Effects of vibration and G-loading on heart rate, breathing rate, and response time

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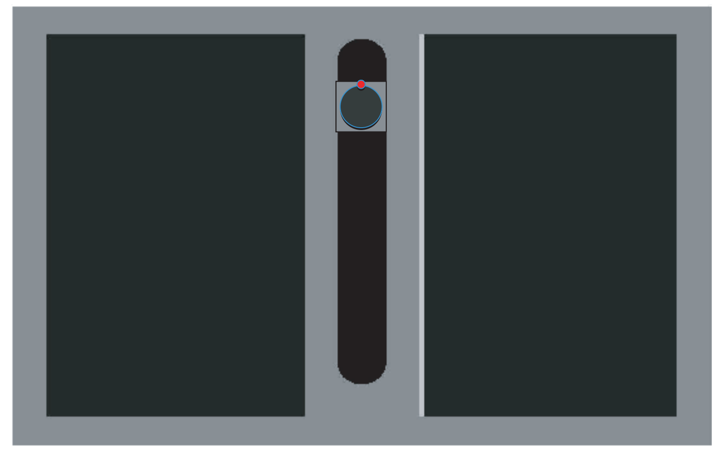
I. Introduction

Aerospace and applied environments commonly expose pilots and astronauts to G-loading and vibration, alone and in combination, with well-known sensorimotor (Cohen, 1970) and performance consequences (Adelstein et al., 2008). Physiological variables such as heart rate (HR) and breathing rate (BR) have been shown to increase with G-loading (Yajima et al., 1994) and vibration (e.g. Guignard, 1965, 1985) alone. To examine the effects of G-loading and vibration, alone and in combination, we measured heart rate and breathing rate under aerospace-relevant conditions (G-loads of 1 Gx and 3.8 Gx; vibration of 0.5 gx at 8, 12, and 16 Hz).

II. Methods



Task parameters:

G conditions:	1 Gx
	3.8 Gx
Vibration conditions (0.5 gx):	no vibration
	8 Hz
	12 Hz
	16 Hz
Participants:	10

Heart rate and breathing rate data were collected using a Zephyr bio-harness

Task: Observers were asked to hold a switch at the end of the armrest and fixate a central red LED. After a randomized interval (200 - 700 ms), the LED extinguished and a target spot appeared at a random location on the touch panel and was visible for 133 ms (closed-loop) and until observers touched the pannel (open-loop). Observers where asked to look at then point to the location where the spot had appeared.

Facilities:

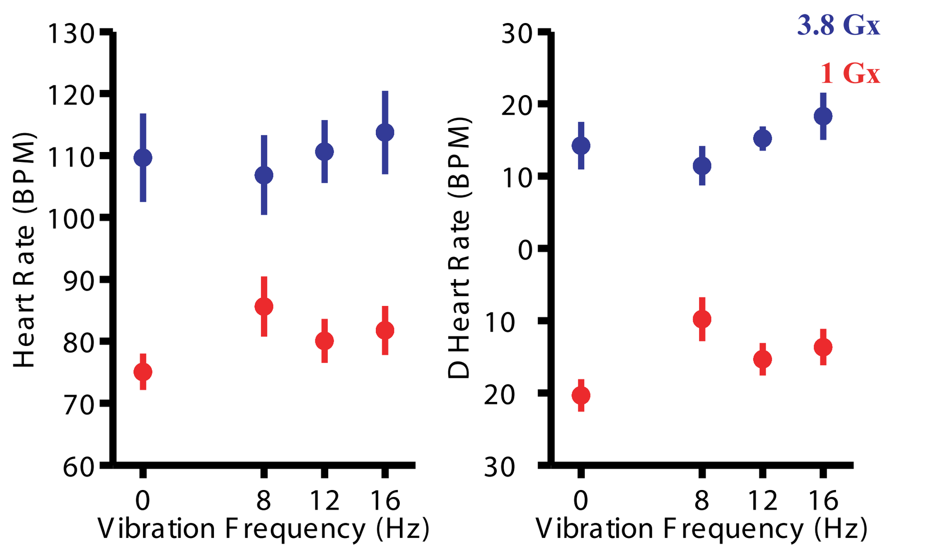
Fixed-based vibration platform (1 Gx):

The laboratory is equipped with a recumbent vibration chair that can deliver single-frequency and complex broadband motion to seat occupants in up to three degrees-of-freedom (vertical, pitch, and roll).

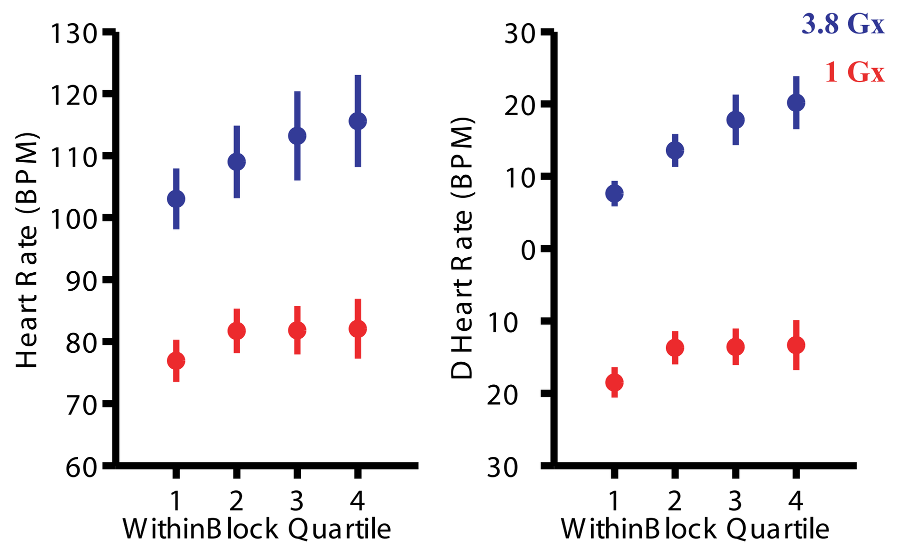
20 G centrifuge (3.8 Gx):

A vibration chair within the 20-G centrifuge can deliver Gx vibration during centrifugation.

III. Heart rate

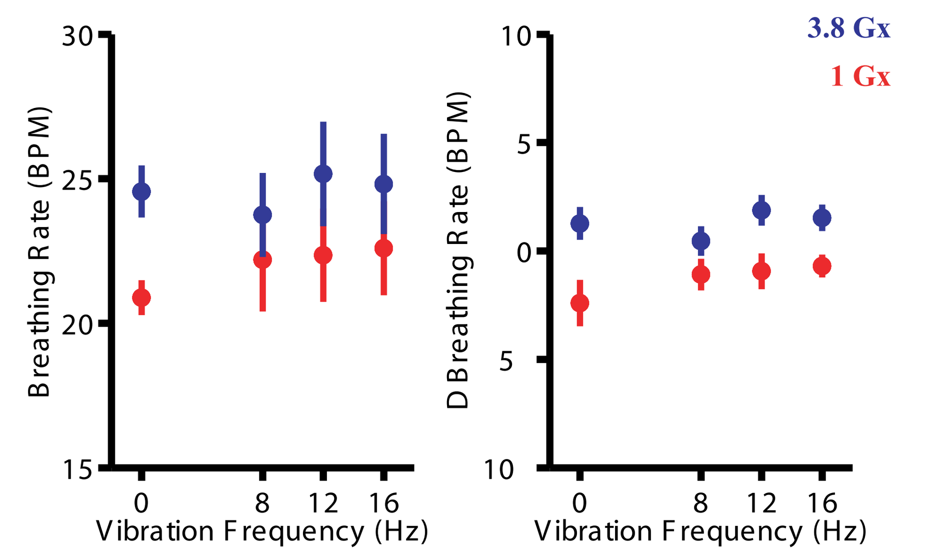


We observed a significant main effect of G-loading ($p<0.0001$), no effect of vibration frequency ($p>0.05$), and no interaction ($p>0.05$).

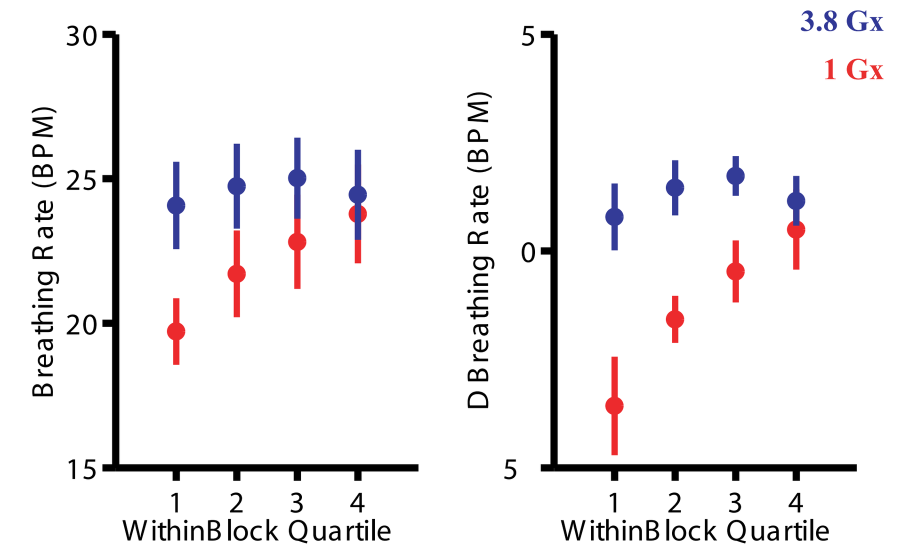


We observed a significant main effect of G-loading ($p<0.0001$), a significant within-block effect ($p<0.05$), and no interaction ($p>0.05$).

IV. Breathing rate

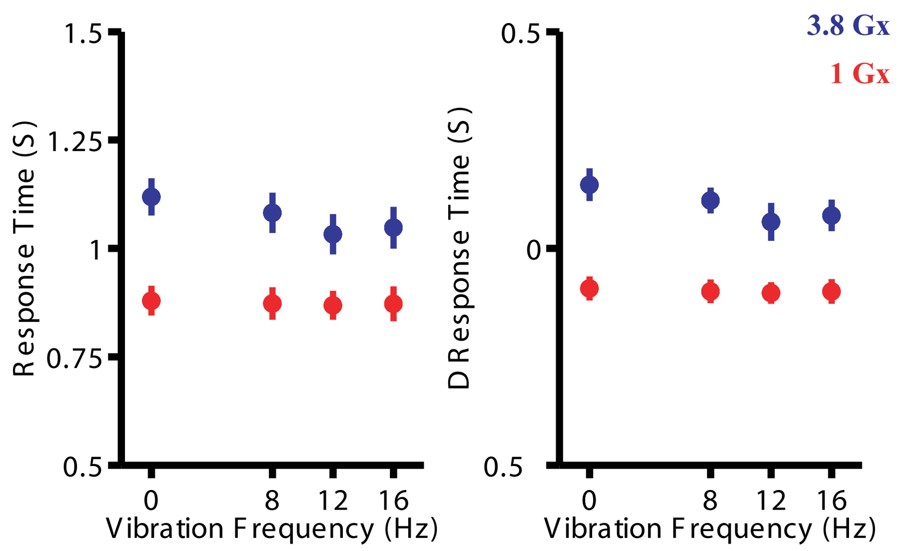


We observed a significant main effect of G-loading ($p<0.0001$), no effect of vibration frequency ($p>0.05$), and no interaction ($p>0.05$).



We observed a significant main effect of G-loading ($p<0.0001$), a significant within-block effect ($p<0.05$), and no interaction ($p>0.05$).

V. Response time



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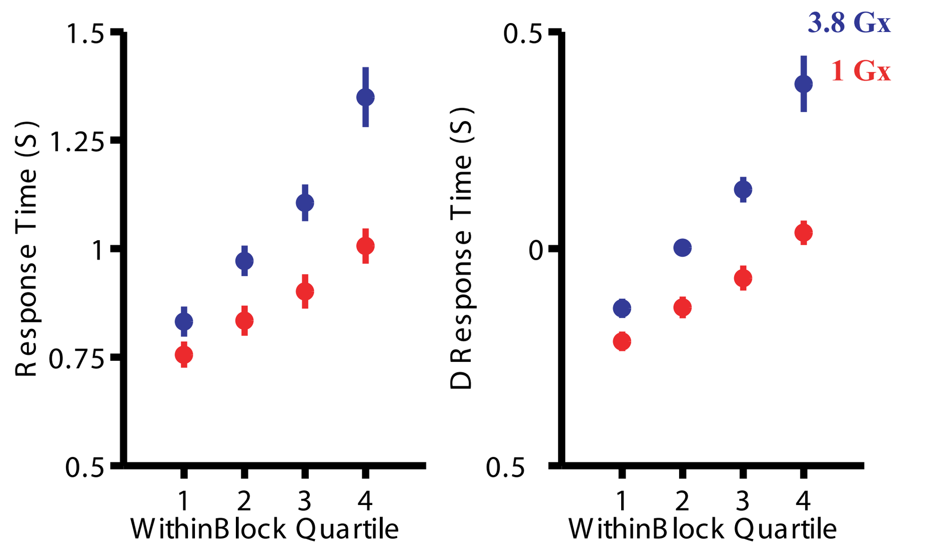

We observed a significant main effect of G-loading ($p<0.0001$), a significant within-block effect ($p>0.0001$), and significant interaction ($p<0.01$).

VI. Conclusions

G-loading had a strong effect on heart rate, breathing rate, and response time.

The effects of vibration frequency on heart rate, breathing rate, and response time are less robust.

For all measures, we observed strong within-block effects, which would obscure any potential effect of vibration frequency.

Further analysis is necessary to compensate for the strong within-block effects.

References

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