ISETC2025

UNIVERSITI TEKNOLOGI MARA

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2 ND INTERNATIONAL SCIENCE, ENGINEERING AND TECHNOLOGY COLLOQUIUM

THE POWER OF SCIENTIFIC INNOVATION

INTELLIGENT SOLUTIONS FOR A SUSTAINABLE WORLD

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PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob
Dr. Saiyidah Nafisah Hashim
Ms. Lili Widarti Zainuddin
Ms. Nurul Nazwa Mohammad
Ms. Rozaina Saleh

ISETC 2025 Proceedings Editors

DOMINANT FREQUENCY BAND PATTERNS ANALYSIS OF A SINGLE-CHANNEL ELECTROENCEPHALOGRAM (EEG) IN MULTISENSORY MOTOR IMAGERY TASKS

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Abstract: This study analyses how the brain responds during motor imagery (MI) in a multisensory setting using a single- channel electroencephalogram (EEG). This is a part of early research toward brain-computer interface (BCI) development. The MI tasks involved four types of hand movements, each representing movement instructions to the right (RI), left (LI), forward (FI) and backward (BI). EEG signals were collected from eight healthy participants with ages ranging from 20 to 22 years (mean age= 20.94 ± 0.873) using the EMOTIV Insight 2.0 headset. For this study, only the AF3 channel positioned over the prefrontal cortex was selected for further analysis as a single-channel EEG configuration. The MI tasks are commonly associated with changes in brain activity within the alpha (8-12 Hz) and beta (13-30 Hz) bands, particularly over sensorimotor areas. The results show the variation in dominant frequency band for each stimulus, providing valuable insights into the variation brain activity in the multisensory setting. The power spectral density (PSD) demonstrates the dominant frequency for the signal of AF3 is mainly within the alpha and beta bands as commonly applied in MI-BCI. However, theta (4-8 Hz) activity emerged as the dominant frequency band in specific tasks and stimulus such as RI and BI with the stimulus of the sound of rain. This could mean that MI requires additional efforts in certain circumstances. The presence of the theta band for MI is beneficial to ensure that relevant information is not excluded for further analysis.

Keywords**:** *Motor imagery, dominant frequency, brain-computer interface (BCI), and EEG*

INTRODUCTION

Motor Imagery (MI) enables people to imagine physical movement in the mind without performing an action (Collinger et al., 2013). Specific areas of the brain could be activated, particularly those related to motor control. The brain's electrical signals are recorded by using electroencephalography (EEG). It is a non-invasive method that does not require any surgical as if the electrode is attached to the scalp. Previous research has shown that brainwaves in the alpha (8-13 Hz) and beta (13-30 Hz) ranges are active during MI tasks (Almeida et al., 2023; Ji et al., 2019). These frequency bands are linked with motor planning, attention, and readiness. In some cases, theta waves (4-8 Hz) also play a role, especially when the task requires more focus and effort (Van der Lubbe et al., 2021). In this study, dominant frequencies in the theta, alpha, and beta ranges are observed during MI tasks performed by healthy participants. Small number of EEG channels could degrade the performance of MI-BCI, and the focus is on the channel located over the motor cortex (Attallah et al., 2020; Yin et al., 2024). However, AF3 is used in this study as a single EEG channel placed on the forehead based on the finding of the previous work (Khare & Bajaj, 2020; Van Caenegem et al., 2024; Yassin et al., 2024). The area is free from hair and positioned slightly higher and farther from the eyes compared to Fp1. This may minimize the influence of eye blinks. A variety of sensory cues are introduced, including both visual and auditory stimuli to create a more engaging experience and possibly elevated cognitive activity during the task.

MATERIALS AND METHODS

Eighteen healthy participants were involved in this study, with ages ranging from 20 to 22 years (mean age= 20.94± 0.873). However, after inspection of the 3-second segments in each run, only eight healthy participants were considered for further analysis. This study was reviewed and approved by the USIM Research Ethics Committee (USIM/JKEP/2022-230). EEG data was recorded using EMOTIV Insight 2.0. However, only the AF3 channel was employed for further analysis as a single-channel EEG configuration. Each participant was asked to perform a series of motor imagery (MI) tasks within a specific paradigm. It involved imagining four different hand movements representing four different directions. The directions are to the right (RI), left (LI), forward (FI), and backward (BI). To vary the experience, participants were exposed to two types of sensory input for seven seconds instead of using the standard stimulus of MI (MI_BASE). They are sound of rain (A1) for auditory cues, and photo of hallway (V1) for visual cues. For the control condition, the first 3 seconds of each trial began with a fixation cross displayed in the center of the monitor, accompanied by a beeping sound at t=0 to prepare participants for the MI task. It is followed by visual cue of a red arrow to perform one of MI tasks for 4 seconds until the cross and arrow disappear. After each task, the participant rests for 6 seconds before performing the second trial. Either A1 or V1, the stimulus is applied at t=0 until t=7. For MI_BASE, A1, and V1, 20 trials for each were collected from each participant. The EEG signals were filtered to focus on the theta, alpha, and beta bands using the BrainVision Analyzer 2.0. The dominant frequency band, which is the one showing the strongest brain activity, was identified for each task and stimulus condition.

RESULTS AND DISCUSSION

Across all conditions, the dominant brainwave activity during MI tasks fell within the commonly reported 8-30 Hz range, which induces the alpha and beta frequencies. In control condition, most tasks show dominant alpha activity (RI, FI, and BI), reflecting a relaxed but alert state during MI as shown in Figure 1. The task of LI shows beta dominance, suggesting increased mental effort. For A1, the taks of RI and BI shifted to theta activity as shown in Figure 2, often related to deeper concentration to stay focus during the MI task. This aligned with the work of Van der Lubbe et al. (2021) whereby the frontal theta increased during MI. While the other two tasks remained in the alpha. Under visual stimulus, the beta activity became dominant in RI, LI, and FI as shown in Figure 3. It reflects higher MI engagement. There is only BI task showing the alpha activity. These results suggest that different sensory inputs can influence brainwave patterns during MI, potentially enhancing engagement to the MI tasks depending on the type of stimulus.

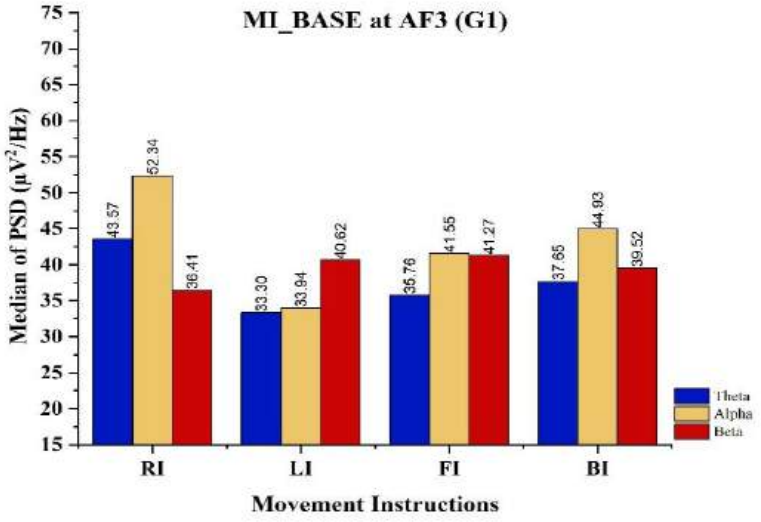

Figure 1. The median of PSD for control condition (MI_BASE)

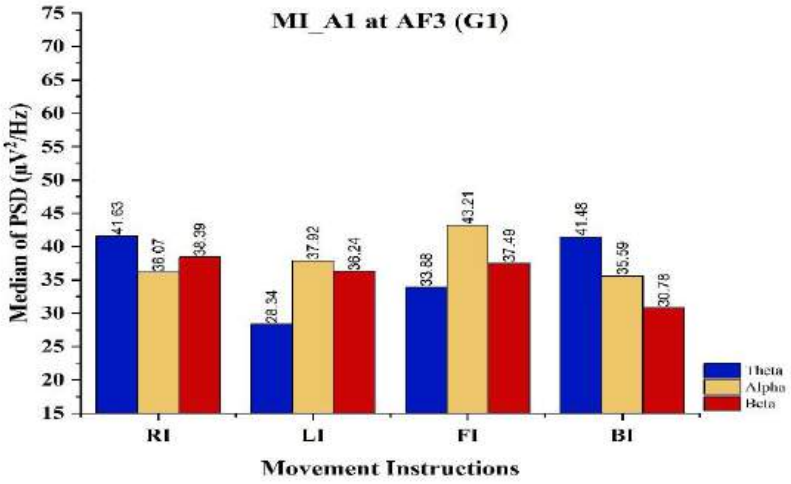

Figure 2. The median of PSD for A1

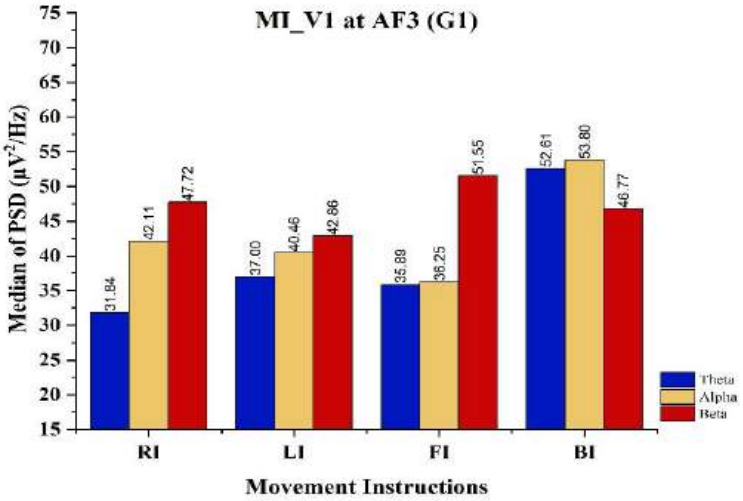

Figure 3. The median of PSD for V1

CONCLUSIONS

This study highlights the potential of using a single EEG channel to detect meaningful brainwave patterns during MI tasks across the group of healthy participants. The control condition was found to have the dominant frequency bands in the range normally applied for MI-BCI (alpha and beta band). By exploring the effects of different sensory inputs, it is found that both visual and auditory stimuli can shape how the brain responds in the frequency band of theta, alpha and beta (4 Hz to 30 Hz). These insights may help create a simpler, more accessible brain-computer interface (BCI) in the future.

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Kelulusan daripada pihak tuan dalam perkara ini amat dihargai.

Sekian, terima kasih.

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Setuju.

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Saya yang menjalankan amanah,

SITI BASRIYAH SHAIK BAHARUDIN
Timbalan Ketua Pustakawan

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