Detection of Dangerous Drivers using the Empathizing-Systemizing theory and the measurement of Driver’s Visual Attention Capabilities with Real-time UFOV Method

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1. Introduction

Safety driver

Danger sensitivity is higher and tries to estimate its risky movement (latency risk), and get further information to perceive "Actual risk". Thus, he can have Td time to take evasive action.

Non-safety driver

Do not have a sense of danger, that is, there is no perception and cognition of the presence of danger at Time of Ta and the probability of evading an accident is low because there is a little room to take evasive action in the later stages.

An inherent component of "Danger sensitivity" is associated with near misses and accidents, and its acquired component is the ability to control oneself even when emotional.
The empathizing–systemizing (E-S) theory is based on the mind-blindness theory of autism spectrum conditions

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that has been successful in explaining the social and communication difficulties

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With the extreme male brain theory (Baron-Cohen, 2009), extended to two factors
to explain not only social but non-social features (the narrow interests, need for
sameness, and attention to detail).

**Cognitive style --＞ a person’s fundamental cognitive processes**

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E-S theory is a valuable to investigate the relationship between driving style and
cognitive style for risk assessment.

**Empathizing** is defined as the drive to identify and predict the moment-by-moment change in others’ emotions, thoughts, and behaviour, and to respond to these appropriately. This consists of cognitive and affective (sympathetic) components and is superior in the ability to read the minds of the traffic participants to evade accident or near miss (accident).

**Systemizing** refers to the drive to construct systems, to predict the behaviour of a system, and to control it. Thus, this system cannot read the minds of the individual person who changes.

Uruno et al (2001) reported that drivers involved in many accidents have a tendency towards weak perception ability and strong driving ability, and have a shortage of sympathy, that is, accident-prone drivers are inadequate at acting based on guessing others’ standpoints and feelings.
2. Method: E-S brain type model

To measure a person’s cognitive style (brain type), we classified into three an inherent nature of cognitive styles, based on Empathizing-Systemizing (E-S) theory.

**Type E brain --> Empathizing brain type: E > S**

**Type S brain --> Systemizing brain type: S > E**

**Type B brain --> Balanced brain type: E = S**

E-S theory plots empathizing and systemizing as two-dimensional coordinates and measure with Empathy Quotient (EQ) and Systemizing Quotient (SQ).
rUFOV measurement system

To measure the degree of driver's cognition error in actual normal driving, we focused the function of peripheral vision that is used to detect information.

Two video camera systems connected to a PC.

1. A road camera --> to measure the capability of driver's peripheral vision
   (to understand whether a driver is detecting traffic moving objects).
2. A driver-monitoring camera --> detects the driver's direction of gaze.

Road camera
uEye UI-1225LE-M (IDS-imaging Inc).
USB connection, 1/3” CMOS sensor, MT9V032 (Micron Inc.),
monochrome W-VGA resolution (752x480 pixels), 125° wide-angle lens

Driver monitoring camera
OpenCV computer vision library, TrackEye (10Hz framerate)
the practical spatial resolution level was about 3-5°, Haar face detection algorithm
and template matching algorithm was selected for detection of eye movement.
rUFOV measurement method

First stage (at Time A :Ta)
A driver with Ca of Central vision angle (β1 - β2) detected with a Pr (Peripheral angle : α1 - α2) of the road camera

Second stage (at Time B: Tb)
A driver move to his gaze direction with Cb of central vision range (u-, u+) to the bicycle (located in the column 370, Uob). and when it intersect the bicycle' position (Uob, Vob) as (1), he perceive it.

\[ u^- \leq u_{ob} \leq u^+ \quad ...(1) \]

Calculation process
The time to observe (reaction time): T [sec], the moved angles (yaw angle): Φ [degree] (such as β 0), the reaction speed: S [degree/sec] is defined by the following formula (2) from (4) with.

\[ T = T_a - T_b \quad ...(2) \]

\[ \Phi = |\Phi_a - \Phi_b| \quad ...(3) \]

\[ S = \Phi / T \quad ...(4) \]
3. Results: E-S type and near misses

E-S type and the near misses experienced in frequency (average value)

The monistic arrangement analysis of the variance result ($F(2,945)=4.85$, $p<.05$)

There is no main effect of sex ($F(1,946)=0.11$, $p>.1$) and no two-factor interaction of E-S type and sex ($F(2,945)=1.62$, $p>.1$).

The near misses experienced **Type S > Type E**

a "dangerous" driver is Type S and a "safe" driver is Type E
### E-S type vs. Perception/cognition factors for crossing-path accident

<table>
<thead>
<tr>
<th>Perception /Cognition</th>
<th>E type (160 people)</th>
<th>B type (554 people)</th>
<th>S type (233 people)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Share % (No./160)</td>
<td>Number</td>
</tr>
<tr>
<td>Distraction</td>
<td>1</td>
<td>0.6%</td>
<td>7</td>
</tr>
<tr>
<td>Eyes off the road</td>
<td>2</td>
<td>1.3%</td>
<td>11</td>
</tr>
<tr>
<td>No Safety Check</td>
<td>2</td>
<td>1.3%</td>
<td>9</td>
</tr>
<tr>
<td>Unable to Confirm</td>
<td>4</td>
<td>2.5%</td>
<td>13</td>
</tr>
<tr>
<td>Not enough Confirmation</td>
<td>5</td>
<td>3.1%</td>
<td>17</td>
</tr>
<tr>
<td>No miss</td>
<td>1</td>
<td>0.6%</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15</strong></td>
<td><strong>9.4%</strong></td>
<td><strong>62</strong></td>
</tr>
</tbody>
</table>

**Type S > Type E**

“No safety check” and “No miss”

**Type E > Type S**

“Not enough confirmation”

Type S is defined as the drive not to identify emotions and thoughts in others and not to respond to these with an appropriate emotion.

Type E tend to try to confirm anyhow
### E-S type vs. Judgment factors for crossing-path accident

<table>
<thead>
<tr>
<th>Judgement</th>
<th>Type E (160 people)</th>
<th>Type B (554 people)</th>
<th>Type S (233 people)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Share % (No./160)</td>
<td>Number</td>
</tr>
<tr>
<td>No attention movement</td>
<td>3</td>
<td>1.9%</td>
<td>24</td>
</tr>
<tr>
<td>Unable to predict</td>
<td>6</td>
<td>3.8%</td>
<td>21</td>
</tr>
<tr>
<td>Failure to check traffic rules and signs</td>
<td>6</td>
<td>3.8%</td>
<td>8</td>
</tr>
<tr>
<td>No miss</td>
<td>0</td>
<td>0.0%</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>15</td>
<td>9.4%</td>
<td>62</td>
</tr>
</tbody>
</table>

**Type S > Type E**
- "Unable to predict",
- "No attention movement"
- "No miss"

- "Not mindful of other drivers’ movements, and tend to neglect others’ movements"

**Type E > Type S**
- "Failure to check traffic rules and signs"

- Weak in rules
UFOV measurement results

<table>
<thead>
<tr>
<th>Subject (E-S type)</th>
<th>Normal driving</th>
<th>Haste driving</th>
<th>Change (Haste/Normal)</th>
<th>Normal driving</th>
<th>Haste driving</th>
<th>Change (Haste/Normal)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Response speed (Deg./Sec)</td>
<td>Vehicle speed (km/h)</td>
<td>Response speed (Deg./Sec)</td>
<td>Vehicle speed (km/h)</td>
<td>Response speed (Deg./Sec)</td>
<td>Vehicle speed (km/h)</td>
</tr>
<tr>
<td>A(B)</td>
<td>17.84</td>
<td>42.79</td>
<td>7.79</td>
<td>54.45</td>
<td>0.44</td>
<td>1.27</td>
</tr>
<tr>
<td>B(EE)</td>
<td>7.73</td>
<td>24.66</td>
<td>11.99</td>
<td>43.29</td>
<td>1.55</td>
<td>1.76</td>
</tr>
<tr>
<td>C(E)</td>
<td>13.63</td>
<td>51.44</td>
<td>8.16</td>
<td>42.36</td>
<td>0.60</td>
<td>0.82</td>
</tr>
<tr>
<td>D(S)</td>
<td>13.32</td>
<td>31.12</td>
<td>6.55</td>
<td>43.64</td>
<td>0.49</td>
<td>1.40</td>
</tr>
<tr>
<td>E(ES)</td>
<td>10.94</td>
<td>38.50</td>
<td>5.66</td>
<td>44.05</td>
<td>0.52</td>
<td>1.14</td>
</tr>
<tr>
<td>Average</td>
<td>12.69</td>
<td>37.70</td>
<td>8.03</td>
<td>45.56</td>
<td>0.63</td>
<td>1.21</td>
</tr>
</tbody>
</table>

Note: Degree is converted from yaw angel data (rad) measured with the faceLab system and ±180 of real-valued.

**Human factor (Mental workload change)**
Change S in "Average" was decreased to 0.63 (normal driving : 12.69 --> hasty : 8.03)
Vehicle speeds in "Average" was increased to 1.21 (normal driving : 37.70 --> hasty : 45.56)
-->Hasty driving for driver’s gaze direction to turn to objects that are closer to the driver due to Td time difference caused with the driving speeds.

**Environmental factor (Traffic scenario change)**
Change S in "Average" was increased to 1.08 (normal scenario : 12.69 --> complicated : 13.65)
Vehicle speeds in "Average" was decreased to 0.37 (normal scenario : 37.70 --> hasty : 13.88)
-->Where drivers are not visible for hazards that hides in shape, they tend to slowdown their vehicle speed and increase response speed to encounter the latency risk.
Attention mechanism

In the complicated traffic scenario (Left figure),
A driver increase deep (longer time) cognition with the smaller size of UFOV and increase their eye movement frequency.

--> Risk in detection error since no mutual overlap of UFOV

In the normal traffic scenario (Right figure)
A driver decrease deep cognition with the larger size of UFOV with smaller moving distance, and decreasing its moving frequency and overlap mutually

Complicated traffic scenario

Normal traffic scenario
Response speeds (S) comparison between Type E and Type S

<table>
<thead>
<tr>
<th></th>
<th>Normal driving</th>
<th>Haste driving</th>
<th>Change (H/N)</th>
<th>Normal traffic</th>
<th>Complicated traffic</th>
<th>Change (H/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE E</td>
<td>13.81</td>
<td>9.43</td>
<td>0.68</td>
<td>10.38</td>
<td>12.86</td>
<td>1.24</td>
</tr>
<tr>
<td>TYPE S</td>
<td>11.28</td>
<td>6.72</td>
<td>0.60</td>
<td>9.12</td>
<td>8.88</td>
<td>0.97</td>
</tr>
</tbody>
</table>

Human factor: Normal driving ---> Haste driving
Type E > Type S,
Change S for Type E < Change S for Type S
--> Type E shows a lower influence

Environment factor: Normal traffic ---> Complicated traffic
Type E > Type S,
Change S for Type E < 1.0 ---> Type E increased his speed
Change S for Type S >1.0 ---> Type S decreased his speed
--> Type S shows an inability to cope with

“Safety” drivers tend to decrease their vision angle and increase reaction speeds to percept the increased number of traffic hazards.
--> Type S is “Non-safety drivers”, or “dangerous drivers”
--> No contradiction with the Web survey findings
4. Discussion

Measurement results for subject B as an example case

Normal driving for complicated traffic scenario

Comparison
- Closer to the hazard
- Vision range (UFOV) seems to become narrower
- More on the central view and less on the peripheral view
- Unable to detect hazards
- Lack of Td time
- Resulted in a collision

Hasty driving for complicated traffic scenario

Note A green line: the traced propagation path of the object
The red box: the gaze area of 13° measured from the yaw angle
The blue box: the face direction
5. Conclusion

Driver education in Japan puts more importance on driving skill and complying with road law.

The E-S theory is intended to identify drivers’ inherent cognitive styles as the primary cause of traffic accidents and to measure “degree of accident-proneness” in advance of driving, since not all drivers are equally “dangerous”.

--> E-S theory is useful to identify “dangerous” drivers.

--> We propose that the E-S theory can be incorporated into the driver aptitude test (before a license provision) with regard to the inherent nature of cognitive style.

Incorporating into a driving simulation environment with the rUFOV method, the response speed of Type S compared to Type E has shown slower for both with increasing mental load task and the complicated traffic scenario (high risky circumstance).

--> Type S is the “dangerous driver” in comparison with Type E and can be measured its degrees in terms of the reduction change between current values and the past (standardized) values over an extended period of time to warn drivers during driving.
The driver’s visual attention capability (the function of the peripheral view) that may be impaired due to alcohol, fatigue or conversation can be measured by the rUFOV method, -->it would be preferable to install it into a driver support systems and monitor the driver’s UFOV in real-time instead of an annual check for renewing the driver’s license for safe driving.