Comparing the Efficacy of Visual and Verbal Guidance for a Target Car-Seat Posture

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ABSTRACT

Car seats are becoming increasingly complex, aiming to promote driver wellbeing and comfort, and overcome musculoskeletal problems caused by poor driving posture and extended exposure. With an increasing amount of adjustments available, the navigation of seat controls can be difficult. A 'posture coach' is proposed to help drivers achieve a target seating position. However, it is unclear how best to deliver advice. In a static luxury vehicle, visual (animations) or verbal (speech) threestage incremental guidance was provided on repeated occasions in a counterbalanced, withinsubjects study to thirty experienced drivers - aiming to help guide them to the target seating posture (in terms of backrest and slide-axis seating adjustment). The on-board ECU diagnostic tool was used to determine the current seat position and inform subsequent advice. Results show that, overall, visual instructions were more effective in guiding participants toward the target. Moreover, participants were increasingly effective (proximity to target) in each successive attempt, suggesting positive learning effects following the guidance. A small majority of participants (16 of 30) preferred visual to verbal presentation of instruction. Those who preferred visual instructions were significantly better at following visual instructions than verbal, whereas there was no difference in accuracy for participants who preferred verbal instructions between visual or verbal instructions. This result suggests a multi-modal format may be most effective, especially given the potential distraction of visual information while driving. Results are discussed in the context of developing a 'posture coach' to make recommendations periodically throughout a journey (based on the real-time position of the seat) to prevent static posture-related strain.

KEYWORDS

Car seats, driver comfort, posture coach

Introduction

Achieving a good seating position is important for the prevention of musculoskeletal conditions (Castanharo et al., 2014). This is particularly true for drivers, who may sit in static positions for prolonged periods of time. Previous studies have investigated the effect of seating on office workers (Grooten et al., 2017). However, the driving task is not as flexible as office work – the driver is bound by the task, with hands on the steering wheel and feet on the pedals, and there is seldom opportunity to offload structures strained or compressed by poor posture.

Static sitting postures have been shown to be damaging to the lower back due to the sustained muscular activity required to maintain the postural position against gravity and on-road vibrations (Troup, 1978). When the car seat position is not optimal, more muscle contraction is needed for stabilisation, resulting in greater spinal disc pressures (Maradei et al., 2015). Nevertheless, there is a

lack of consensus regarding the ideal sitting position when driving (Schmidt et al., 2014). Recommendations have been made regarding the position of the car seat and the position of the occupant on the car seat. For example, in a sports utility vehicle (SUV), it is recommended that the optimum range of hip joint angles is from 84° to 126°, and knee angles from 95° to 135° (e.g. Gyi and Porter, 1999). A reduced curve thoraco-lumbar posture has been recommended (Magee, 2006), or a flat lumbar posture with backrest support, based on the premise that sitting postures with a maintained lumbar lordosis demand too much sustained muscle activity (Kendall, 2005). In contrast, spinal curves similar to the standing 'ideal' anatomical normal – thoracic kyphosis with lumbar lordosis – have been advocated by some authors (e.g. Lee, 2003).

With respect to the user's behaviour, it is known that the further forward their pelvis is from the chair backrest, the more likely they are to sit with a flexed lumbar curve (Scannell & McGill, 2003). Luxury car seats are thus often fitted with height and depth adjustable lumbar supports able to assist supporting the driver's lumbar spinal curve.

A further concern is drivers' perception of their posture. Claus et al. (2009) investigated whether participants were able to reproduce prescribed 'ideal' sitting postures following specific training, both with and without facilitation by an expert. The results indicated that some postures were never achieved without intervention.

The effects of regular physical exercise have been shown to improve the body awareness of humans, suggesting that it is possible to train proprioception and spatial awareness (to some extent) (Yip, 2006). This may provide scope for a car to provide feedback to the occupant on their sitting position, but questions remain regarding the driver's mental model with respect to sitting, and what information they are likely to use to inform their sitting position. These will likely influence whether they choose to adopt an ideal posture, or whether they are more concerned with the image they would like to portray whilst driving (Schmidt et al., 2014).

A further point of interest is in the human driver's ability to follow instructions in the context of adopting a required posture. Research regarding the provision of feedback for motor training has mostly focused on visual feedback for guidance. Neurophysiologists discovered that the same neurons in the ventral premotor cortex of the monkey brain fired when monkeys performed a specific action (e.g., grasping a raisin) (Rizzolatti et al., 1996) and when the monkey watched another monkey or a human researcher execute the same action. It is therefore concluded that these neurons respond to actions that are either observed or performed (so-called "mirror" neurons) (Wohlschläger & Bekkering, 2002).

Egocentric and allocentric reference frames to represent spatial information have been proposed by spatial memory researchers (Iachini et al., 2009). However, there is contradicting research regarding whether humans navigate surrounding environments in an egocentric or allocentric map. It has been suggested that the representation of location in memory is defined relative to intrinsic reference frames, and geometric aspects of the environment can affect which strategy is adopted (Xie et al., 2017). Survey perspective descriptions of position take a view from above the environment and describe it in terms of cardinal references: north, east, south, west. In a route perspective, descriptions take a view from within the environment and provide instructions based on locations relative to the person, such as left, right, forward or backward (Anacta et al., 2016).

Relative motion information has been shown to be a key source of instructions for physical activities. Spatiotemporal relationships can be between the limbs and the trunk and the body and the

surrounding area (Al-Abood et al., 2001). However, the reliance on feedback in visual conditions has led to the reliance on external feedback, such as a visual display, to the detriment of the internal feedback to motor control, proprioception (Schmidt, 1991). Even with appropriate knowledge and training, it can be difficult to achieve the desired results. In a study involving chiropractors who were tasked with adjusting their car head rests to a proposed position, even these experts with musculoskeletal training, were not fully aware of how to reproduce recommended sitting positions (Taylor et al., 2005). In addition, it was observed that these individuals were unable to correctly reproduce their perceived ideal position in their own car set-up.

Aims and Overview of Study

The aims of the study were to understand whether people are able to follow instructions to guide the set-up of a car seat. In particular, the study aimed to assess which means of presenting seat adjustment instructions (visual or verbal) was most effective at guiding the occupant to a target position. The study also investigated whether repeatedly following posture guidance influenced the driver's own ability to subsequently self-select this position.

Method

Participants

Thirty experienced drivers took part in the study (16 male and 14 female). Participants comprised employees and contractors from Jaguar Land Rover (JLR) research department, with ages ranging from 23 to 54 years. Participants' heights ranged from 159cm to 183cm (M= 174.72, SD= 8.14), and their functional leg length, from 96cm to 120cm (M=107.9, SD= 6.62) (functional leg length was required to be between 94cm and 122 cm to ensure that the recommended target position could be achieved in the test vehicle). Participants were excluded if they had a history of respiratory conditions, neurological conditions, or if they had ever experienced thoracic or lumbar spinal pain that required treatment or rest from normal activities for more than two days in line with similar research (Claus et al., 2009). All participants were fluent in English.

Apparatus

A 2017 Land Rover Velar fitted with the hi-line seat extension was used as the test vehicle. This offers electronic power car seat position adjustments, encompassing: seat height, seat depth, seat tilt, slide axis, backrest angle, lumbar support depth and height adjustment arcs. The car was parked in the JLR research lab workshop with the electrical power supply attached and the car set to a comfortable temperature. The car remained stationary at all times.

Visual (animations) or verbal (speech) guidance was provided to assist the participant in achieving a seating posture. Although it is recognised that the research literature is inconclusive regarding an 'ideal' driving posture, we required a standardised target posture for the study and therefore utilised published joint angle recommendations applicable for SUV seating (Schmidt et al., 2014; Peng et al., 2017). Specifically, our target position was defined as the backrest reclined 20° from upright, and the slide axis providing an angle of 120° behind the knee and trunk to thigh angle of 110°.

The final format of the guidance was determined by a panel of sixteen automotive Human Factors experts, based on factors such as clarity, ease of understanding and suitability for use in a stationary vehicle, with each including three guidance notes. The first instruction provided the participant with the target position. The subsequent two instructions 'nudged' the participant in the direction of the target position relative to the position they had already achieved. Both verbal and visual instructions

had variations for seat backrest adjustment, forward and back toward the target position, and slide axis, backward and forward towards the target position. Verbal instructions were scripted and spoken by the experimenter. Still images from the visual guidance are shown in Figure 1.

Design and Procedure

The study adopted a within-subjects design with instruction format (visual or verbal) as the independent variable. At the start of the study, participants were shown the car seat controls, and told what each was used for and how to operate them. Participants were invited to spend some time using the seating controls to ensure they were familiar with them. Participants were not given any indication regarding how the seat should be configured at this stage.



Figure 1: Visual instructions, showing backrest adjustment (left) and seat slide adjustment (right)

When the participant was familiar with the seating controls, they were asked to leave the vehicle and the car seat position was randomly adjusted. The participant was then invited to re-enter the vehicle and set up the car seat in a position they would find comfortable for driving, using the footrest next to the pedal for reference ('control condition'). This position was recorded. The participant was then presented the first instruction (either verbal or visual) and required to reposition the seat in line with the guidance. The seat position was recorded again. A subsequent instruction was then provided to 'nudge' the seat closer, and after following this, the new seat position was recorded. Directional nudge instructions were then presented for a final time and the final seat position was recorded. The participant was then asked to exit the vehicle and the seat position was randomly adjusted.

The procedure (control and experimental condition) was then repeated with the second format of instructions (verbal or visual guidance). Finally, the control condition was repeated for a third time. After each attempt, the seat configuration was obtained from the ECU diagnostic tool and the distance from the target at each attempt was calculated. At the end of the study, participants were asked which means of receiving instructions (visual or verbal) they preferred. Visual and verbal conditions were counterbalanced to avoid inevitable learning effects between the different conditions.

Results and Analysis

One-way repeated measures ANOVAs were conducted to compare the effect of visual and verbal guidance on the accuracy of the car backrest and the car slide axis adjustments (Figures 2 and 3).

For *visual instructions*, there was a significant effect of the condition number on *backrest position* accuracy in relation to the target position. Wilks' Lambda = 0.541, F (3, 27) = 7.626, p = 0.001. Paired-samples t-tests indicated that there was a significant difference in the distance from the target between baseline backrest adjustment condition (M=8.17, SD=6.066) and the first visual instruction (M=12.72, SD=9.98); t(29)= -2.19, p= 0.037.

There was also a significant effect of the condition on *slide axis position* accuracy in relation to the target position following visual instructions. Wilks' Lambda = 0.253, F (3, 27) = 26.55, p = <0.001. However, paired samples t-tests revealed no significant difference in the distance from the target for baseline slide axis adjustment condition (M=17.92, SD=11.05) and the first visual slide axis instruction (M=18.99, SD=16.22); t(29)= -0.302, p= 0.765.



Figure 2: Mean percentage error for backrest arc, with visual and verbal guidance



Figure 3: Mean percentage error for slide axis, with visual and verbal guidance

For *verbal instructions*, there was a significant effect of the condition number on *backrest position* accuracy in relation to the target position following verbal instructions. Wilks' Lambda = 0.632, F (3, 27) = 5.231, p = 0.006. Paired samples t-tests revealed that there was a significant difference in the distance from the target for baseline backrest adjustment condition (M=8.17, SD=6.066) and the first verbal backrest instruction (M=14.67, SD=6.07); t(29)= -3.14, p= 0.004.

There was also a significant effect of the condition on *slide axis position* accuracy in relation to the target position following visual instructions. Wilks' Lambda = 0.398, F (3, 27) = 26.55, p = <0.001. Paired samples t-tests revealed no significant difference in the distance from the target for baseline slide axis adjustment condition (M=17.92, SD=11.05) and the first verbal slide axis instruction (M=20.47, SD=18.06); t(29)= -0.643, p= 0.525.

Delivery Method

A paired-samples t-test revealed a significant difference in the scores for distance from the backrest target between visual (M= 3.73, SD= 4.09) and verbal (M= 10.18, SD= 11.18) guidance; t(29)=-2.919, SEM= 2.21, p= 0.007. In addition, there was a significant difference in the scores for distance from the slide axis target under visual (M= 5.89, SD= 9.43) and verbal (M= 8.31, SD= 8.62) conditions; t(29)= -2.063, SEM= 1.62, p= 0.048. These results indicate that the target position (in terms of both backrest adjustment and slide axis) was achieved more accurately when following visual instructions than when following verbal instructions.

Effect of Preferences

A paired-samples t-test was conducted to compare the distance from the backrest target under visual and verbal instruction conditions for those participants who preferred verbal instructions (N=14). There was no significant difference in the scores for distance from the backrest target in verbal (M= 6.23, SD= 6.12) and visual (M= 7.97, SD= 9.41) conditions; t(13)= 0.65, SEM= 2.66, p= 0.526.

A paired-samples t-test was conducted to compare the distance from the backrest target under visual and verbal instruction conditions for participants who preferred visual instructions (N=16). There was a significant difference in the scores for distance from the backrest target in verbal (M= 10.14, SD= 10.18) and visual (M= 4.07, SD= 10.18) conditions; t(15)=-3.965, SEM= 1.53, p= 0.001.

These results indicate that for participants who indicated that they preferred to receive visual guidance, the target position could be achieved more accurately when following visual instructions than when following verbal instructions. However, for participants who preferred verbal instructions, there was no significant difference between accuracy of achieving the target when following visual instructions compared to verbal.

Discussion

The study presents a novel approach to assess the accuracy of drivers' seat positioning in real-time (utilising the on-board ECU diagnostic tool) and using this information to provide incremental advice in the form of a 'posture coach' to influence seating position. In particular, it aimed to explore which format (visual or verbal) was most effective at guiding the participant to a target position.

It is interesting to note that in both conditions (visual and verbal), there was an improvement in accuracy between the first and the third instruction given, i.e. participants were able to move progressively closer to their target (for both backrest and slide axis) with each subsequent instruction when 'nudges' were provided relative to their current position. This highlights the value and utility of a posture coach in this context, and is consistent with other research, such as Anacta et al. (2016), who found that instructions formatted using a 'route perspective' are easier to follow than survey instructions. It also suggests that an incremental approach involving relative adjustments is more effective than showing a single image with no point of reference. This supports the findings of Xie et al. (2017) that for relative instructions, a mental transformation of the geometrical space and layout of the car cabin is not required, but rather self-orientation to the direction of the instructions provided visually. It is possible that if the initial instruction was given in relation to other features in the car, the success in reaching the target following the initial instruction would be greater, and this could be considered in future work.

Overall, findings indicate that instructions provided visually resulted in participants achieving a more accurate position (in relation to the target) than verbal instructions, suggesting that visual representations of the target position were easier to mirror (Sigrist et al., 2013). Nevertheless, this is not necessarily in line with other research, for example, Ringenbach et al. (2012), who reported that continuous or repeated movements were easier to follow verbally than visually. Moreover, providing visual instructions raises potential concerns of distraction in a driving context, particularly if advice is provided periodically throughout a journey.

It is also noteworthy that the mean distances away from the target significantly reduced from the baseline condition through to the final control condition, for both backrest and slide axis, indicating that the participant's own choice of initial position was closer to the target position at the end of the trial than at the beginning. This supports the findings of Xie et al. (2017), who reported that target positions become easier to replicate after repeated attempts. It also suggests that drivers will likely benefit in the long-term from the provision of a posture coach (i.e. following repeated exposures to posture instructions), in that they will be able to achieve the target position routinely. It also suggests a high level of trust and acceptance associated with the recommendations provided by the posture coach system (Cross and Ticini, 2012). As such, it is important that the advice is accurate, i.e. the size of the occupant and the range of sizes within target populations are taken into account, to avoid inappropriate recommendations that could not only affect driver comfort but also jeopardise vehicle safety.

Preference results suggest that for participants who indicated they would rather receive visual instructions, the target position could be achieved more accurately when following visual instructions than when following verbal instructions. However, for participants who preferred to receive verbal instructions, there was no significant difference between the accuracy of achieving the target when following visual instructions than when following verbal. The fact that a similar number of participants preferred each method suggests that a combination of the two approaches (i.e. a multi-modal interface) would be most appropriate if incorporating seat guidance into a commercially-available product.

It is also worth considering that the study was conducted in a Land Rover Velar. This is a luxury SUV that attempts to position the driver is an upright, 'command' position. It is therefore likely that drivers in such vehicles may have been influenced by environmental factors (seat and cockpit design) to assume a more upright posture, and this may override other sitting priorities; the same drivers may choose a more reclined and relaxed driving position in another vehicle. It is important that such factors are also acknowledged and incorporated in the provision of seating advice.

Conclusion

The posture coach appears to offer a viable solution to aid drivers in understanding and maximising the range of seat adjustments now available in modern cars. Combined with the novel use of the ECU diagnostic tool for the detection of seat position (an approach that could be applied elsewhere), there is clear potential for a posture coach to make recommendations periodically throughout a journey (based on the real-time position of the seat) to prevent static posture-related strain, although the potential impact on driver distraction would need to be considered, particularly if advice is provided visually.

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