



Human factors and road tunnel safety regarding users

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Introduction

Human behaviour models

behaviour in normal situations

behaviour in critical situations

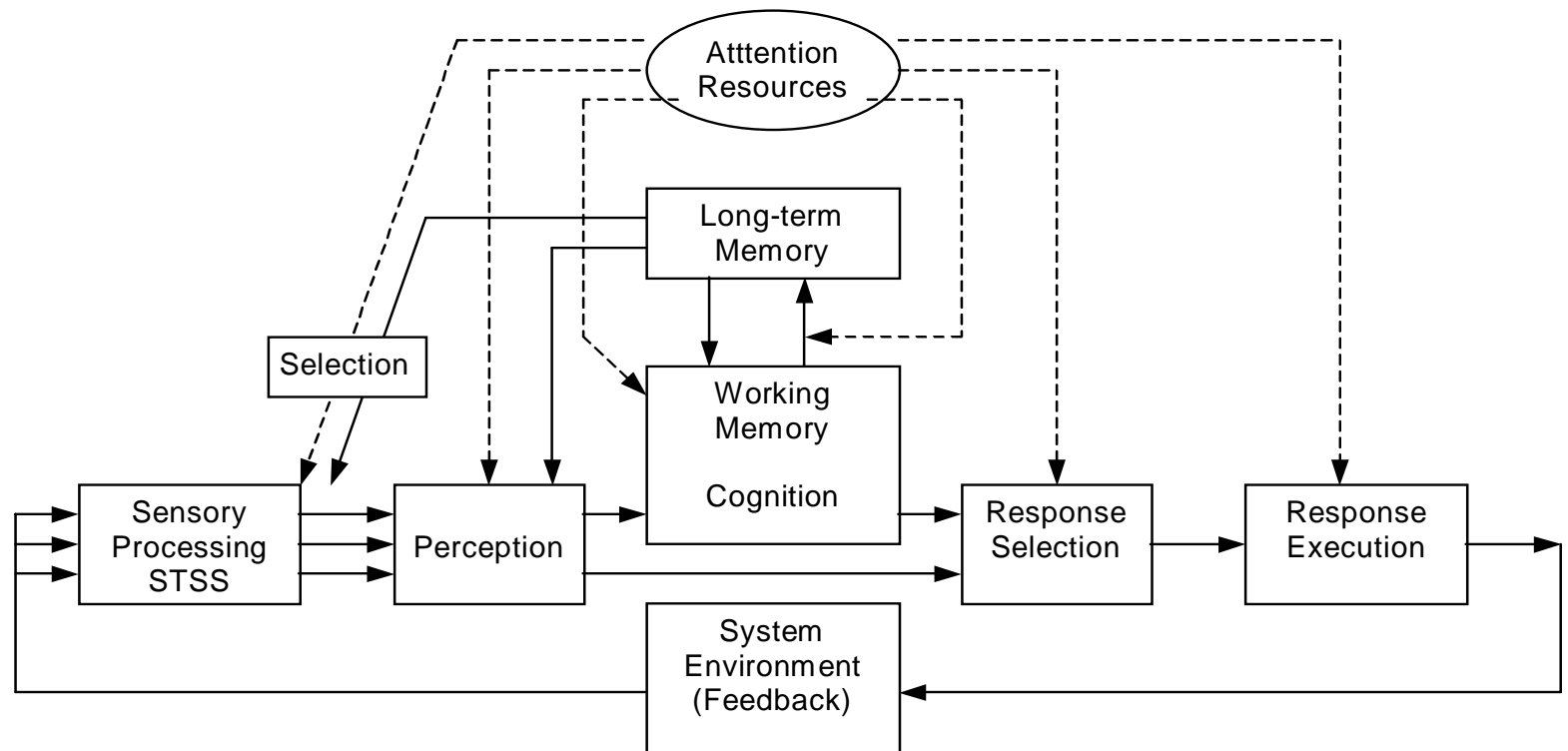
recommended additional measures for normal situations

recommended additional measures for critical situations

main conclusions

- **Better understanding of human behaviour**
- **Integral tunnelsystem**
 - road user
 - operation
 - infrastructure
 - vehicles
- **Minimum requirements**
- **Additional possibilities**

Wickens scheme





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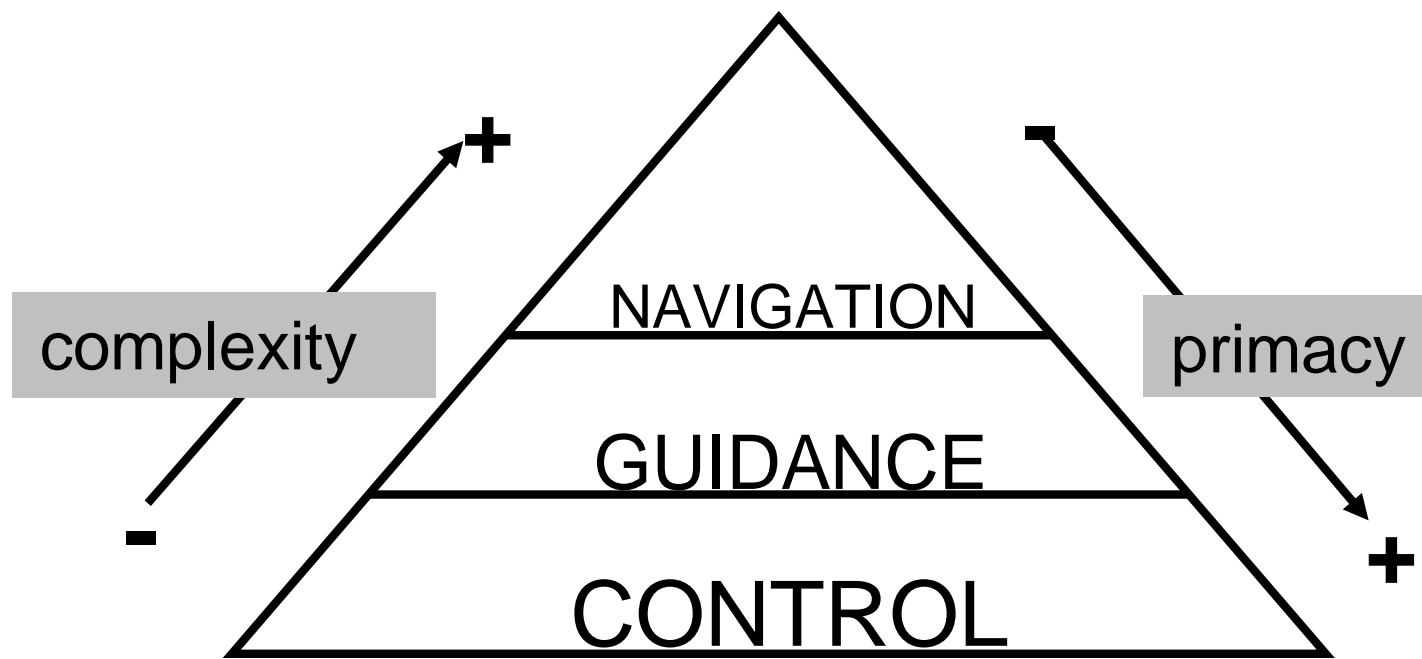
recommended additional measures for critical situations

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Rasmussens model:

- **Skill based**
- **Rule based**
- **Knowledge based**

Allen et al



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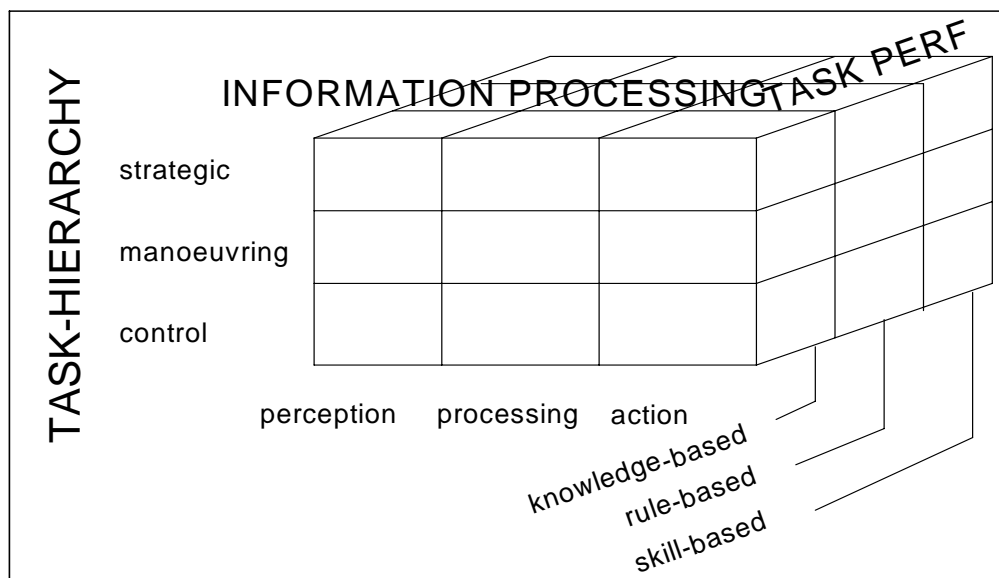
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main conclusions

Theewes scheme



Perception:

- Perceivable
- Simple
- Readable
- Credible
- Reliable
- Memorable
- Easy to understand



Before the tunnel entrance:

- **Warning for approaching last exit**
- **Dangerous entrance zone**
- **Sight conditions**
- **Drivers attention focussed on entrance**
- **Narrowing**



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In the tunnel:

- **Tunnel fear**
- **Threat of getting stuck**
- **Interior design**
- **Monotony**
- **Possibility of receiving radio**



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In the tunnel:

- **Speed**
- **Keeping distance**
- **Perceiving signs**
- **Lack of knowledge**
- **Junctions**



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Leaving the tunnel:

- **Clear exits?**
- **Unexpected weather conditions**
- **Glaring light from the sun**



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Important scenarios:

- **Congestion**
- **Vehicle breakdown**
- **Accidents**
 - **injuries**
 - **vehicle damage**
 - **fires**



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Important behaviour:

- **Not keeping distances**
- **Not aware of critical situation**
- **No idea about safety measures**
- **Try to turn**
- **Not realising danger of smoke**



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Important behaviour:

- **'Normal' action as long as possible**
- **Not knowing how to use an extinguisher**
- **No idea of escape routes**
- **Late reaction**



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Recommendations:

- **Driving lessons**
- **License tests**
- **Special training for truck drivers**
- **International sign indicating last exit**
- **Harmonise sign prohibiting dangerous goods**

Recommendations:

- **Modern tunnel sign**
- **Extend meaning of sign (EU leaflet)**
- **Signs far enough before entrance**
- **Repeat signs**
- **Trajectory control instead of 'point' control**



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Recommendations:

- **International sign for trajectory control**
- **Tunnel length remaining and already covered**
- **Standard colours indicating verges of the road**
- **Rumbling strips for edge lane marking?**



Recommendations:

- **International harmonisation for VMS**
- **Improve lay out lay-bys**
 - **TMS**
 - **CCTV monitoring**
 - **combining with emergency stations**
 - **combining with emergency exits**





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Recommendations:

- **Emergency stations:**
 - **standard orange**
 - **avoid feeling save**
 - **standard opening detection**
 - **standardised pictograms**



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Recommendations:

•Radio communication:

- rebroadcast all stations**
- equipment to support RDS, EON and TA**
- prerecorded messages**

Recommendations:

•Evacuation:

- uniform and harmonise signage systems**
- use additional direction signs**
- visual / tactile / acoustical signalling**
- guidance also behind the escape doors**



Main conclusions:

- **Importance of understanding how to behave**
 - **driving lessons**
 - **continuous information campaigns**
- **Harmonise**
 - **safety equipment**
 - **signs**
 - **signals**
 - **messages**
 - **colours**

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Main conclusions:

- **Green:** emergency exits
- **Orange:** emergency stations / communication equipment
- **Red:** fire extinguishing equipment





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Main conclusions:

- **signs and signals not at the entrance**
- **alert by different channels**



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Thank you for your attention