

PS3060: Perception and Action
**(L.3) Driving a vehicle: control of heading,
collision avoidance, braking**
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- the ecological approach to vision: from insects to humans
- standing up on your feet, keeping posture control
- visual control of speed and travelled distance
- collision: judging time to impact, braking a vehicle
- heading: how you know in which direction you are moving
- staying on the road: strategies to coordinate eye, head, steering wheel

http://www.pc.rhul.ac.uk/zanker/teach/Ps3060/L3/Ps3060_3.htm
(see also chapters 11, 12 of Bruce, Green & Georgeson 2003)

**the ecological approach to vision
- evolution & development**

- perception happens in an ecological context: surfaces offer rich information and are behaviourally relevant
- direct perception: visual information is directly used for behavioural control, without any high-level processing, storage, representation

insects: can be regarded as simple systems operating like automats
extensive evidence for direct visual control mechanisms (lecture 2)

what about humans? complex control, planning, decision making

- driving vehicle as example of most advanced case, clearly learned (but still largely automatically ?)
- some basic aspects appear to be innate: defensive response to approaching objects (Dunkeld and Bower 1980)

>>> interesting to look at development: fast behavioural responses without previous experience could be interpreted as 'direct perception'

the visual cliff

crucial for all terrestrial (walking, climbing) animals: not to drop from large heights >> needs to be learned? what is the crucial visual information?

visual cliff paradigm (Gibson & Walk 1960):
move along a platform with two sides: deep and shallow, covered by (invisible) glass

- human babies from earliest crawling age (6 months) avoid to cross the deep side
- increase pattern size on deep side (both sides identical static images) > still avoiding deep side > motion parallax used as cue
- decrease pattern size on one of two shallow sides (same motion parallax) > avoiding smaller texture > texture size used as cue



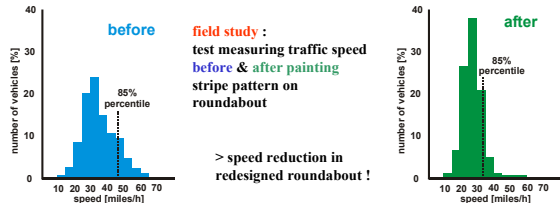
- two sources of visual information : texture gradients and motion parallax
- sensory mechanisms mature faster than locomotion: no experience required
- innate ? comparative approach (deprived animals)

speed perception

- simple psychophysics: **misjudgement of speed**, ambiguities from size, distance, field of view (Brown 1931, Zanker & Ryan 2001)
- what are the consequences for driving ? (Denton 1980)

experimental study : driving simulator, reduce speed after adaptation period

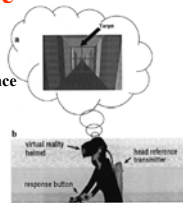
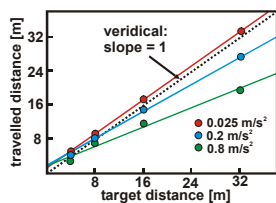
- underestimation of actual speed
- stronger reduction of speed (overestimation) if additional markers are introduced (stronger with higher frequency of markers)



travelling distance

virtual reality experiments (Redlick et al 2001):

- subjects are moving along a corridor: asked to stop at a defined (memorised) target distance
- subjects need to estimate travel distance from simulated optic flow



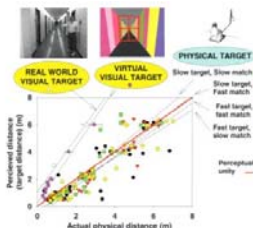
- target distance ~ travel distance
- constant velocity: undershoot
- constant acceleration (supra-threshold): good approximation of veridical distance

⇒ optic flow can be used for measuring travelling distance (remember the honeybee study...)

mixed input - crossmodal interactions

combined visual and vestibular stimulation for distance estimation (Harris et al. 2000)

- presentation of target distance ('perceived distance'): visually (real or virtual corridor) or physical (being moved in the dark to the target)
- **judgement of travelled distance by being moved in the dark** ('actual physical distance travelled' shown in figure), or by moving through virtual corridor



- good match of physically presented targets (perceptual gain approx. 1)
- substantial underestimation of target distance when presented visually (perceptual gain approx. 0.25)

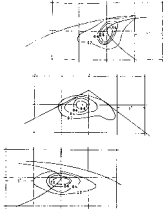
visual motion (virtual) shows the inverse effects : visually targets are matched well (gain approx. 1), physical target distances are substantially underestimated (gain approx. 0.25)

⇒ different sensory signals are processed with different gains, good performance only in combined or consistent type of information !

staying on the road

what do drivers do when steering a car through the real world?

the eye and steering movements of drivers have been recorded while negotiating a 'tortuous' road, suggesting simple pragmatic geometrical strategies that can produce adequate driving stability (Land and Lee, 1994)



drivers are found to keep their gaze in the direction of the tangent point of a curve for a large proportion of the time

this is thought to be an important point because its angle relative to the car's heading is a good predictor of the curvature of the road - keeping a constant angle is a simple pragmatic rule to keep the car on the road! (Land, 2001)

summary: control of locomotion

- posture, locomotion, vehicle control involves a lot of low-level mechanisms that can be related to direct perception
- such strategies seem to be mature before the onset of the relevant locomotor activity, do not require learning, are innate in certain animals
- travelling speed and distance can be estimated from optic flow, but is not always accurate
- a simple optical variable, tau, can be used to estimate the time until collision with objects, and may be used in braking - but its scope is debated
- the direction of heading can be derived from the analysis of the optical flowfield - but again, the actual importance of such mechanisms is debated
- the behaviour of drivers in real life can offer some surprises - a simple geometrical strategy has been identified for negotiating sharp bends

specific reading

- Bruce V, Green PR & Georgeson M (1996) Visual Perception: Physiology, Psychology and Ecology (3rd ed.) Hove: Psychology Press, (152.14 BRU) (ch 12, 13)
- Land, M F 2001 "Does Steering a Car Involve Perception of the Velocity Flow Field" In JM Zanker & J Zeil (Eds.), *Motion Vision - Computational, Neural, and Ecological Constraints*. (pp. 227-235). Berlin Heidelberg New York: Springer. (resources room)
- Lappe M, Bremmer F, Van den Berg AV 1999 "Perception of self-motion from visual flow" *Trends in Cognitive Sciences* 3, 329-335 (resources room)
- Lee DN 1976 "A theory of visual control of braking based on information about time-to-collision" *Perception* 5, 437-459
- Lishman JR, Lee DN 1973 "The autonomy of visual kinaesthesia" *Perception* 2, 287-294
- Tresilian JR 1999 "Visually timed action: time-out for 'tau'?" *Trends in Cognitive Sciences* 3, 301-310 (resources room)

complete reference list at :

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