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Control/Tracking Number: 2024-S-3962-SfN
Activity: Scientific Abstract
Current Date/Time: 5/6/2024 1:39:26 PM

Reliability testing of EEG spectral features in a robot-based arm movement task

AUTHOR BLOCK: *S. RUEDA-PARRA[1], R. L. HARDESTY, Jr.[1], D. GEMOETS[2], J. HILL[1,3], D. GUPTA[1,3];
[1]Natl. Ctr. for Adaptive Neurotechnologies (NCAN), Albany, NY; [2]Res., Stratton Veterans Affairs Med. Ctr., Albany, NY; [3]Electrical and Computer Engin., Univ. at Albany, Albany, NY

Abstract:
Introduction
We test the intersession reliability of kinematic and EEG low-beta (Lβ, 12 - 20 Hz) power features in a center-out motor task performed with the inMotion Arm rehabilitation robot from Bionik labs. Integrating EEG data collection with robotic tasks aims to reduce trial and session movement variability, and to obtain precise movement onset markers. We hypothesize that this setup would help reduce intersession variability and increase reliability, for potential use of these features in longitudinal assessments.
Methods
Ten right-handed healthy individuals used the Bionik robot in two sessions (on average 40 days apart) to perform planar movements within a predefined workspace. Targets were situated 10 cm from the center at 4 cardinal positions. Movement and targets were displayed on a screen. Movement was initiated upon visual cue and target position maintained till subsequent cue. Targets were presented randomly. Each arm performed a block of 80 movements, with randomized block order. Session two kept individual block order. Study was IRB approved (1584762); informed consent was obtained.
EEG data (DSI-24, Wearable Sensing) were collected at 300 Hz with BCI2000, referenced to linked earlobes, and synchronized with Bionik's positional data. Movement onsets were detected using inertial kinematic data with (Xsens, Movella). Lβ power was analyzed for epochs of 0 to 200 ms post-movement onset; expressed as a percentage change from trial baseline. Power distributions of this feature at contralateral hand motor regions (C3 and C4) were computed. Kinematic features (mean speed and movement duration) were gathered from the robot.
Inter session distribution differences were evaluated at individual (Lβ) and group levels (kinematics and Lβ). Wilcoxon rank sum test was used for intra-individual comparisons, and Wilcoxon signed rank for paired group comparisons. The group feature was the median Lβ power. Intersession agreement was quantified with the Inter-Class Correlation (ICC) coefficient.
Results
Lβ power in contralateral motor regions show expected desynchronization. Group analysis shows excellent agreement between sessions for right-arm (ICC: Lβ = 0.92, Speed = 0.86, Duration = 0.71), and left-arm (ICC: Lβ = 0.90, Speed = 0.86, Duration = 0.83) movements. Individual and group differences were not significant for both left- and right-hand movements, supporting group intersession agreement.
Conclusion
This study demonstrates a setup with robust EEG and kinematic features across sessions in healthy individuals, providing some assurance of its reliability for use in longitudinal assessments. We aim to test this on a larger cohort.

Author Disclosure Information:

S. Rueda-Parra: None. **R.L. Hardesty:** None. **D. Gemoets:** None. **J. Hill:** None. **D. Gupta:** None.
Presentation Preference (Complete): Poster Only
Linking Group Selection (Complete): None selected
Theme and Topic (Complete): E.04.i. Cortical planning and execution – Neurophysiology – Human ; E.04.e. Reaching control – Motor learning – Human neurophysiology
Linking Group and Nano Info (Complete):
Keyword (Complete): EEG ; BETA ; Robot
Support (Complete):
Support: Yes
Grant/Other Support: : NIH Grant P41 EB018783 (Wolpaw)
Grant/Other Support: : NYS Spinal Cord Injury Research Board C37714GG (Gupta)
Grant/Other Support: : NYS Spinal Cord Injury Research Board C38338GG (Wolpaw)
Grant/Other Support: : Stratton Veterans Affairs Medical Center

Special Requests (Complete):
How do you plan to participate in Neuroscience 2024?: In-Person Only
At this time, is your author block complete?
Note that you will have a chance to edit your author block through the editing deadline and again in July.: No
Religious Conflict?: No Religious Conflict
Additional Conflict?: No
Is the presenting author of this abstract a high school or undergraduate student?: None
Select: Human

Status: Finalized