

Activation Response Profiles for Eccentric Rotating Mass Vibration Motors Used for Sensory Augmentation

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1. Introduction

- Decreased sensations of limb position and movement are experienced by ~50% of stroke survivors¹
- Sensory augmentation through supplemental vibrotactile feedback of limb movement has been explored to enhance closed-loop control of the arm²
- Eccentric rotating mass (ERM) vibration motors provide a low-cost approach to supplying continuous, graded feedback of limb position and movement for sensory augmentation

Aim
Compare stimulus response characteristics of two types of ERM vibration motors used in recent studies of sensory augmentation for real-time control of limb movement.

2. Methods

- Experimental Setup**
- A multi-axis load cell measured mechanical vibrations from ERM motors driven by a pulse-width modulated signal ranging from 0% to 100% activation
 - Motors (coin-style and pager-style) were tested 5 times each at 1000 Hz

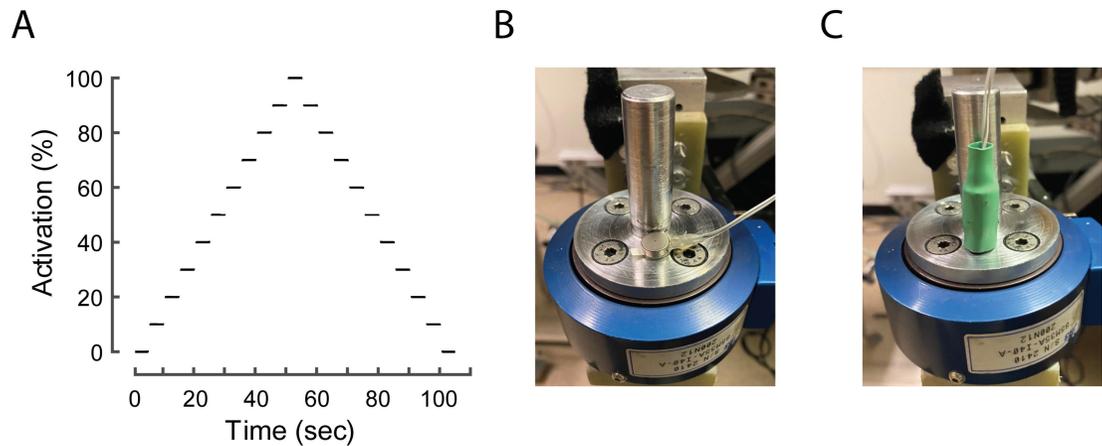


Figure 1: A) Ramp input to motors. B) Coin-style motor on load cell. C) Pager-style motor on load cell.

- Data Analysis**
- Data were notch-filtered at 60 Hz
 - A short-time Fourier transform was applied using a Hamming window (128 ms window; 50% overlap)
 - The across-trial mean peak power and its associated frequency were identified at each activation level for each motor

3. Results

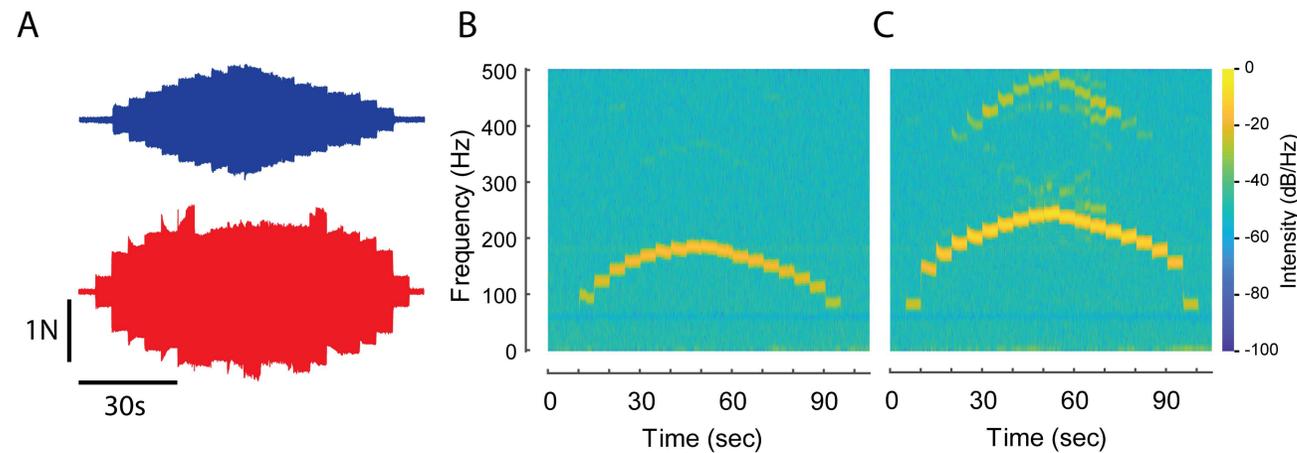


Figure 2: A) Raw x-force data from one coin-style trial (blue) and one pager-style trial (red) vibration motor. B) Spectrogram of total {x, y, z} force signal power for one coin-style motor trial. C) Spectrogram of total {x, y, z} force signal power for one pager-style motor trial.

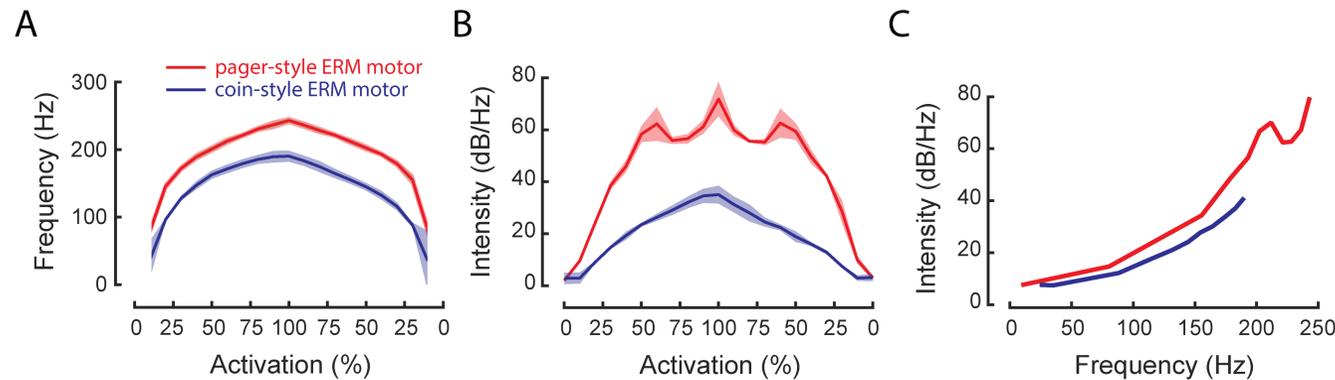


Figure 3: Activation characteristics of coin style (blue) and the pager-style (red) vibration motors averaged across trials. A) Vibration frequency vs. activation. B) Intensity vs. activation. C) Intensity vs. vibration frequency. Shading: mean \pm 1 SD.

4. Conclusions

- Both motors**
- Required ~20% activation to overcome initial stiction
 - Exhibited similarly-shaped vibration frequency – activation curves (Fig 3A)
- Coin-style motor**
- Linear activation response (Fig 3B, blue) may be preferred in applications providing graded supplemental vibrotactile feedback of movement
- Pager-style motor**
- Stronger intensity (Fig 3B, red) may be preferred by individuals with more significantly impaired tactile sensation
 - Non-monotonic amplitude-frequency characteristic (Fig 3C) might complicate the interpretation (cognitive decoding) of vibrotactile feedback

5. References

- Rand D. *PLOS ONE*. 2018.
- Risi N, et al. *Journal of Neurophysiology*. 2019.

6. Acknowledgements

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