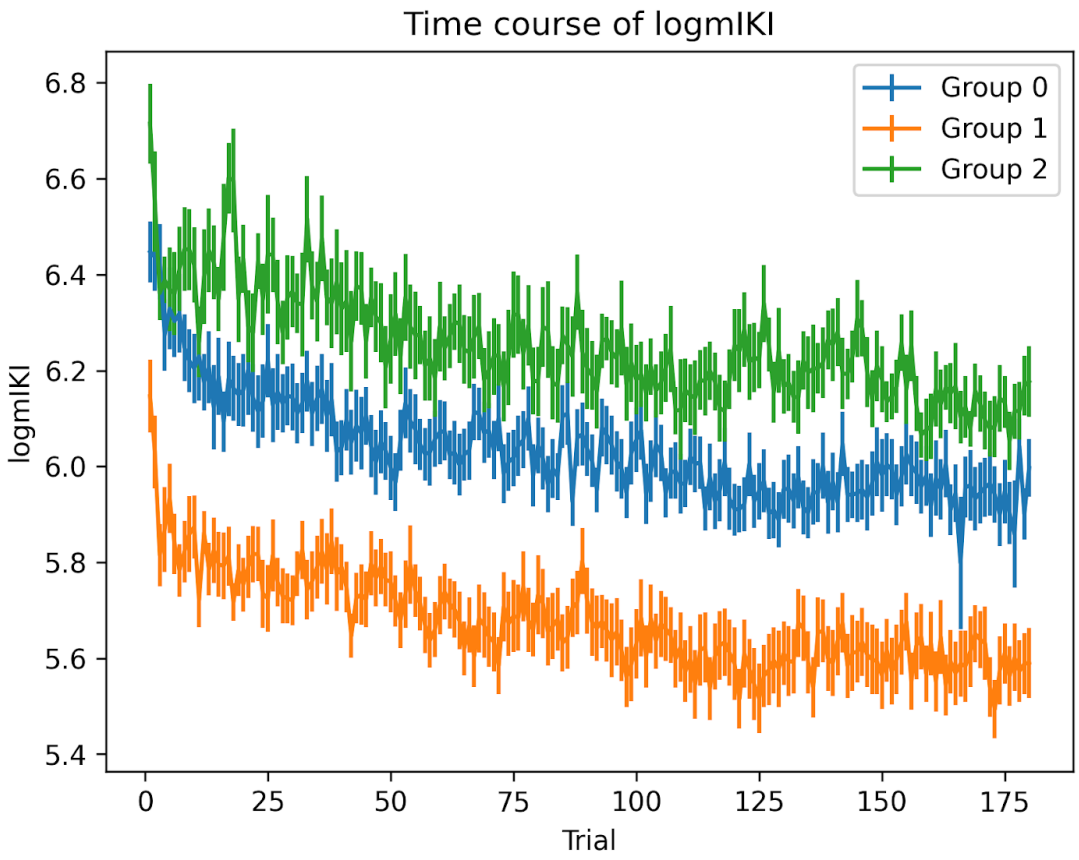

Figure 1: Trial-wise motor performance tempo in three different groups.

This figure shows the trial-wise mean log-transformed inter-keystroke-interval (logmIKI) for each of the three groups separately. The error bars represent the standard error of the mean (SEM) for each group.

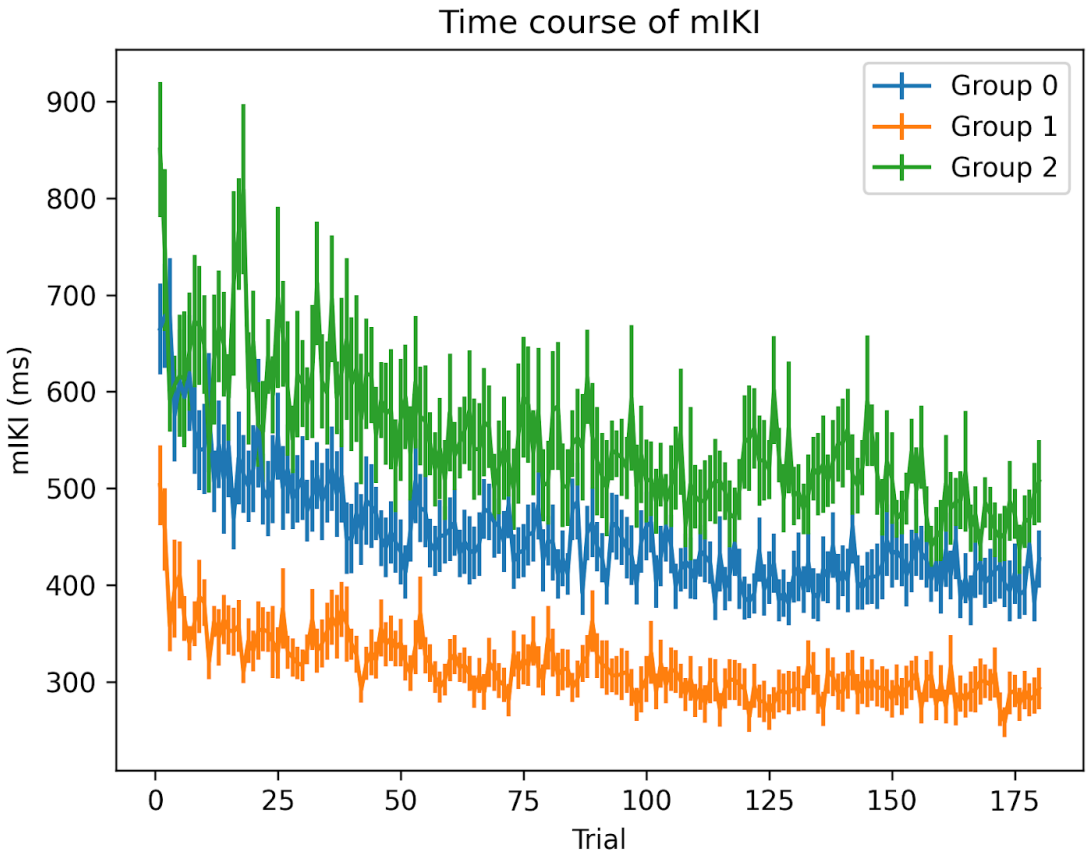

Figure 2: Trial-wise motor performance tempo in three different groups (mIKI scale)
This figure shows the trial-wise mean inter-keystroke-interval (mIKI) in milliseconds for each of the three groups separately. The error bars represent the standard error of the mean (SEM) for each group. The mIKI values were obtained by exponentiating the logmIKI data.

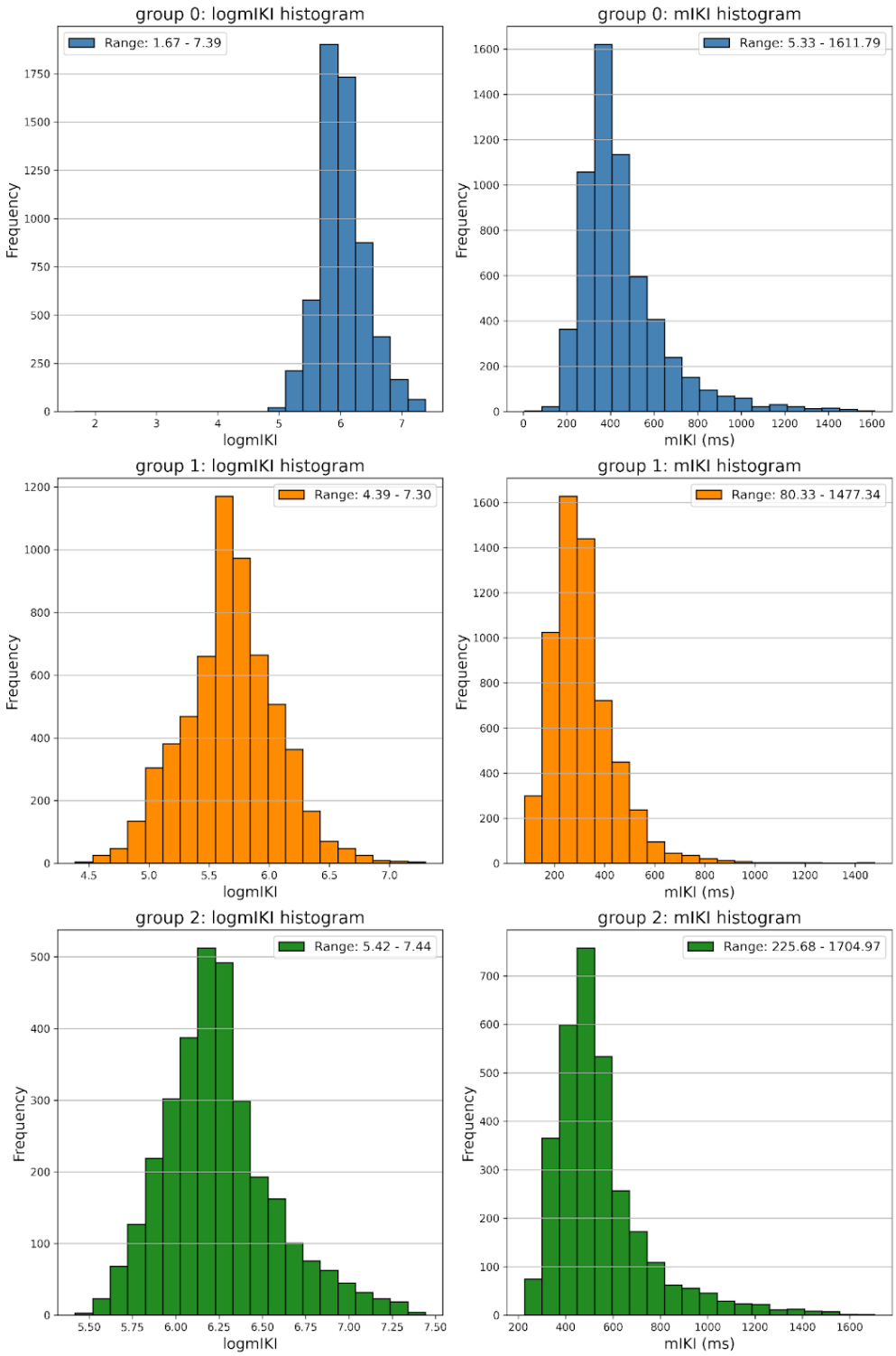

Figure 3: Histograms of logmIKI (left) and mIKI (right).

Histograms of logmIKI (left) and mIKI (right) data for each group separately. Each bar represents the frequency of logmIKI or mIKI values in the given bin.

Choice of mIKI or logmIKI

Logarithmic transformation of the inter-key interval (IKI) is commonly used in studies that investigate motor sequence learning, such as Marshall et al. (2016) and Sporn et al. (2020). For this study, logmIKI was used for BF analysis as it can normalize response time data, reduce the influence of outliers, and facilitate the interpretation of the effects of predictor variables on response times.

Results

The ANOVA test revealed a significant main effect of the group on performance tempo ($F(2, 89) = 33.528$, $p < .001$), indicating that there were notable differences in the mean logmIKI scores among the three groups. To further evaluate these differences and similarities, post-hoc pairwise independent sample t-tests were conducted to identify which specific groups are significantly different from each other.

The Bayes factor analysis provided strong evidence for the alternative hypothesis (i.e., group differences) over the null hypothesis (BF = 3.8262e+08). Additionally, the t-tests revealed that there was strong evidence for the difference between group 0 and 1 (BF = 1.0563e+04, p = 2.0000e+00), moderate evidence for the difference between group 0 and 2 (BF = 1.5586e+01, p = 2.2919e-03), and strong evidence for the difference between group 1 and 2 (BF = 1.0668e+07, p = 6.8471e-10).

Discussion

The results demonstrate that the performance tempo during sequence learning differed significantly among the three groups. Specifically, the healthy young (group 1) exhibited significantly faster performance tempo than the healthy old (group 0) and Parkinson’s disease patients (group 2). The Bayes factor analysis provided strong evidence for the existence of group differences, and the post-hoc analyses further revealed specific group differences. These findings suggest that age and neurological disorders such as Parkinson's disease may affect the learning of novel motor sequences, as performance tempo during sequence learning was impaired in older adults and Parkinson’s disease patients compared to young adults.

References

1. Marshall, L., Mathys, C., Ruge, D., de Berker, A. O., Dayan, P., Stephan, K. E., & Bestmann, S. (2016). Pharmacological fingerprints of contextual uncertainty. *PLOS Biology*, *14*(11). https://doi.org/10.1371/journal.pbio.1002575
2. Sporn, S., Hein, T., & Herrojo Ruiz, M. (2020). Alterations in the amplitude and burst rate of beta oscillations impair reward-dependent motor learning in anxiety. *ELife*, *9*. https://doi.org/10.7554/elife.50654