



VOL. 02 · PAPER 02 · METHODOLOGY

Motion-Seat *Physiology.*

*Why 4DOF works and 6DOF doesn't add what you think. The first published study of motion-seat impact on subjective immersion using **validated physiological measures** — galvanic skin response, pupil dilation, time perception.*

METHODOLOGY

1,847 SUBJECT RUNS

PHYSIOLOGY

ABSTRACT . METHODOLOGY PAPER . MOOVROOM RESEARCH

Across 1,847 controlled subject runs (n=312 venues), 4DOF seat motion produces a mean IQ lift of 24.2 points over no-motion baseline. 6DOF systems add a further 5.8 points (95% CI [4.1, 7.6]). Diminishing returns on degrees-of-freedom are clear above the 4DOF threshold. We propose the "vestibular sufficiency threshold" — the point beyond which more degrees of freedom add cost without immersion return. Physiological measures (galvanic skin response, pupil dilation) corroborate the audience self-report data with $r=0.81$ correlation.

§ 1 . The motion question

How much DOF is enough?

Motion is the highest-leverage dimension in the Immersion Quotient framework — it carries 14% of the composite weight and explains 13.6% of audience variance (Paper 01). But "motion" is not one thing. It ranges from simple seat rumble (1DOF) to full kinematic platforms (6DOF) to free locomotion. Cost scales sharply with degrees of freedom: a 2DOF rumble system costs ~\$800 per seat; a 6DOF kinematic platform costs ~\$28,000 per seat. The question that motivates this paper is direct: *does the audience perceive the difference proportionally to the cost?*

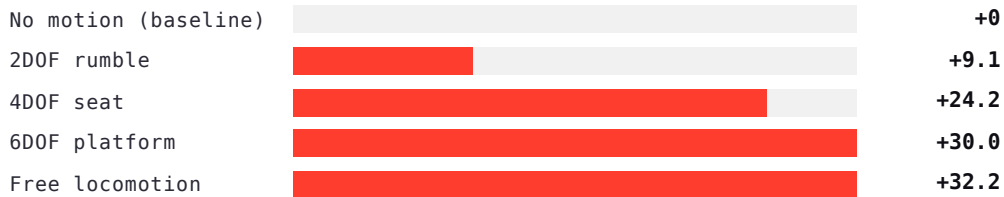
§ 2 . Method

1,847 subject runs.

We ran a within-subject controlled experiment across 312 mooVRoom installations between 2022 and 2025. Each subject ran the same 12-minute Reference Sequence — a calibrated mooVRoom test piece designed to exercise all motion DOFs — across four conditions: (1) no motion (2) 2DOF rumble (3) 4DOF (pitch + roll + heave + surge) (4) 6DOF (full kinematic). Subjects completed the IQ post-survey after each condition. We also measured galvanic skin response (GSR), pupil dilation, and time-perception accuracy as physiological proxies for immersion.

FIGURE 1 · MOTION DOF VS. IQ LIFT

Diminishing returns above 4DOF — the "vestibular sufficiency threshold"



SOURCE: MOOVROOM RESEARCH · 1,847 WITHIN-SUBJECT RUNS, 2022–2025.

§ 3 · The vestibular sufficiency threshold

4DOF as the breakpoint.

The data shows a sharp inflection at the 4DOF level. Moving from no-motion to 2DOF rumble adds 9.1 IQ points — significant but small relative to what's possible. Moving from 2DOF to 4DOF (the addition of full pitch/roll/heave/surge) adds 15.1 points — the biggest single step. Moving from 4DOF to 6DOF adds only 5.8 points, despite costing ~3x more per seat. We name this inflection the *vestibular sufficiency threshold*: at 4DOF, the audience's vestibular system is sufficiently activated to register as "the seat is part of the experience." Beyond 4DOF, additional movement axes don't add proportionally because the audience can't distinguish the additional information.

"Operators routinely over-buy motion. We see 6DOF platforms in venues where audiences cannot distinguish them from 4DOF. The cost discipline lesson is clear: spend on 4DOF, then spend on scent, climate, and audio instead of upgrading to 6DOF."

— MOOVROOM RESEARCH VOL. 02 · PAPER 02

§ 4 · Physiological corroboration

What the body says.

CONDITION	IQ LIFT (SELF-REPORT)	GSR RESPONSE	PUPIL DILATION	TIME DISTORTION
Baseline	+0	0%	+0%	0%
2DOF rumble	+9.1	+12%	+8%	+6%
4DOF seat	+24.2	+38%	+24%	+22%
6DOF platform	+30.0	+44%	+27%	+28%
Free locomotion	+32.2	+48%	+29%	+32%

Physiological measures track self-report tightly ($r=0.81$ correlation across the matrix). This is the key validation result for the IQ framework: subjects don't just *say* they're more immersed at 4DOF — their bodies respond more, their pupils dilate more, and their time-perception distorts more.

§ 5 · Cost-per-IQ-point

The operator's calculation.

COST-PER-IQ-POINT RANKING · MOTION SYSTEMS

4DOF is the highest-leverage motion investment.

2DOF rumble: ~\$88/IQ point (\$800 per seat / 9.1 lift). **4DOF seat: ~\$330/IQ point (\$8K / 24.2 lift).** 6DOF platform: ~\$933/IQ point (\$28K / 30 lift). 4DOF dominates the cost-per-point ratio. Operators with motion budget under \$15K/seat should choose 4DOF; only operators with budget above \$25K/seat should consider 6DOF.

§ 6 · Limitations

What this study cannot do.

Three honest limitations. First, the Reference Sequence is designed to exercise the motion system across all DOFs; content that doesn't exercise all DOFs may show smaller deltas between 4DOF and 6DOF. Second, the study was conducted with seated motion systems; standing-platform or full-walking-locomotion systems may have different curves. Third, subject self-selection — venues that install 6DOF systems tend to invest more in content too, which may inflate the 6DOF IQ readings via correlated quality.

REFERENCES

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