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Age related postural responses during repeated virtual stimulation: traditional analysis and analysis of the complexity

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BACKGROUND

The aging of the sensorimotor system alters the perception of our environment and reduces our ability to react quickly to stimuli. This phenomenon contributes to increase the risk of falling in older adults. One way to artificially induce sensory conflicts is to expose individuals to virtual environments, causing conflicts between visual and sensory signals. Postural control reflects the central nervous system's processing of sensory conflicts. A traditional analysis uses the postural parameters resulting from the center of pressures such as the length of the trajectory of the center of pressures or even the mean velocity. It allows to observe the repercussions of sensory conflicts. On the other hand, a complexity analysis uses postural parameters such as fractal dimension or entropy. Complexity is a marker of sensory state. A decrease in complexity and variability may be due to a pathological condition. Complexity is an estimator of fall risk in older adults (Seigle et al., 2009, Zhou et al., 2017). On the other hand, repetitive patterns are adaptation markers (Riley, Balasubramaniam & Turvey, 1999). This is why this study addresses the following question: are age, repetition and translations influencing traditional and complexity-based postural parameters when exposed to repeated virtual stimulation?

PURPOSE Investigate the effects of age on postural responses during virtual reality stimulation using traditional analysis and complexity analysis

METHODS



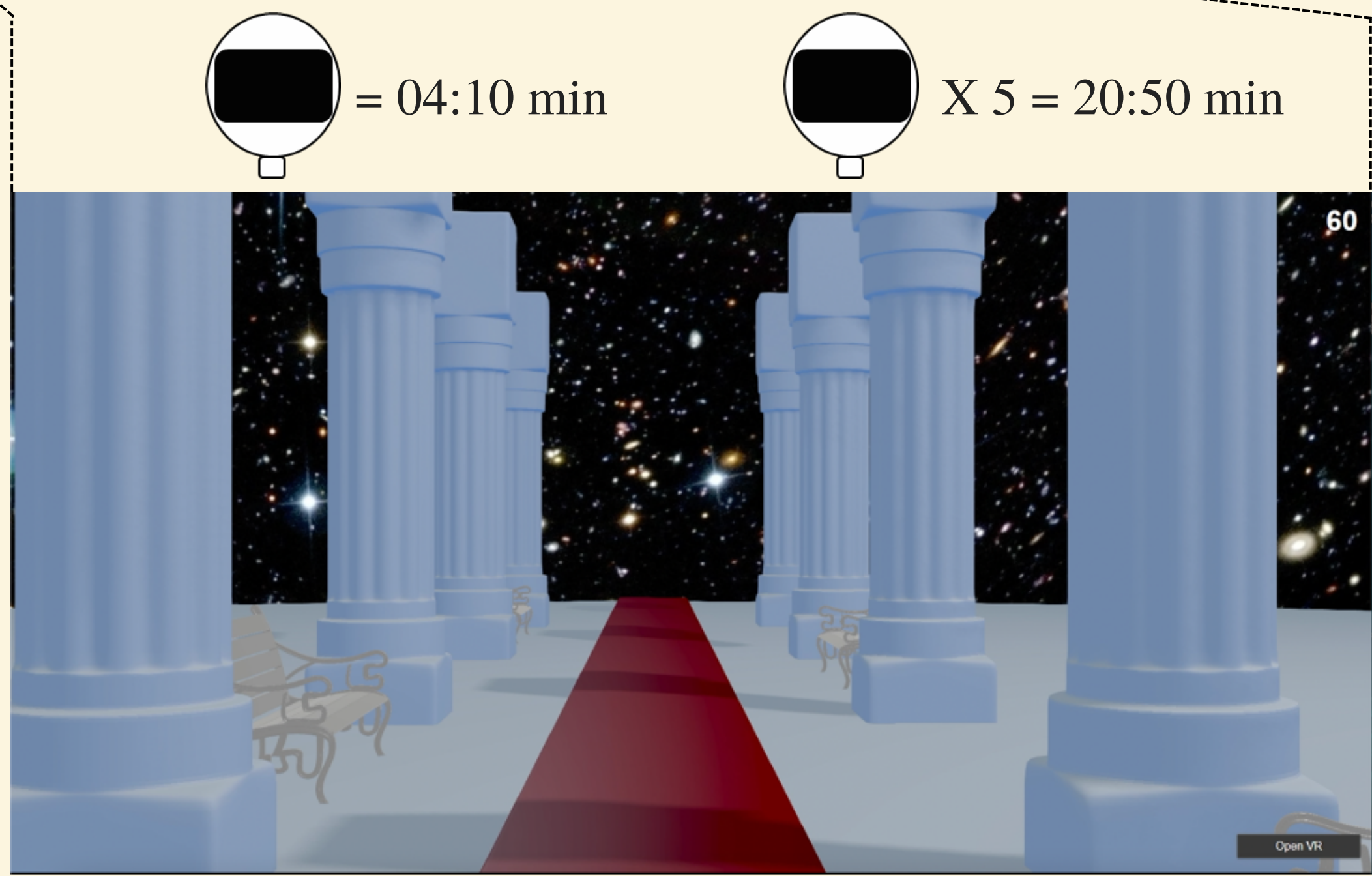
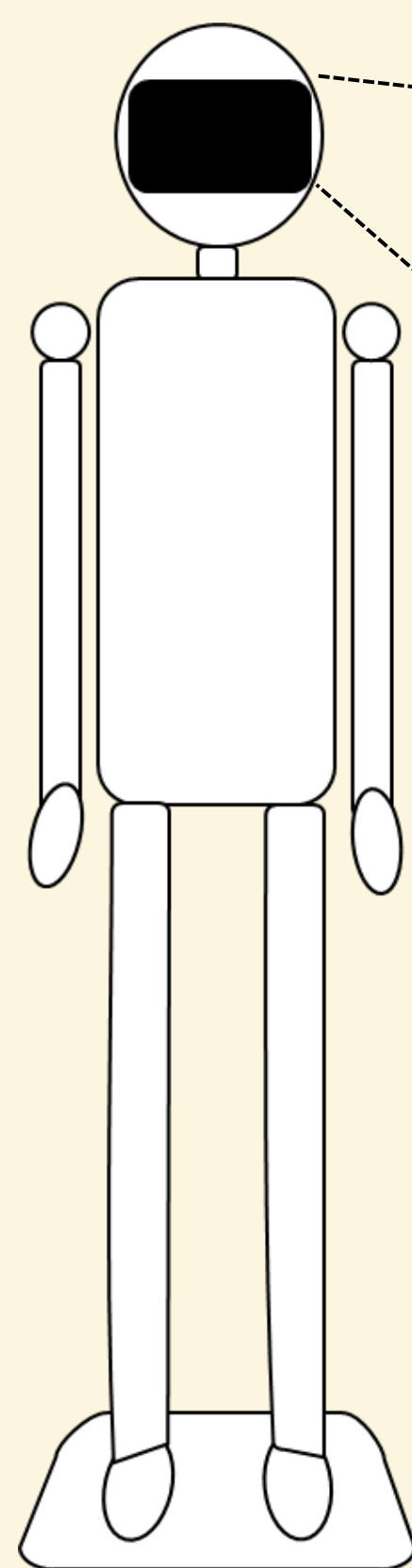
84 healthy adults aged 21 to 86
M : 42.41 SD : 18.00



Oculus Rift (CV1)



Wii Balance Board



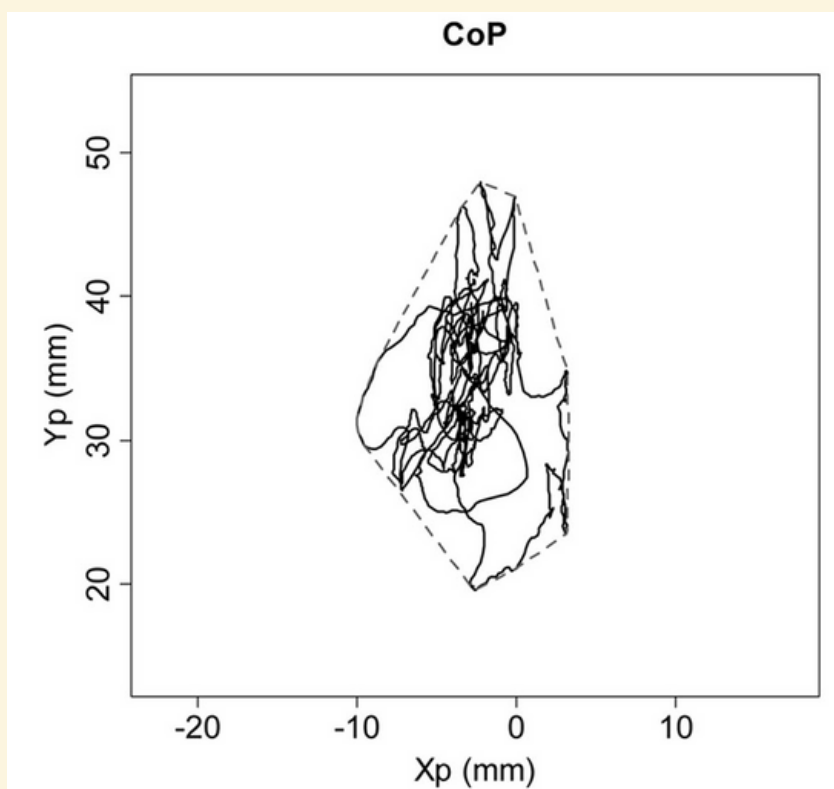
Note. The analyzes here focus only on the sequences before and after the forward and backward translations.



IN BRIEF

WHAT IS A TRADITIONAL COP TRAJECTORY ANALYSIS?

Observing the variability of the system in proportion to the disturbance experienced in postural control



WHAT IS A COP TRAJECTORY COMPLEXITY ANALYSIS?

Quantifying exploratory postural strategies. Identifying repeating patterns.

INDEPENDANT VARIABLES

- Virtual stimulation: Translation direction (forward or backward)
- Number of repeated exposure x 5
- Age

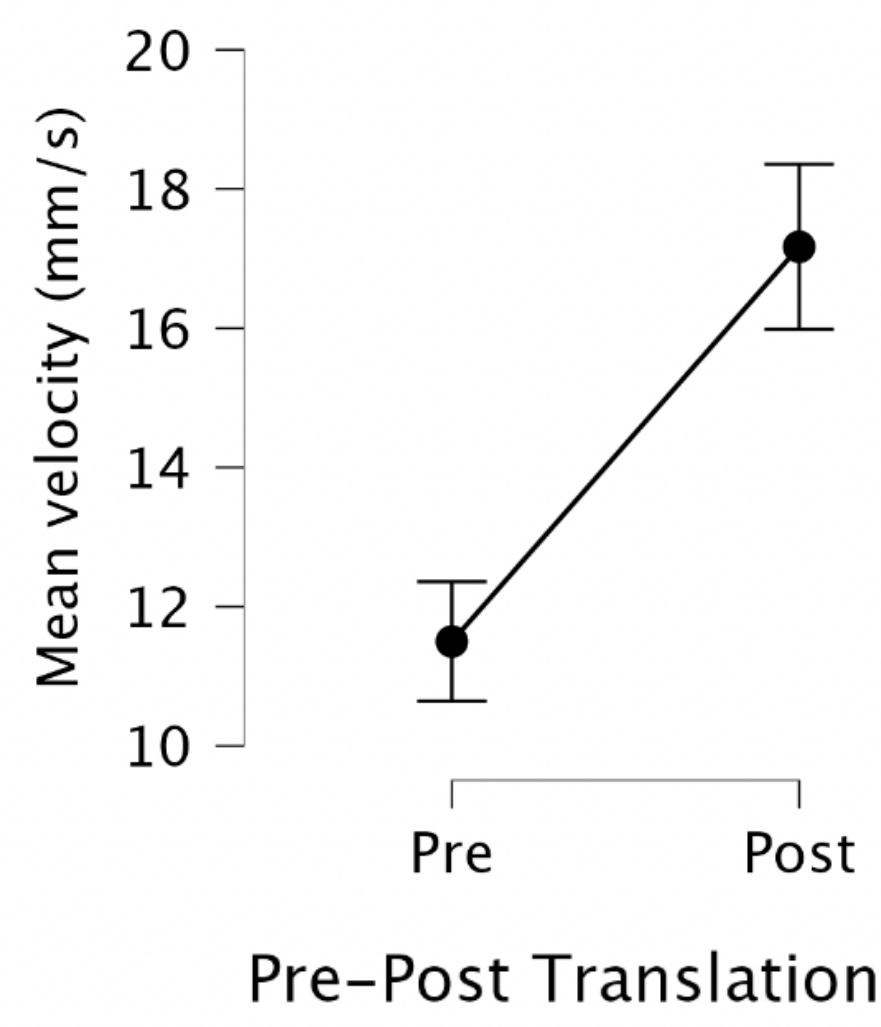
DEPENDANT VARIABLES

- Mean Velocity
- Surface
- Fractal Dimension
- Percent Recurrence in the AnteroPosterior axis (AP)
- Sample Entropy AP

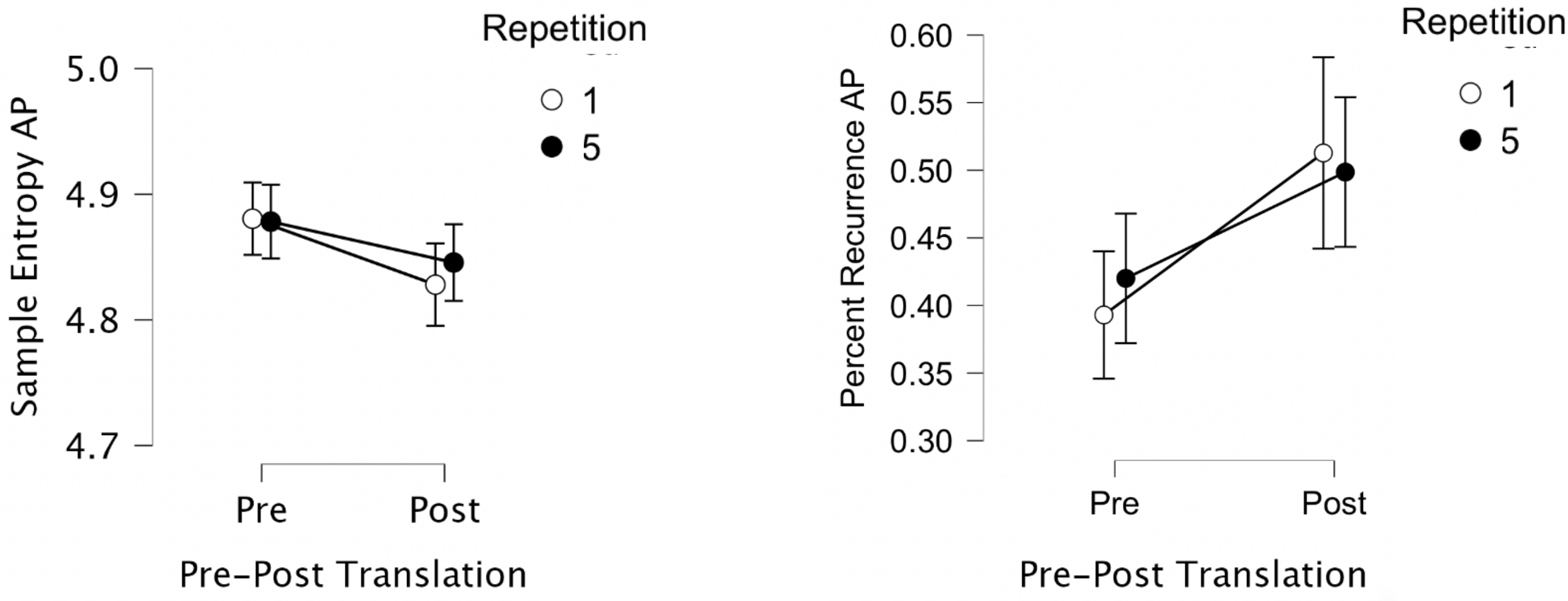
RESULTS

REPEATED MEASURES ANCOVAS

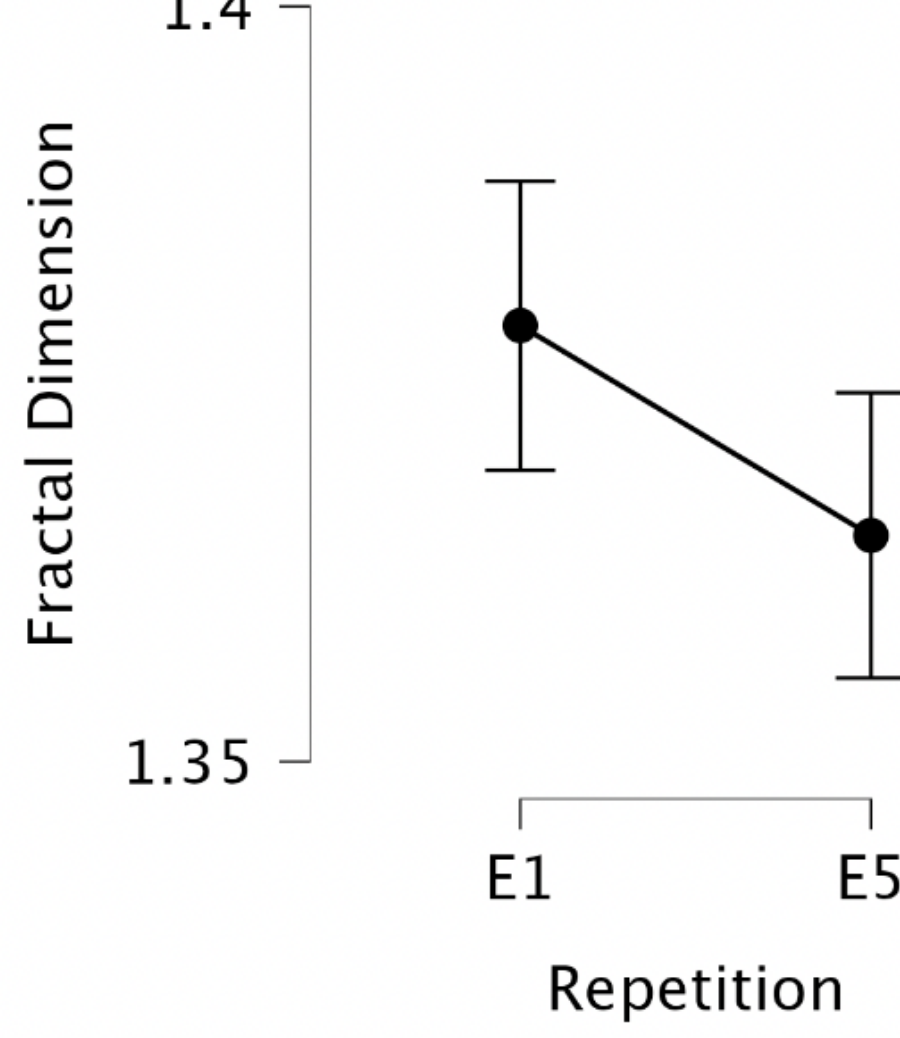
Translation effect on Mean Velocity



Translation and repetition effects on Sample Entropy AP and Percent Recurrence



Repetition effect on Fractal Dimension



CORRELATIONS WITH AGE AND POSTURAL PARAMETERS

Exposure number	1				5			
	Pre-forward translation	Post-forward translation	Pre-backward translation	Post-backward translation	Pre-forward translation	Post-forward translation	Pre-backward translation	Post-backward translation
Translation								
Mean Velocity	0.22* p = .04	0.17 p = .13	0.20 p = .08	0.20 p = .06	0.29* p = .006	0.15 p = .19	0.10 p = .35	0.22* p = .047
Surface	-0.08 p = .45	0.08 p = .49	-0.02 p = .84	-0.02 p = .87	0.18 p = .10	-0.06 p = .56	-0.02 p = .89	0.05 p = .68
Fractale Dimension	0.17 p = .12	0.40* p = .0002	0.12 p = .28	0.43* p = .0001	0.13 p = .22	0.10 p = .34	0.08 p = .48	0.18 p = .10
Sample Entropy AP	0.08 p = .48	0.29* p = .007	-0.02 p = .89	0.26* p = .02	0.09 p = .40	-0.03 p = .78	0.17 p = .11	0.08 p = .48
Percent Recurrence AP	-0.07 p = .51	-0.28* p = .01	-0.11 p = .34	-0.34* p = .001	-0.03 p = .81	-0.04 p = .75	-0.19 p = .09	-0.05 p = .62

DISCUSSION

According to the mean velocity, the visual disturbance have indeed caused a sensory conflict. Before the visual disturbance, aging led to an increase in mean velocity, but after the disturbance, all participants appeared to be equally affected. Complexity analysis (Sample Entropy and Percent Recurrence) showed that after the disturbance, participants restricted their postural oscillations. It is by looking at the complexity of the signal according to the age of the participants that differences emerged after visual disturbance. There was an increase in fractal dimension with age, an increase in sample entropy, and a decrease in percent recurrence. But with repetition, the age of the participants no longer correlated with the complexity of the signal. Five repetitions allowed adaptation to the visual disturbance (translations) with aging (Fransson et al., 2019).

KEY POINTS

- Studying aging and sensory conflicts with Virtual Reality
- 5 identical exposures to forward and backward translations
- Age as a continuous variable (21 to 86 y.o.)
- Traditional analysis and analysis of the complexity of CoP data
- Increase of mean velocity after visual disturbance
- The fractal dimension, the entropy and the percentage of recurrence reveal the influence of age on postural adaptation to visual disturbances

CONCLUSION

Traditional analyzes and the complexity of the center of pressure allow to observe the impact of a sensory conflict on posture and quality of adaptation. With age, visual disturbances cause a restriction of postural oscillations, but repetition allows adaptation to the stimulus through a relaxation of postural oscillations.

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