LETTER TO THE EDITOR

Visual Analog Scale for easy detection of at-the-moment subjective fatigue in implementation of Tetris gameplay in a neurorehabilitation program

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Dear Editors,

We previously recommended maintaining mood states, especially fatigue, as constantly as possible if neurorehabilitation training is conducted using functional near-infrared spectroscopy with Tetris gameplay (Nakahachi, 2021).

The study focused on mood states in general, and fatigue was measured using one subscale of the *Profile of Mood States* (POMS). Subjects responded to several items by recalling their condition in the previous week (Yokoyama, 1990). Measuring fatigue with POMS was deemed to be unsuitable in actual rehabilitation training because it is necessary to have patients intuitively record at-the-moment fatigue within a short time and with minimum burden (while allowing the therapist to observe changes in fatigue before/after training).

This time we instead measured fatigue using a visual analog scale (VAS), hypothesizing that such measurement (FV) is not inferior to fatigue measurement by POMS (FP). The study subjects were 22 of the 24 healthy subjects previously reported (Nakahachi 2021), who also indicated their fatigue by VAS after Tetris gameplay. The VAS was a 100 mm straight line with the left extremity labelled as 'no fatigue' (zero) and the right extremity as 'the highest degree of fatigue experienced' (100%).

We first calculated the Pearson correlation coefficient between FP and FV. Next, we calculated the Pearson correlation coefficient between LINE (the number of the deleted lines, a goal during Tetris gameplay) and activation (mean values of relative changes in oxygenated hemoglobin concentration during Tetris gameplay) (R), the partial correlation coefficient between LINE and activation controlling for FP (FP-PR), and the partial correlation coefficient between LINE and activation controlling for FV (FV-PR) for each of the 52 measurement points (channels). R, FP-PR, and FV-PR were compared using repeated-measures one-way ANOVA followed by Bonferroni correction.

FP and FV had significant correlation (r = 0.527, p = 0.012), consistent with a study that showed significant correlations between FV and FP in healthy subjects and patients with sleep disorders (Lee, 1991). Channels with significant R, FP-PR, and FV-PR were not detected using significant α levels of 0.05 corrected by the false discovery rate to control for multiple comparisons. Only when analyzing FV-PR, five channels with $p < 0.05$ appeared, four of which were distributed around the areas centered on the right dorsolateral prefrontal cortex (Brodmann area 46) (Figure 1; Nakahachi 2020 shows the positional relationship of channels). These four channels were identical to those estimated to show greater activation in high performers than in low performers of Tetris gameplay (Nakahachi, 2020). Repeated-measures one-way ANOVA for R, FP-PR, and FV-PR showed significant differences with Greenhouse-Geisser correction at $p < 0.05$ (F = 50.814, p =1.928E-09). According to Bonferroni's correction, all combinations had significant differences (mean ± standard deviation of R, FP-PR, and FV-PR: 0.058 ± 0.141, 0.112 ± 0.137, and 0.182 ± 0.168, respectively).

Controlling FV is suggested to be a valid alternative to FP for the partial correlation between LINE and activation. Controlling FV typically had increased partial correlation coefficients compared with FP. When measuring fatigue during Tetris gameplay, FV may be more sensitive than FP as a subjective measurement of fatigue.

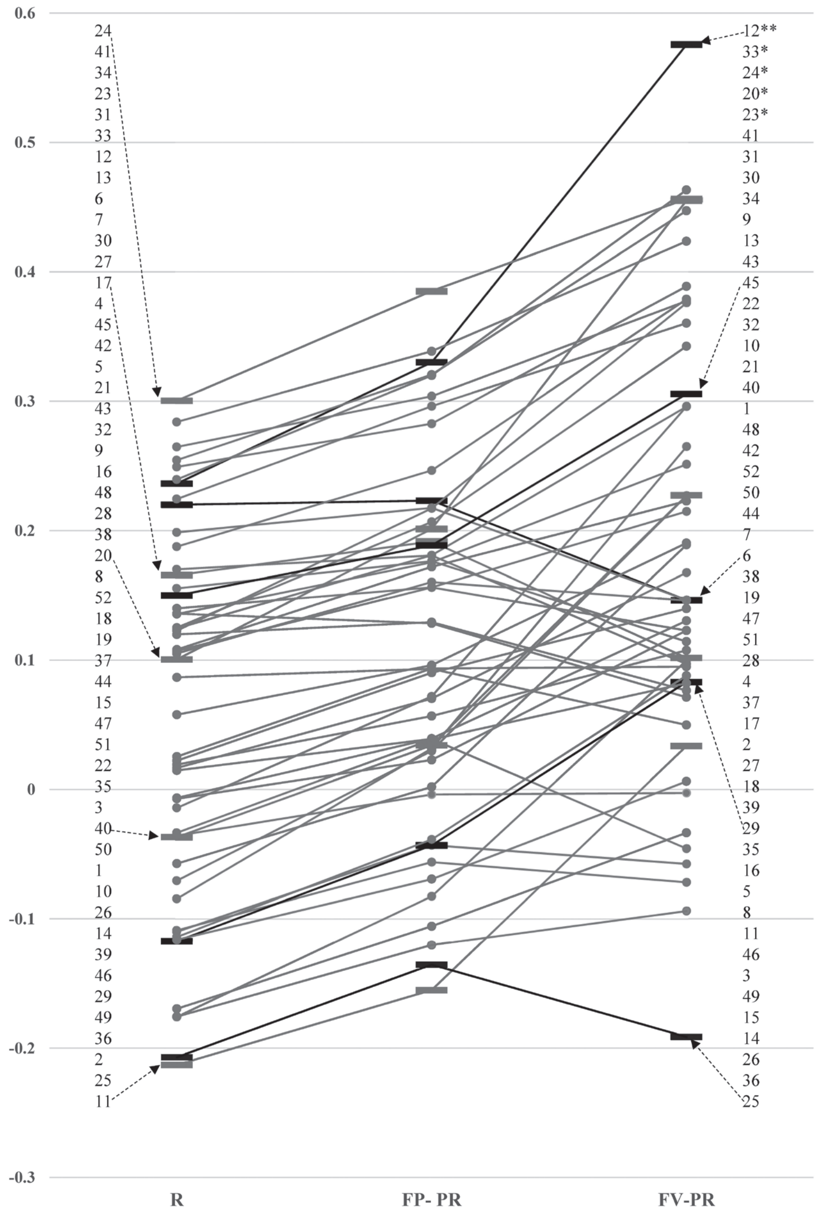

Figure 1. Pearson correlation coefficients between LINE (the number of the deleted lines) and activation (mean values of relative changes in oxygenated hemoglobin concentration) during Tetris gameplay and the two types of partial correlation coefficients controlling for fatigue.
Each line graph represents a single channel. The vertical axis denotes the (partial) correlation coefficients. The numbers on the far right represent the channel numbers arranged in descending order of FV-PR. For reference, the numbers on the far left represent the channel numbers arranged in descending order of R. Correspondences between channel numbers and line graphs are shown by arrows to bar markers added to five graphs of every 13 channels for R or FV-PR (for FV-PR, the five line graphs are shown in black).
R, Pearson correlation coefficient between LINE and activation; FP-PR, Partial correlation coefficient between LINE and activation controlling for fatigue measured using POMS; FV-PR, Partial correlation coefficient between LINE and activation controlling for fatigue measured using visual analog scale
**, A channel showing correlation coefficient between LINE and activation at $p < 0.01$; *, A channel showing correlation coefficient between LINE and activation at $p < 0.05$.

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