Searching for Gait Markers of Cognitive-Motor Dual-task Interference using Machine Learning

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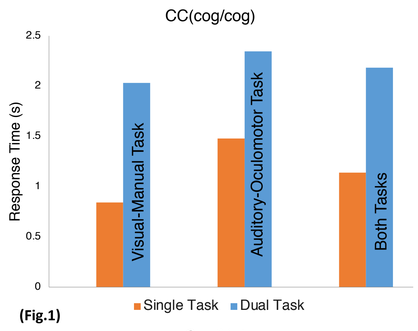
Introduction

Background

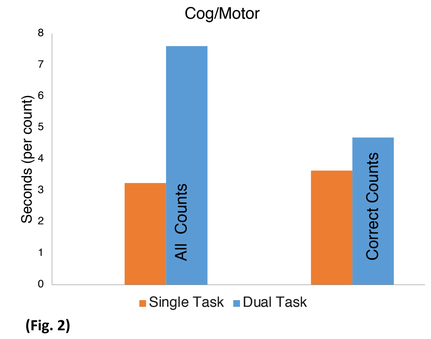
- Dual-tasking (DT) – performing two concurrent tasks – results in reduced performance compared to single-task performance
- DT has been separately investigated for:
  - concurrent cognitive tasks[1] (CC; Fig. 1)
  - cognitive task simultaneous with a motor task[2] (CM; Fig. 2)

Present Study

- Proof-of-principal for study linking CC and CM DT in at risk populations (e.g. elderly)
- This project focuses exclusively on CM
- Goal: to evaluate a potentially more sensitive measure of CM DT



(Fig.1)



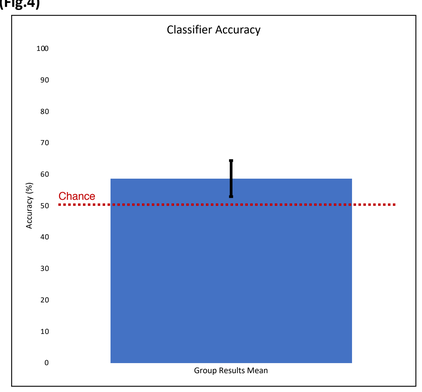
(Fig. 2)

Results

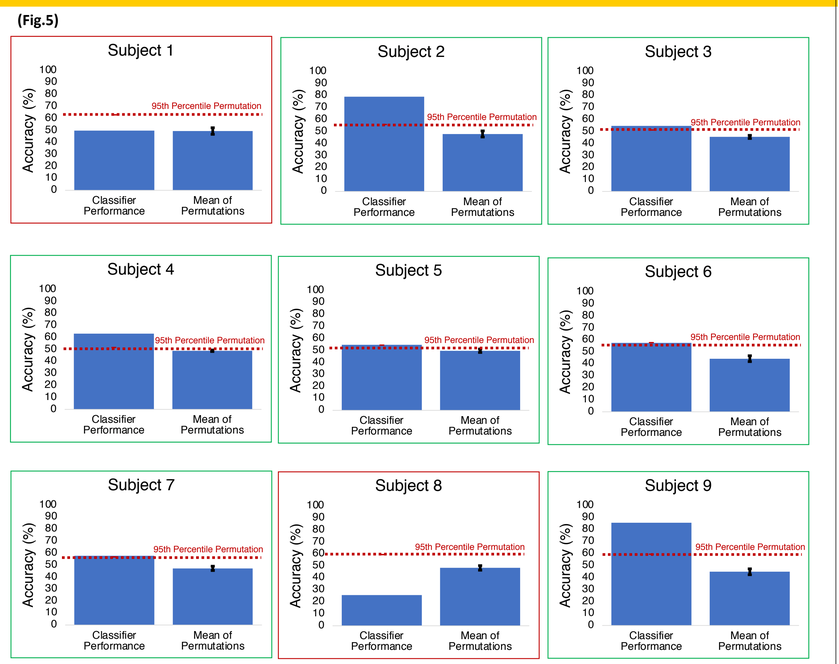
- Above-chance classification of ST vs CM DT walking
- t-test resulted in no statistical significance for group (Fig. 4)
- Permutation test showed 7 out of 9 individuals classified above chance* (Fig. 5)

*more sensitive analysis than group t-test

(Fig.4)



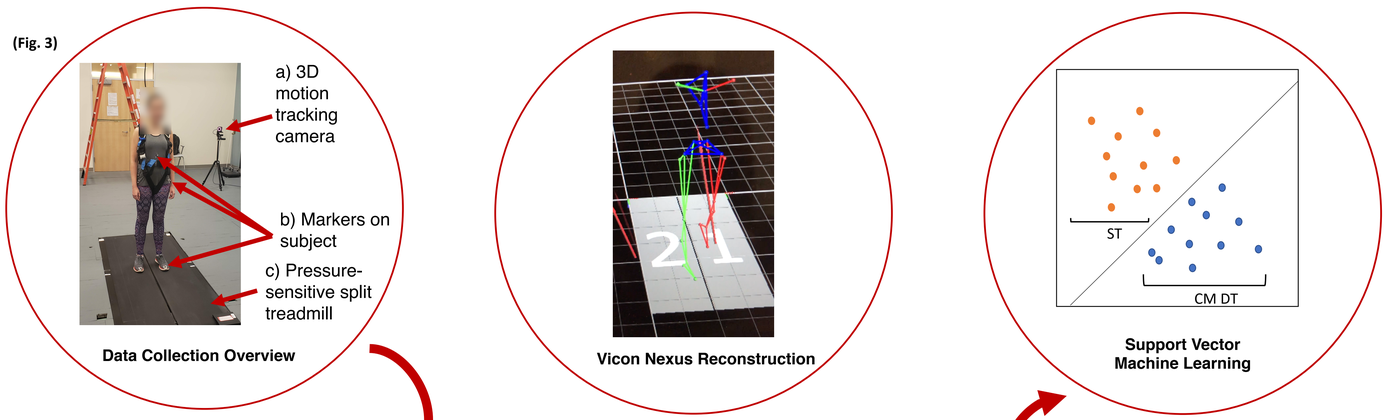
(Fig.5)

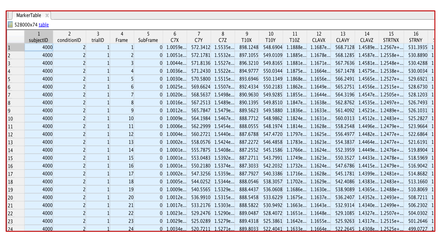


Methods

Experimental Design

(Fig. 3)





Present Project

- Initial analysis with extremely minimal preprocessing
- Build MATLAB code to organize data for machine learning
- Due to gaps in the data, all analyses were performed within-subjects to determine if the marker data could distinguish between single- and dual-task walking
- Implement “leave one out” training/testing of linear support vector machine classifier
- Iterate combinations of individual marker times, locations, and relationships to create an optimal “dual-task detector”
- Perform statistical testing to determine if performance is meaningfully greater than chance

Conclusion

- 3D motion capture data can determine if participants were distracted by a cognitive task while walking
- Initial step towards more refined preprocessing and machine learning to build a more sensitive detector

Future Directions

- Classification significant in 7/9 subjects but well under 100%; suggests need for more refined preprocessing and machine learning methods
- Improve sensitivity through classification on higher-order features (e.g. using gait cycle and center of mass)
- Examine model feature weights to determine whether some 3D markers are uninformative and do not need to be collected in future studies

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References

[1]Marois, R., & Ivanoff, J. (2005). Capacity limits of information processing in the brain. *Trends in Cognitive Sciences*, 9(6), 296–305. https://doi.org/10.1016/j.tics.2005.04.010
[2]Amboni, M., Barone, P., & Hausdorff, J. M. (2013). Cognitive contributions to gait and falls: evidence and implications. *Movement disorders : official journal of the Movement Disorder Society*, *28*(11), 1520–1533. https://doi.org/10.1002/mds.25674