to UDP–*N*-acetylglucosamine is catalysed by LpxA, was present only in trace amounts in the mutant. Also, no other *O*-linked 3-OH fatty acids in the range C_{10} to C_{20} could be detected. LPS biosynthesis could be restored in this knockout mutant by retransformation with wild-type *lpxA*, showing that the observed LPS deficiency must result from mutation in this gene only.

The availability of LPS-deficient mutants will allow new approaches to vaccine development against *N. meningitidis*[10] and the closely related pathogen *N. gonorrhoeae*, or any other bacteria for which such mutants can be isolated. Using an *lpxA* mutant, it will be much easier to purify OMPs or other cell-surface components without contamination by endotoxin. Also, the role of LPS in outer-membrane-vesicle or whole-cell vaccines (for example as adjuvant[11]) can be investigated: it may be possible to substitute a less toxic compound. And at a more basic level, such mutants can be used for studying how LPS contributes to the structure and biogenesis of the outer membrane.

Liana Steeghs, Ronald den Hartog, Arie den Boer, Bert Zomer, Paul Roholl, Peter van der Ley
National Institute of Public Health and the Environment, RIVM, PO Box 1, 3720 BA Bilthoven, The Netherlands
e-mail: peter.van.der.ley@rivm.nl

1. Zähringer, U., Lindner, B. & Rietschel, E. Th. in *Advances in Carbohydrate Chemistry and Biochemistry*, vol. 50 (ed. Horton, D.) 211–276 (Academic, San Diego, 1994).
2. Raetz, C. R. H. *Annu. Rev. Biochem.* **59,** 129–170 (1990).
3. Anderson, M. S & Raetz, C. R. H. *J. Biol. Chem.* **262,** 5159–5169 (1987).
4. Coleman, J. & Raetz, C. R. H. *J. Bacteriol.* **170,** 1268–1274 (1988).
5. Steeghs, L., Jennings, M. P., Poolman, J. T. & van der Ley, P. *Gene* **190,** 263–270 (1997).
6. Odegaard, T. J. *et al. J. Biol. Chem.* **272,** 19688–19696 (1997).
7. van der Ley, P., van der Biezen, J., Hohenstein, P., Peeters, C. & Poolman, J. T. *Infect. Immun.* **61,** 4217–4224 (1993).
8. van der Ley, P. *et al. Mol. Microbiol.* **19,** 1117–1125 (1996).
9. Friberger, P., Knos, M. & Mellstam, L. in *Endotoxins and their Detection with the Limulus Amebocyte Lysate Test* (eds Watson, S. W., Levin, J. & Novitsky, T. J.) 195–206 (Liss, New York, 1982).
10. Poolman, J. T. *Infect. Agents Dis.* **4,** 13–28 (1995).
11. Nakano, M. & Matsuura, M. in *The Theory and Practical Application of Adjuvants* (ed. Stewart-Tull, D. E. S.) 315–335 (Wiley, Chichester, 1995).

Speed perception fogs up as visibility drops

Many horrendous vehicle accidents occur in foggy weather. Drivers know they should slow down because fog reduces visibility, but many still drive too quickly[1]. The 'blame' for many such accidents may be due to a perceptual quirk: it appears that drivers think they are driving far more slowly than they actually are in foggy conditions, and therefore increase their speed.

We used a virtual-environment driving simulator to show that, as fog increases and therefore reduces the contrast of the driver's image, the apparent speed of the vehicle slows. Participants asked to drive at a certain speed drove faster as the scene became foggier.

An accurate representation of the current speed is normally provided to drivers by the speedometer. However, reading this instrument requires drivers to divert their gaze and attention from the road to the appropriate dial. In conditions of reduced visibility produced by fog, drivers are reluctant to divert their gaze from the road to the speedometer for fear of missing an object emerging from the fog[2]. Hence it is exactly in conditions of reduced visibility caused by fog that drivers rely on their own perceptual judgement of speed.

Thompson[3] has reported that the perceived speed of a moving-grating pattern depends on its level of contrast. As contrast decreases, the grating appears to drift more slowly. This effect has been replicated several times (and extended to other stimulus patterns[4]), but others have failed to replicate it or have shown that perceived speed is unaffected by random variations in contrast[5]. So it remains an open question as to whether this illusion of reduced speed with decreasing image-contrast will occur in conditions akin to those encountered when driving in fog.

We tested for the perceived slowing of a visual scene by conducting two experiments in a virtual environment that simulated the view from a vehicle moving along a road. Such a set-up allowed us to manipulate the visual stimulus in a highly specific manner.

Our first experiment involved showing the observer two scenes. In one scene, the weather was 'clear'; in the other, it was either 'clear', 'misty' or 'foggy'. The physical speed at which the two scenes appeared to move at the same speed was calculated (Fig. 1a) using standard psychophysical techniques. Subjects perceived the foggier scenes to be moving more slowly[6].

Does this perceptual change affect driving speed in a more realistic task? We trained subjects (in clear conditions) to 'drive' a simulated vehicle at set speeds along a winding road, using a brake, accelerator and steering column.

In the experimental phase, the subject was given a target speed and told to adjust the car speed (while steering along the road) to this target, using the accelerator and brake. Subjects accelerated and decelerated as they thought appropriate for as long as they pleased, and then signalled that they believed that they were travelling at the target speed. Trials in which the weather was 'clear', 'misty' and 'foggy' were randomly interleaved. As the scene became more foggy, subjects drove at faster speeds (Fig. 1b).

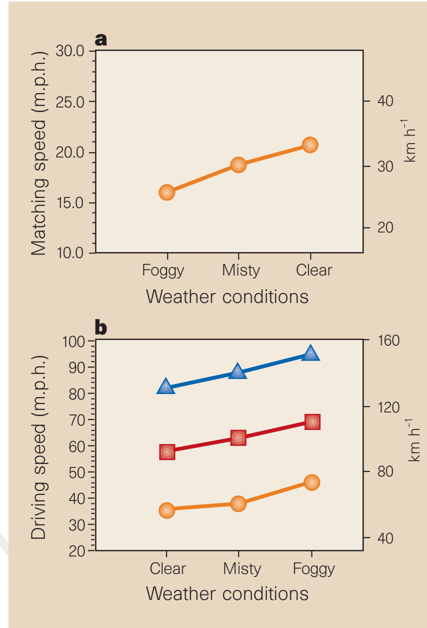

Figure 1 Sense of speed decreases in fog. **a,** Perceived matching speed averaged over all subjects (n = 5) in three weather conditions under passive viewing. Foggier scenes gave the impression of slower movement (one-way analysis of variance; $P < 0.001$). Simulation was performed using a Silicon Graphics Crimson Reality Engine that updated the viewing screen (60 Hz VDU monitor) at a rate of 15 Hz. 'Fog' was simulated by blending a partially transparent polygon over each pixel. For each pixel, the red, green and blue guns levels were recalculated (R') from the original pixel values (R) drawn from memory according to the formula, $R' = 255F + (1 - F)R$. 'Clear' conditions: $F = 0$, contrast (root mean square) = 0.61; 'misty': $F = 0.5$, contrast = 0.20; 'foggy': $F = 0.8$, contrast = 0.07. **b,** The actual speed driven under three weather conditions (n = 9). Target speeds: circles, 30 m.p.h. (48 km h^{-1}); squares, 50 m.p.h. (80 km h^{-1}); triangles, 70 m.p.h. (112 km h^{-1}). Analysis of variance showed significant effects of target speed ($P < 0.0001$) and weather conditions ($P < 0.0001$), but no interaction ($F < 1$).

This finding suggests that the 'blame' for many such accidents may not lie solely in the irresponsible nature of the drivers but with an unfortunate quirk of our perceptual systems.

Robert J. Snowden, Nicola Stimpson, Roy A. Ruddle
School of Psychology, University of Wales Cardiff, Cardiff CF1 3YG, UK
email: snowden@cardiff.ac.uk

1. Sumner, R., Bagulay, C. & Burton, J. *Driving in Fog on the M4* (Department of the Environment/Department of Transport, TRRL, Crowthorne, Berkshire, UK, 1977).
2. Brown, I. *New Scientist* 24 December 1970, 544–545 (1970).
3. Thompson, P. *Vision Res.* **22,** 377–380 (1982).
4. Blakemore, M. R. & Snowden, R. J. *Perception* **25,** 34A (1996).
5. Thompson, P. in *Visual Motion and its Role in the Stabilization of Gaze* (eds Miles, F. A. & Wallman, J.) 29–52 (Elsevier, Amsterdam, 1993).
6. Distler, H. & Bulthoff, H. H. *Perception* **25** (suppl.), 58 (1996).

Nature © Macmillan Publishers

Nature © Macmillan Publishers Ltd 1998