Analyzing the relationship between behavioral measures of the attentional networks performance & self-report data of attention-related driving errors

M.F. López Ramón, C. Castro*, J. Roca*, Ledesma, R., y J. Lupiañez***

• University of Granada. SPAIN

•Centro de Investigación en Procesos Básicos, Metodología y Educación CONICET-

•Universidad Nacional de Mar del Plata. ARGENTINA

Attention & Driving
Distraction & Driving

Driving is an example of an everyday task in which survival relies on attention and, particularly, on visual attention Recarte and Nunes (2008)

DISTRACTION

Explanatory concept for traffic accidents,

= attentional inefficiency:
a dysfunction in information processing
leading to increased risk and human error.

Research Aim

By combining **attentional behavioral measures** and **self-report data**, it was explored the relationship between:

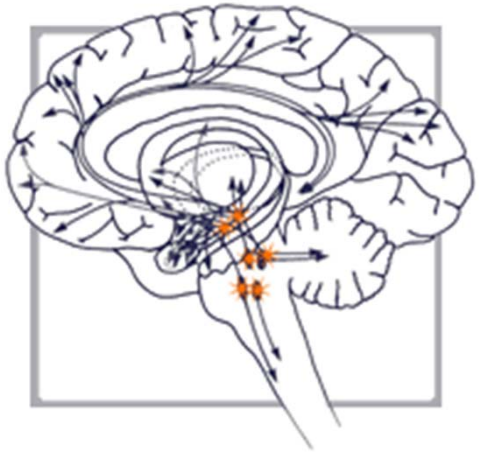
- **Attentional Networks Functioning**

  ANTI & ANTI-V (+ Vigilance)

  - **Alerting,**
  - **Orienting, and**
  - **Executive Control Networks (Posner´s 1994)**

- **personal proneness to attention-related errors while driving- ARDES- Scale**
- Driver Behaviour Questionnaire - DBQ

Combining **attentional behavioral measures** and **self-report data**, could be a successful tool to study attentional errors to better understand driving behaviour and to spot specific ways to tackle accident prevention?



+

Aim of the study

Experiment 1

ANTI

Attentional Network Test- Interactions

ARDES-Scale

personal proneness to attention-related errors while driving

Experiment 2

ANTI-V

Attentional Network Test- Interactions

+ Vigilance

Driver Behaviour Questionnaire

(DBQ)

Inattentional Errors & Traffic Accident

- Reason (1990) defined as “INATTENTIONAL ERRORS” the ones that take place during the execution of highly exercised routine actions and play an important role in the study of traffic accidents.

What is a driver distraction?

What is a driver distraction? What is driver inattention?

- See Regan, et al. (2011)

The term distraction has been defined as the "diversion of the mind, attention, etc., from a particular object or course; the fact of having one's attention or concentration disturbed by something"

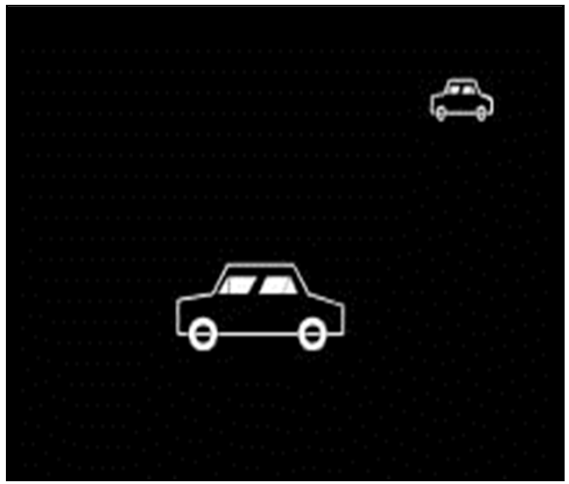
(Shorter Oxford English Dictionary on Historical Principles, 2002,1772 M.A.

Attention and Driving Performance

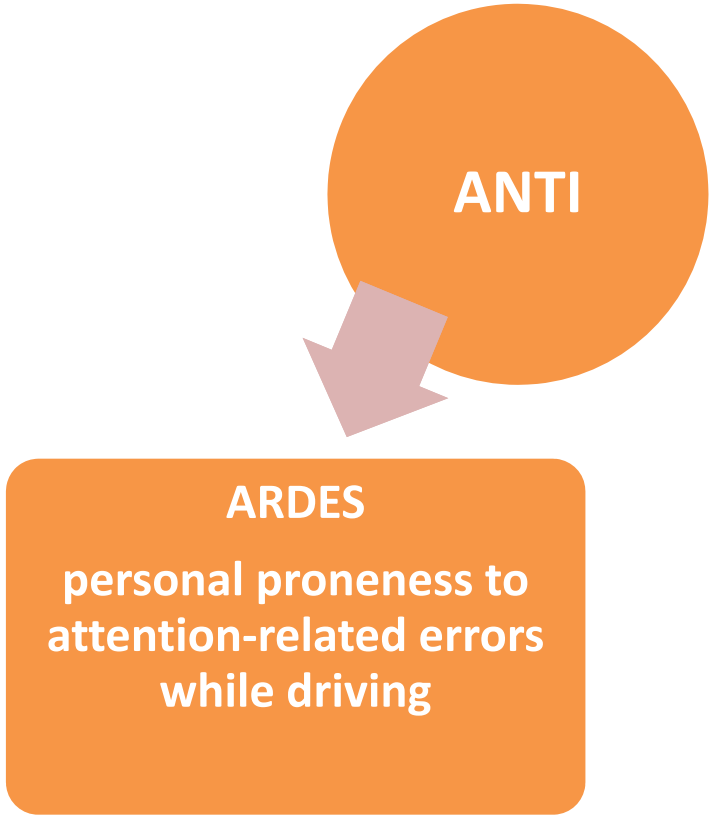
ANT measures → Driving performance

Weaver et al. (2009):

- ANT Global RT → Useful Field of Vision (R^2=.685) Association UFOV & **EC** (R^2=.21)
- ANT Global RT → Manitoba Road Test (R^2=.564)
- But **no association** with **PhA**, **O** or **EC**
  - (neither with real or simulated driving) Why?
  - Too unspecific ?



EXPERIMENT 1



ATTENTIONAL NETWORKS Test:

ORIENTING

EXECUTIVE CONTROL

ALERTING

Safe driving relies on the Attentional Networks functioning correctly.

ORIENTING

Orienting is manipulated by

presenting a cue indicating

where in space a person should focus attention

to direct attention to the cued location

either overtly by moving the eyes

or covertly without any eye movement

EXECUTIVE CONTROL

Is active when the cognitive system faces situations that involve: *(Norman and Shallice, 1986)*

- *planning,*
- *making a decision,*
- *detecting an error,*
- *giving a novel response or*
- *overcoming habitual actions*

TASKS dealing with: *CONFLICT,*
HANDLING NOVELTY
DETECTING ERRORS

ALERTING

can be considered as…

Phasic alertness

Non-specific activation occurs when a warning signal is presented prior to the target.

Studied by measuring the influence on reaction time (RT) of a signal that provides only temporal information.

ANTI

BASED on ANT, Fan, McCandliss, Sommer, Raz and Posner (2002)

ANTI by Callejas, Lupiañez and Tudela (2002)*

Combines elements of:

Posner's cueing paradigm. ORIENTING

Valid Invalid

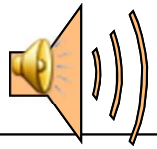
X *

Eriksen & Eriksen flanker task EXECUTIVE CONTROL

CONGRUENCY **<= <= <= <= <=** Congruent

<= <= => <= <= Incongruent

Alerting tone Phasic Alertness ALERTING



The ANTI- Test Provides measures of 3 distinct functions of attention in aprox. 30 min

» **- Orienting – Alerting - Executive Function**

Instructions ANTI test

A series of five arrows will be shown in the centre of the screen.

Your task consists of saying in which direction the central arrow is pointing.

To answer, please press the following keys:

"c" if the central arrow points to the left <=

"m" if the central arrow points to the right =>

For instance, in this case you should press the “left” key:

<= <= <= <= <=

but in this case you should press the “right” key:

=> => => => =>

…Instructions

Sometimes the central arrow will point in the opposite direction to the other arrows. Please, remember:

You should pay attention to the direction of the central arrow.

=> => <= => =>

In this case you should press the “left” key.

In the centre of the screen a small cross “+” will appear. This is the fixation point. The arrows will appear above or below the fixation point.

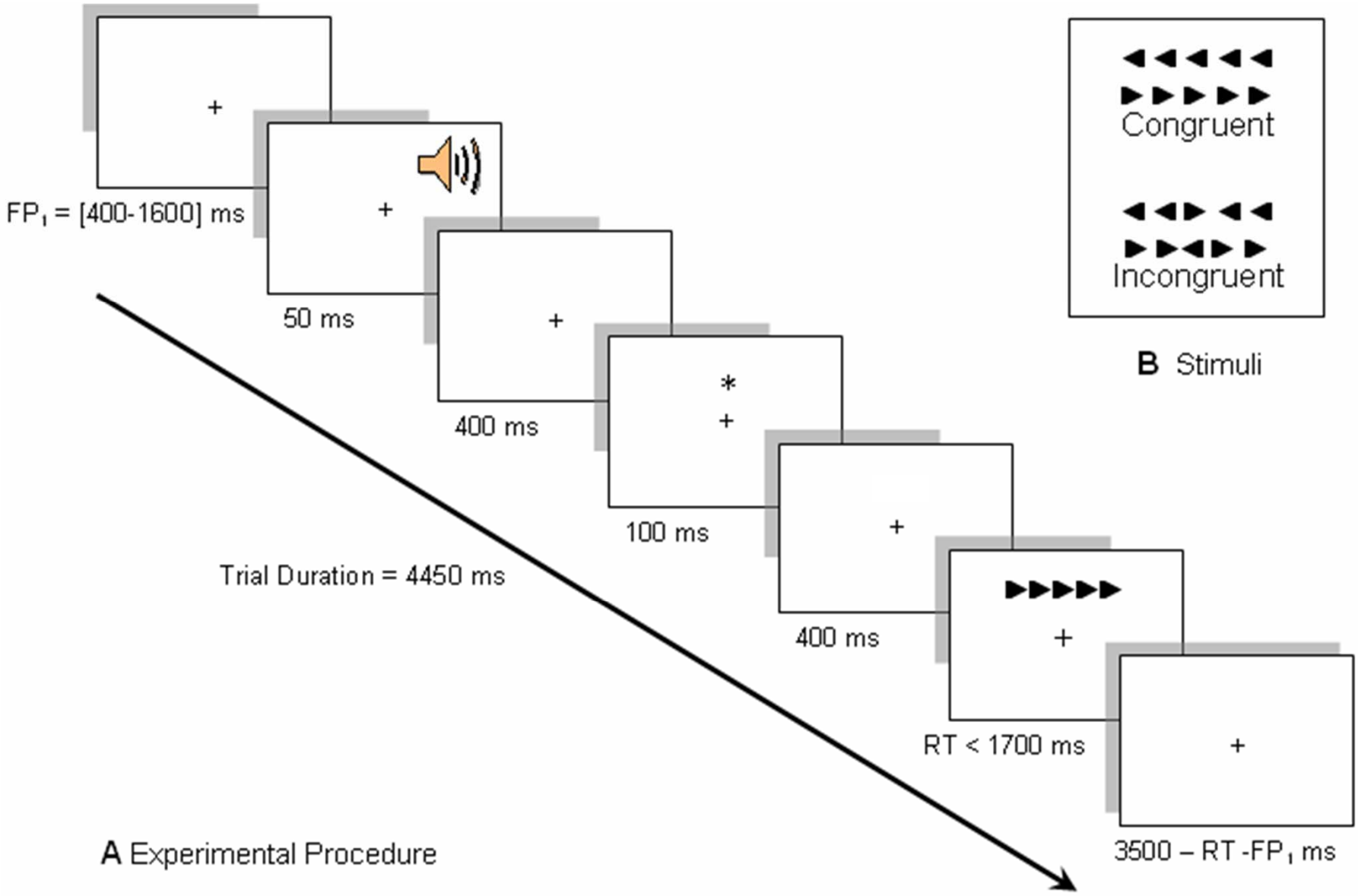
=> => <= => =>

+

=> => <= => =>

KEEP LOOKING AT the fixation point THROUGHOUT THE EXPERIMENT

Method


FP1 = [400-1600] ms
50 ms
400 ms
100 ms
400 ms
RT < 1700 ms
3500 – RT -FP1 ms
Trial Duration = 4450 ms
A Experimental Procedure
Congruent
Incongruent
B Stimuli

ARDES

(Propensity Attention-related Driving Error Scale)

- The ARDES (Ledesma, Montes, Poo & López-Ramón, 2010) scale is composed of 19 items that are formulated as affirmations concerning **errors of inattention** which participants may experience during driving.

- Examples:
- **"Suddenly I notice that I have the wrong way in a road that I know ”**
- **"When I come to a corner, sometimes I don't realize that a pedestrian is crossing the street ”.**

- 1) never or almost never, 2) sometimes, 3) often, 4) frequently, 5) always.

Participants: 55 Drivers

31 males, 24 females. Driving experience no less than twice a week during the last 2 years

ARDES-LOW (Lower Driving Errors)

ARDES-HIGH (Higher Driving Errors)

ARDES Propensity Attention-related Driving Error Scale

AGE

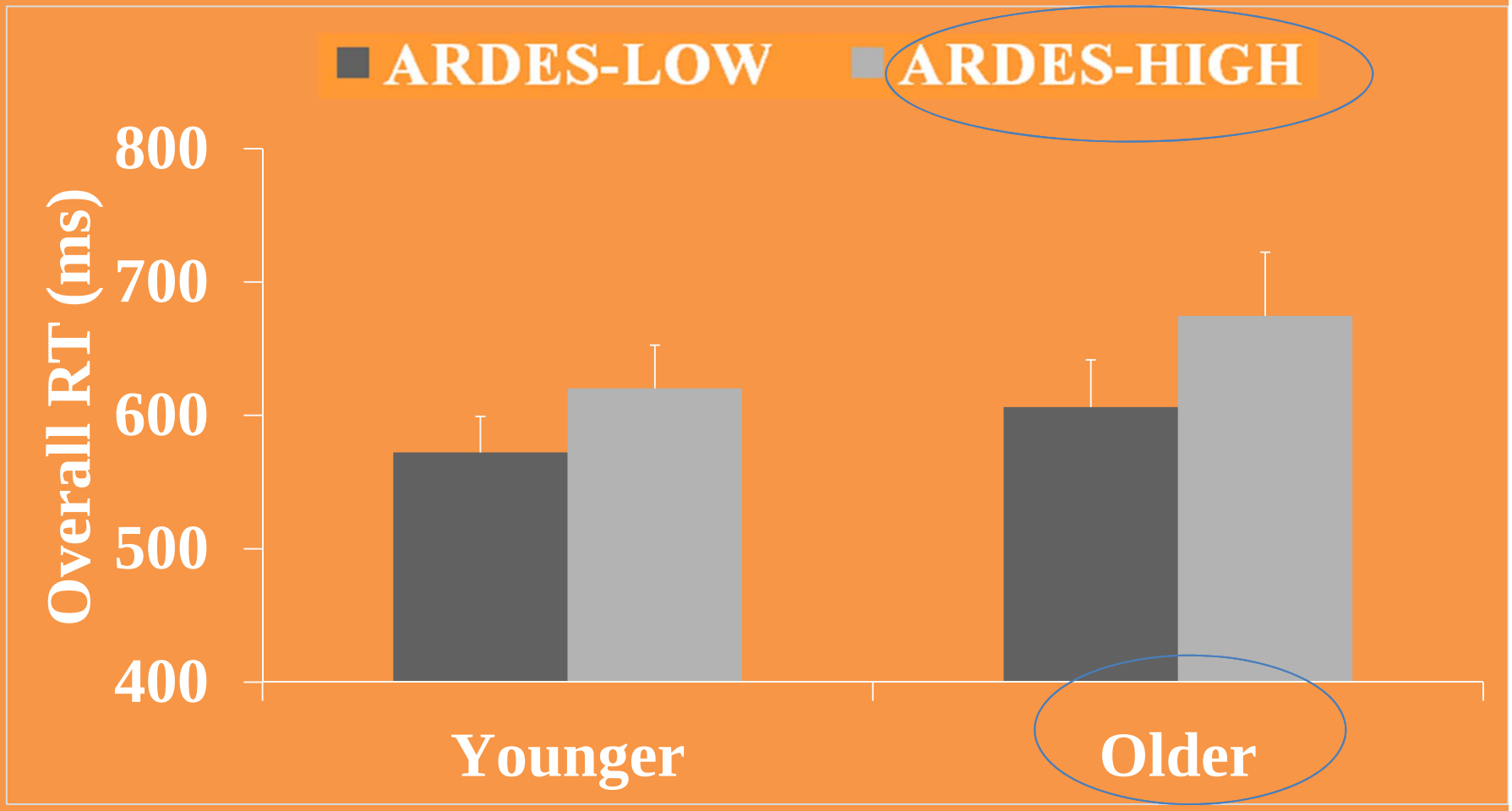
Younger (21 to 39 years old) (M=31,51)

Older (40 to 70 years old) (M=52.5)

AGE (N)	ARDES Low	ARDES High
Younger	15	12
Older	11	17

Main Effects

Slow down in performance



ARDES: (*F*(1, 51)=8.43, *p*<.01, *Eta*^{2}=.14)

AGE: (*F* (1, 51) =4.87, *p*<.05, *Eta*^{2}=.09)

Two way interactions

ALERTING x ARDES: (*F* (1, 51) = 4.20, *p*<.05, Eta^2=.08)

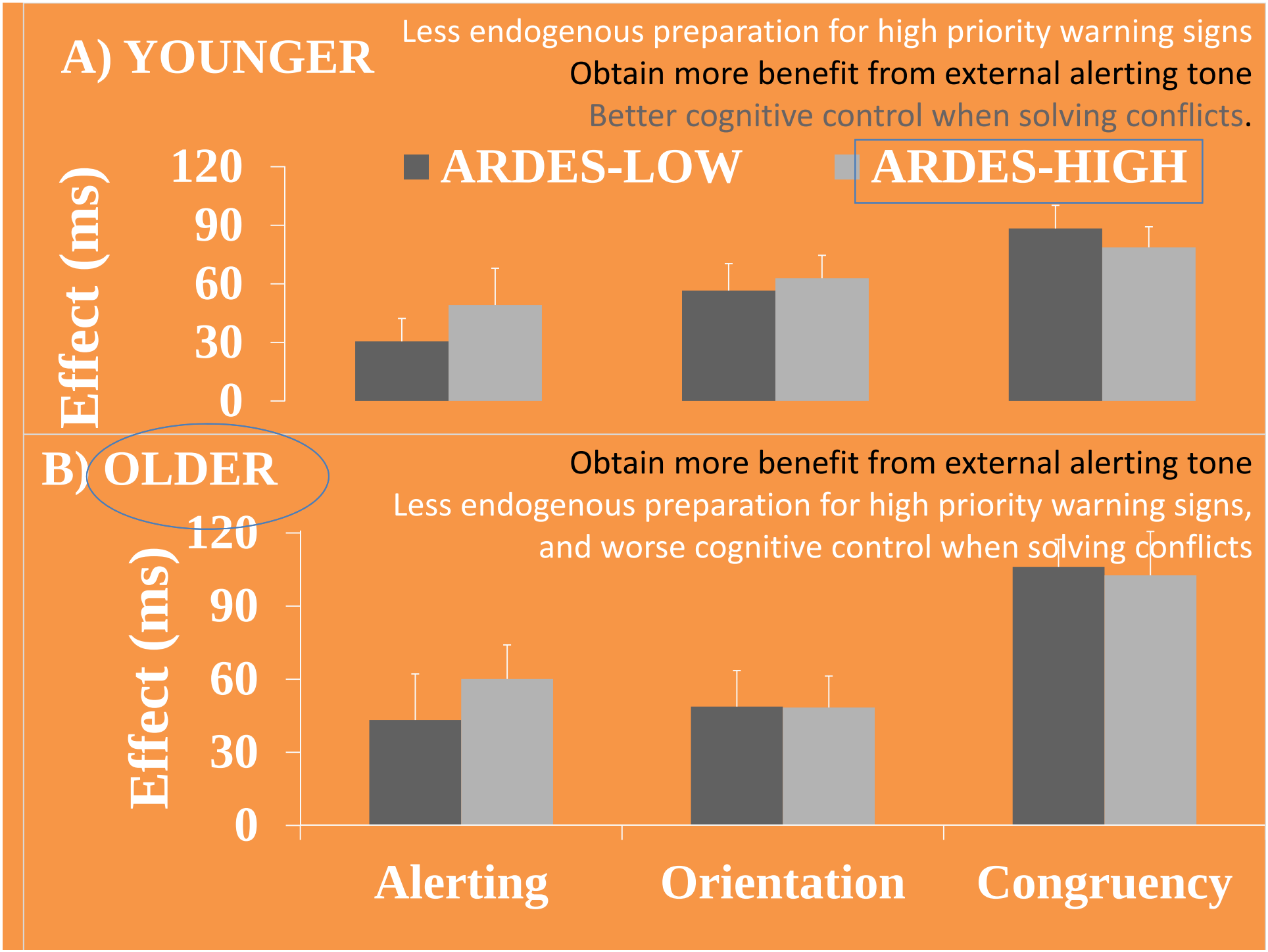
ALERTING x AGE: (*F* (1, 51)=5.5, *p*<.05, Eta^2=.1)

CONGRUENCY x ARDES: *p* = ns

CONGRUENCY x AGE: (*F* (1, 51) =7.8, *p*<.01, Eta^2=.13)

ORIENTING x ARDES: *p* = ns

ORIENTING x AGE: *p* = ns


A) YOUNGER
Less endogenous preparation for high priority warning signs
Obtain more benefit from external alerting tone
Better cognitive control when solving conflicts.
ARDES-LOW
ARDES-HIGH
Effect (ms)
120
90
60
30
0
B) OLDER
Obtain more benefit from external alerting tone
Less endogenous preparation for high priority warning signs,
and worse cognitive control when solving conflicts
Effect (ms)
120
90
60
30
0
Alerting
Orientation
Congruency

Conclusions

We replicated the data of Callejas et al. (2005) to the general functioning of the attentional networks and their interactive modulations.

ARDES HIGH + OLDER DRIVER

Overall slowdown in performance.

Obtain more benefit from external alerting tone, that is,

endogenously less able to process alerting tone.

More Phasic Alertness

A low level of vigilance.

See: López-Ramón, M. F., Castro, C., Roca, J., Ledesma, R., & Lupiañez, J. (in press). Attentional networks functioning and attentional lapses while driving. *Traffic Injury Prevention.*

Conclusions

ARDES HIGH =/= OLDER GROUP

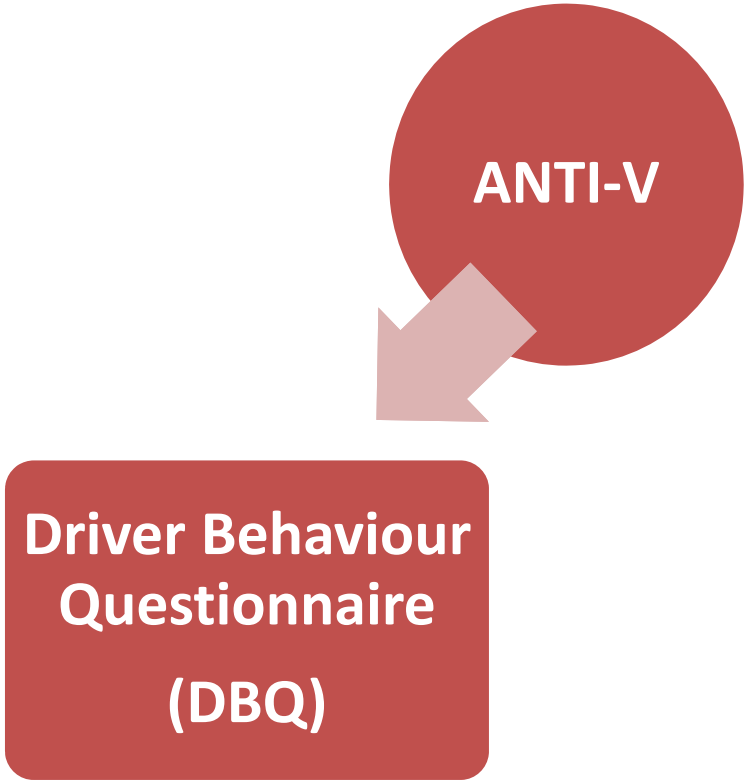
ARDES HIGH : A *better response to conflict in the presence of valid cues* than the group having fewer attentional lapses while driving (that is more engaged in the attentional task, and shows a greater increase of interference in the presence of invalid cues).

OLDER DRIVERS: Greater effect of cognitive interference that is, worse cognitive control when solving conflicts, worse decision making, in comparison with younger drivers.

We suggest that each attention-related error and age group shows a particular combination of attentional networks functioning relevant to the driving domain.

See: López-Ramón, M. F., Castro, C., Roca, J., Ledesma, R., & Lupiañez, J. (in press). Attentional networks functioning and attentional lapses while driving. *Traffic Injury Prevention.*

EXPERIMENT 2

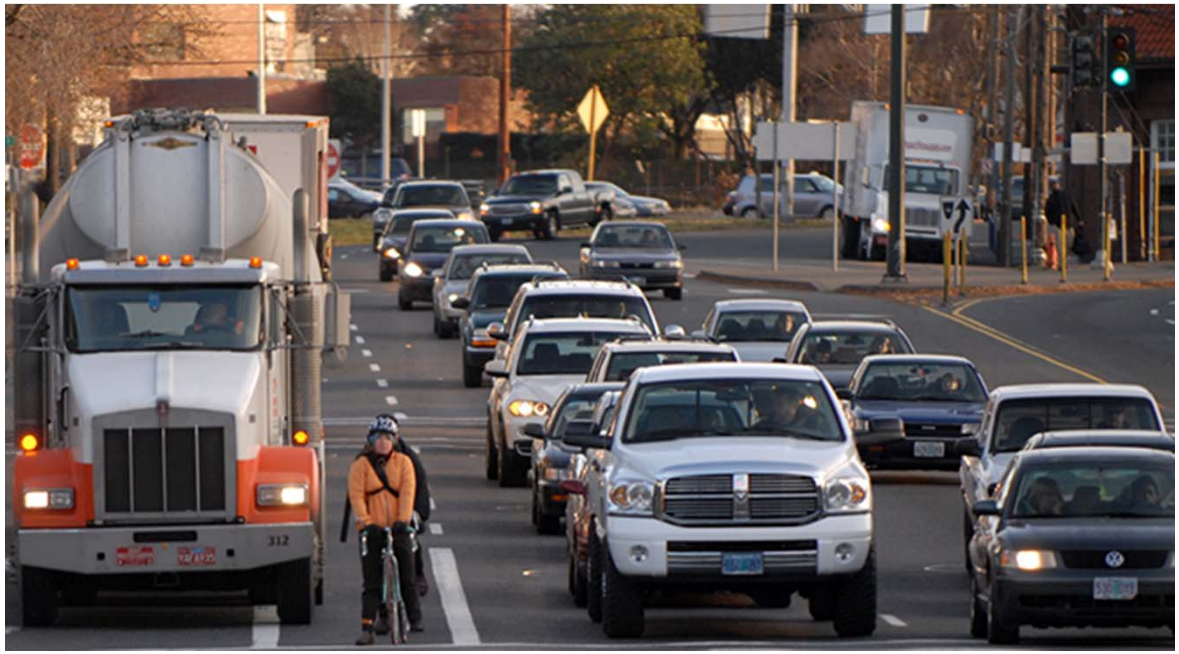


New ANTI-V

30 minutes

3 attentional networks measurement

+ a measure of vigilance



ATTENTIONAL NETWORKS:

ORIENTING

EXECUTIVE CONTROL

ALERTING

VIGILANCE

Safe driving relies on the Attentional Networks functioning correctly.

To measure….
ATTENTIONAL NETWORKS:

ORIENTING

EXCECUTIVE CONTROL

ALERTING

VIGILANCE

ORIENTING

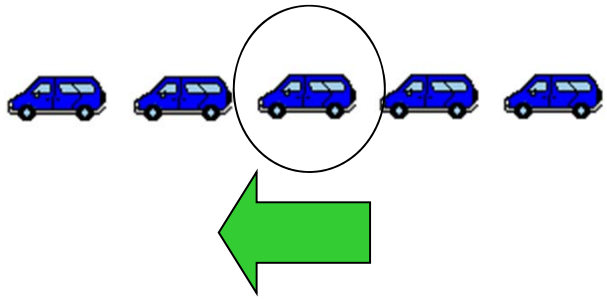
Orienting is manipulated by

presenting a cue indicating

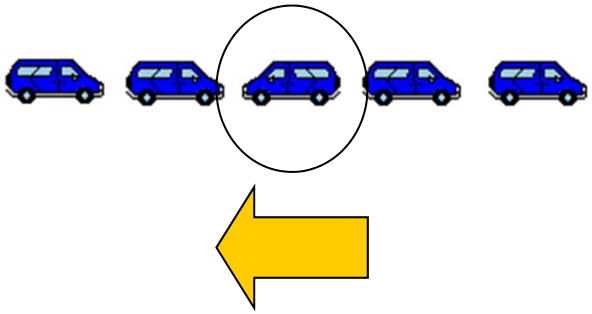
where in space a person should focus attention

*

EXECUTIVE CONTROL



i.e. TASKS dealing with: CONFLICT



ALERTING

can be considered as…

Phasic alertness

Non-specific activation occurs when a warning signal is presented prior to the target.

+

*

VIGILANCE

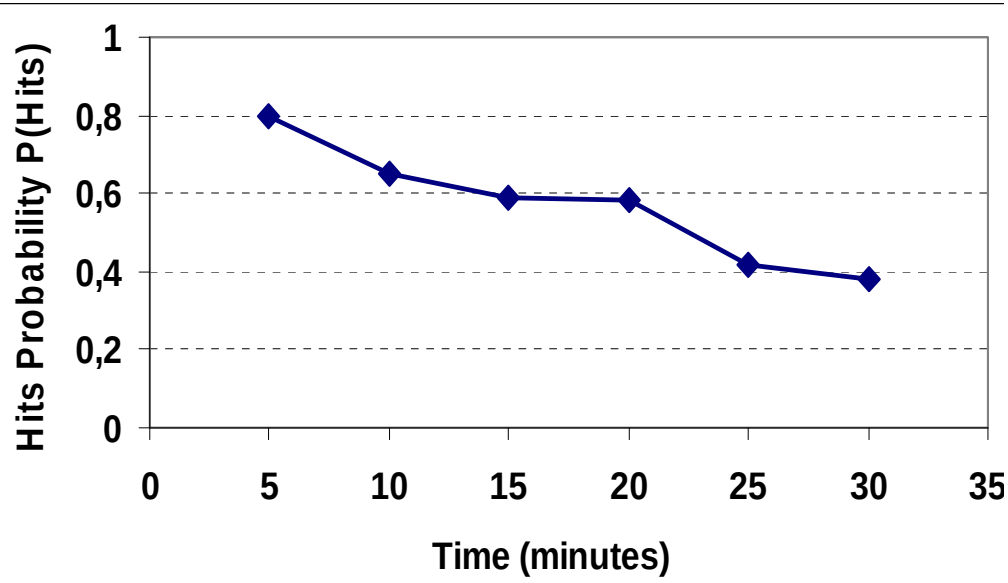
Alerting

ATTENTIONAL NETWORK

Tonic alertness or vigilance

Sustained activation over a period of time

Participants have to attend to a location over a period of time and detect infrequent targets.



The Vigilance Decrement: detecting the not equidistant

.

Grier, R.A., Warm, J.S. Dember, G.M., Galinsky, T., Szalma, J.L., & Parasuraman, R

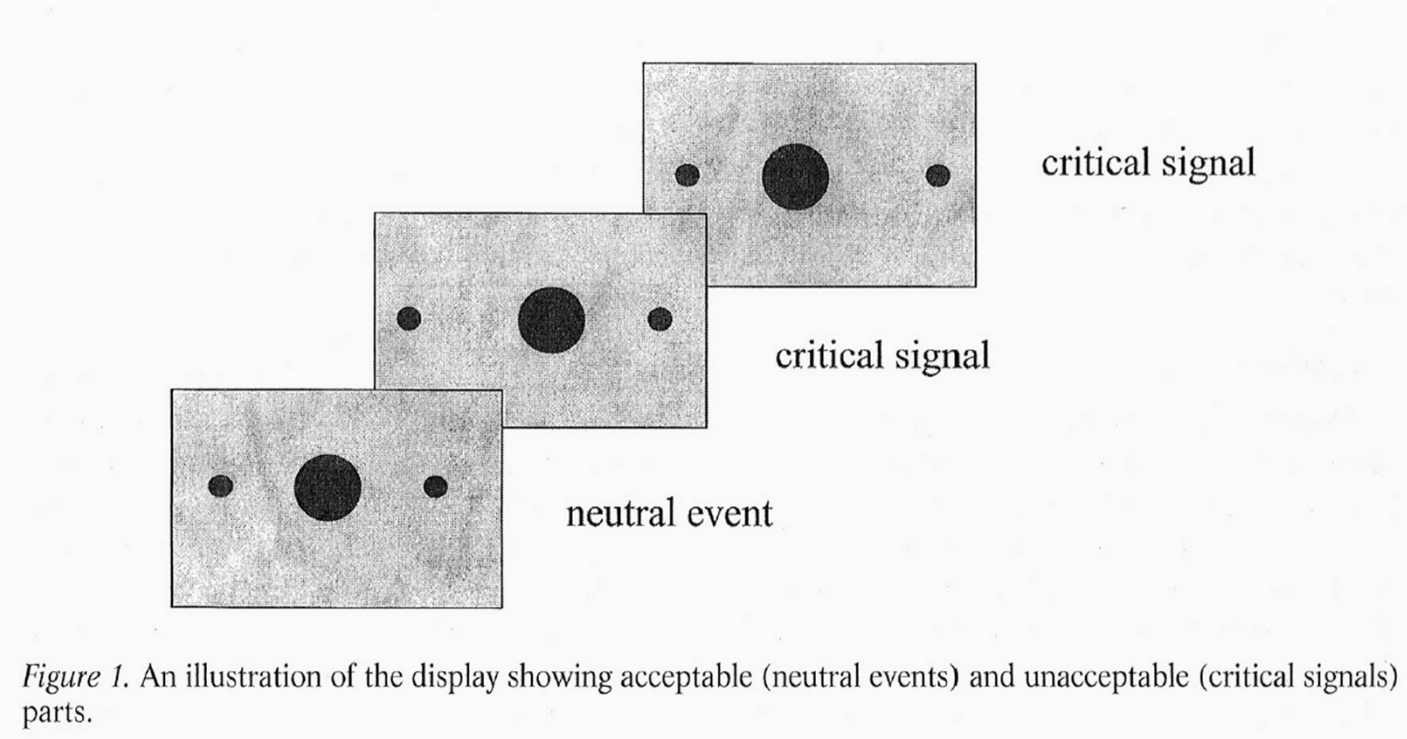
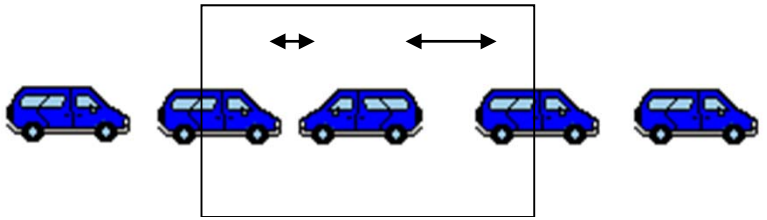


Figure 1. An illustration of the display showing acceptable (neutral events) and unacceptable (critical signals) parts.

Roca, J., Castro, C., López-Ramón, M.F., & Lupiáñez, J. (2011). Measuring vigilance while assessing the functioning of the three attentional networks: The ANTI-Vigilance task. Jorunal of Neuroscience Methods, 198(2), 312-324.



INSTRUCTIONS

Imagine that you are working in a Centre for Traffic Management and you are studying the drivers' parking habits.

A row of five cars will be shown on the screen either just above or below a fixation cross
Your task consists on deciding whether the car in the centre of the row (the third car) is facing Left or Right.

Your answer should be:
"C" if the centre car is pointing to the left and
"M" if the center car is pointing to the right.

For instace, you should press "C" in this case:

and you should press "M" in this other case:

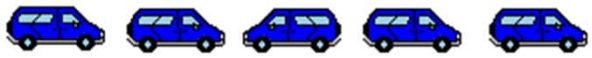
< Press the SPACE BAR to carry on >

Sometimes the centre car is wrongly parked and is pointing to the opposite direction to the other cars in the row.

Remember:
Your answer will be determined by the direction of the car of the middle.

For instance:

In this case you should press "C".



< Press the SPACE BAR to carry on >

Sometimes the car in the middle will be shown slightly closer to the next vehicle to the left or to the right leaving a gap in the row of cars.
In other words: The flanking cars will not be equidistant from the centering car.

When that happens you should press the SPACE BAR. In these cases the car is moving and will be excluded from the study.

Such trials will occur very infrequently, which is why you KEEP A HIGH LEVEL OF VIGILANCE thoroughout the experiment.

For instance here:

and here too:

In these examples you should press "SPACE BAR".

< Press the SPACE BAR to carry on >

Driver Behaviour Questionnaire

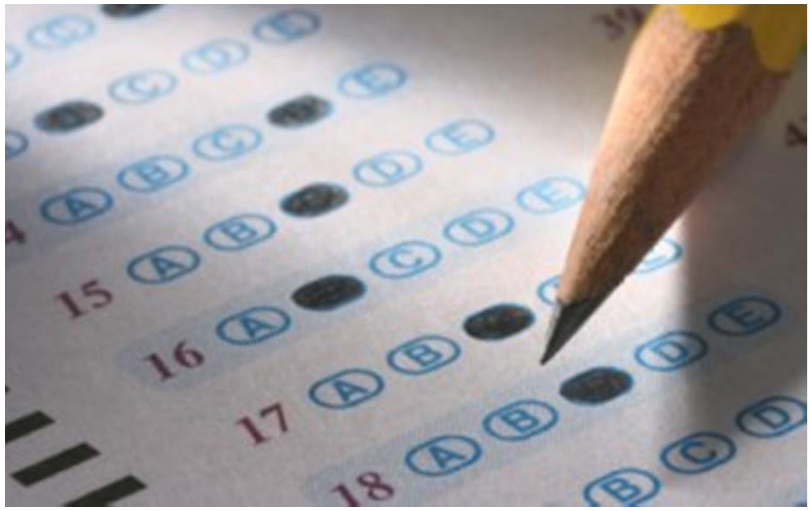
- DBQ: A measure of **aberrant driving behaviour**.

  7. "Fail to notice that pedestrians are crossing when turning into a side street from a main road" ……

  (Never) (Nearly all the time)

  0 1 2 3 4 5

- Factors: **Attentional lapses**, driving errors, highway code violations, and aggressive violations.
- **Spanish** version (34-item): López de Cózar et al. (2006).



Method

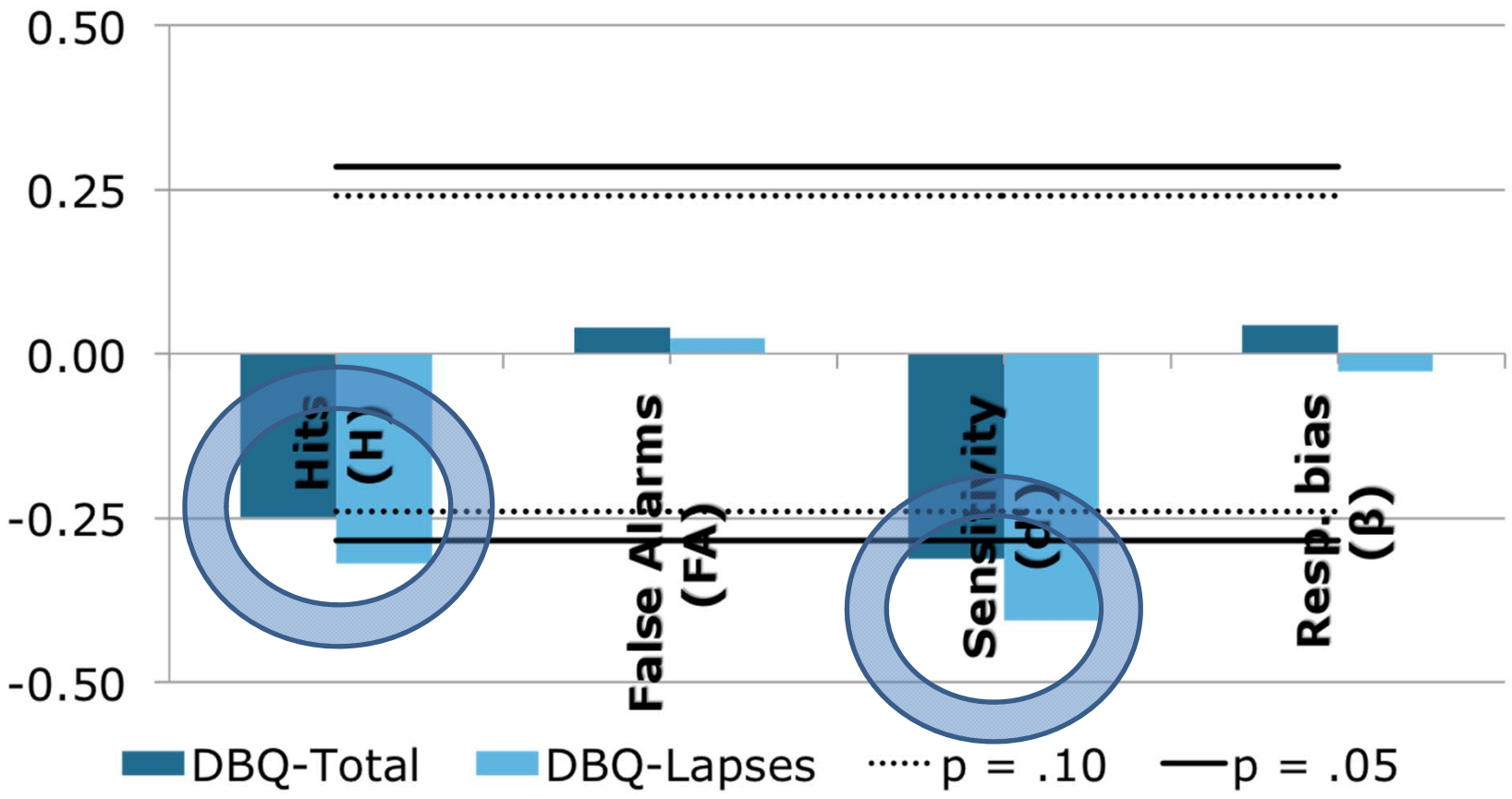
- **DBQ Spanish** version (34-item): López de Cózar et al. (2006)
- **Participants**: **N = 48 drivers** in Granada
  (Age = 21 ± 4; Driving experience > 1 year).
- **Analyses**: **Correlations** ANTI-V and DBQ

  Signal Detection Theory (STD) parameters

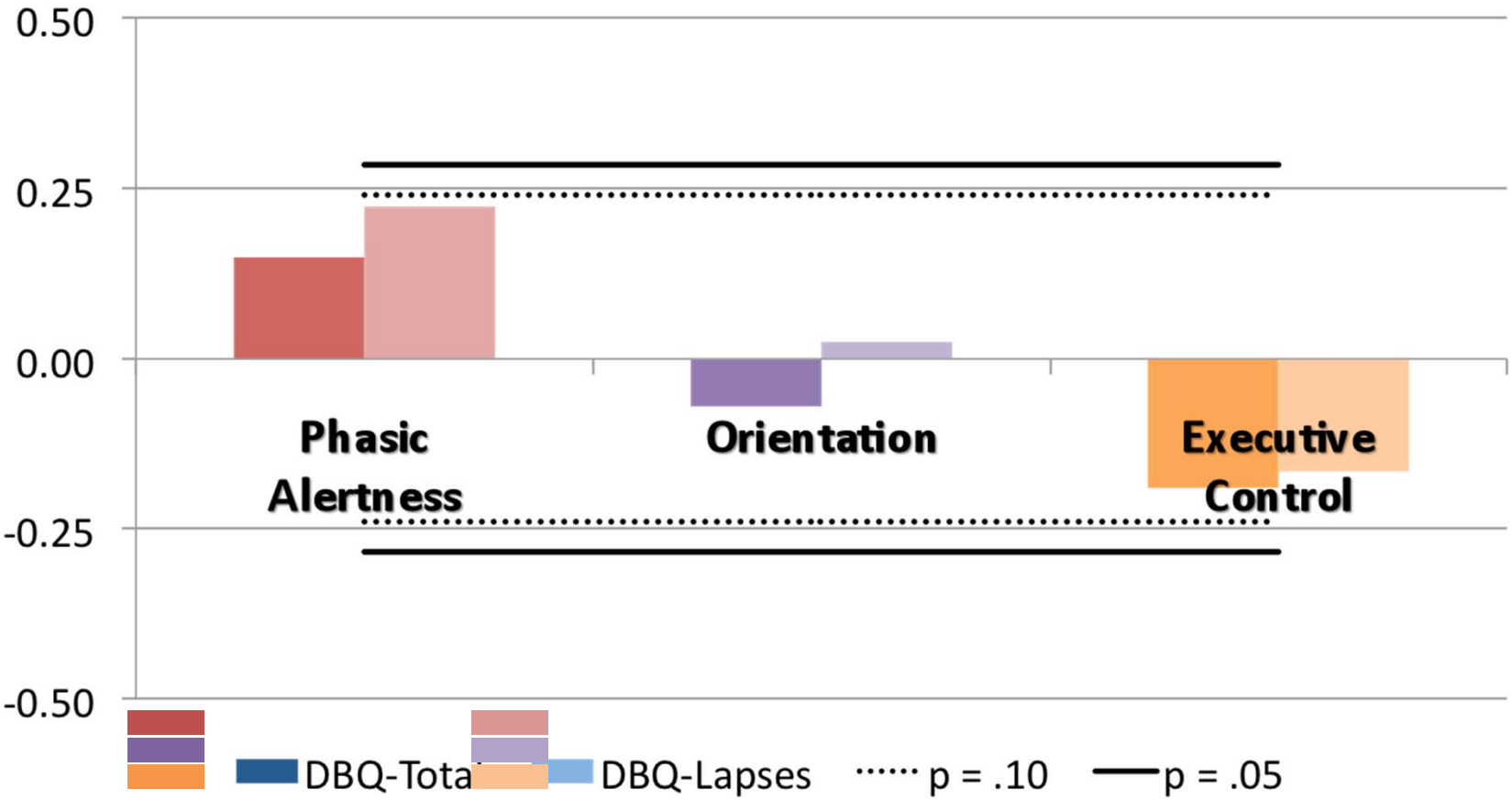
  Task: Detecting the infrequent target:

  → The not equidistant centre car.

Correlations ANTI-V and DBQ



Correlations ANTI-V and DBQ

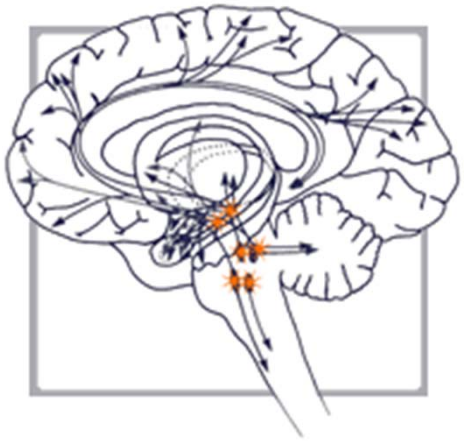


Conclusions

- DBQ-Total and DBQ-Lapses are negatively correlated to hits and sensitivity (d') **in the ANTI-V.**
  - Worst vigilance performance -> Higher aberrant behaviour
    - Worst vigilance performance -> More attentional lapses

Low vigilance can be a relevant factor explaining driving aberrant behaviour, particularly attentional lapses.

Combining **attentional behavioral measures** and **self-report data**, seems to be a successful tool to study attentional errors to better understand driving behaviour and spot specific ways to tackle accident prevention



+

To be continued...

Thank you for your sustained attention!

Candida Castro (candida@ugr.es)

Funding provided by ***Ministerio de Ciencia e Innovación*** (SEJ-2007-61843, PSI-2008-03595, EUI2009-04082, PSI-2010-15883), and ***Junta de Andalucía*** (PO7-SEJ-02613).

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN

JUNTA DE ANDALUCIA

MINISTERIO DEL INTERIOR
Dirección Gral. de Tráfico

FESVIAL

Also, we would like to thank the ***Dirección General de Tráfico*** **(DGT)** and the ***Fundación para la Seguridad Vial*** **(FESVIAL)** for their support.

Extra material

References (1)

1. **Posner, M.I. (2008).** Measuring Alertness. *Annals of the New York Academy of Sciences, 1129*, 193–199.
2. **Fan, J., McCandliss, B. D., Sommer, T., Raz, A., & Posner, M. I. (2002).** Testing the efficiency and independence of the attentional networks. *Journal of Cognitive Neuroscience, 14*(3), 340–347.
3. **Fan, J., Gu, X., Guise, K.G., Liu, X., Fossella, J., Wang, H., & Posner, M. I. (2009).** Testing the behavioral interaction and integration of attentional networks. *Brain and Cognition, 70*, 209–220.
4. **Callejas, A., Lupiáñez, J., Funes, M. J., & Tudela, P. (2005).** Modulations between Alerting, Orienting and Executive Control Networks. *Experimental Brain Research, 167*(1), 27-37.
5. **Roca, J., Castro, C., López-Ramón, M.F., & Lupiáñez, J. (2011).** Measuring vigilance while assessing the functioning of the three attentional networks: The ANTI-Vigilance task. Jorunal of Neuroscience Methods, 198(2), 312-324.

Extra material

References (2)

6. **Roca, J., Martella, D., Marotta, A., López-Ramón, M.F., Castro, C., Lupiáñez, J., & Fuentes, L. (2011).** *The effects of sleep deprivation on the attentional functions and vigilance*. Manuscript in preparation.

7. **Weaver, B., Bédard, M., McAuliffe, J., & Parkkari, M. (2009).** Using the Attention Network Test to predict driving test scores. *Accident Analysis and Prevention, 41*, 76–83.

8. **López-Ramón, M. f., Castro, C., Roca, J., Ledesma, R., & Lupiañez, J. (in press).** Attentional networks functioning and attentional lapses while driving. *Traffic Injury Prevention.*

9. **Reason, J.T., Manstead, A.S.R., Stradling, S.G., Baxter, J.S., & Campbell, K.** (1990). Errors and violations on the road: a real distinction?. *Ergonomics, 33*, 1315-1332.

Extra material

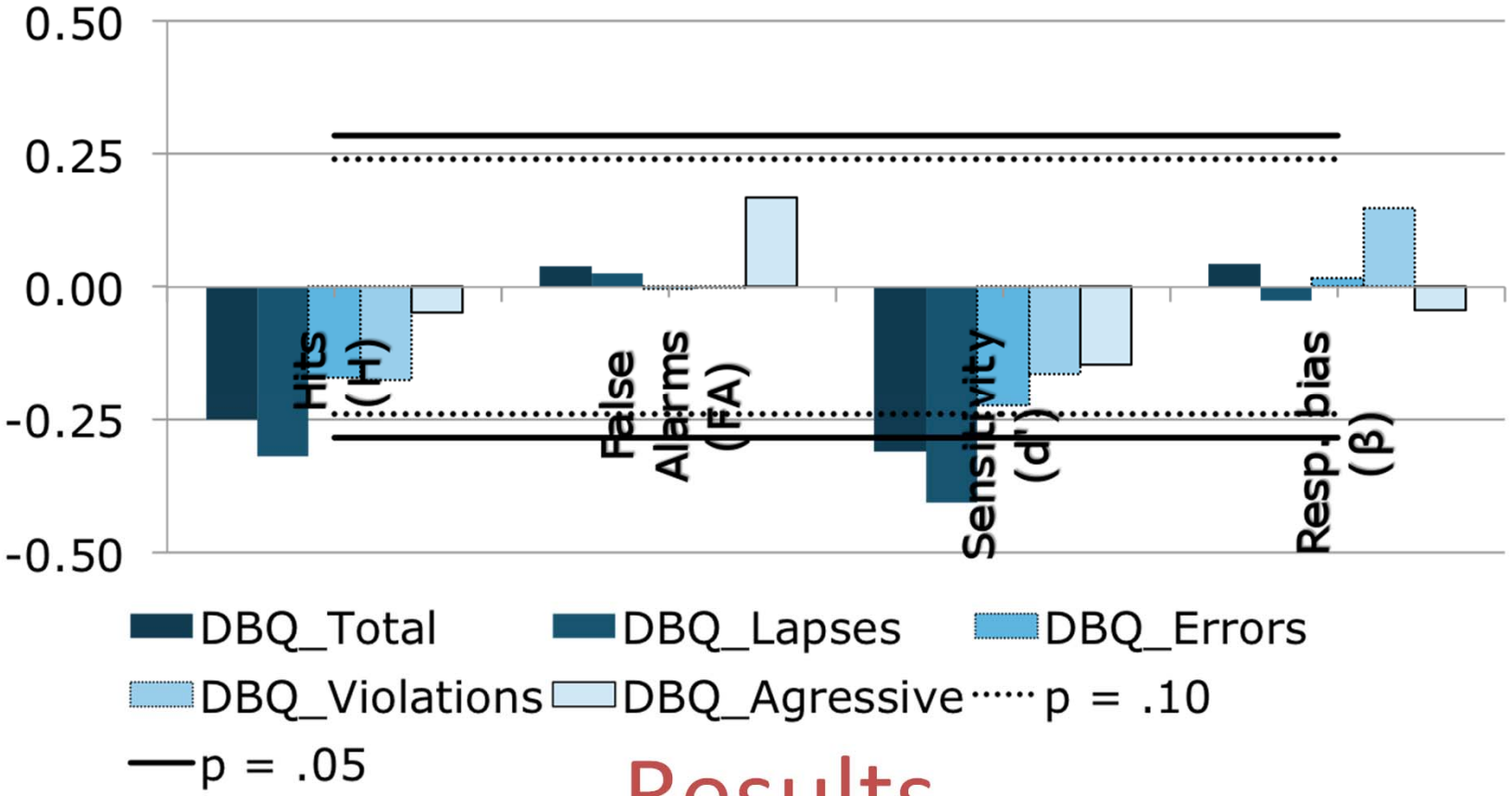
References (3)

10. **López de Cózar, E., Molina, G., Chisvert, M., Aragay, J.M., & Sanmartín, J. (2006).** Spanish adaptation of the driver behaviour questionnaire and comparison with other european adaptations. *5th Conference of the International Test Commission: Psychological and educational test adaptation across languages and cultures building bridges among people*. Bruselas, 6-8 July.

11. **Crundall, D., Andrews, B., van Loon, E., & Chapman, P. (2010).** Commentary training improves responsiveness to hazards in a driving simulator. *Accident Analyses and Prevention, 42*, 2117-2124.

Extra material

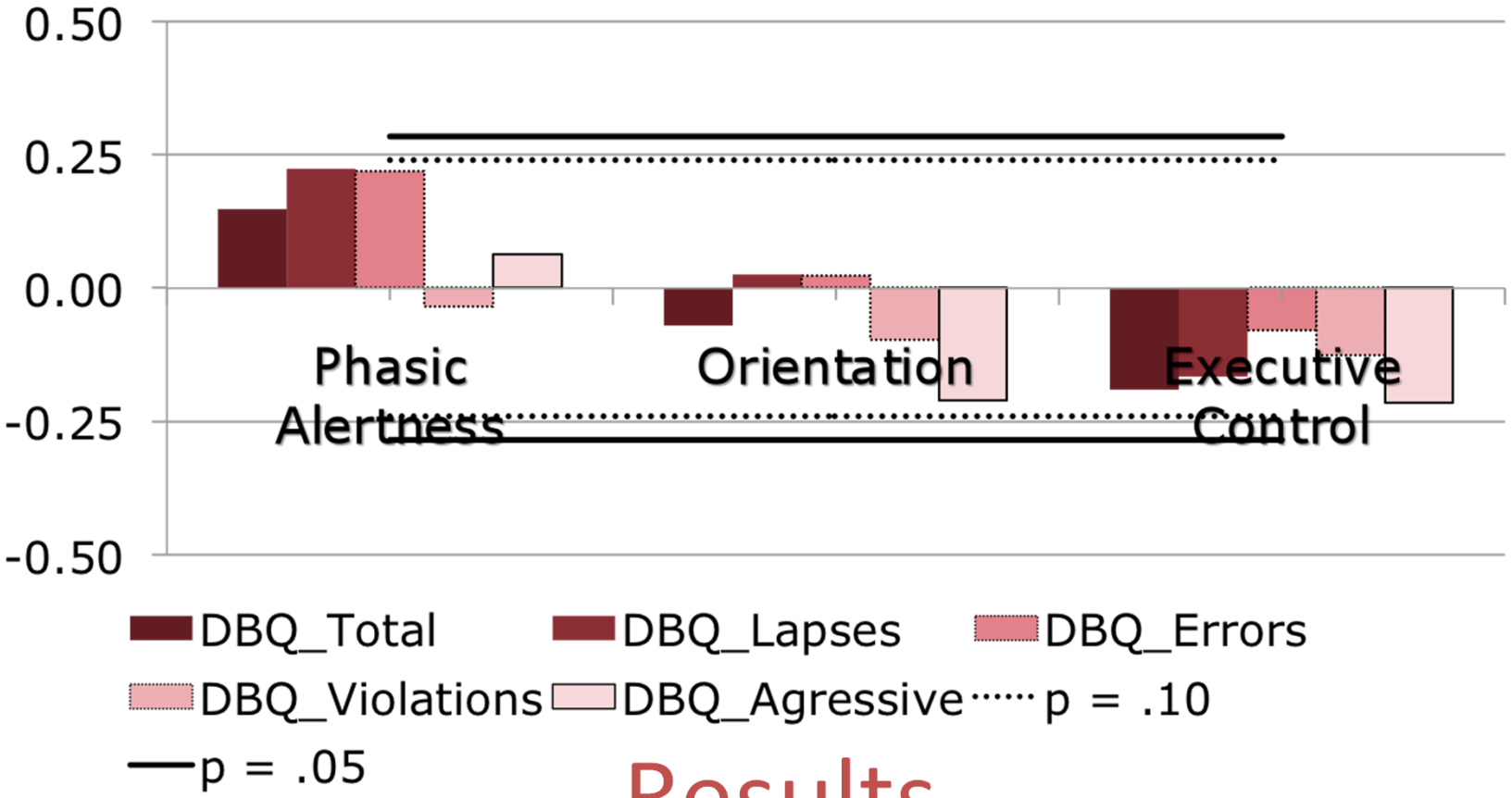
Correlations ANTI-V and DBQ: Four factors (V)



Results

Extra material

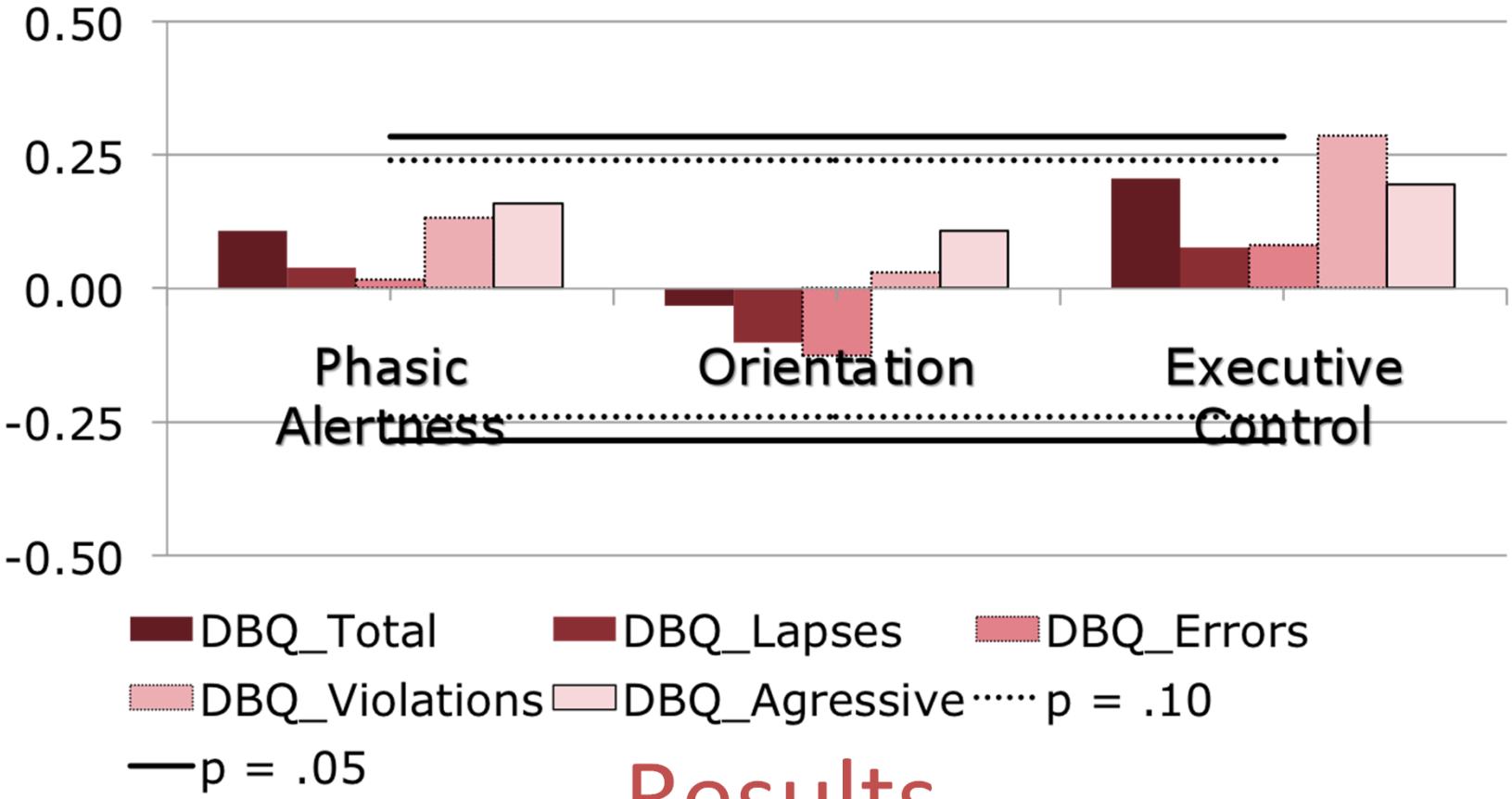
Correlations ANTI-V and DBQ: Four factors (RT)



Results

Extra material

Correlations ANTI-V and DBQ: Four factors (ACC)

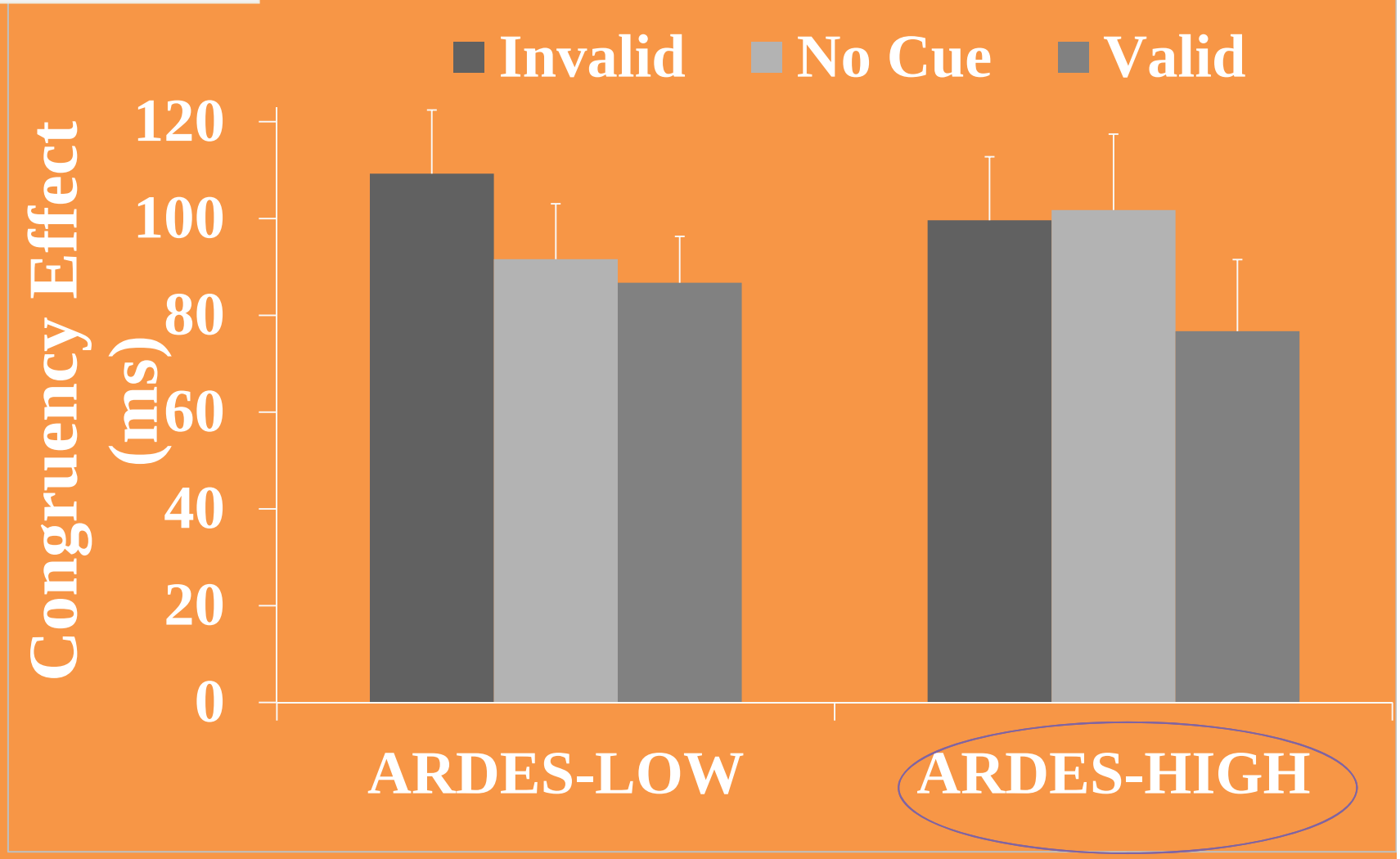


Results

Extra material

Three way interaction

ARDES-HIGH:
better response to conflict in the presence of valid cues



CONGRUENCY x CUE X ARDES: F (2, 102) = 3.16, p<.05, Eta^2=.06

References

- **Callejas A, Lupiáñez J, Funes MJ, Tudela P (2005). Modulations among the alerting, orienting and executive control networks. *Experimental Brain Research, 167*, p27.**
- **.Ledesma, R.D., Montes, S.A., Poó, F.M., & López-Ramón, M. F. (2010).** Individual Differences in Driver Inattention: The Attention-Related Driving Errors Scale. *Traffic Injury Prevention*, 11(*2*), 142 - 150
- **Posner, M. I. (1993). Attention before and during the decade of the brain. In D. E. Meyer, & S. Kornblum (Orgs), *Attention and Performance, XIV*. Cambridge, MA: MIT Press.**
- **Weaver, B.;Bédarda, M.; McAuliffed, J.; Parkkaria, M. (2009). Using the Attention Network Test to predict driving test scores. *Accident Analysis and Prevention*, *41* (1), 76-83.**

References

- Callejas, A. Lupianez, J. and Tudela, P. (2004). The three attentional networks: On their independence and interactions. *Brain and Cognition, 54*, 225-227.
- Callejas, A., Lupianez, J., Funes, M.J., Tudela, P. (2005). Modulations among the alerting, orienting and executive control networks. *Experimental Brain Research, 167,* 27-37.
- *Grier, R.A., Warm, J.S. Dember, G.M., Galinsky, T., Szalma, J.L., and Parasuraman, R () The Vigilance Decrement Reflects Limitations in Effortful Attention, Not Mindlessnesss Human Factors; 45, 3;* 349-358.
- Fan, J., McCandliss, B.D., Sommer, T., Raz, A., and Posner, M.I. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience, 14(3),* 340/347.
- Posner, M.I. (1978). *Chronometric explorations of mind*. Hillsdale, NJ: Erlbaum.
- Posner, M.I. (1980). Orienting of attention. *Quarterly Journal of Experimental Psychology*, *32*, 23-25.
- Posner, M.I., and DiGirolamo, F.J. (1996). Executive attention: conflict, target detection and cognitive control. In: R. Parasuraman (Ed.). *The attentive brain*. M.I.T. Press: Cambridge, MA.
- Posner, M.I., and Fan, J. (2005). Attention as an organ system. In: J. Pomeranz (Ed.). Neurobiology of perception and communication: from synapse to society. The IVth de Lange conference. Cambridge University Press, Cambridge, UK (press)
- *Schneider*, W., Eschman, A. and Zuccolotto, A. (2002). *E-Prime User's guide.* Pittsburgh, P.A.., U.S.A.: Psychology Software Tools Inc.
- Underwood, G, Chapman, P, Brocklehurst, N, Underwood, J, Crundall, D (2003). Visual attention while driving: sequences of eye fixations made by Experienced and Novice drivers. *Ergonomics, 46(6), 629-46*
- Underwood, G., Crundall, D. and Chapman, P. (2008). Experience and Visual Attention in Driving. In: C. Castro, and L. Hartley (Ed.). *Human Factors of Visual and Cognitive Performance in driving*. Boca Raton, FL.: CRC Press.
- Weaver, B., Bédard, M., McAuliffe, J. and Parkkari, M. (In press, 2008) Using the Attention Network Test to predict driving test scores. *Accident Analysis and prevention*. doi: 10.1016/j.aap.2008.09.006