Modifying the Lane Change Task – How does increased unpredictability of lane changes affect performance?

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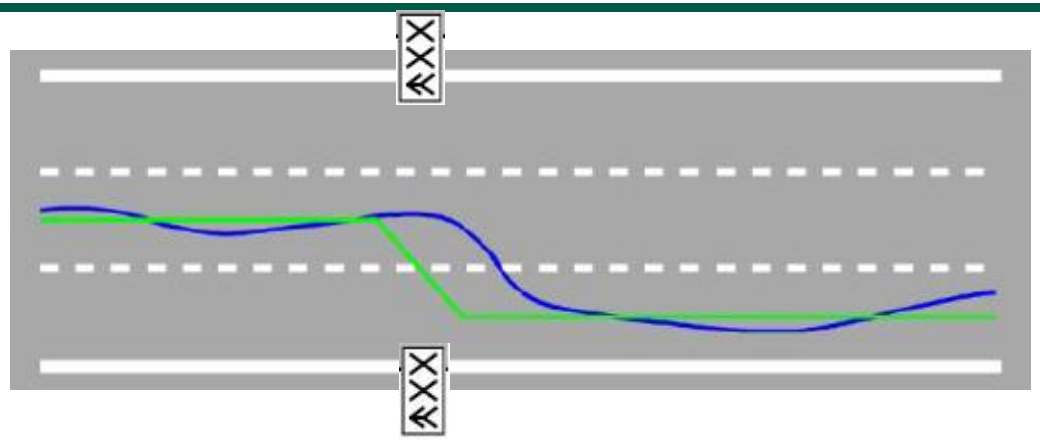
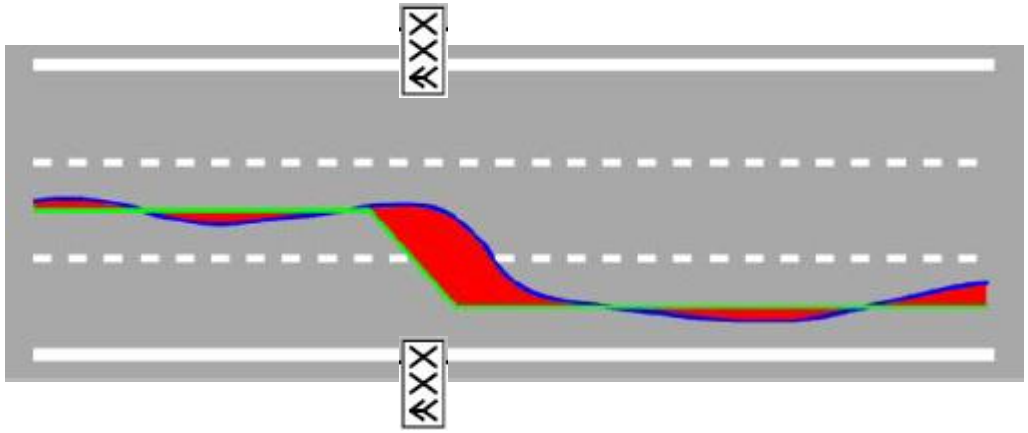
Lane Change Task/Test (LCT)

- speed limited to 60 km/h
- no other traffic present
- change to indicated lane as fast as possible

LCT Analysis



- reaction time
- accuracy of manoeuvre
- lane keeping performance



→ MDEV

LCT ISO standard

- “The intent of the LCT method is to have the following properties:
  - [...] Contain elements important to the driving task:
  - course following and maneuvering
  - event detection […]”

    (ISO/DIS 26022, 2010; p. 21)

    Results obtained from object and event detection methods “have direct links to driving safety”, whereas “the safety relevance of longitudinal and lateral control metrics [...] is less direct.” (Victor, Engström & Harbluk, 2009; p 145/146)

Distraction and event detection

- meta-analysis of effects of cell phones on driver performance (Caird et al., 2008):
  - among various variables, reaction time to events and stimuli was affected most
- other systems/technology with similar effects:
  - speech based e-mail systems (Lee et al., 2001)
  - visually demanding in-car tasks (Lamble et al., 1999b)
  - climate control adjustment (Greenberg et al., 2003)
- potential events:
  - suddenly braking lead vehicles (e.g. Alm and Nilsson, 1995; Lamble et al., 1999)
  - pedestrian stepping onto the driver's lane (Laberge et al., 2004)
  - changing traffic signals (Hancock et al., 2003)
  - artificial tasks/events – e.g. PDT/DRT (e.g. Patten et al., 2004)

LCT and event detection

- “mean distance from sign to sign is 150 m (a minimum of 140 m plus an exponentially distributed random variable with a mean of 10m)” (ISO/DIS 26022, 2010; p. 7)
  - none of the distances is shorter than 140 m
  - in more than 85% of all cases, the distance from sign to sign is between 140 and 160 m
  - lane change intervals are between 8.4 and 11.4 s
- “lane change signs are always visible”, although they remain “blank until the lane indications on the signs appear (i.e., pop up) at a distance of 40m before the signs” (ISO/DIS 26022, 2010; p.7)
  - position of the event to detect is known well in advance, just as when the event will occur
- in two out of three possible lane positions (left and right), no information processing or decision making is required to initiate a response
  - only behavioural option when arriving at a lane change sign: steer towards the other side of the road

What if the LCT would be less predictable?

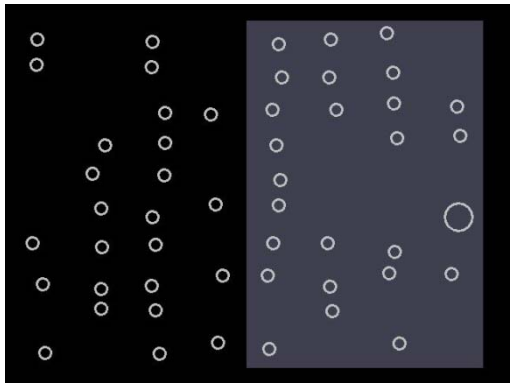
- overall degraded LCT performance (e.g. Green, 2000)
- event detection – unclear
  - e.g. Jamson & Merat (2005): stronger influence of cognitive distraction on event detection than visual distraction
  - e.g. Liang & Lee (2010): stronger influence of visual distraction on event detection than cognitive distraction
- response selection – probably stronger effect of cognitive distraction on LCT performance
  - e.g. Engström & Markkula (2007): LCT study, changes to the wrong target lane only under cognitive, not visual distraction; explained as either recognition or response selection failure
  - once information is perceived (which has to be the case in order to select a response), cognitive resources certainly are more relevant to facilitate the decision on an appropriate response than visual resources

Our experiments - LCT

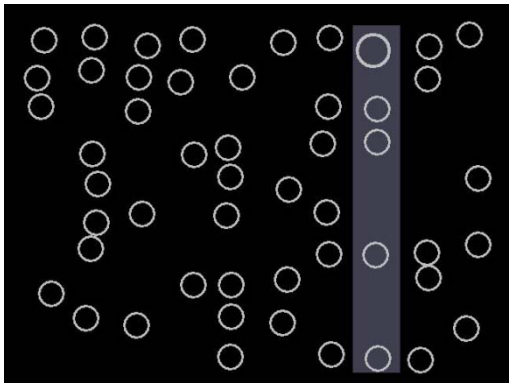
- Experiment I (ISO)
  - lane change signs permanently visible
  - lane change information popping up 40 m before passing the sign
  - distances between two signs of about 150 m (SD = 9.6 m; range 140.05-188 m); 8.4 to 11.4 s between lane changes
- Experiment II (position unpredictable)
  - blank signs removed from simulation, sign + information popping up 40 m before passing the sign
  - distances between two signs of about 150 m (SD = 33.7 m; range 73-219 m); 4.4 to 13.1 s between lane changes
- Experiment III (position & response unpredictable)
  - changes from Experiment II kept
  - additional signs: six instances in which two consecutive signs point to the same lane, i.e. no response required

Our experiments – Secondary tasks

- visual task - Surrogate Reference Task (SuRT)



easy



difficult

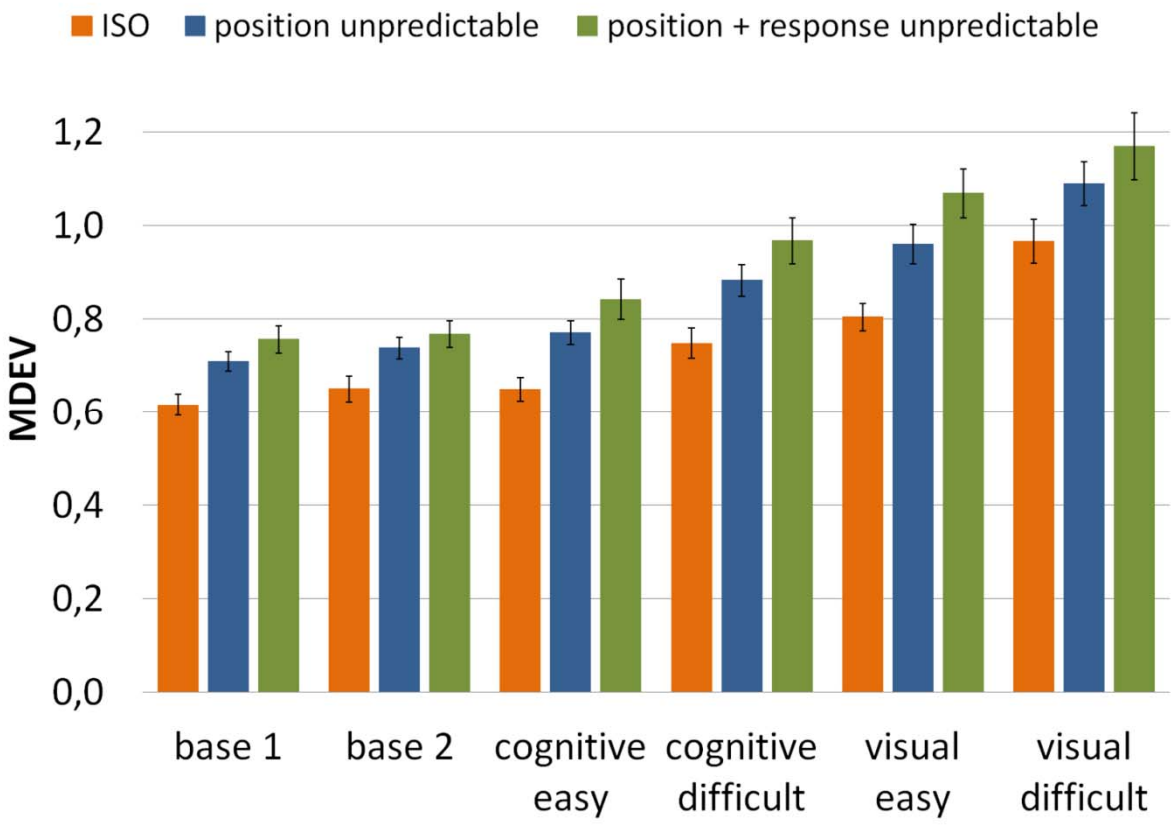
- cognitive task - counting task
  - easy: count forwards in steps of two, starting with 212
  - difficult: count backwards in steps of seven, starting with 581

Our experiments - General

- sample
  - 72 participants, 69 datasets in analysis (3 outliers)
  - 43 female, 26 male, mean age 22.7 years (*SD* = 3.1)

- procedure (in compliance with ISO recommendations)
  - LCT practice until performance threshold is reached
  - LCT baseline trial
  - secondary task (a) single task practice trial
  - dual task practice trial
  - dual task experimental trial
  - secondary task (b) single task practice trial
  - dual task practice trial
  - …
  - LCT baseline trial

Results – Basic MDEV

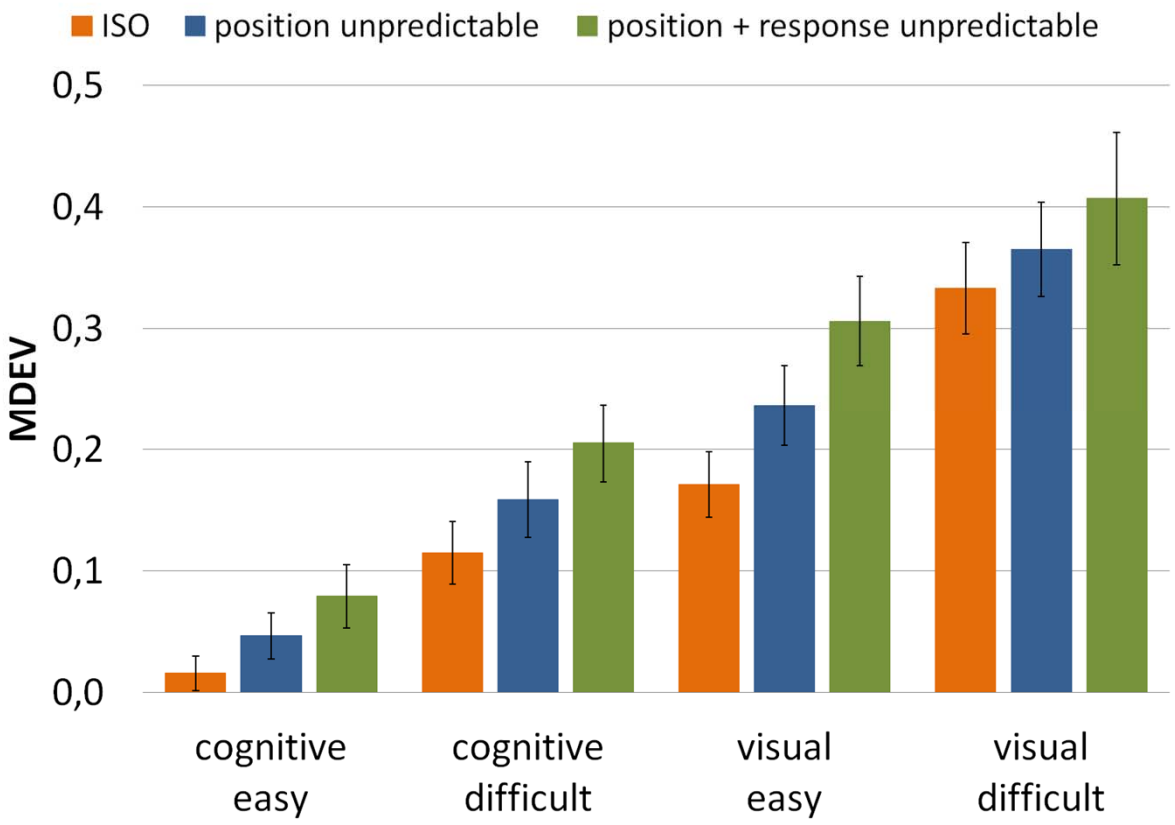


Task type
$F(5, 330) = 110.47$, $p < .001$, $\eta_p^2 = .626$

LCT implementation
$F(2, 66) = 9.67$, $p < .001$, $\eta_p^2 = .227$

no interaction

Results – Distance to Baseline (Basic MDEV)

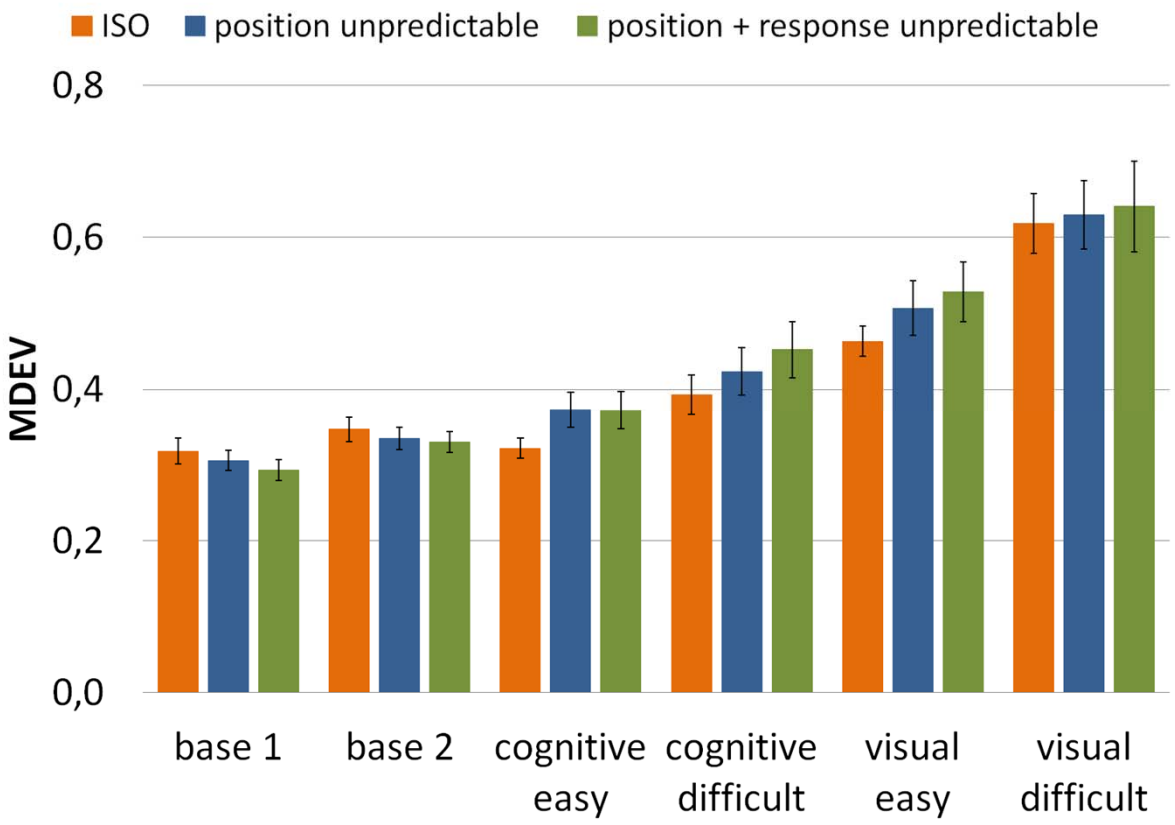


Task type
$F(3, 198) = 76.47$, $p < .001$, $\eta_p^2 = .537$

LCT implementation
$F(2, 66) = 3.92$, $p = .025$, $\eta_p^2 = .106$

no interaction

Results – Adaptive MDEV

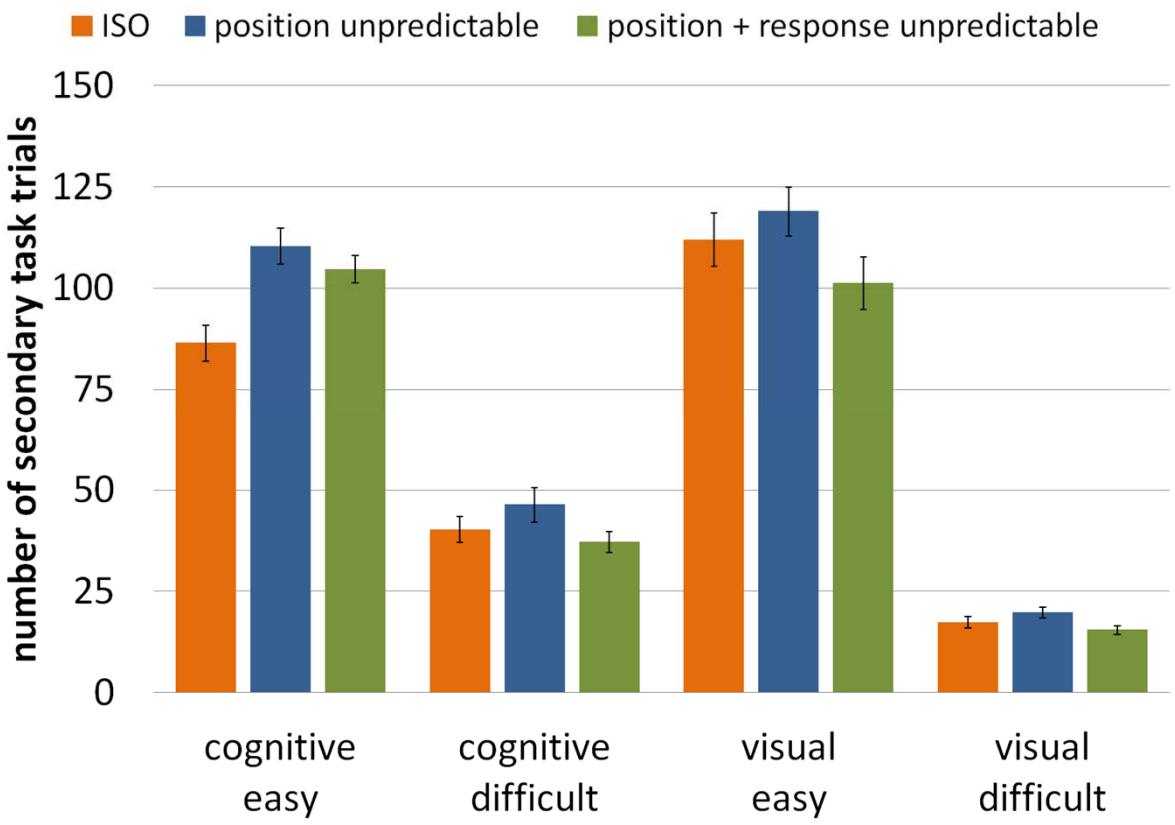


Task type
$F(5, 330) = 77.99$, $p < .001$, $\eta_p^2 = .542$

LCT implementation
$F(2, 66) = 9.67$, $p = .637$, $\eta_p^2 = .014$

no interaction…

Results – Secondary Tasks



Task type
$F(3, 198) = 570.54$, $p < .001$, $\eta_p^2 = .896$

LCT implementation
$F(2, 66) = 3.08$, $p = .053$, $\eta_p^2 = .085$

interaction
$F(2, 66) = 4.42$, $p = .001$, $\eta_p^2 = .118$

Summary

- influence of lowered predictability only on basic, not adaptive MDEV
- no influence on overall pattern of LCT results
  - (difference to baseline increased with decreased predictability)
- no clear sign of compensation for increased LCT difficulty in secondary task data

- a higher level of unpredictability in the LCT (i.e. a higher level of realism with regard to relevant safety critical events) did not produce fundamentally different results
- despite the lack of realism, the LCT as recommended by the ISO standard appears to generate quite valid results

Thank you!

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