

Measuring the thrill of driving in electric vehicles

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EXECUTIVE SUMMARY (1)

WHAT WE DID

WHAT WE FOUND

The two cars were different, but not in the obvious way / A purpose-built rating scale separated the cars most clearly / Pleasantness tracked the driving, and so did bodily arousal / We could link what the car did to how the driver's body responded / What thrill actually is, in drivers' words

WHY IT MATTERS

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Ethics

The automotive industry can measure almost everything a car does in physical units, but it has no established way to measure what driving one feels like. That gap matters more for electric vehicles than for vehicles that preceded them. EVs reach performance figures that used to signal a fast car with ease, while removing many of the sensory cues, such as engine note, vibration, and gear change, that historically told a driver they were having a thrilling drive. As performance figures converge across cars, driver's felt experiences become an increasingly important differentiator, and there is no widely established multimodal approach to measuring those experiences beyond conventional questionnaires and qualitative feedback. This matters in the wider transition to sustainable mobility: while EV adoption is often understood through practical considerations such as range, charging, cost, and usability, achieving the full benefits of electrification may also require understanding what might make people actively desire the EV experience itself. That, in turn, requires a better way to understand and measure the experiential nature of driving.

This pilot set out to close that methodological gap. Working with 12 experienced Polestar drivers at the Gotland Ring circuit, we evaluated whether a combined battery of self-report questionnaires, body-based sensors (heart rate, skin response, eye-tracking, EEG), and vehicle telemetry could capture the thrill of driving in a way that is both feasible in the field and sensitive to real differences between cars and driving styles. Each driver drove two versions of the Polestar 4, a single-motor variant and a dual-motor Performance variant, in both a calm everyday driving mode and a dynamic, "pushing the limits" mode.

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We found that the multimodal measurement approach was feasible to deploy during a live track day, although several measures presented substantial data-quality and synchronization challenges. Within this feasibility sample, several measures differentiated driving conditions and vehicle variants. A custom-built post-drive psychological rating scale distinguished the two cars on perceived performance and experiential quality; pleasantness ratings and eye-tracking metrics tracked the shift from calm to dynamic driving; and vehicle telemetry showed promising associations with moment-to-moment physiological activation. Interviews suggested that drivers experienced thrill as a combination of heightened bodily arousal, trust and control in the car, and absorbed attention, an experience several participants compared to a ‘controlled roller coaster’.

The pilot’s purpose was to answer whether there is a rationale for a larger, definitive study. What follows sets out what we did, what we found, why it matters, and how a Phase 2 study should be built from these lessons.

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Ahead of the fieldwork at Gotland, we ran a short open-ended survey with 60 Polestar owners across 15 countries to find out, in drivers' own words, what they feel when driving and which features they attribute those feelings to. **Handling and road connection** was the most cited theme (35 of 60), followed by **performance and acceleration** (26), with **thrill and joy the most common emotional response** (21). This shaped which questionnaires and interview questions we took into the field.

The field study used a 2×2 design: every driver experienced all four combinations of car (single-motor “low-spec” versus dual-motor Performance “high-spec”) and driving mode (calm versus dynamic). Using two specifications of the same model let us change performance while holding the cabin, interior, and controls constant, so any difference in experience could be attributed to the car's performance rather than to unrelated design differences. The order of cars was counterbalanced between drivers, and drivers followed a lead car that set the pace.

While they drove, we collected four kinds of data at once: **what drivers said** (questionnaires between segments and a full interview at the end), **what their bodies did** (heart rate and skin conductance, eye-tracking, and exploratory EEG), **what the car did** (full CAN-bus telemetry covering speed, acceleration, cornering load, steering, and braking), and where relevant, where on the track it happened (GPS). Bringing these together allows us to see the same moment of a drive from the driver's body, the driver's report, and the car's own sensors simultaneously.

Because this was a feasibility pilot with 12 people, we analysed the data descriptively rather than running formal significance tests, as there was insufficient data to run those tests. The numbers below describe what happened in this sample. They are strong enough to justify a bigger study, but not to stand as validated conclusions.

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Telemetry confirmed the two cars gave drivers materially different experiences, which matters because it means the rest of the findings are responding to a real difference. On matched fast laps the two cars were driven at essentially the same pace (79 versus 78 km/h); the circuit capped how fast anyone could go, so the difference showed up in how that pace was produced, not in raw speed. The Performance car produced 32% higher peak acceleration, in all six drivers with telemetry, and hard-acceleration events nearly nine times as often. It reached slightly higher cornering loads and spent more time near the grip limit.

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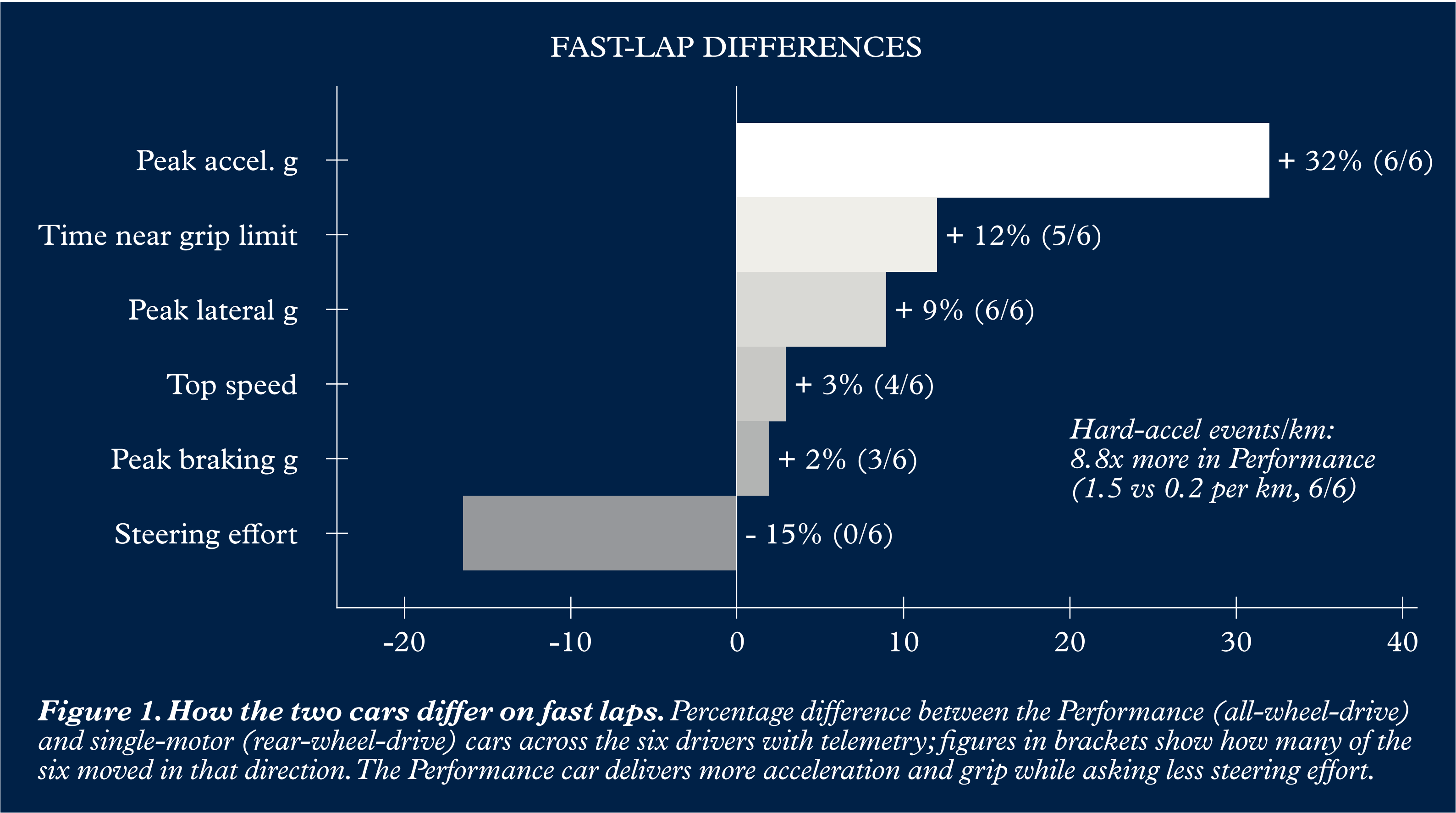
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The most revealing number runs the other way: steering effort was 15% lower in the Performance car, for every driver. The all-wheel-drive car delivered more capability while asking less physical work at the wheel. The extra traction was spent mainly on getting out of corners, not on higher top speed or harder braking, both of which are limited by the shared brakes and available grip. These findings demonstrate how engineering teams are “engineering a feeling”; the Performance car does not simply go faster; participants experienced it as making fast driving easier.

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Of all the questionnaires, the one we built specifically for this study was the most sensitive. On its Performance/Dynamics composite, drivers rated the Performance car 89.2 out of 100 against 67.7 for the single-motor, a gap of roughly 21 points. On Experiential Quality it was 93.0 versus 77.9, and the Performance car's ratings were far more tightly clustered, meaning drivers agreed more about it, while the single-motor car produced a wider range of experiences. Most drivers rated the Performance car higher on both.

One part of this scale did not behave as expected. An Embodiment/Confidence composite came out nearly flat between the cars (47.5 versus 46.6). We interpret this as a problem with how the items were worded rather than evidence that the two cars inspired equal driver confidence and we are recommending it for revision before Phase 2 rather than drawing any conclusion from it due to how few participants were included in Phase 1.

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A quick two-part “how pleasant / how activated do you feel” rating showed pleasantness rising steadily across the day, from 3.6 before driving to around 3.9–4.0 in calm segments and 4.4–4.8 in dynamic ones. Some of that lift happened before any hard driving, so being at a racetrack is itself activating. The between-car difference was smaller but consistent (4.8 versus 4.4 in dynamic driving). Bodily arousal on the same scale stayed flat until the dynamic segments, which suggests it tracks how you are driving more than which car you are in.

The body-based sensors agreed. Heart rate and skin conductance both rose more in dynamic than calm driving, with no reliable difference between the two cars. One caution here is important and shapes the next study: dynamic driving is also physically harder work, with more steering and more bracing, so we cannot yet separate a racing heart caused by excitement from one caused by exertion. Eye-tracking added a cleaner signal: drivers blinked less, had larger pupils, and held their gaze longer during

demanding driving, all consistent with deeper attentional engagement, and it was easy to collect without getting in the driver's way.

Two questionnaires carried over from the wider literature were less useful here. A standard mood checklist showed that participants were generally happy throughout, with positive mood high and negative mood near zero, but the measure did not discriminate meaningfully between driving conditions. A flow questionnaire hit a ceiling, meaning these experienced drivers reported near-total absorption in both cars (5.78 versus 5.72 on a 7-point scale), so it could not distinguish between the cars.

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A. TELEMETRY-PSYCHOLOGY CORRELATIONS

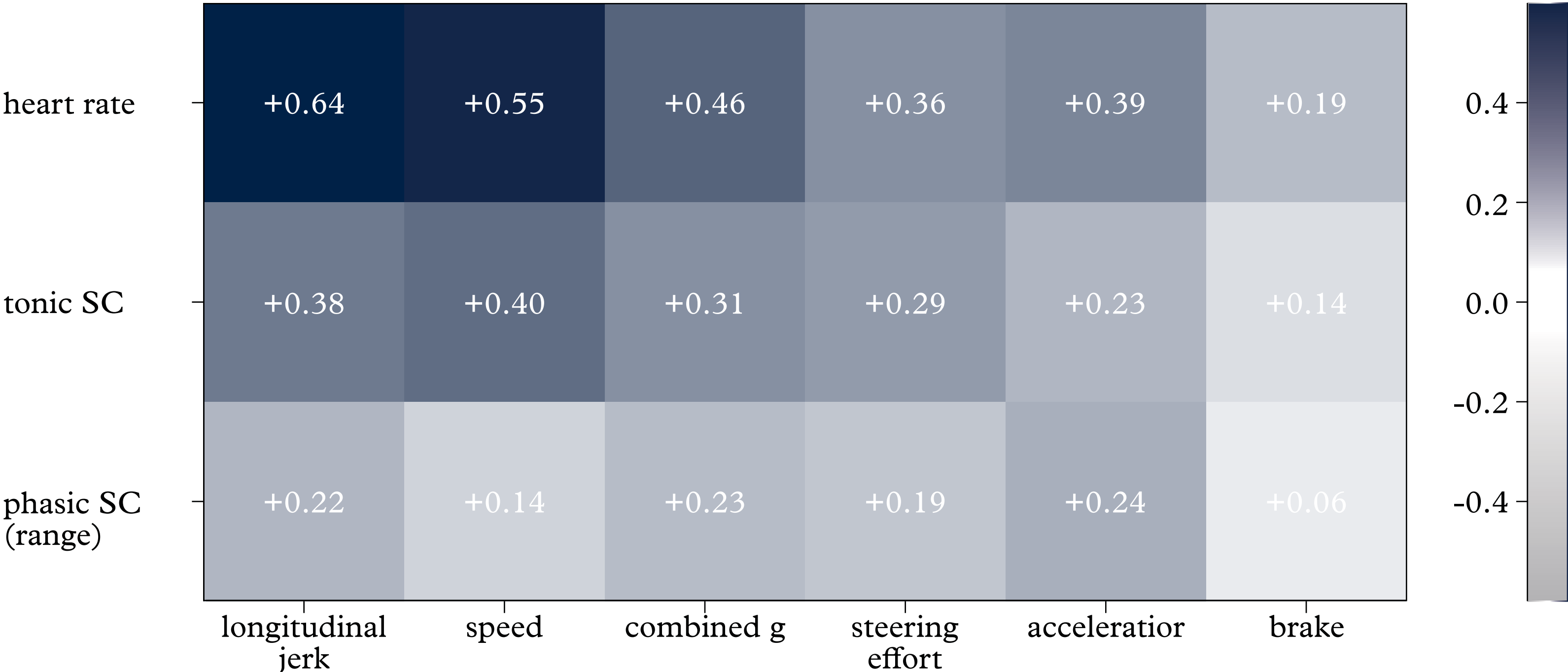


Figure 2. Linking car behaviour to driver arousal. (A) Associations between what the car was doing and how physiologically activated the driver was, across the six drivers with telemetry. The rate of change of force (longitudinal jerk) was the variable most strongly associated with physiological arousal. (B) Driver arousal rises steadily as cornering load increases.

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B. DOSE-RESPONSE: AROUSAL RISES WITH G-LOAD

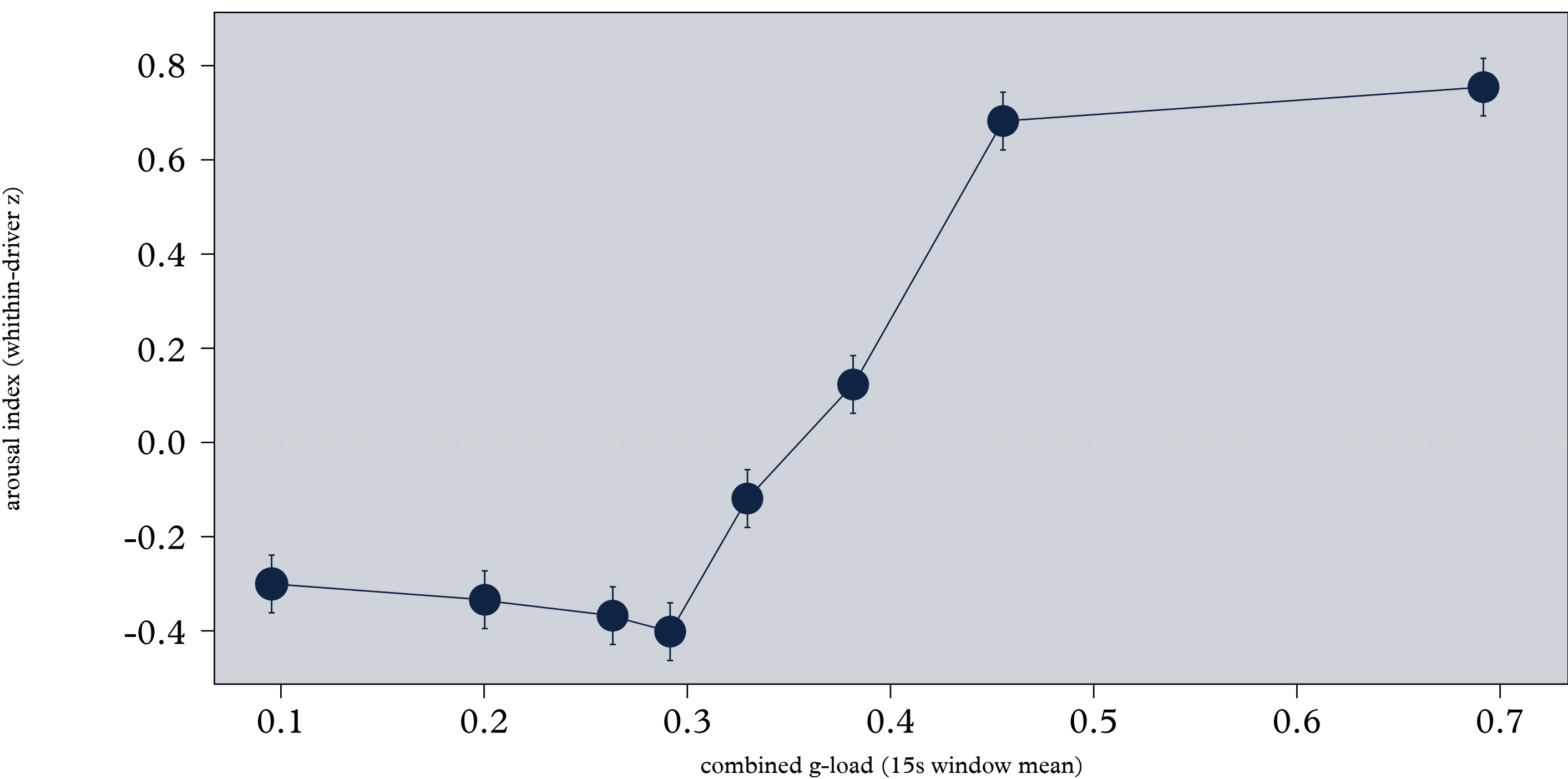


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Combining the continuous telemetry and physiology streams for the six drivers with full data, every aspect of how the car was being driven was positively associated with how activated the driver's body was. The single strongest associated variable was longitudinal jerk, the abruptness of acceleration and braking transitions, ahead of speed and overall g-load. Arousal rose steadily as cornering load increased.

The ordering is the interesting part. It is not sustained speed or steady cornering that most moves the driver's body, but the rate of change of force, such as the surge out of a corner, the braking point, the crest of a hill. That matches exactly what drivers told us in interviews, where the peak moments were transitions rather than stretches of fast running. Together with the interview findings, this suggests that moments of heightened thrill may be concentrated around specific, identifiable driving events.

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The interviews gave the richest and most consistent account. Drivers did not describe thrill as raw excitement or as losing control behind the wheel. Instead, **they described a joint state of a strongly activated body (involuntary laughter, a pounding heart, a floating stomach, in one case a scream), combined with complete trust that the car would do what they asked, and an absorbed, almost automatic attention in which the rest of the world fell away.** Several reached independently for the same image, a roller coaster, indicating a curated risk you can allow yourself to feel intensely because you know you are safe.

Interviews indicated that, for distinguishing excitement from thrill, **sense of control was critical.** High arousal became joy specifically when drivers trusted the car; the same physical intensity without that trust was experienced by drivers as stress and danger rather than thrill. Drivers tied that trust to concrete engineering, naming steering response, chassis balance, and road feel, and several

described the car as an extension of themselves. One line captures the experiential prize better than any number: the car “makes you feel like a better driver than you are.” Participants tended to describe the Performance car as producing this state more consistently. Some described the single-motor car as engaging in a different way, requiring more active driver involvement.

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For years, performance has been primarily sold in car specs, such as power, torque, and nought-to-sixty, because those numbers reliably tracked how exciting a car was to drive. Electric powertrains break that link since they hit the numbers easily, and remove the noise and vibration that used to make these feel like something very specific. When every fast EV can quote similar figures, the numbers stop being a differentiator, and how the car feels becomes the product. For electric vehicles specifically, that feeling has not been measurable in a way that marries specs, driver physiology, and subjective experience. Until it is, **EV manufacturers are limited in how precisely they can design and subsequently market electric vehicles.**

This pilot demonstrates the feasibility of measuring several components of the felt driving experience, and more specifically that the felt experience can be tied back to things the car physically does, which is the bridge between engineering and emotion that has been missing.

That capability has three uses:

1. It gives product and chassis teams a way to check whether a design change actually lands as a better experience, not just better performance numbers.
2. It gives EV marketing and communications teams a basis for driving-pleasure claims that rests on data rather than assertion.
3. It may help broaden the conversation around EVs beyond functionality and sustainability, towards understanding how electric vehicles can provide compelling driving experiences on their own terms, rather than through imitation of combustion-engine cues.

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Phase 2 should be a larger, properly powered study that turns this feasibility groundwork into validated findings. The pilot points to a clear design.

The most important lesson is to keep a mix of measures rather than a single score. **Thrill does not reduce to one number**; pleasantness, bodily arousal, control, and absorbed attention move on different axes and are picked up by different instruments.

A single “thrill index” would throw away the structure we found is worth further exploration.

On the specific instruments:

- Keep the purpose-built car rating scale and the brief pleasantness rating; these were the most sensitive self-report measures. Revise the Embodiment/Confidence items before reuse.
- Keep heart rate and eye-tracking as the body-based measures; both were informative and unobtrusive.
- Drop skin conductance, which mostly duplicated heart rate and was more prone to interference, and drop EEG from the default setup, since recording in a moving car proved too artefact-prone to justify its cost unless a specific question needs it.
- Use the mood and flow questionnaires sparingly or in shorter form; they were feasible but not discriminating in this population.

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Beyond the instruments, three design changes matter for Phase 2.

1. Build the next study to separate excitement from exertion, so a raised heart rate can be attributed to emotion rather than physical effort.
2. Reinstate GPS logging on every car and log satellite time natively, so arousal can be mapped to named corners and features for the whole sample, which is the form in which these findings are most directly useful to vehicle development.
3. Size the study from the effect sizes this pilot produced rather than a generic rule of thumb; some of the field subsamples here were as small as six drivers, and Phase 2 will need to be meaningfully larger.

This work provides a first step in developing a validated way to measure the EV driving experience and connect it to the car's own engineering, a capability that is not yet established or widely documented within the automotive sector, and which fits naturally with Polestar's position as a performance brand making the experiential case for electric driving.

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This research was funded by Polestar and conducted in collaboration with the Oxford SDG Impact Lab. Polestar recruited participants and provided essential practical and logistical support, including access to the racetrack and study vehicles. The research team retained responsibility for the study design, methodological decisions, and data analysis, while working in close communication with Polestar throughout the project.

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The study received prior approval from the University of Oxford Central University Research Ethics Committee (CUREC; ref. R94385/RE001) and was conducted in accordance with the University's research guidelines.

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