Doctoral Thesis by
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Emotional Modulation of Urgent and Evaluative Behaviors in Risky Driving Situations

TESIS DOCTORAL

Doctorado Internacional

Modulación emocional del comportamiento urgente y evaluativo en situaciones de riesgo en conducción

Emotional modulation of urgent and evaluative behavior in risky driving situations

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El doctorando Alberto Megías Robles y los directores de la tesis Antonio Maldonado López, Antonio Cándido Ortiz y Andrés Catena garantizamos, al firmar esta tesis doctoral, que el trabajo ha sido realizado por el doctorando bajo la dirección de los directores de la tesis y hasta donde nuestro conocimiento alcanza, en la realización del trabajo, se han respetado los derechos de otros autores a ser citados, cuando se han utilizado sus resultados o publicaciones.

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Publicaciones de la Tesis

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Publicaciones relacionadas

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Serrano, J., Di Stasi, L.L., **Megías, A.**, & Catena, A. (2014). Affective-sound effects on driving behaviour. *Transport*, *29*(1), 100-106.

Di Stasi, L.L, **Megías, A**., Cándido, A., Maldonado, A., & Catena, A. (in press). The Influence of Traffic Signal Solutions on Pedestrian Behaviour. *Spanish Journal of Psychology*.

Cada uno de los capítulos de la tesis consiste de uno o varios de los artículos listados. Estos artículos de investigación han sido publicados o están en proceso de publicación en revistas internacionales. Por tanto, puede existir cierto solapamiento entre algunas partes de la introducción y discusión de algunos capítulos.

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OVERVIEW

Road traffic accidents are one of the most common causes of injury-related fatalities in the world (World Health Organization, 2013). There are multiple factors related to road accidents, but most research shows that the human factor is the main cause (Wierwille et al., 2002). Sometimes drivers can inadvertently engage in behaviors that involve some risk (e.g., distractions). However, it is shocking how many road accidents result from conscious risk taking (e.g., driving under the influence of alcohol or exceeding the speed limit). Investigating what factors influence risky behavior can help to develop techniques for prediction and control of risky driving.

Emotional factors play a key role in decision-making and risk behavior. People evaluate risks and adapt their behavior in risk situations not only following rational thought but also following the emotions (Loewenstein, Weber, Hsee & Welch, 2001; Slovic, Finucane, Peters, & MacGregor, 2007). The conceptual framework of this thesis focused on the interaction between emotional and cognitive processing in decision-making in risky driving situations. The thesis consists of three broad foci:

a) Chapter I and II review the most current literature on the impact of emotional factors on decision making processes and driving behavior. These two chapters serve as a background to the development of the experimental blocks of the thesis (Chapters III to VIII). We discuss the need to investigate emotional factors from different perspectives in order to achieve a better understanding of the behavior of drivers. Furthermore, we offer possible solutions to the dangers associated with emotional factors and discuss the benefits that these factors can have in the design of risk assessment and prevention programs.

b) The first experimental block (Chapters III to V) focuses on how affect-laden stimuli presented during driving affect the driver's risk perception and risk-taking. We approach emotion from a classical perspective: as the driver's subjective reaction to affect-laden stimuli. In four experiments we investigated the influence of emotion as a function of the time at which the affect-laden stimulus is presented: emotional stimuli displayed incidentally while driving (Chapter III), negative emotional stimuli displayed as feedback after drivers have performed risk behaviors (Chapter IV), and emotion as an implicit factor in the driving task (Chapter V). Our findings show that the situation, time, and presentation format of the emotional stimuli influence driving behavior. In particular, negative emotional content leads to a response bias towards more cautious behavior; however, negative emotional content can also cause distractions while driving and its effect varies between individuals. We conclude that including emotional factors in road safety programs can lead to a driving style closer to the traffic agencies' recommendations; however, care should be taken that emotional factors are implemented under the right circumstances.

c) The second experimental block (Chapters VI to VIII) investigates why drivers occasionally engage in risky behaviors that are incongruent with a rational analysis of the situation, resulting in a significant gap between the perceived risk and the behavior finally performed. We focused on two types of behaviors that fit the characteristics of this dissociation: urgent and evaluative behaviors. Our goal was to explore the features that differentiate between these behaviors, considering the dynamic interaction of cognitive and emotional processes in dual processing systems (Kahneman, 2011; Reyna, 2004). The results showed that urgent behaviors (risk taking) and evaluative behaviors (risk perception) can be distinguished both on the behavioral and on the neural level. Our findings showed a more automatic processing of risk situations in urgent tasks, guided by heuristics and affect appraisal. Drivers making urgent decisions mainly rely on the experiential processing system. In contrast, evaluative behaviors are primarily controlled by a more rational system, guided by normative rules. The nature of the relationship between risk perception and risk taking suggests that the features of the task and the extent to which they evoke more automatic or more controlled processing can help explain part of risky driving behavior.

Taken together, this thesis demonstrates that emotion plays a crucial role in risky decision-making and risk perception in driving. Studying the interaction between emotion and cognition is essential for the advance of road safety research. The inclusion of emotional factors in transport policies should be a key tool in the design of programs aiming to evaluate and control risky behavior in driving and can thus help to improve road safety.

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CHAPTER I

Introducción / Introduction

(In Spanish)

1. El problema

Los accidentes de tráfico son una de las mayores causas de siniestralidad en nuestra sociedad. Alrededor de 1.24 millones de personas fallecen cada año a nivel mundial en algún tipo de accidente de tráfico, y cerca de 50 millones resultan heridas de diversa consideración (World Health Organization, 2013). Estos daños tienen un enorme impacto en nuestra sociedad al quedar las familias y comunidades irrevocablemente afectadas por estas tragedias. Esta situación cobra mayor importancia aún si tenemos en cuenta que las estadísticas muestran que este tipo de accidentes es la principal causa de muerte en el grupo de población comprendido entre los 15 y 29 años (World Health Organization, 2004; ver figura 1). Además, las expectativas futuras no parecen ser muy alentadoras, ya que las previsiones para el año 2030 describen un aumento de los fallecidos por accidente de tráfico hasta alcanzar los 2.4 millones de personas, convirtiéndose en la quinta causa de muerte a nivel global. Todo ello ha llevado a la Organización Mundial de la Salud a describir esta problemática como una "epidemia oculta", especialmente en los países en vías de desarrollo.

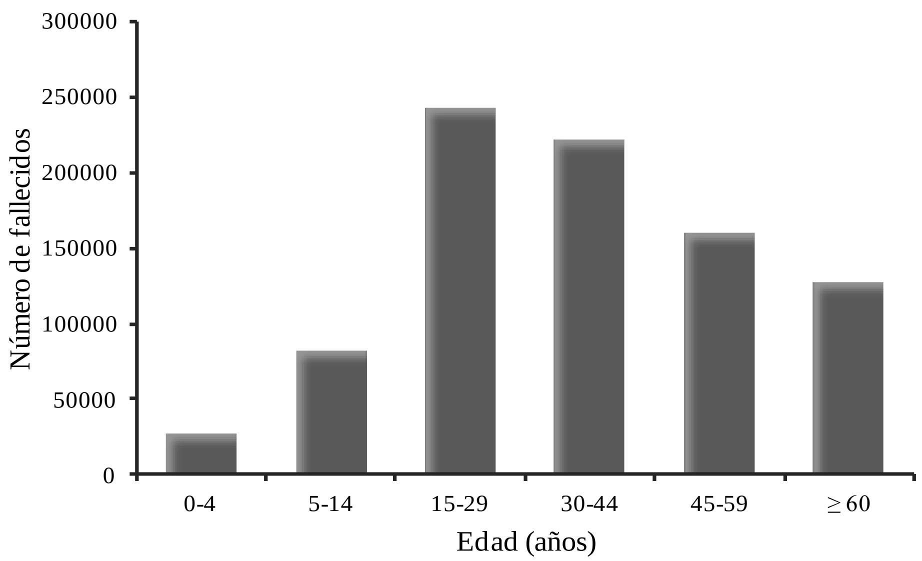

Figura 1. Fallecidos por accidentes de tráfico a nivel mundial en función de la edad (World Health Organization, 2004).

Cierto es también que no todo son noticias negativas. Durante la última década el número de accidentes mortales ha disminuido considerablemente en los países más desarrollados, especialmente en algunos países de Europa Occidental. El esfuerzo llevado a cabo por las agencias de seguridad vial, la mejora de las infraestructuras y la mayor concienciación de la población acerca de los riesgos derivados de la conducción han alcanzado resultados destacados. Sin embargo, a pesar de existir una significativa reducción de los accidentes de tráfico, éstos continúan copando cerca del 20% de los fallecidos implicados en algún tipo de accidente en muchos países desarrollados como los pertenecientes a la Unión Europea (EuroSafe, 2007; ver Figura 2).

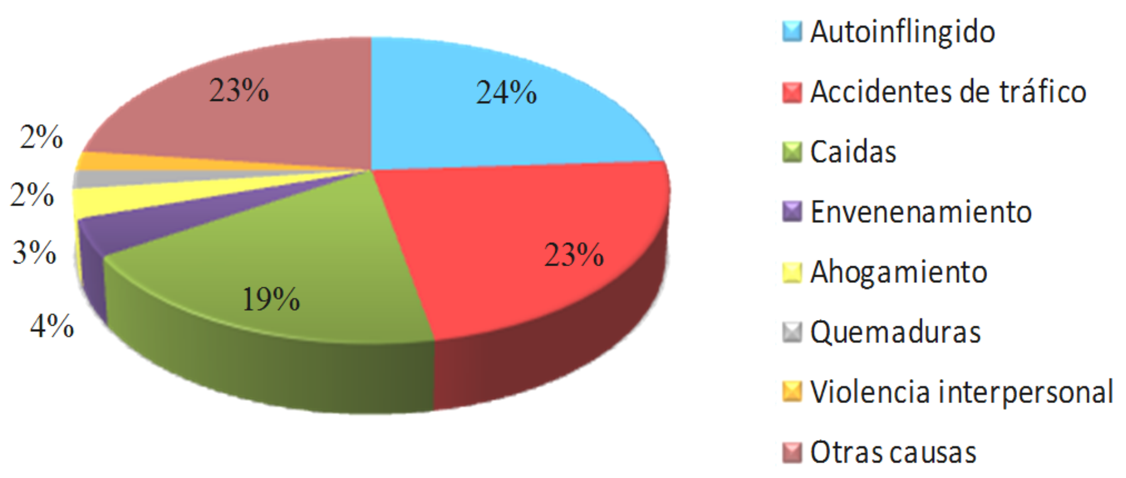

Figura 2. Causas de muerte por accidente en la Unión Europea.

Por ejemplo, en el ámbito español resulta preocupante observar las cifras que cada año la Dirección General de Tráfico presenta sobre la mortalidad en carretera. En el balance de seguridad vial de 2013 (DGT, 2013) se informa que, durante ese año, se produjeron 994 accidentes mortales en carretera, en los que fallecieron 1128 personas y 5206 resultaron heridas graves.

Los factores implicados en los accidentes de tráfico pueden ser muy diversos; sin embargo, la mayoría de investigaciones están de acuerdo en considerar el factor humano como uno de los principales responsables de los accidentes. Las estimaciones ofrecidas en diversos estudios varían en sus cifras, pero todas ellas reflejan altos porcentajes que oscilan entre el 70% y el 95% (Treat et al., 1977; Rumar,1985; Wierwille et al., 2002; ver figura 3).

La conducción de un vehículo es una tarea compleja que requiere la coordinación de numerosas subtareas de forma concurrente. En determinados escenarios, la conducción puede demandar al conductor una gran cantidad de recursos cognitivos (p.ej. situaciones en las que existen varias alternativas de respuesta y debemos tomar una decisión urgente); en estas situaciones, pequeños cambios en el rendimiento de la tarea pueden conllevar severas consecuencias. En algunos contextos los conductores pueden incurrir en comportamientos que conllevan cierto riesgo de accidente de forma inadvertida (no consciente); por ejemplo debido a distracciones involuntarias o por falta de unas habilidades apropiadas (conductores nóveles o ancianos). Sin embargo, es impactante la excesiva frecuencia con la que los accidentes de tráfico se ven acompañados por la ejecución consciente de conductas de riesgo por parte del propio conductor, como no ponerse el casco, conducir bajo los efectos del alcohol o exceder la velocidad permitida. Además, es notorio que sean los propios conductores quienes detectan este tipo de conductas de riesgo como uno de los mayores determinantes de los accidentes de tráfico (RACC, 2008). De hecho, un gran número de las infracciones de tráfico son cometidas por conductores reincidentes, los cuales ya han sido amonestados previamente por sus comportamientos inapropiados (SARTRE 3, 2004). Aunque los conductores conocen qué comportamientos son arriesgados, muchos de ellos continúan realizándose de forma habitual en carretera.

Profundizar en el estudio de por qué llevamos a cabo este tipo de comportamientos de riesgo es de gran relevancia para la sociedad. La investigación de esta problemática podría ayudarnos a salvar cientos de vidas. Explorar los factores que determinan los comportamientos de riesgo ayudaría a lograr no sólo explicar y comprender dichos comportamientos, sino, sobre todo, a desarrollar técnicas de predicción y control de riesgos en situaciones de conducción. Una mejor comprensión de este tipo de conductas podría reportar grandes beneficios en el ámbito social, político y económico en cuanto que, el hecho de que se reduzcan los riesgos, se traduce en una reducción de la tasa de accidentes mortales y en un incremento de la seguridad y bienestar de la sociedad.

2. Comportamiento de Riesgo

En nuestro día a día debemos tomar una gran cantidad de decisiones, algunas de las cuales podríamos calificar de arriesgadas o que entrañan cierto riesgo. El concepto de riesgo es un constructo complejo, cuya definición ha llevado a un controvertido debate desde diferentes disciplinas (Trimpop, 1994; Yates & Stone, 1992). El riesgo carece de una definición sistemática aceptada, ha sido definido de muy diversas formas; sin embargo, parece existir un consenso en considerar la probabilidad de ocurrencia de un evento adverso como parte fundamental (Rayner & Cantor, 1987). Una definición de riesgo, citada frecuentemente en la literatura psicológica, es la ofrecida por Yates y Stone (1992); en ella se destacan tres elementos principales: a) la existencia de posibles pérdidas, b) que estas pérdidas sean importantes para la persona, y c) que exista cierta incertidumbre en el resultado de la acción (figura 1).

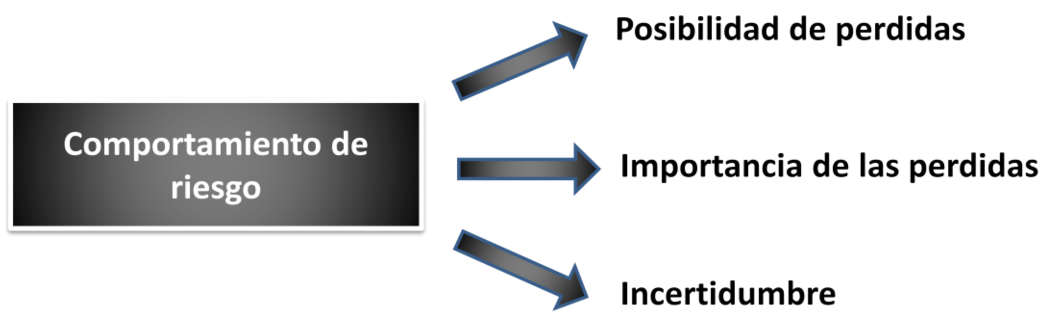

Figura 3. Elementos destacados por Yates y Stone (1992) en su definición de riesgo.

En determinadas ocasiones, ante situaciones que percibimos cómo arriesgadas, es difícil encontrar comportamientos individuales que nos protejan, como ocurre con los desastres naturales o tecnológicos. No obstante, en la mayoría de ocasiones, nuestra percepción de riesgo podría protegernos si adoptamos la decisión adecuada, como sucede cuando decidimos hacer uso del casco al conducir una motocicleta o cuando decidimos frenar ante un semáforo en ámbar. Es evidente que en la mayoría de las situaciones de riesgo el individuo se enfrenta a una elección con varias alternativas: ponerse o no el casco, frenar o no frenar ante el semáforo, etc. El problema surge cuando no tomamos las medidas adecuadas para prevenir el posible peligro, a pesar de percibir la situación como arriesgada o, lo que es peor, cuando conscientemente llevamos a cabo conductas que conllevan riesgo en sí mismas. Justamente, lo que más llama la atención es que muchos conductores toman ciertas decisiones aun a sabiendas de que están eligiendo la alternativa que mayores daños puede provocar: conducir a velocidad muy superior a la permitida o realizar adelantamientos imprudentes. Desde un punto de vista de la psicología y del estudio del factor humano, la cuestión que se nos plantea es: ¿por qué realizamos este tipo de actos que pueden tener consecuencias tan adversas para nosotros e incluso llegar a poner en peligro nuestra vida?.

3. Factores explicativos del comportamiento de riesgo

3.1 Percepción de riesgo y comportamiento de riesgo desde un modelo de toma de decisiones

Un modelo capaz de explicar las conductas de riesgo debería tener en cuenta gran cantidad de variables tanto personales como contextuales. Dentro de los factores personales habría que encuadrar una serie de variables cognitivas (p.ej. creencias previas, expectativas, funciones atencionales), conductuales (p.ej. experiencia con la situación, habilidades motoras) y emocionales. Por otro lado, como factores contextuales podríamos considerar, por ejemplo, la complejidad estimular de la situación. Desde un punto de vista del aprendizaje, y tomando el comportamiento de riesgo como una conducta instrumental, todos estos factores pueden ser considerados como "antecedentes" de la conducta de riesgo, la cual estaría compuesta, además, por otros dos términos que serían la propia conducta y sus consecuencias.

Partiendo de esta base, podemos tratar las conductas de riesgo como una toma de decisiones caracterizada por los tres elementos propuestos por Yates y Stone (la existencia de pérdidas, que estas pérdidas tengan un significado para la persona y que exista cierta incertidumbre sobre el resultado de la acción). Desde el punto de vista de las aproximaciones más actuales del análisis de la toma de decisiones (p.ej. Rangel, Camerer & Montague, 2008), los procesos de decisión se consideran articulados en cinco etapas: a) primero, se construye una representación de la situación en la que se plantea el problema de decisión; b) segundo, se evalúan los comportamientos disponibles en términos de las recompensas y castigos que se puedan alcanzar; c) tercero, se selecciona una acción en función de la evaluación previa y de las propias necesidades; d) cuarto, una vez la acción ha sido realizada, se produce una reevaluación del proceso basándose en la deseabilidad de las consecuencias obtenidas; y e) quinto, la reevaluación de nuestra acción es empleada para actualizar el resto de procesos de decisión y así aprender a mejorar la calidad de las futuras decisiones (ver Figura 2).

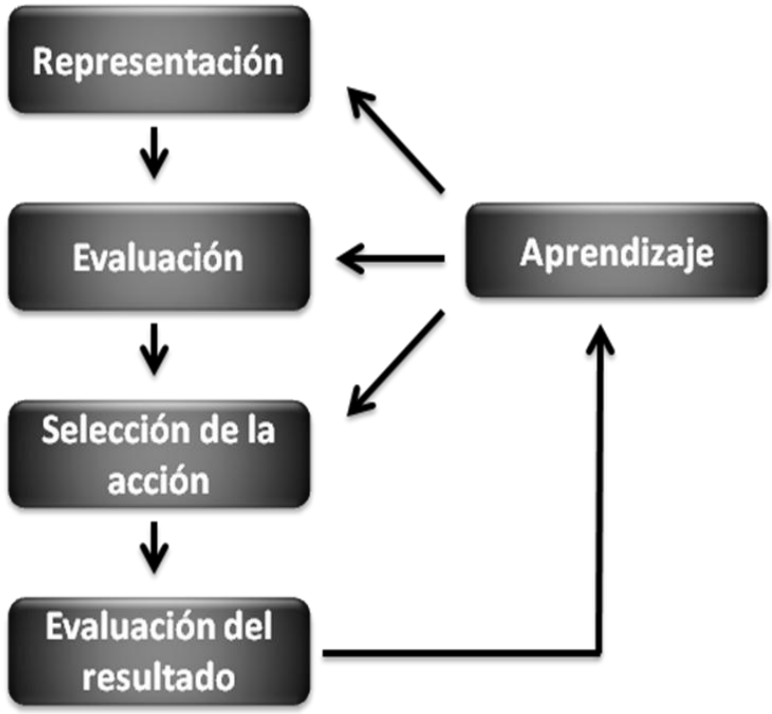

Figura 4. Etapas del proceso de toma de decisiones propuestas por Rangel, Camerer y Montague (2008).

Para entender mejor el proceso vamos a ejemplificarlo mediante una conducta más o menos habitual en nuestras carreteras: decidir rebasar los límites de velocidad porque llegamos tarde a un destino. En un primer momento, antes de decidir exceder la velocidad límite, creamos una representación de la situación en la que, simplificándolo mucho, tendríamos en cuenta las condiciones de la carretera y el tiempo del que disponemos para alcanzar nuestro destino. Posteriormente, se evaluarían los comportamientos disponibles, en este caso acelerar o mantener nuestra velocidad en los límites establecidos, en función de las recompensas y castigos esperados. Por ejemplo, si decidimos acelerar podríamos llegar a tiempo a una reunión a la que creemos importante asistir pero esto conllevaría una pequeña probabilidad de sufrir un accidente o recibir una multa de tráfico. Nuestra decisión final dependerá de nuestra experiencia previa y de los factores personales y contextuales anteriormente comentados. Una vez realizada la acción y en función de sus consecuencias, se producirá un aprendizaje que será la base para futuras decisiones ante situaciones similares. Si la experiencia al exceder el límite de velocidad ha sido negativa, por ejemplo porque hemos estado cerca de salirnos de la vía en una curva, probablemente evitaremos conducir a esta velocidad cuando se nos vuelva a presentar la misma situación; sin embargo, si no hemos sufrido ningún percance y hemos llegado a tiempo a la reunión, esto reforzará la conducta de exceder los límites de velocidad en un futuro.

Los dos primeros pasos de este modelo (representación y evaluación) son claves para percibir el riesgo asociado a la situación y a cada una de las posibles acciones que podemos realizar. En esta primera fase tienen gran influencia todas aquellas variables que hemos considerado anteriormente como antecedentes de la conducta; de ellas dependerá tanto nuestra percepción de riesgo como las expectativas de resultado. La elección de la conducta que creamos más conveniente ante la situación de riesgo será consecuencia de esta evaluación previa y, en la mayoría de ocasiones, irá ligada al riesgo percibido. Así, de forma general, intentaremos evitar aquellas situaciones que se encuentren asociadas a un mayor riesgo percibido.

Por otro lado, aunque no sea la norma, no es difícil encontrar situaciones en las que parece existir una falta de relación entre la evaluación de la percepción de riesgo y la posterior decisión que tomamos. En ocasiones, podemos percibir una situación como arriesgada y finalmente, a pesar de esto, la realizamos (no usar el cinturón de seguridad o realizar un adelantamiento rebasando una línea continua). Esto abre la posibilidad de que nuestras conductas no se adapten exclusivamente a un análisis racional de la situación, observándose una importante disociación entre la percepción de riesgo y la conducta de riesgo.

3.2. Modelos de la doble vía: Racional-analítica vs. Experiencial-afectiva

En la actualidad, tanto la psicología cognitiva como la neurociencia admiten que las personas percibimos y valoramos las situaciones de riesgo a través de dos sistemas de procesamiento que, de forma conjunta, determinarían nuestras elecciones. Los modelos teóricos más destacados, como el “modelo del proceso dual” de Epstein (1994) o la teoría del “affect heuristic” (heurístico afectivo) de Slovic, Finucane, Peters y MacGregor (2007), coinciden en conceptualizar uno de los sistemas de procesamiento como predominantemente emocional y basado en conexiones asociativos aprendidas a través de la experiencia: “sistema experiencial-afectivo”; mientras que el otro sistema realizaría un análisis más racional de la situación de acuerdo a un conjunto de reglas lógicas o estadísticas: “sistema racional-analítico” (en la Tabla 1 quedan reflejadas la características de uno y otro sistema).

Desde un punto de vista neurobiológico, el sistema analítico estaría localizado principalmente en el neocortex, mientras que el sistema experiencial, intuitivo y afectivo, estaría localizado en la amígdala, corteza prefrontal ventromedial y áreas del tronco cerebral (Bechara, Damasio & Damasio, 2003; Kahneman & Frederick, 2007; Lieberman, 2003). Es importante notar que nuestras decisiones serán el resultado de la interacción de ambos sistemas, teniendo en algunas situaciones más peso un sistema que otro, pero siempre operando en paralelo y estando ambos sistemas implicados en la decisión.

Tabla 1. Características del sistema experiencial-afectivo y racional-analítico propuestas por Epstein (1994).

Sistema Experiencial-afectivo	Sistema Racional-analítico
Holístico	Analítico
Afectivo: orientado por el placer-dolor.	Lógico: orientado por el razonamiento.
Conexiones asociativas.	Conexiones lógicas.
Comportamiento mediado por la experiencia.	Comportamiento mediado por la evaluación consciente de la situación.
Codifica la realidad en imágenes concretas, metáforas y narraciones.	Codifica la realidad en símbolos abstractos, palabras y números.
Procesamiento rápido: orientado hacia la acción inmediata y automática	Procesamiento lento: orientado hacia la acción retardada y reflexiva.

Es evidente que la capacidad humana para procesar información de modo analítico y racional garantiza que, en muchas ocasiones, se alcance una solución óptima cuando se aplica correctamente. Este sistema de procesamiento codifica la realidad de forma simbólica (palabras, números, símbolos algebraicos) y opera con ella a través de reglas lógicas, pesando los pros y contras de cada una de las acciones que pueden realizarse ante una determinada situación (ver Tabla 1). Sin embargo, este tipo de análisis de la situación requiere esfuerzo mental y conciencia, y esto provoca que, en determinadas circunstancias, este sistema sea excesivamente lento. De este modo, a lo largo de la historia evolutiva, el sistema experiencial-afectivo, orientado hacia la acción inmediata, ha sido de vital importancia para elegir la alternativa de comportamiento que mejor procurara la supervivencia. El sistema experiencial-afectivo generaría respuestas rápidas y eficaces con un coste reducido en el momento de realizarlas. Este sistema estaría guiado principalmente por el concepto de “marcador somático” o “affect heuristic” (Damasio, 1994; Slovic et al., 2007).

Damasio (1994) propone a través de su teoría del marcador somático que nuestras representaciones mentales de un estímulo o situación llevan asociadas un componente emocional adquirido a través de la experiencia previa. Cuando un componente emocional negativo es asociado a la representación mental de una determinada situación o estímulo se produciría un efecto de alarma que evitaría una acción de aproximación a ese estímulo; mientras que, si el marcador somático asociado es positivo, constituiría un incentivo para realizar dicha acción. De este modo, las reacciones emocionales guiarían el procesamiento de la información y los juicios de cada persona, lo cual puede llevar a asociar el exceso de velocidad o rebasar un semáforo en ámbar con una emoción negativa (sufrir un accidente) y con ello el consiguiente rechazo; o bien, con una emoción positiva (llegar a nuestro destino a la hora establecida) y por tanto su aceptación.

En general, guiarnos por el sistema experiencial tendría importantes ventajas adaptativas en determinadas situaciones, podría conllevar una mayor eficiencia dado el procesamiento automático de las mismas sin llevar a cabo necesariamente una evaluación profunda de la situación. Este tipo de procesamiento sería especialmente útil en aquellos casos en los que sea necesaria una respuesta rápida, el contexto no nos ofrezca toda la información necesaria, o las decisiones sean complejas y se cuente con pocos recursos mentales disponibles. En esencia, éstos son algunos de los rasgos que caracterizarían a la toma de decisión en situaciones de riesgo, lo que nos lleva a justificar que, en la práctica, cuando debemos afrontar un cierto peligro, el sistema experiencial cobre gran peso. Pero también puede ocurrir que los resultados de nuestra acción sean muy diferentes a los inicialmente esperados a través de la vía experiencial, ya que no se realiza un análisis en profundidad de la situación; es entonces cuando los posibles riesgos de guiarse por el sistema experiencial se hacen patentes, y éstos pueden llegar a tener consecuencias negativas.

En resumen, más allá de las variables cognitivas que puedan estar influyendo en la toma de decisiones, las cuales nos llevarían a ser casi siempre racionales, el comportamiento de riesgo sugiere la existencia de otro tipo de factores más emocionales, relacionados con el sistema experiencial, los cuales son esenciales en el proceso de toma de decisiones, pero también podrían determinar gran parte de la asunción de riesgos.

4. Emoción y situaciones de riesgo en conducción

Los factores emocionales desempeñan un papel fundamental en la elección entre alternativas de comportamiento, y tienen una función determinante en la ejecución de conductas de riesgo. Las emociones son soportes de procesos atencionales, evitando o dirigiendo la atención hacia diferentes fines externos o procesos internos (Dolan, 2002) y son el sistema motivacional primario de nuestras acciones (Plutchik, 1980). Nuestro comportamiento, como ha sido descrito anteriormente, es explicado por un mecanismo que incluye una base racional y emocional (Damasio, 1994; Epstein, 1994; Loewenstein, Weber, Hsee & Welch, 2001; Kahneman, 2011; Reyna, 2004). Debe quedar clara, entonces, la necesidad de su estudio en la comprensión del comportamiento de riesgo.

La cualidad de los estímulos contextuales influye en nuestra conducción y de ellos, los emocionales, tienen una especial relevancia puesto que disfrutan de un status privilegiado en el cerebro hasta el punto de que se procesan de manera preeminente (Davidson, 2001; Fox, 2008; Vuilleumier, 2005). Esto es, un estímulo o suceso será detectado más rápidamente en tanto su valor emocional sea elevado. Zajonc (1980) propuso una de las primeras explicaciones sobre la importancia que las emociones tienen en la toma de decisiones al considerar que las reacciones emocionales debían ser las primeras en surgir ante un estímulo y éstas guiarían automáticamente el procesamiento de la información y los juicios del receptor. Ello conlleva que cualquier estímulo podría generar una emoción, de modo que no se podría realizar una valoración al margen de la misma ante tal estímulo, pues en multitud de ocasiones nos guiaríamos por la emoción que nos produce.

En este sentido, es frecuente encontrar en la carretera estímulos que pueden inducir emociones concretas de relativa corta duración, ya sean negativas o positivas, los cuales pueden modular nuestra percepción de riesgo y nuestro comportamiento. Algunos ejemplos habituales pueden ser observar una maniobra peligrosa realizada por otro conductor en la que nos sentimos implicados, una retención de tráfico o las vallas publicitarias que apelan a las emociones para capturar la atención. Este tipo de estímulos en algunos casos puede interferir la conducción atenta y segura, o generar un estado emocional que, en un alto porcentaje de casos, guiará nuestro comportamiento (Mesken, 2006).

El efecto emocional también puede ser manipulado como instrumento para modificar el comportamiento del conductor hacía conductas más seguras como suele ser aplicado por las agencias de seguridad vial. Campañas de prevención de riesgos y cursos de rehabilitación de conductores suelen apelar al contenido emocional como forma de modificación de conducta y reestructuración cognitiva para evitar los comportamientos de riesgo en los conductores.

Por otro lado, tal como hemos expuesto en el análisis de los modelos de duales de decisión, las emociones son determinantes en la toma de decisiones en general y en el comportamiento de riesgo en particular, demostrando que las personas evaluamos el riesgo y adaptamos nuestro comportamiento a este tipo de situaciones no sólo desde un punto de vista racional, sino también a través de un componente emocional intrínseco a la valoración de la propia situación.

5. Objetivos de la tesis doctoral

La presente tesis tiene como principal objetivo el estudio de la interacción entre procesos cognitivos y emocionales en el comportamiento riesgo en situaciones de conducción. Este trabajo se encuentra dividido en dos grandes objetivos principales:

a) La primera parte de la tesis se centra en el estudio de cómo la presencia de estímulos con contenido emocional durante la conducción pueden modificar nuestras decisiones ante situaciones de riesgo que podemos encontrarnos en la carretera. En este caso se estudiará la emoción desde el punto de vista más clásico, como una reacción subjetiva al ambiente acompañada de un conjunto de manifestaciones cognitivas, fisiológicas y conductuales que conlleva el proceso de expresión emocional (Lang, 1994) y que pueden influir en el comportamiento de los conductores.

b) El segundo bloque de la tesis estará centrado en explorar por qué los conductores, en determinadas ocasiones, se implican en comportamientos de riesgo los cuales no se adaptan exclusivamente a un análisis racional de la situación, observándose una importante disociación entre el riesgo percibido y la conducta finalmente realizada. En este apartado centraremos nuestro esfuerzo en discernir cómo los factores emocionales desempeñan un papel fundamental en la elección entre alternativas de comportamiento, tomando como base los sistemas duales de procesamiento (Damasio, 1994; Slovic et al., 2007).

A continuación describimos brevemente el objetivo específico de cada uno de los capítulos de la presente tesis.

Chapter II: Two ways of understanding the emotional influence in traffic psychology.

El capítulo II está dedicado a realizar una revisión, desde la literatura más actual, de cómo el factor emocional puede modular el comportamiento de los conductores. Este capítulo complementa la información ofrecida durante la introducción de la presente tesis, y sirve como visión general para el desarrollo de los dos bloques experimentales. En él analizamos la influencia emocional desde diferentes puntos de vista, para así alcanzar una mejor comprensión del comportamiento de los conductores. Además intentamos abordar posibles soluciones a los peligros derivados del factor emocional y aprovechar los beneficios que estos mismos factores pueden tener en el diseño de programas de evaluación y prevención de riesgos.

Experimental Block 1

Processing and influence of affect-laden stimuli in driving

El primer bloque experimental de la tesis está dedicado a explorar la influencia que diversos estímulos con contenido emocional pueden tener en situaciones de riesgo durante la conducción de un vehículo. Trabajamos el efecto de la emoción desde tres puntos de vista en función del momento temporal en el que el estímulo emocional es presentado: el efecto de estímulos emocionales visualizados de forma incidental previamente a la situación de riesgo (Chapter III), el efecto del feedback emocional presentado una vez la conducta de riesgo ha sido realizada (Chapter IV) y la emoción como un factor implícito en la propia tarea de conducción (Chapter V). Además estudiamos cómo la emoción puede modular patrones atencionales y coómo su influencia puede depender de características interindividuales de los conductores.

Chapter III: Modulation of risky driving behaviors by emotional stimuli presented incidentally on the road.

El capítulo III estuvo conformado por dos experimentos (experimento 1: Modulation of Attention and Urgent Decisions by affect-laden roadside advertisement in Risky Driving Scenarios; experimento 2: Emotion-laden stimuli influence our reactions to traffic lights). El objetivo de estos dos estudios experimentales fue explorar la influencia que un conjunto de vallas publicitarias con contenido emocional puede tener sobre el comportamiento de los conductores. Nos centramos en el estudio de la influencia del contenido emocional en la toma de decisiones ante una situación de riesgo y en el efecto atencional que conllevan las vallas publicitarias, pudiendo actuar como distractores.

Chapter IV: How does feedback appealing fear modulate risky driving behavior?

Este estudio tuvo como objetivo mostrar el efecto que el feedback con contenido emocional aplicado tras la realización de conductas imprudentes o arriesgadas tiene en el comportamiento de los conductores de motocicleta. La efectividad de estos mensajes es evaluada mediante el uso de un simulador de motocicleta, lo cual nos permite el análisis de una gran cantidad de variables sobre el rendimiento en la conducción y el cumplimiento de las normas de tráfico.

Chapter V: The passenger effect: Risky driving is a function of the driver-passenger emotional relationship.

El quinto capítulo explora la influencia del valor emocional asociado al contexto de conducción y si cambios en éste pueden modificar la percepción de probabilidad de sufrir un accidente. En este caso, el factor emocional manipulado no es un elemento presentado de forma incidental en la carretera o posteriormente como feedback a la respuesta del conductor, sino que es un cambio en el factor emocional implícito en la propia tarea. Evaluamos la probabilidad de sufrir un accidente que los conductores perciben en función de ir acompañado de un pasajero con el que se tiene un fuerte vínculo afectivo o de un pasajero con el que no se tiene una relación estrecha. Además, exploramos si el efecto emocional depende de variables individuales como el sexo del conductor.

Experimental Block 2

Urgent and Evaluative Behavior Dissociation

El segundo bloque experimental de la tesis se centra en intentar dar respuesta a la falta de contingencia a veces encontrada entre la percepción de riesgo y la toma de decisiones en situaciones arriesgadas. Durante la conducción de un vehículo debemos tomar una gran cantidad de decisiones, eligiendo entre opciones alternativas de acción cuyas consecuencias en algunas situaciones son inciertas. Tomar decisiones es una habilidad adaptativa especialmente importante cuando las consecuencias de nuestra decisión pueden entrañar riesgo para nuestra salud o bienestar. Sin embargo, en determinadas ocasiones los conductores se implican en comportamientos de riesgo que no se adaptan exclusivamente a un análisis racional de la situación. ¿Cómo podemos explicar que un individuo elija la alternativa de comportamiento que puede llevarle a resultados catastróficos, incluso siendo evaluada ésta como una situación arriesgada y siendo consciente de que esa decisión puede tener consecuencias muy negativas? Es en este tipo de decisiones arriesgadas en él que está interesado el presente bloque experimental.

Para estudiar esta falta de relación entre el riesgo percibido y la toma de decisión finalmente realizada, centramos nuestros estudios en dos tipos de comportamientos que se adaptan a las características de esta disociación: conductas urgentes y conductas evaluativas. Conductas urgentes serían aquellas decisiones comportamentales guiadas por el estímulo, que se encuentran bajo una fuerte presión temporal y que, en caso de no tener éxito nuestra respuesta, conllevarían consecuencias negativas; por ejemplo, decidir frenar cuando observamos un peatón cruzar la carretera de forma inesperada. Por otro lado, las conductas evaluativas consistirían en juicios evaluativos donde tan sólo se le atribuye un valor a la situación, la respuesta puede ser demorada y no conlleva perjuicios; por ejemplo, una conducta evaluativa sería la actitud que un observador de la situación anteriormente comentada (peatón cruzando de forma inesperada) podría tener a la hora de evaluar si la acción implica riesgo o no.

A partir de esta clasificación, nuestro objetivo en los capítulos VI, VII y VIII consiste en explorar los rasgos que diferencian cada una de estas conductas teniendo en cuenta la dinámica interactiva de los sistemas cognitivo y emocional propuesta por los sistemas duales de procesamiento (Damasio, 1994, Reyna, 2004, Kahneman & Frederick, 2005).

Chapter VI. Emotional Modulation of Urgent and Evaluative Behaviors in Risky Driving Scenarios.

Se introduce la distinción entre conductas evaluativas y urgentes. Estudiamos posibles diferencias comportamentales entre ambas conductas con el objetivo de comprobar si éstas pueden explicar parte de la falta de relación directa entre la evaluación del riesgo percibido y la toma de decisiones que se derivada de esta percepción. Además examinamos la influencia que una serie de estímulos con diferente valencia emocional pueden tener sobre ambos comportamientos.

Chapter VII. Driving risk perception vs. Driving risk taking: Influence of the task features.

Exploramos los rasgos de la tarea que diferencian las conductas urgentes y evaluativas en situaciones de riesgo de conducción con el objetivo de explicar las discrepancias encontradas entre ambas conductas en el capítulo anterior. Estas diferencias son estudiadas desde un punto de vista de un procesamiento tanto racional como emocional de las situaciones de riesgo, tal como es propuesto por los sistemas duales de procesamiento.

Chapter VIII. Neural mechanisms underlying urgent and evaluative behaviors: an fMRI study on the interaction of automatic and controlled processes.

En este último estudio experimental nos proponemos explorar las bases neurales de las conductas urgentes y evaluativas llevadas a cabo en el contexto de conducción. Si la conducta de riesgo es explicable a partir de factores cognitivos y afectivos, la construcción de un modelo completo requerirá conocer su base cerebral anatómica y funcional. Por tanto tenemos como objetivo final explicar qué factores inciden sobre ambos sistemas de procesamiento, cuáles son las áreas implicadas y cómo estos dos sistemas interactúan entre sí a nivel cerebral.

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CHAPTER II

Emotion & driving overview: Two ways of understanding the emotional influence in traffic psychology

(In Spanish)

Resumen

La emoción constituye un elemento fundamental en el estudio del comportamiento de conducción. En la actualidad, desde el ámbito de la psicología y la neuro-economía se suele diferenciar dos posibles formas de modulación emocional del comportamiento. Por un lado, la emoción es comúnmente definida como una reacción subjetiva al ambiente acompañada de una serie de cambios fisiológicos, cognitivos y conductuales que pueden modificar nuestro comportamiento. Pero existe otro tipo de modulación emocional más sutil, asociada al proceso de toma de decisiones, la cual no tiene por qué conllevar cambios conscientes en el organismo y, sin embargo, también orientaría el comportamiento del conductor. En Psicología del Tráfico, la distinción entre estos dos tipos de modulación emocional no ha recibido toda la atención necesaria. En este trabajo se analiza la necesidad de estudiar ambas concepciones emocionales desde puntos de vista diferenciados, para así alcanzar una mejor comprensión del comportamiento de los conductores, y poder incluir estos factores emocionales en el diseño de programas de evaluación y prevención de riesgos.

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1. Introducción

El estudio de la interacción entre procesos cognitivos y emocionales, y el efecto de éstos sobre el comportamiento de los conductores es de gran importancia en el ámbito de la seguridad vial (p.ej. Alonso, Esteban, Calatayud, Alamar & Egido, 2006; Mesken, 2006; Levelt, 2002; Groeger, 1997). Es fácil recordar situaciones en las que algún estímulo o evento en la carretera, como puede ser una retención de tráfico o una maniobra más o menos peligrosa realizada por otro conductor en la que nos sentimos implicados, pueden generar un estado emocional de ira que, en un alto porcentaje de casos, guiará nuestro comportamiento hacia conductas relacionadas con la conducción agresiva y el incremento de comportamientos de riesgo (James & Nahl, 2000). Este tipo de comportamiento irá acompañado además de un conjunto de manifestaciones cognitivas, fisiológicas y conductuales que conlleva el proceso de expresión emocional (Lang, 1994) que, en muchos casos, interfiere la conducción atenta y segura.

Generalmente, la investigación sobre la influencia emocional en conducción se ha centrado en este tipo de escenarios; la emoción se ha estudiado como una reacción subjetiva al ambiente acompañada de una serie de cambios fisiológicos, como ocurre bajo un estado de ánimo negativo o positivo, o cuando algún evento en la carretera genera una emoción en el conductor (James & Nahl, 2000; Mesken, 2006). En estos casos la respuesta emocional del organismo se produce normalmente de forma consciente y es posible analizar el significado afectivo y las reacciones fisiológicas que desencadena un determinado evento (aumento de la tasa cardiaca, sudoración, etc.). No obstante, existe otro tipo de modulación emocional asociado al proceso de toma de decisiones y el comportamiento de riesgo, el cual estaría centrado en el concepto de marcador somático (Damasio, 1994) o más recientemente el “affect heuristic” (Slovic et al., 2007), donde el proceso de expresión emocional y los cambios fisiológicos derivados pueden pasar desapercibidos para el propio sujeto que los protagoniza y, sin embargo, serían la guía fundamental del comportamiento en algunas situaciones (Simon, 1997). Este segundo tipo de influencia emocional estaría basada en la representación de las posibles consecuencias de nuestras decisiones, la cual no sólo contendría elementos descriptivos de la situación, sino también un componente emocional asociado que daría lugar a conductas de evitación en el caso de que la emoción fuera negativa y de aproximación si fuera positiva.

En psicología del tráfico, a diferencia de otros ámbitos de la psicología, la distinción entre estos dos conceptos emocionales ha sido escasamente considerada. El estudio de la influencia del estado de ánimo y las emociones generadas durante la conducción, como pueden ser la ira o la tristeza, ha dejado en un segundo plano el efecto que el componente emocional asociado a la toma de decisiones puede tener en nuestro comportamiento, siendo obviado su efecto en la conducción o siendo interpretado como parte del proceso emocional del estado de ánimo. Sin embargo, estas dos formas de modulación emocional conllevan diferentes características, factores causales y consecuencias, y de ahí, la necesidad de estudiarlas desde puntos de vista diferenciados para poder alcanzar una mejor compresión del comportamiento de conducción y de la seguridad vial. A continuación desarrollaremos cada uno de estos dos modos de influencia emocional haciendo hincapié en los estudios realizados hasta la fecha e intentando exponer las posibles aplicaciones que pueden tener en el campo de la seguridad vial.

2. Emoción y estado de ánimo en la seguridad vial

2.1. Modulación emocional de la conducción

Estado de ánimo y emoción son conceptos muy relacionados, ambos pueden ser caracterizados por un proceso de expresión emocional acompañado de una serie de cambios fisiológicos, cognitivos y conductuales que puede modular el comportamiento. En el ámbito de la conducción, los “estados de ánimo” son considerados como estados afectivos independientes de las situaciones de tráfico, que no están relacionados con una situación o estímulo en particular y que suelen prolongarse en el tiempo; por ejemplo, conducir bajo un estado emocional de tristeza. Por otro lado, el concepto de “emoción” en tráfico está relacionado con una reacción asociada a algún evento u estímulo presente durante la conducción y que provoca cambios bruscos en la valencia emocional y la activación durante un corto periodo de tiempo (Davidson et al., 1994; SWOW, 2010). Ambos conceptos serán tratados dentro de este mismo apartado, pero siempre sin dejar a un lado las diferencias existentes entre ellos, ya que poseen características específicas que pueden influir de forma desigual en la conducción.

a) *Estado de ánimo y conducción.* En primer lugar, en el estudio de las relaciones entre “estado de ánimo” y comportamiento del “conductor” numerosos trabajos han mostrado cómo cada estado de ánimo influencia diferencialmente la percepción de riesgo y nuestras decisiones durante la conducción (Fuller, 2011; Nygren, Isen, Taylor, & Dulin, 1996). De acuerdo con el modelo "affect infusion model" propuesto por Forgas (1995), ante un estado de ánimo con valencia emocional positiva, la persona tenderá a asumir más riesgos, ya que los aspectos positivos de la situación tomarán mayor peso y percibirá consecuencias más favorables; sin embargo, si el estado de ánimo es negativo es probable que realice menos acciones arriesgadas debido a que relacionará la acción con consecuencias negativas.

En este misma dirección, Megías, Díaz y Cándido (2012) realizaron un estudio donde, mediante la inducción de estados emocionales negativos y positivos a través del visionado de videos y el recuerdo autobiográfico de sucesos con diferente valencia emocional, encontraron que el estado de ánimo negativo fue asociado con una mayor frecuencia de conductas de frenado ante situaciones arriesgadas de conducción, en comparación con el estado de ánimo positivo.

Además, numerosos estudios (ver Mesken, 2006, para una revisión más completa) han demostrado que un estado emocional con alta valencia positiva, como puede ser la "euforia", generaría una peor conducción, dando lugar a una mayor violación de las normas de tráfico y a un sesgo hacia conductas más arriesgadas, debido a un cambio en el umbral de percepción del riesgo. Por otra parte, emociones negativas relacionadas con la "tristeza" conllevarían una menor cantidad de conductas de riesgo; sin embargo, este estado de ánimo depresivo, también puede provocar un peor rendimiento en la conducción debido a una menor atención sobre las zonas relevantes de la carretera y a unos tiempos de respuesta más elevados, por lo que un estado emocional de trísteza no tiene por qué ser causa de una mejor conducción (RACC, 2008).

Por último, otra emoción negativa frecuente durante la conducción, especialmente en conductores noveles, es el "miedo" (Sánchez, 2012). Éste puede ser considerado como un estado emocional aversivo producido por un peligro presente o imaginado, que incita al escape o a la evitación de la situación amenazante. Por tanto, una actitud temerosa hacía ciertos sucesos o circunstancias suprimirá o atenuará los comportamientos de riesgo, dando lugar a conductas más prudentes. Sin embargo, es necesario matizar que esta mayor prudencia en determinadas situaciones no tiene por qué estar ligada a una conducción más segura, ya que en muchos casos puede originar situaciones peligrosas para los demás, siendo uno de los factores de los accidentes de alcance, debido a comportamientos excesivamente conservadores (Alonso et al., 2006). Además, el miedo, a partir de cierto umbral subjetivo, puede pasar a convertirse en ansiedad desadaptativa, caracterizada por la percepción de una amenaza sin existir un estímulo peligroso o por una percepción del riesgo muy alejada del peligro real. Esto provocaría un estado de activación excesivo, dando lugar a niveles elevados de fatiga y a una conducción no adecuada a las características del tráfico; e incluso, dependiendo de características personales, podría interferir seriamente e impedir la conducción, como le ocurre a algunos conductores tras un accidente de tráfico en el que se han visto involucrados (Taylor, Deanem & Podd, 2002). La frecuente apelación al miedo que realizan las campañas de tráfico parece tener éxito en su objetivo de conseguir una mayor prudencia en la conducción, pero habría que tener en cuenta que, para conseguir beneficios óptimos, deberían ser adecuadas a las características de personalidad de diferentes conductores o grupos poblacionales.

b) *Emociones y conducción.* En segundo lugar, centrándonos en el análisis de la influencia de las "emociones" originadas durante la conducción, es frecuente encontrar en la carretera estímulos o eventos que pueden inducir "emociones" concretas de relativa corta duración, como ocurre al observar un accidente o una maniobra arriesgada por parte de otro conductor. Este tipo de situaciones o estímulos, especialmente los que poseen un alto contenido emocional, ya sea negativo o positivo, modulan nuestra percepción del riesgo y actúan como distractores, provocando un decremento de la atención sobre la zona relevante de carretera que es necesaria para realizar una buena conducción (Crundall, Van Loon & Underwood, 2006; Di Stasi et al., 2010a; Megías et al., 2011c; Serrano, J., Di Stasi, L.L., Megías, A. & Catena, A., 2014).

En este sentido, Megías et al. (2011c) llevaron a cabo un estudio con el objetivo de explorar la influencia que un conjunto de vallas publicitarias con carga emocional puede tener sobre el comportamiento de los conductores. Los participantes, sentados en el simulador de motocicleta Honda Riding Trainer (HRT) (ver Di Stasi et al., 2009, para más detalles sobre el simulador) visionaron una serie de videos que mostraban secuencias de conducción en carretera en las que fueron insertadas vallas publicitarias. Cada uno de estos carteles publicitarios contenía una imagen seleccionada desde el International Affective Picture System (IAPS) (Lang, Bradley & Cuthbert, 2005; versión española, Vila et al, 200), la cual podía tener una valencia emocional negativa, positiva o neutra. Posteriormente a la presentación de los estímulos emocionales los participantes se enfrentaban a una situación arriesgada, en la cual debían decidir si frenaban o no para evitar el elemento peligroso (una posible colisión con otro vehículo, bicicleta o peatón en el caso de Megías et al. (2011c); y pasar un semáforo en ámbar para Megías, Maldonado & Cándido (2011a)). Además se llevó a cabo un registro de los movimientos oculares de los participantes mediante el sistema Eyelink.

Los resultados mostraron que las imágenes con contenido emocional, especialmente las negativas, provocan una fuerte captura atencional y reducen la atención sobre las regiones relevantes de la carretera. Por otro lado, se observó que los estímulos visuales con valencia negativa, una vez fueron rebasados y la atención volvió a ser dirigida a la carretera, conllevaron una menor tendencia a realizar comportamientos de riesgo (se cruzó con menor frecuencia el semáforo en rojo) y aceleraron las respuestas de frenado para evitar el riesgo.

Continuando esta misma línea, Di Stasi et al. (2010a) mediante la presentación de sonidos con contenido emocional como el llanto o la risa de un niño, observaron que este tipo de sonidos provocaron un patrón ocular no adecuado a la conducción y una mayor probabilidad de sufrir un accidente en comparación con las situaciones en las que sólo se presentaron sonidos emocionalmente neutros.

Otro ejemplo habitual de modulación emocional a partir de un evento presente en la carretera puede ser la "ira" generada por una retención de tráfico o por verse implicado en alguna maniobra imprudente de otro conductor (SWOW, 2010). En estos casos, esta emoción (ira) provoca una conducción agresiva, la cual se caracteriza por una menor percepción del riesgo (Mesken, Lajunen, & Summala, 2002), una mayor violación de las normas de tráfico (King & Parker, 2008) y un aumento en el número de accidentes (Nesbit, Conger & Conger, 2007).

En resumen, parece claro que tanto el estado de ánimo previo a la conducción (p.ej. euforia, tristeza o miedo), como las emociones inducidas por situaciones o estímulos presentes mientras conducimos, aunque en ciertas situaciones puedan llevar asociado comportamientos más prudentes, en general conllevan más riesgos que beneficios y alientan comportamientos que pueden ser peligrosos para la seguridad vial. El problema que se plantea desde una perspectiva psicológica es el estudio experimental de sus efectos sobre el comportamiento del conductor y la posibilidad de control de dichas emociones para favorecer una conducción más segura.

2.2. ¿Cómo controlar nuestras emociones?: conducción con inteligencia emocional.

Como hemos visto, muchos de los comportamientos inseguros o peligrosos de los conductores se deben a una excesiva activación emocional, cuyo ejemplo más representativo podría ser la conducción agresiva originada por la ira. El control de nuestras emociones puede ser una herramienta para mejorar nuestra conducción, pero ¿es posible controlar las emociones que afectan negativamente a nuestra conducción? y, sobre todo, ¿cómo podemos aprender a controlarlas?.

En el ámbito de la psicología del tráfico se está extendiendo el concepto de conducción emocional inteligente, entendiéndose ésta como el intento de comprender y adaptar nuestras emociones para llevar a cabo una conducción segura (Alonso et al., 2006). Basándonos en las ideas propuestas desde el campo de investigación de la inteligencia emocional (Mayer & Salovey, 1997; Goleman, 1995) serían necesarios dos elementos fundamentales: 1º) toma de conciencia: el primer paso para poder controlar efectivamente las emociones sería la capacidad de reconocer las emociones de manera temprana; 2) capacidad y estrategias de control: en segundo lugar, el conductor debe poseer o aprender las habilidades para manejarlas, conociendo las estrategias de afrontamiento adecuadas, además de otras habilidades como pueden ser la autoconciencia, el control de impulsos o la empatía que incrementen la conducción emocional inteligente .

Un buen punto de partida podría ser un conjunto de estudios donde se proclama la "conducción amable", la cual es principalmente caracterizada por ser tolerante, exculpatoria y cooperadora (Alonso et al., 2006). Un estilo de conducción en el cual sabemos cómo controlar nuestra excesiva activación emocional, permitiéndonos comprender qué está ocurriendo en la circulación del tráfico, interpretar de forma intuitiva la conducción del resto de conductores y poder desarrollar nuestras habilidades como conductores. Este modo de conducción se alejaría de otros dos estilos bastante frecuentes en nuestra sociedad y que deberían ser evitados: la conducción defensiva y la conducción agresiva (James, 2006).

La conducción defensiva estaría caracterizada por una alerta continua del conductor, centrando excesivamente su atención en las acciones del resto de conductores y los posibles peligros en la carretera. Este tipo de conducción implicaría una gran demanda de recursos hacia áreas de la carretera que no son relevantes. Incluso podría causar una sensación de indefensión que provocaría no poder desarrollar nuestras habilidades como conductores y la realización de conductas inadecuadas como conducir a velocidades demasiado lentas o frenar de forma inesperada en situaciones donde no es necesario, incrementando de esta forma la posibilidad de sufrir algún accidente de alcance (Megías, Maldonado, Cándido & Catena, 2011b).

Por otro lado, la conducción agresiva se caracteriza por acciones que exceden las normas de una conducción segura y que afectan directamente a los demás usuarios del tráfico, siendo generalmente motivada por la impaciencia, enfado, hostilidad o un intento de ahorrar tiempo provocado en muchas ocasiones por las condiciones del tráfico (NHTSA, 2009). La intolerancia y los estereotipos hacia otros conductores y peatones es un denominador común en este tipo de conducción. Estos conductores se caracterizan por un locus de control externo, atribuyendo los errores e infracciones al resto de usuarios de la vía, lo cual provoca una mayor asunción de riesgos (Alonso et al., 2006). Por ejemplo, los conductores agresivos tienden a realizar más adelantamientos arriesgados, no suelen respetar la distancia de seguridad y se ven implicados con mayor frecuencia en accidentes o en el incumplimiento de las normas de tráfico (James & Nahl, 2000).

De este conjunto de ideas se deriva la necesidad de evitar tanto la conducción agresiva guiada principalmente por un estado emocional de ira, como la conducción defensiva guiada por el miedo; y buscar una conducción en la que nuestras emociones se mantengan en unos límites apropiados para la conducción; siendo la "conducción amable", basada en una conducción con inteligencia emocional, la más adecuada. Leon (2000), basándose en este concepto, propone un conjunto de habilidades que debería poseer y practicar un conductor competente, como puede ser centrarse en uno mismo en vez de culpar a los demás, reconocer la diversidad de conductores y sus necesidades y estilos, o aceptar el tráfico como un trabajo colectivo en equipo en vez de como una competición individual (p.ej. "el tráfico es muy lento, ¿qué le pasa a esta gente?, conducen muy mal" frente a "hoy me siento muy impaciente, todo me saca de mis casillas" o “tampoco es tanto tiempo y puedo aprovechar para ir más tranquilo y escuchar música”).

Nuestra propuesta para una conducción con inteligencia emocional se basaría en la existencia de dos componentes: 1º) la autoconciencia temprana del estado emocional alterado, basada en técnicas de auto-observación y 2º) el desarrollo de técnicas de autocontrol, basado en la adquisición de habilidades de afrontamiento. Por ejemplo, mediante el uso de pensamientos y auto-instrucciones positivas frente a negativas; o bien, mediante la difusión y adquisición de un estilo de conducción amable, centrado en la empatía y no en la competencia y la agresividad. Todas estas ideas intentaremos retomarlas posteriormente, una vez completado el análisis de la influencia emocional en la conducción.

3. El componente emocional asociado a la toma de decisiones en conducción.

3.1. Influencia en la conducción.

El concepto de emoción asociado a la conducción, no sólo puede ser considerado como una reacción subjetiva al ambiente, normalmente consciente y acompañada de una serie de cambios internos de carácter fisiológico, cognitivo y conductual, como hemos estudiado en el apartado anterior. Desde la perspectiva de la psicología cognitiva y la neuro-economía se considera que toda toma de decisión conlleva de forma intrínseca un componente emocional independiente del estado afectivo de la persona in situ. Este componente emocional orientaría y motivaría nuestro comportamiento en la conducción y, sin embargo, puede normalmente pasar desapercibido para el propio conductor que lo protagoniza, influenciando la conducta de forma no consciente.

Los modelos teóricos actuales que explican la toma de decisiones, como el "modelo del proceso dual" (Epstein, 1994) o la teoría del "affect heuristic" (Slovic, Finucane, Peters & MacGregor, 2007), consideran que valoramos e interactuamos con nuestro entorno a través de dos sistemas de procesamiento: uno racional-analítico y otro experiencial-afectivo. Ambos sistemas determinarían nuestras decisiones de forma conjunta pero en función de la situación y de características interindividuales un sistema puede cobrar mayor peso que otro.

El sistema experiencial estaría guiado, en gran medida, por el concepto que Damasio (1994) y Slovic et al. (2007) han denominado como "marcador somático" o "affect heuristic", respectivamente. Estos autores proponen que nuestras representaciones mentales de un estímulo o situación llevan asociado un componente emocional aprendido (positivo o negativo) que permitiría predecir las consecuencias de nuestras acciones de acuerdo con la experiencia previa. Cuando la representación mental conlleva un componente emocional negativo, se producirá un efecto de alarma que evitará una acción de aproximación al estímulo o situación; mientras que si la representación mental conlleva un carácter positivo, éste constituirá un incentivo para realizar una acción de aproximación. Guiarnos por este sistema sería especialmente útil en aquellos casos, muy comunes en entornos de tráfico, donde es necesaria una respuesta urgente, el contexto no nos ofrece toda la información necesaria o existe incertidumbre acerca del resultado de nuestra acción. Así, por ejemplo, ante un adelantamiento arriesgado en el que es demandada una respuesta urgente, la asociación de esta conducta con un componente negativo, como puede ser la representación de un posible accidente, generaría respuestas rápidas y eficientes con un coste reducido en el momento de realizarlas, evitando el peligro sin tener que realizar un análisis racional y en profundidad de la situación.

Basándose en esta idea, Megías, Cándido, Catena, Molinero y Maldonado (2012) han demostrado cómo las diferencias en el componente emocional inducidas a través de un cambio en el contexto del pasajero que nos acompaña en el vehículo (nuestro hijo o un compañero de trabajo) pueden influir en la conducción. La tarea de los participantes consistió en estimar la probabilidad de que ellos, como conductores de una motocicleta, sufrieran un accidente en un conjunto de situaciones de conducción que fueron categorizadas en función del nivel de riesgo. Los autores observaron que el grupo de mujeres que componía el estudio percibió una mayor probabilidad de accidente cuando el pasajero fue su hijo que cuando fue su compañero de trabajo, a pesar de que la situación de riesgo fue exactamente la misma. De este modo, cambios en el componente emocional asociado a un posible accidente pueden originar diferencias en factores de carácter mayormente racional como la estimación de la probabilidad de accidente y, con ello, provocar una esperable modulación de nuestras decisiones.

Por otra parte, también puede ocurrir que en algunas ocasiones asociemos un comportamiento arriesgado (p.ej. pasar un semáforo en ámbar o exceder el límite de velocidad), con llegar antes a nuestra casa o no llegar tarde al trabajo, lo cual conllevará un componente emocional positivo que motivaría una respuesta de aproximación a la conducta de adelantamiento, ensombreciendo el peso del sistema racional-analítico y poniendo en evidencia los posibles riesgos que en algunas ocasiones puede tener guiarse por el sistema experiencial-afectivo. De este modo, es presumible que parte del problema de la toma de decisiones en situaciones arriesgadas sea consecuencia de una falta de equilibrio entre estructuras ligadas al impulso (afectivas), y estructuras de control de impulsos (racionales) (Eshel, Nelson, Blair, Pine & Ernst, 2007). Individuos proclives a adoptar decisiones arriesgadas podrían tener un déficit en el balance entre los dos sistemas. Esto es, en términos generales la proclividad al riesgo será mayor cuanto mayor sea la hipoactivación de las estructuras de control del comportamiento, medida en relación a estructuras implicadas en el impulso y la búsqueda de recompensas.

3.2. Modificación del comportamiento de conducción a través del componente emocional asociado a la toma de decisiones.

Existen elementos relacionados con el comportamiento de riesgo en conducción que cierta parte de la población, sobre todo en el caso de los jóvenes, asocian con un componente emocional positivo, como son el exceso de velocidad, realizar un adelantamiento arriesgado o el consumo de drogas legales e ilegales; ello parece ser debido principalmente a una búsqueda de sensaciones positivas, de diversión o deseabilidad social en su entorno (Bina, Graciano, & Bonino, 2006; Reyna & Farley, 2006). Eliminar este tipo de comportamientos que no se adecuan a una buena conducción es importante en nuestra sociedad. Para ello, un cambio en el componente emocional asociado a la conducta es fundamental, aun más si tenemos en cuenta que muchas de las decisiones que se toman en carretera se encuentran bajo una fuerte presión temporal, donde no es posible realizar un análisis mayormente racional de la situación.

La modificación de la conducta a partir del componente emocional puede ser llevada a cabo mediante la asociación de un componente negativo a aquellos comportamientos relacionados con una conducción deficiente, pero también es posible mediante la asociación de emociones positivas a conductas adecuadas. Por tanto, una buena forma de trabajar sería intercalar ambas estrategias; siempre teniendo en cuenta que, como comentamos anteriormente, la apelación al miedo u otros contenidos negativos puede tener éxito sólo en caso de aplicarlo de manera específica y adecuada a características individuales. Algunos ejemplos pueden ser observados en las campañas que la DGT realiza sobre seguridad vial, en las que no sólo se relacionan conductas como el exceso de velocidad o el consumo de alcohol con imágenes de contenido negativo, sino que también se relacionan conductas prudentes con contenidos positivos, como, por ejemplo, llegar a casa con toda la familia en Navidad (DGT, 2012).

Por otro lado, las conductas guiadas mayormente por el componente emocional a través del sistema experiencial, en la mayoría de las ocasiones, serán conductas automatizadas o hábitos aprendidos para ser ejecutados ante determinadas circunstancias específicas, sobre todo en aquellos casos en los que es demandada una conducta urgente (Megías et al., 2011b). Así, dadas unas condiciones, se produce la respuesta sin que el individuo tenga que tomar consciencia de todos los elementos de la misma (Anderson, 1999). Los hábitos, debido al refuerzo conductual a través del cual se han generado, son más difíciles de modificar, pues depende de la situación que automáticamente los "dispara", más que de las decisiones llevadas a cabo mediante un proceso deliberativo (reflexivo) en el que el sistema analítico tendría un mayor peso (Domjan, 2007; Megías, López-Riañez & Cándido, 2012). De aquí, la necesidad de trabajar sobre comportamientos concretos y el componente emocional asociado a ellos desde que comenzamos a iniciarnos en la conducción, o incluso antes, mediante programas de seguridad vial.

4. Conclusiones

A lo largo de este documento hemos diferenciado dos modos de modulación emocional de la conducta: por una lado tendríamos la derivada de los estados de ánimo y las emociones generadas por estímulos en la carretera, y por otro el componente emocional que conlleva la consecuencia esperada de una decisión.

Nuestro estado de ánimo o las emociones generadas por los estímulos presentes en la carretera pueden modificar nuestro comportamiento, repercutiendo, como en el caso de la ira o la euforia, en el rendimiento y en la capacidad para llevar a cabo una conducción segura. Estas características han llevado a que, en algunas circunstancias, la emoción sea considerada como un aspecto disfuncional para la conducción. Pero esta apreciación tiene que ser matizada, ya que sí es cierto que la emoción puede condicionar nuestra conducta e impedir realizar un análisis racional profundo de la situación, pero también hay que considerar que las emociones, lejos de ser un obstáculo para la toma de decisiones adecuada, son un requisito imprescindible para la misma, como refleja el segundo modo de modulación emocional que proponemos -el componente emocional asociado a la toma de decisiones- (Simon, 1997). Este otro tipo de influencia emocional posibilita que podamos llevar a cabo muchas de las conductas de conducción que son demandadas en situaciones urgentes. Este componente emocional es la guía de muchas de nuestras conductas de riesgo, dando lugar a conductas prudentes o imprudentes, en función de su valencia emocional.

Trabajar sobre ambos tipos de modulación emocional de forma conjunta puede llevar a una mejor comprensión de las conductas de riesgo y así poder intervenir sobre los comportamientos inapropiados que, a veces, se realizan durante la conducción. Por un lado, el control de las emociones y su expresión emocional pueden ayudar a llevar a cabo una conducción más segura y adecuada a las características del tráfico; por otra parte, la modificación del comportamiento mediante la asociación del componente emocional adecuado a la representación de una determinada situación puede tener grandes beneficios en el escenario vial; por ejemplo, reduciendo el número de conductas de riesgo. Por tanto, asumimos que para un control adecuado de la modulación emocional de la conducción serían necesarios dos elementos fundamentales: en primer lugar, la toma de conciencia por parte del propio conductor de cómo su estado emocional alterado, sea por ira, tristeza, miedo o incluso por emociones positivas como la euforia, puede afectar negativamente a su conducción generando riesgos innecesarios para sí mismo o para los demás. En segundo lugar, la toma de conciencia por parte de la sociedad y de las autoridades competentes de la importancia de las emociones en la conducción, para así promover programas de formación de conductores y campañas de conducción más seguras y eficientes, basadas en el concepto del componente emocional asociado a nuestras decisiones y dirigidas a un tipo de "conducción amable" o "conducción con inteligencia emocional".

Los programas formativos basados en el cambio de actitud de los conductores ayudarían a reducir y prevenir las graves consecuencias que ocasionan los comportamientos de riesgo en conducción (Jariot & Montané, 2009). La inclusión de los factores emocionales en el diseño de estos programas de evaluación, prevención y control de la conducta son un factor esencial a tener en cuenta en las políticas de transporte y seguridad vial, e incluso pueden ser claves para el desarrollo de futuros sistemas avanzados de asistencia a la conducción (SAAC).

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Experimental Block 1

Processing and influence of affect-laden stimuli in driving

CHAPTER III

Modulation of risky driving behaviors by emotional stimuli presented incidentally on the road

Study 1

Modulation of attention and urgent decisions by affect-laden roadside advertisement in risky driving scenarios

Abstract

In road safety literature the effects of emotional content and salience of advertising billboards have been scarcely investigated. The main aim of this work was to uncover how affect-laden roadside advertisements can affect attention -eye-movements- and subsequent risky decisions –braking- on the Honda Riding Trainer motorcycle simulator. Results indicated that the number of fixations and total fixation time elicited by the negative and positive emotional advertisements were larger than the neutral ones. At the same time, negative pictures got later gaze disengagement than positive and neutral ones. This attentional capture results in less eye fixation times on the road relevant region where the important driving events happen. Finally, the negative emotional valence advertisements sped up braking on subsequent risky situations. Overall results demonstrated how advertisements with emotional content modulate attention allocation and driving decisions in risky situations and might be helpful for designing roadside advertisements regulations and risk prevention programs.

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1. Introduction

In the field of driving, we often find situations that can involve risk. When we overtake another car, a pedestrian suddenly crosses the street or a car appears at an intersection, we need to make urgent behaviors, such as braking to avoid accidents with serious consequences (Megías, Maldonado, Cándido, & Catena, 2011). Driver distraction is a significant road safety issue worldwide (Young & Lenné, 2010) and has been suggested as one of the factors that contribute most to the occurrence of risk situation and road crashes (Gras, Planes, & Font-Mayolas, 2008; Stutts, Reinfurt, Staplin, & Rodgman, 2001). In Spain, for example, according to the 2008 national road safety balance (MIR, 2009) there were 1,928 fatal accidents on the roads, and distractions were a contributing factor in 44% of accidents that occurred on non-urban roads. Therefore, the study of factors that influence both distractions and behaviors in risky situations will help us to better prevent casualties and to develop forecasting and effective techniques of risk taking in driving situations.

Many accidents due to distractions occur because drivers do not focus their attention on the relevant region of the road (Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006). The allocation of visual attention to a spatial location when driving shows a typical pattern of ocular exploration (Di Stasi, Contreras, Cañas, Cándido, Maldonado, & Catena, 2010a; Mourant & Rockwerll, 1972; Underwood, Chapman, Bowden, & Crundall, 2002). Most eye fixations are directed to the focus of expansion, the area of the road in front of the vehicle. Fixations outside this central region usually follow the left and right line of the focus of expansion, within a horizontal visual search window, in which most of the relevant information commonly happens (Crundall, Van Loon, & Underwood, 2006). When events outside the focus of expansion capture the driver’s attention, less attentional resources can be allocated to the relevant area of the road. These visual distracters could lead to a greater likelihood of fatal casualties, especially when they happen together with an unexpected risk situation.

Roadside advertisements are common visual external distractions from driving (Brumec, Herman, Hrabar, & Polic, 2010). External distractions are influenced by those situations in which the driver's attention is captured by an event, object, person or activity irrelevant to driving and outside the vehicle (NHTSA, 2009). The influence of advertisements on drivers’ behavior and attention has been widely shown (see Research and Education Program of Kingston, 2007; Crundall et al., 2006; Smiley, Smahel, & Eizenman, 2004; Wallace, 2003). The magnitude of their visual capture effect is a function of several factors, such as driving context (Young et al., 2009; Farbry, Wochinger, Shafer, Owens, & Nedzesky, 2001), the different types of advertising (Beijer, Smiley, & Eizenman, 2004; Lee, McElheny, & Gibbons, 2007) or its position (Chattington, Reed, Basacik, Flint, & Parkes, 2009; Crundall et al., 2006). The position on the road has been an issue largely studied as one of the most important factor in the drivers’ distraction. For example, billboards placed on curves are especially distracting because of its location close to the line of sight when drivers enter the bend (Beijer, 2002). Chattington et al. (2009) showed also that advertisements in the center of the driver´s field of view tend to receive more glances than lateral ones.

It also seems important to acknowledge that the outdoor advertising strategy was dominated by static large billboards, but in the last decade it has experienced a radical change: the digitalization of their contents. Digital billboards are illuminated from within and are able to display video. The presence of motion and greater brightness make them more of attractive for drivers increasing distractions. In fact, recent studies have showed how they attract more the driver´s attention causing a significantly greater impairment to driving performance when compared with static billboards (Lee et al., 2007; Chattington et al., 2009). These findings have important applications for marketing agencies and advertising experts to attract the attention of the maximum number of observers to the displayed product or service (Brumec et al., 2010); but they also have important consequences because the higher the drivers distraction, the more the probability of fatal casualties (Klauer et al, 2006).

A factor scarcely cited in road safety literature is the effect of the emotional content and salience of roadside advertisements, even though it is well known that attention is easily captured by emotional stimuli (Pessoa, Kastner, & Ungerleider, 2002; Compton, 2003; Vuilleumier, 2005) and its processing can enhance or impair decisions in risky situations, as a function of its positive or negative content (Chou, Lee, & Ho, 2007; Loewenstein, Weber, Hsee, & Welch, 2001). Most importantly for our purposes, emotional stimuli affect driving performance (Pêcher et al., 2009; Di Stasi et al., 2010 a, b), especially if urgent actions are required (Megías et al., 2011). The main aim of our study was to look for the impact of emotional advertisement both on attention and decisions of drivers.

A few studies have recently investigated the effect of emotional induction while driving (Pêcher et al., 2009; Di Stasi et al., 2010 a, b). Pêcher et al. (2009) using music clips with different emotional valence (happy, sad, and neutral), demonstrated that happy clips distracted drivers more than sad and neutral ones, decreasing their speed and impairing lateral control. Analogous results were found by Di Stasi, et al. (2010a, b), showing that emotional sounds interfere with safe driving/riding behavior in a simulated road environment. Negative or unpleasant sounds (scream), rather than positive (laugh) or no sounds, led to shorter reaction times. Additionally, hearing a beep induced the riders to decrease their speed and focus their gaze on relevant areas of the visual field, while the emotional sounds did not. More recently, Megías et al. (2011)

have obtained similar findings using emotional pictures. Results showed that negative pictures rather than positive or neutral ones speed up the evaluation of risk at the cost of reducing or impair the discrimination of risk.

Consequently, the main aim of this study was to analyse whether static roadside advertisements containing pictures of different emotional valence (negative, positive, and neutral) modulate both external attention, measured by eye-movements, and decisions-making related with breaking in risky driving situations. We assume that the emotional content of the road advertisements will change the drivers' allocation of attention and their typical pattern of ocular exploration of the road and, will also influence the speed of braking in anticipation of a risk situation. In this study, the influence of roadside advertisements was analysed in a vulnerable road users category, young inexperienced motorcycle riders (16% of all road accident deaths in Europe in 2006 (ETSC, 2008)). Previous research has shown that young motorcycles drivers are more easily distracted (Miltenburg & Kuiken, 1991) and over-represented in road crashes (Dols, Pardo, Falkmer, & Först, 2001; Triggs, 2004).

2. Methods

2.1. Participants

Twenty two naive (11 women) undergraduate students of the University of Granada (age 18–25 years) took part in this study, in exchange for course credits. All had normal or corrected to normal vision, and had a motor vehicle driver´s license. Before the experiment they were informed of their rights according to the Helsinki declaration and they all signed an informed consent.

2.2. Apparatus and stimuli

The study was carried out on the Honda Riding Trainer motorcycle simulator (HRT) (see Di Stasi et al., 2009; 2010a for details on the HRT simulator). The road scenario was displayed on a projection screen (120 x 90 cm) located 185 cm in front of the rider, seated on the HRT seat. HRT data were collected at a rate of 30 Hz.

Based on the theoretical assumption that eye activity is an index of information processing in driving (Underwood, 2007), we recorded gaze behavior. Eye movements were sampled at 500 Hz using an Eyelink II head-mounted eye tracking system (SR Research, Mississauga, Canada). Spatial accuracy was always better than 0.5°. Saccades and fixations were measured using the saccade detection algorithm supplied by SR Research. Saccades were identified as deflections in eye position in excess of 0.1°, with a minimum velocity of 30° s^{-1} and minimum acceleration of 8000° s^{-2}, maintained for at least 4 ms. Nine-points calibration and validation were performed before starting the experiment. Fixations around blinks, as well as fixations less than 100 ms in duration, were not considered in the analysis.

The riding scenarios were short videos extracted from HRT simulator software. Each video was 7000 ms long and simulated an urban scenario. During the simulated ride, hazardous or risky situations were produced by unexpected incoming vehicles (cars and motorcycles) or pedestrians into the road (see Figure 1, bottom pictures). In these situations frequently found in real settings, participants had to brake using the motorcycle front brake lever (right) to avoid an accident. There were a total of 12 different road situations. Half of them presented the potential risk (unexpected cars, bikes or pedestrian appearing from the right/left side of the road), while the other six situations were identical, but without any risky stimulus.

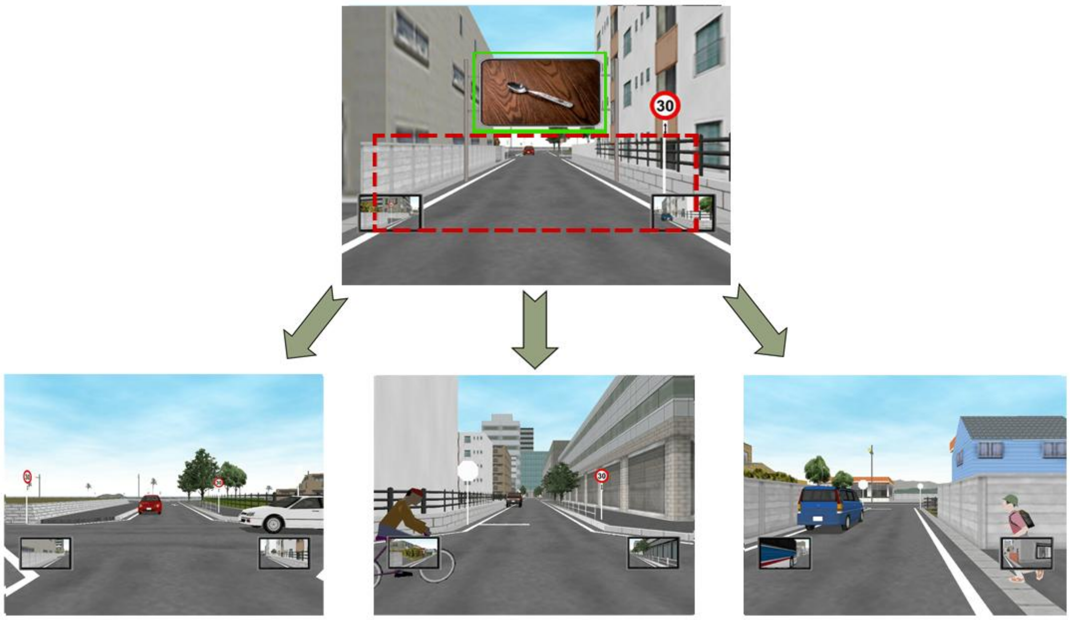

Figure 1. Top: roadside advertisement with neutral valence. Road relevant region indicated by the red broken box. Emotional cue region indicated by the green solid box. Bottom: risky stimuli.

Emotional cues were static roadside advertisements with pictures of different emotional valence inserted in each of the videos (figure 1). These advertisements were positioned in the center of the road to capture the attention as much as possible (Chattington et al., 2009), and appeared always 800 ms before the risky situations. The emotional pictures displayed in the advertisements were selected from the International Affective Picture System (IAPS, Lang, Bradley, & Cuthbert, 2005). The IAPS is a set of normative emotional stimuli standardized across a range of different dimensions for experimental investigations of emotion and attention. The two primary dimensions were taken into account in our study, affective valence (ranging from very unpleasant = 1; to very pleasant = 7) and arousal (ranging from very calm = 1, to very exciting = 7). Twenty-four pictures were used: eight with negative or unpleasant valence, mainly mutilations which could be related to accidents (1.526 average valence, Spanish norms, Vila et al., 2001); 8 had neutral valence, objects without emotional content such as a chair or a book (5.02 average valence) and 8 with positive or pleasant valence, a set of pictures that the IAPS labeled as romantic and related to some of those used in advertisements (7.048 average valence). The average arousal of neutral pictures was much lower (2.468) than negative and positive pictures, which were matched as much as possible in arousal (6.675 and 5.883 respectively), so that any difference between them should only be attributed to the emotional valence.

2.3. Procedure

Before the experiment, all participants were informed that unpleasant pictures would be displayed and that they were free to leave the experiment at any moment they could feel uncomfortable. The experiment had a total of 288 trials (videos) divided into 4 blocks of 72 trials (12 Risk Conditions x 24 Emotional Conditions). Therefore, each one of the 288 trials consisted of a different video, where there were 12 different road situations (6 risky and 6 non-risky) and 24 different roadside advertisement (8 negative, 8 positive, and 8 neutral).

Using a first-person view as a motorcycle driver, participants rode through the city streets. They had to brake (press brake lever) to avoid an accident when they faced a risky situation. Each trial (Figure 1) started with a variable fixation point (800ms-1200ms), followed by a video showing the motorcycle ride, which lasted up to 7000 ms or until the participant's break response. At 4800 ms, the roadside advertisement displaying the emotional picture approached as the motorcycle progressed. In half of the trials, a risky stimulus was displayed 800 ms after the roadside advertisement offset. Participants had to break as soon as possible when the risk stimuli appeared in order to avoid an accident that would have otherwise occurred following the risk appearance (600 ms, 800 ms or 1000ms depending on the video). The experiment lasted about 40 minutes.

3. Results

To estimate the effects of affect-laden roadside advertisement on attention and braking behavior we analyzed eye fixation time while the cues were on, as well as accuracy and reaction time of braking to the subsequent risk situation. A significance level of 0.05 was set up for all statistical decisions and LSD tests were used for all "post-hoc" comparisons.

The analysis of eye movements was performed on two regions of interest (ROI): the road relevant region (see figure 1, red box) and the roadside advertisement where the emotional pictures were displayed (see figure 1, green box).

ROI: Road relevant region.

We first studied the total fixation time (sum of the duration of all fixations on the ROI) on the road region relevant to driving, looking for differences in attention to this area as a function of the advertisements emotional content. This region includes the area in front of the vehicle (focus of expansion) and the lateral left and right regions in which driving related information is common (Figure 1, red box). This ROI was chosen because it includes most of the relevant areas like traffic signals, road crossings, and pedestrians. Each video was segmented in 7 time intervals of 800 ms each. During the first 6 intervals, the roadside advertisements were present with successive increasing visual angles ($M_{interval\ 1} = 4.02°$; $M_{interval\ 2} = 4.64°$; $M_{interval\ 3} = 5.49°$; $M_{interval\ 4} = 7{,}49°$; $M_{interval\ 5} = 14.29°$; $M_{interval\ 6} = 29.99°$). The last interval lasted from the advertisement offset to the onset of the risky stimulus (see Figure 2).

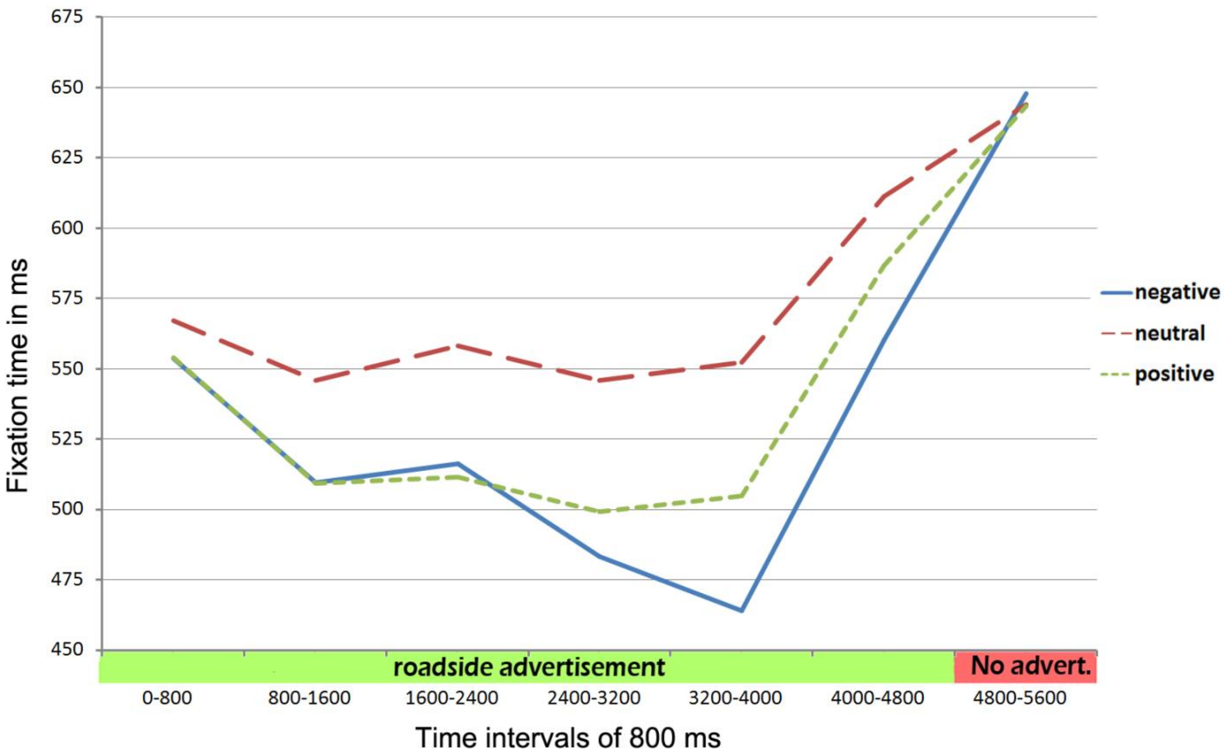

Figure 2. Fixation time on the driving relevant region according to emotional advertisement and time interval.

Total fixation times were submitted to a repeated measures ANOVA 3 (Emotional advertisement: negative, neutral, and positive) x 7 (Interval). There were significant main effects of Emotional content, F (2, 42) = 21.959, MSE = 3710.902, $p < .05$, η^2_p = 0.511, Interval, F (6, 126) = 39.972, MSE = 4444.557, $p < .05$, η^2_p = 0.656, and the interaction Emotional content by Interval, F (12, 252) = 9.815, MSE = 659.238, $p < .05$, η^2_p = 0.319.

The LSD post-hoc analysis of the interaction showed no significant differences between emotional advertisements neither in the first nor in the last interval (Figure 2). Moreover, no differences were reliable between these two intervals. These results suggest a similar attention level during the first interval, as a function of the onset of the advertisements on the road relevant region and, that attention to this ROI was fully recovered after the advertisement offset (last interval). However, from intervals 2-6, there were significant differences for both positive and negative pictures with regards to the neutral pictures, suggesting an emotional modulation of attention allocation. Furthermore, there were significant differences between negative and positive pictures for intervals 4, 5, and 6, which can be thought of as an index of the stronger influence of the negative emotional advertisements on attention to the ROI relevant region. These effects can be clarified if we consider the course of attention allocation during the advertisements time window (Figure 2). Fixation times were lower in the first five intervals than in the last two. This implies that pictures are able to capture the driver's attention just from the advertisements onset, and that this capture is sustained up to the point where advertisements are out of view. However, the first interval’s reduction in fixation times depended on the emotional condition. When negative advertisements were displayed, fixation times gradually decreased up to the fifth interval, whereas fixation times for positive advertisements reached a minimum in the second interval maintained until the fifth one. Finally, the minimum in the neutral condition was reached and maintained from the first interval. Thus, it seems that the pattern of gaze distraction is a function of the emotional content of the advertisements. Stronger gaze distraction, both in the size of the time window and in the magnitude of fixation times, is elicited by emotional pictures more than by neutral ones. Moreover, the deepest and longest distraction is elicited by negative emotional advertisements.

In sum, conditions with negative pictures resulted in the least amount of fixation time on the road region relevant, followed by positive pictures and neutral pictures respectively when the pictures were on sight. However, once the pictures were out of sight, attention to the relevant region of the road was fully recovered and no differences were found.

ROI: Affect-laden roadside advertisement

A repeated-measure ANOVA on the total fixation time on the roadside advertisement, with the emotional cue as the independent variable, showed a main effect of this factor (F (2, 42) = 14.354, MSE = 35831.453, $p < .05$, $\eta^2_p = .406$). A post-hoc analysis indicated that the negative advertisements got more total fixation time (1907 ms) than the positive advertisements (1760 ms), and both more than the neutral ones (1601 ms).

Although affect-laden pictures were observed for a longer time and captured more attention, the average duration of fixations on negative (334 ms) and positive (333 ms) advertisements were significantly lower than on the neutral ones (351 ms). The highest total fixation times on affect-laden pictures were due to differences in the number of fixations (F (2, 42) = 14.338, MSE = .312, $p < .05$, $\eta^2_p = .523$). The post-hoc analysis revealed that negative pictures got more fixations (5.77 fixations) than positive ones (5.35 fixations) and, both more than the neutral pictures (4.64 fixations).

Additionally, we studied the offset of the last fixation on the advertisement to find out whether this increased attentional capture was also gone by with a later disengagement. The ANOVA showed a significant effect of the emotional advertisement, F (2, 42) = 5.440, MSE = 45287.329, $p = .008$, η^2_p=.206. The LSD post-hoc analyses confirmed that the last fixation on the negative picture (3542 ms after the onset of the video) occurred later than in the positive (3415 ms) and neutral (3332 ms) ones, respectively.

Brake responses

Reaction times and accuracy of the brake response were both submitted to a repeated measures ANOVA 2 (Risk: risk, no risk) x 3 (emotional advertisement:

negative, neutral and positive). Neither main nor interaction effects were observed for accuracy. This lack of differences may indicate that the task was very easy (hits: negative = 0.988, neutral = 0.989 and positive = 0.992). However, the ANOVA yielded a main effect of emotional cue on reaction time (F (2, 42) = 7.623, MSE = 48.422, p = .001, η^2_p = .266). LSD post-hoc analyses indicated that responses were significantly faster after negative pictures than after positive and neutral ones, respectively.

4. Discussion

The main aim of advertising billboards is attracting attention to their contents, (voluntarily: the road user wants to read it; or involuntarily: advertisement captures her/his attention) and advertising agencies are interested in locating their panels in sites with dense and frequent traffic. Therefore, it seems very important to put particular effort on studying the effect of these elements on road safety (Brumec et al., 2010).

This research focused on the effects of emotional incidental road advertisements on eye movements, as a measure of attention, and a subsequent urgent decision (braking) in a risky driving situation. Regarding attention, results demonstrate firstly, that the number of fixations and total fixation time elicited by the negative valence emotional advertisements were larger than the positive and neutral ones. At the same time, negative pictures got later gaze disengagement than positive and neutral ones. Secondly, average fixation time on the ROI relevant region was lower for the negative and positive pictures than for the neutral ones, this effect being even stronger for negative advertisements. These results suggest that lesser attention was allocated to the relevant region as the driver approaches these advertisements. Finally, negative emotional pictures sped up the brake response in a subsequent risk situation.

Our results on eye activity support other studies showing how roadside advertisements capture our attention while driving (Crundall et al., 2006; Shinar et al., 1977; Smiley et al., 2004; Wallace, 2003). When the advertisements were displayed on the screen (intervals 1-6), the fixation times on the road relevant region were significantly lower than when they were out of sight (interval 7). More importantly, emotional valence pictures, especially the negative ones, capture our gaze more than neutral ones (Compton, 2003; Pessoa et al., 2002; Vuilleumier, 2005), suggesting how emotional advertisements on the road can act as distracters reducing the attention paid to the road relevant region in which the important driving stimuli commonly appear.

Our findings indicated that the capture of attentional resources is a function not only of the emotional content of the cues, but also of its temporal position. The neutral pictures produced a constant reduced fixation time on the ROI relevant region, even while the advertisement was approaching (intervals 1-5). The positive cues show a similar reduction in the first interval than the neutral ones (interval 1) and, a subsequent fixation time decrement which remains constant thereafter (intervals 2-5). In the negative picture condition, however, our results indicate that as drivers get closer to the advertisement, their attention becomes increasingly captured and they gradually pay less attention to the ROI relevant region (intervals 1-5). Finally, once the advertisements begin to be out of sight (interval 6) or they are not displayed on the screen (interval 7), the differences in fixation times between emotional advertisements disappear and attention is fully captured by the ROI relevant region.

Our results also showed that negative advertisements sped-up the brake response in a subsequent risky situation. These results confirm the influence of emotional stimuli not only on attention, but also on decision making (Chou et al., 2007; Loewenstein et al., 2001; Pereira et al., 2010) and especially on driving behavior in risk situations

(Megías et al., 2011; Di Stasi 2010a, b). However in this experiment, the effects of emotional cues were evaluated only among one specific segments of the population (18-25) which could limit the generality of our results. At the same time, a better understanding of the emotional modulation of driving also needs further research. It will be convenient to enhance the emotional content as well as the complexity of the driving situations to increase the emotional effect. Moreover, as we have only used a central position, future research should analyzed lateral positions, more frequently used in real settings. Finally, as the effect of different emotional message contents would vary by target audience (Tay & Ozanne, 2002), it will be another important factor that needs to be addressed in future investigations.

Our study may have practical applications. For example, although the use of public advertisements near main roads has been forbidden over the past decades (for example in Spain, since 1994 (BOE, 1994)), they still remain in many public roads and streets. At the same time, this research brings to light the higher influence of negative emotional content of the advertisements. However, nowadays national road safety agencies' countermeasures to reduce the number of deaths and the severity of injury include the use of fear-based billboard advertising campaigns, with a strong negative emotional content (Tay, 2002), which in turn might increased drivers distractions and subsequent accidents. Despite years of research with mixed results (Tay & Ozanne, 2002), governments continue to believe in and employ these fear-based campaigns, highlighting the consequences of unsafe driving behavior in an extremely graphic and shocking manner (some recent examples are the New Zealand “bleeding billboard” campaign, (ColensoBBDO, 2009), or the “Runter vom Gas!” (Kill your Speed!) sponsored by the German Road Safety Council (DVR, 2010). Alternatives to the classical fear-based campaigns are possible. Since a decade ago, the Centro Antartide in cooperation with the Italian Ministry for Transport, has promoted a national safety-road campaign entitled “Vacanze coi fiocchi” (First-rate holidays). In order to increase road safety awareness and to educate people about civic driving, the transmitted messages are mainly focused on cartoon irony. Our results suggest that it would be suitable to implement regulations to avoid roadside advertisements having pictures with high emotional content, especially in those places more related with high-risk situations, such as roundabouts, intersections, bends, or roads with a high volume of traffic. At the same time, it would also be necessary to educate drivers to focus their attention on the road relevant regions and to avoid possible visual distractions while driving, especially in risky situations. These evidences could also be useful to better regulate the formal policy about the permission of roadsides memorials (for a recent investigation on this topic see Tay, Churchill, & de Barros, 2010) or to understand and help to control of the behavior of drivers after witnessing an accident. Future research should analyze whether, and to what extent, lower attentional resources focused on the road worsen subsequent decisions in risky driving situations (e.g. braking or speed-up when overtaking a car, in roundabouts or intersections and so on).

5. Conclusion

This study provides important results with regards to the influence that emotional advertisements may have on our attention and behavior as drivers. Our results showed that affect-laden roadside advertisements can modulate drivers’ eye movements (attention) on the road and their subsequent responses under risk. It supports not only the emotional modulation of attention (Compton, 2003; Pessoa et al., 2002; Vuilleumier, 2005), but also of the decisions making in risky driving situations (Chou et al., 2007; Loewenstein et al., 2001). These findings can be useful for a better regulation of roadside advertisements. Furthermore, it could serve as basis for the design of driver assistance systems or driving educational training and risk prevention programs.

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Study 2

Emotion-laden stimuli influence our reactions to traffic lights

Abstract

This study focused on the effects of emotion-laden stimuli (emotional roadside advertisements) on driver decision making. A common dilemma in driving is whether to speed up or brake when lights turn yellow at an intersection. The study focuses on this aspect of driver decision making. We compared the influence of emotion-laden roadside advertisements (positive, negative, and neutral solutions) either on the evaluation of possible risk (i.e. evaluative behavior) or the decision to stop/speed up (i.e. urgent behavior). We showed that after negative advertisements drivers brake more often than after positive and neutral ones and, at the same time, the response latency was shorter when they decided to speed up. We also demonstrated that urgent behavior responses were faster than evaluative ones, independently of the emotional content. Thus, we concluded that urgent behavior could be more automatic than evaluative behavior according to dual system models of risk perception and decision-making. Overall our results suggest that emotional factors play a decisive role in our driving decisions making, particularly in risky driving situations. These findings provide important information for the development of new and advanced driver emotional support systems and in general for the specification of future transportation polices design guidelines.

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1. Introduction

Risk perception as well as risky decision-making is an essential part of our behavior when driving, especially in situations where a sudden reaction is required, and a wrong decision or a slow response could lead to serious consequences (Megías, Maldonado, Cándido, & Catena, 2011). A clear example is when a traffic light turns yellow just as a driver approaches an intersection (i.e. the dilemma zone). In this situation, drivers have to perceive whether there is a potential risk and either stop suddenly to avoid entering the intersection at all or to continue straight across the traffic light junction; even, in some cases, drivers speed up rapidly to try to clear the intersection. All of these actions could be potentially dangerous as it is well known that sudden reactions are a frequent cause of accidents (Lee, LLaneras, Klauer, & Sudweeks, 2007). When a driver brakes suddenly because a traffic light turns yellow, for example, the driver behind him also has to brake hard in order to avoid a collision. The decision of braking in this situation seems to be a function of several variables, including vehicle-related (e.g. cruising speed), environment-related (e.g. distance from the intersection), and driver-related (e.g. emotional state) factors (Cacciabue, 2007; Caird, Chisholm, Edwards, & Creaser, 2007; Konecni, Ebbesen, & Konecni, 1976). Research in road safety had largely investigated most elements of this complex interaction (Cacciabue, 2007), however the driver emotional state and its impact on safety behavior are not so well known yet (Serrano, Di Stasi, Megías, & Catena, 2014). In this research, we will explore the influence of emotional impact upon driving behavioral responses, both risk perceptions and risky decisions, when a traffic light turns yellow suddenly.

Emotional influence on driver behavior has been generally considered to be caused both by the previous emotional state of the person (mood) or by the emotions generated by stimuli presented while driving (SWOW, 2010). Emotions and moods are closely related concepts, however, they involve significant differences. Moods are considered stable affective states not related to a particular object and that are triggered in contexts unrelated to the current information-processing situation. In contrast, emotions are usually intense transitory reactions that fluctuate in valence and level of arousal over short time periods and that arise in reaction to a particular object or event present in the situation itself (Bodenhausen, Mussweiler, Grabriel & Moreno, 2000; Davidson et al., 1994; Frijda, 1993). Although this important distinction has not been frequently realized in the traffic research field (Arnett, Offers & Fine, 1997), we think that given the different characteristics of both concepts, it should be an important point to note. In traffic, moods are affective states independent of traffic situation, for example driving in a depressed mood (Megías, Maldonado, Catena & Cándido, 2012; Mesken, 2006, for an extensive review); while emotions are elicited by some event or object in the current situation. In this work we will focus on influence of emotion-laden stimuli on driving behavior.

Several road element or situations, such as seeing an accident, roadside memorials, or billboards, looking or doing a dangerous maneuver, speech messages from warning alert systems, or being in a traffic jam have been shown to induce emotional responses in the driver (Megías, Maldonado, Catena & Cándido, 2011; Tay, Churchill & de Barros, 2011; Serrano, Di Stasi, Megías & Catena, 2011). Recent research has shown, for example, that driving emotionally aroused could be a source of interference (Di Stasi et al., 2010; Pêcher, Lemercier, & Cellier, 2009; Serrano et al., 2014). Di Stasi and colleagues (Di Stasi et al., 2010), by displaying emotion-laden collision avoidance signals induced unsafe driving behavior instead of increasing road safety. Similarly, Megías, Maldonado, Cándido, & Catena (2011), focusing on visual stimuli, showed that emotion-laden stimuli, especially negative ones, impaired the driver hazards discriminability in risky situations. More specifically, Megías, Maldonado, Catena, Di Stasi, Serrano, & Cándido (2011) by presenting emotion-laden roadside advertisements through a driving simulator observed important changes in the driver behavior, diverting the driver attention from the relevant region for driving. Furthermore, research has also shown that mood and emotion can modulate risk proneness (Mesken, 2006). This modulation can be accounted for by Forgas' affect infusion model (Forgas, 1995) and Bower's associative network theory (Bower, 1981). Both models predict that, when people are involved in a judgment or a decision-making, it is easy to attend to process, and retrieve information congruent with their actual emotional state. Thus, for example, drivers in a negative mood are more likely to consider the negative aspects of risky situations, perceive more unfavorable consequences, and thus reducing their risk proneness level.

In addition, most of the research about the influence of emotions on behavior has focused on the manipulation of contextual (e.g. frame, see Slovic, Finucane, Peters & MacGregor, 2004) and specific factors, as discussed above (e.g. type of moods, see Mesken, 2006 or Pessoa, 2009). Actually, scarce attention has been devoted to uncover whether the effect of emotions can be influenced by the task features (e.g. type of behavior required). In this vein, Megías' urgent-evaluative behavior distinction (Megías, López-Riañez, Candido, 2013; Megías, Maldonado, Cándido, & Catena, 2011) has proven to be important to understand the emotional modulation of behavior. Urgent behaviors are triggered by the stimulus and performed under high time pressure. When successful, they will help to avoid high negative outcomes (e.g. to decide to brake in a risky situation). On the other hand, evaluative behaviors are considered a type of categorization process (e.g. to classify a road scene as risky or not) what is typically done by an observer. According to dual process models (Loewenstein, Weber, Hsee, &

Welch, 2001; Slovic et al., 2004), urgent behaviors are largely controlled by the affective-experiential system, while evaluative behaviors are under the control of the rational–analytic system. Megías, Maldonado, Cándido, & Catena (2011) showed that urgent behaviors (to brake) are considerably faster and have a response bias toward more conservative responses than evaluative ones (risk evaluation). Negative and positive cues slowed down the braking response, but negative ones tended to speed up the risk evaluation. Moreover, lower discriminability indices were only found after emotional cues in the urgent condition. These results support the existence of a task-feature modulator effect.

In summary, the extensive literature on the influence of emotions in decision making (Pereira et al., 2010; Slovic et al., 2004), and more specifically about its modulation of risk decision-making (Chou, Lee, & Ho, 2007; Loewenstein et al., 2001), indicate that emotion should affect both the perception of risk and the subsequent decision-making while driving (Averty, Collet, Dittmar, Aathènes, & Vernet-Maury, 2004; Groeger, 2000; Megías, Maldonado, Cándido, & Catena, 2011). This research aimed at demonstrating how emotion-laden visual stimuli (negative and positive valence), presented incidentally on the road while driving, influence the risk perception (evaluative behavior; e.g. to evaluate risk) and decision-making (urgent behavior; e.g. to brake in a risky situation) when drivers face up simulated driving situations, such as a traffic light turning yellow at an intersection with and without potential risk. Predictions about emotion-laden stimuli effects compared to neutral condition can be directed in different directions (Mesken, 2006, Di Stasi et al., 2010). Following the proposed framework we hypothesize that after observing negative-laden stimuli drivers will show a lower risk proneness level due to the perception of more unfavorable consequences compare to a positive and neutral ones. Moreover, faster and more conservative responses should be related with urgent behaviors joint with a possible task-feature modulator effect on the influence of the emotional stimuli according to the dual system models (Megías et al., 2011).

2. Method

2.1 Participants

Because young drivers are over-represented in road crashes and risky behaviors are common among this population (Deery, 1999), twenty four naive students (16 women) of the University of Granada took part in this experiment in exchange for course credits. Participants were between the ages of 18 and 34 years (M = 23.4, SD = 4.34 years). All had normal or corrected to normal visual acuity, and had a motor vehicle driver´s license. Before the experiment they were informed of their rights according to the Helsinki declaration and they read and signed an informed consent form.

2.2. Apparatus and stimuli

The Honda Riding Trainer simulator [HRT] was used to carry out this study (see Di Stasi et al., 2009, for details on the HRT simulator). The road scenario was displayed to a refresh rate of 30 Hz on a large projection screen (120x90 cm) located 185 cm in front of the participant, seated on the HRT seat. The task was controlled by the SR Research Experiment Builder (SR Research Ltd., Mississauga, Ontario, Canada).

Participants, using a first-person view, observed a riding scenario in which they were simulating to drive along a street in a straight line. The riding scenario was a video extracted from HRT simulator software (the video lasted 6400 ms or until the participant's response). Simulation always displayed the same scenario with a motorbike approaching and entering an urban intersection regulated by a traffic light, after which an oncoming vehicle could be presented (see Figure 1; see supplementary Video S1). A cruising speed (50 km/h average), and distance to the traffic light from the beginning of the video (2933 ms) were maintained constant among the participants to control other plausible side effects (Konecni, Ebbesen, & Konecni, 1976). It is important to notice, that even though we used a riding simulator, the selected scenario did not require any specific behavior associated to ride motorcycles (e.g. we did not present any overtaking through narrow spaces, the simulated motorcycle occupied the same space on the road as a car, etc.). Thus, the simulated experience could be easily extrapolated to driving behavior.

Alongside the road and before the intersection and the traffic light, different emotional roadside advertisements were presented. Billboards were located in the center of the road to capture the attention as much as possible (Chattington, Reed, Basacik, Flint, & Parkes, 2009), and displayed pictures with different emotional valence (see Figure 1; see supplementary Video S1). Twenty four emotional pictures were selected from the International Affective Picture System (IAPS)[1] (Lang, Bradley, & Cuthbert, 2005; Spanish norms, Vila et al., 2001) according to affective valence (ranging from very unpleasant = 1; to very pleasant = 9) and arousal level (ranging from very calm = 1, to very exciting = 9). The negative emotional valence stimuli were eight pictures (mainly mutilations), similar to those used in real road safety campaign (normative average: valence = 1.53, *SD* = 1.08; arousal = 6.67, *SD* = 2.41). The neutral emotional valence stimuli were eight pictures (objects as a chair or a book) similar to those used in

[1] The IAPS codes of the pictures were the following: negative (3015, 3030, 3053, 3064, 3102, 3120, 3170, and 3266), neutral (2880, 7004, 7006, 7010, 7035, 7041, 7090, and 7233), and positive (4599, 4601, 4607, 4608, 4611, 4623, 4641, and 4660).

general advertisements (normative average: valence = 5.03, *SD* = 1.14; arousal = 2.46, *SD* = 1.79). The positive emotional valence stimuli were eight pictures (mainly romantic pictures) similar to those used in cosmetics advertising (normative average: valence = 7.05, *SD* = 1.60; arousal = 5.88, *SD* = 2.05). The negative and positive pictures were matched as much as possible in level of normative arousal.

2.3. Procedure

The experiment consisted of 240 trials, plus 20 practice trials. Half of the trials required an evaluative response and the other half an urgent one. Evaluative and urgent task were presented in counterbalanced two different blocks. In each block, one third of the trials billboard pictures had positive, negative, and neutral valence. Thus, there were 40 experimental trials per condition, defined by type of task (urgent/evaluative) and picture emotional content (positive, negative, and neutral). The sequence of trials within each block was selected randomly for each participant. The complete experiment session lasted approximately 40 minutes.

Trials simulated a motorcycle ride through urban road (see Figure 1; see supplementary Video S1). Each trial started immediately after the presentation of a fixation point. The simulation involved two key moments: first, a roadside advertisement containing the emotional pictures (negative, neutral, or positive) was displayed on the back of the scenario; second, green traffic light was placed just after the roadside advertisement and just before crossroads. This traffic light had a 0.75 probability of turning yellow 200 ms after the motorbike overran the road advertisement. At this point, in case the traffic light turned to yellow, the participants have to make a decision.

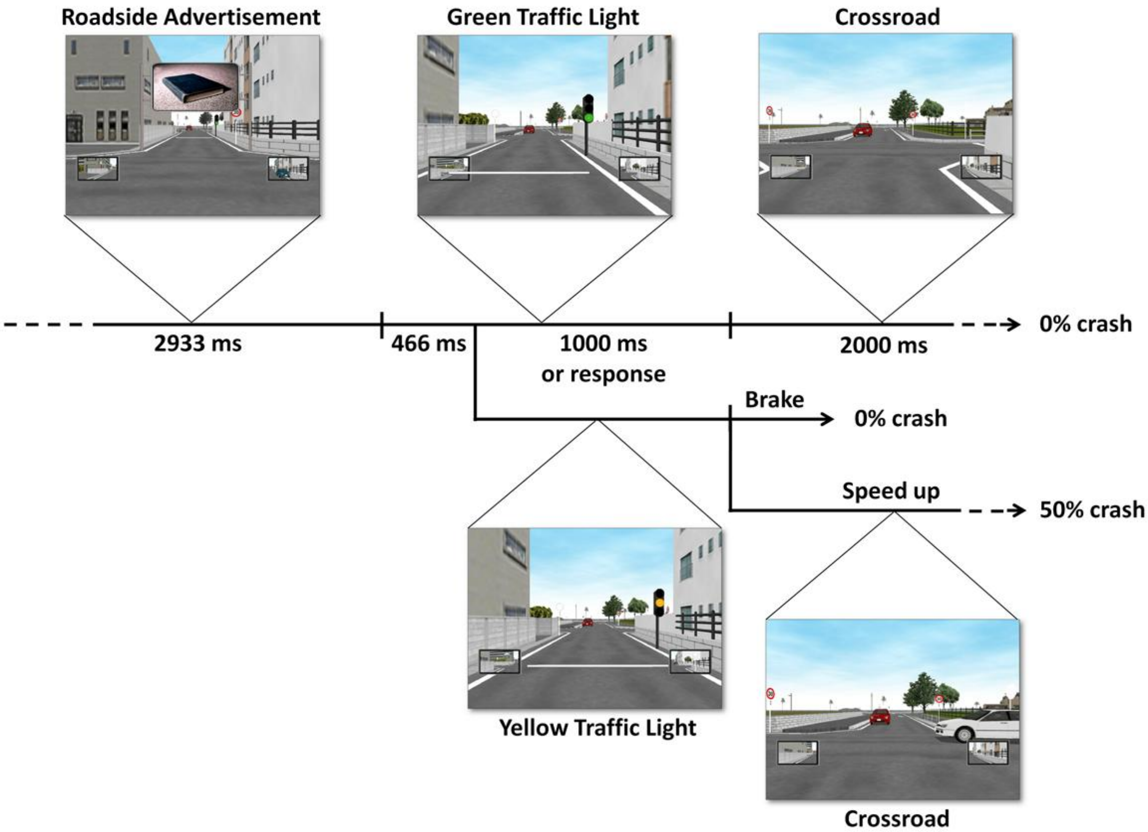

Figure 1. Experimental procedure and parameters.

In the urgent task condition, participants had to decide to “speed up” or “brake” before the light turned red (1000 ms maximum response time). If the participant decided to speed up, the motorcycle crossed the intersection with traffic light in yellow, and there was a 0.50 probability of having a car crash with a car in the later intersection. If participants decided to brake the probability of having a crash was 0. Not responding at all always caused a crash, meaning the rider crossed the intersection with the traffic light in red. On the other hand, in the evaluative task condition, the participants had to evaluate if the rider would have "time to cross” or “not time to cross” the intersection. In both task conditions participants answer by clicking mouse buttons (right and left mouse buttons were balanced across participants).

At this point it is important to note that procedure was similar for both type of behaviors (videos and response are operationalized in the same way) except for the question asked to the participants. This difference involves significant changes in the task features, turning the participant to an external observer of the situation (to evaluate risk) or to a driver involved in a risky situation (to brake) (a detailed explanation about this manipulation is presented in Megías, Maldonado, Cándido, & Catena, 2011).

Finally, to avoid that participants always decided to "brake" or always evaluated that there was "not time to cross" (i.e. they never have accidents), we create a context accompanied by a points reward system. We told the participants that the rider was a courier worker whose aim was to arrive as soon as possible at their destination. Thus to brake at the traffic light will cause delay in his/her shipping. Thereby, if the package arrives on time he/she will be rewarded with 200 points, if not he/she will not get any point, and in the case of a crash lose 200 points. We presented the score only at the end of each block, so we avoid a possible effect of the cumulative score. In addition, to increase participants' motivation, we said that a rank list of the best couriers will be created.

3. Results

Four types of dependent variables were submitted to separated 2 (Task: urgent, evaluative) x 3 (Emotional advertisement: negative, neutral, and positive) repeated measures analysis of variance. Firstly, we counted the proportion of times (i.e. rate) the participant decided to speed-up (urgent task) or said that there was "time to cross" (evaluative task). Consecutively, we also considered the analysis of brake/not time to cross rate. Finally, we measured the median latency of the speed-up/time to cross responses, and the average latency of brake/not time to cross responses in two different analyses. A significance level of 0.05 was set up for all statistical decisions. Kolmogorov-Smirnov and Levene's tests were used to verify normality and homogeneity of variances for type of response and reaction times data.

Participants cross the yellow traffic light in more than half of the trials (0.54). The analysis of speed-up/time to cross rate shows a main effect of Emotional advertisements, F (2, 46) = 3.93, p = .027, η^2_p = 0.15 (see figure 2). However, there were no Task main effect or Task by Emotional advertisements interaction (F < 1). Paired comparisons were applied using Holm-Bonferroni correction in order to control for Type I error. The proportion of times the participant decides to speed-up/time to cross were significantly lower for negative advertisements (0.49) compared to neutral (0.57) and positive ones (0.56) (p < .05, see table 1). The analysis of the brake/not time to cross rate also showed a main effect of Emotional advertisements, F (2, 46) = 3.43, p = .041, η^2_p = 0.13. Task main effect and its interaction with Emotional advertisements were not significant (F-values < 1). The brake rate was higher for negative (0.49) compared to neutral (0.42) and positive advertisements (0.43) (p < .05). The results for the brake response were close to the complementary to speed-up/time to cross, because the number of non-response was low (0.2).

Table 1. Descriptive statistics of the rate (mean and standard deviation) and the latency (median and standard deviation) of "*speed-up/time to cross*" and "*brake/not time to cross*" for each experimental condition (Task x Emotional advertisement).

speed-up/time to cross rate

Emotion	Urgent	Evaluative
Negative	0.51 (0.28)	0.48 (0.21)
Neutral	0.59 (0.28)	0.55 (0.24)
Positive	0.56 (0.27)	0.56 (0.23)

brake/not time to cross rate

Emotion	Urgent	Evaluative
Negative	0.48 (0.27)	0,51 (0.20)
Neutral	0.41 (0.28)	0,43 (0.23)
Positive	0.43 (0.26)	0,43 (0.22)

speed-up/time to cross latency (ms)

Emotion	Urgent	Evaluative
Negative	449 (140)	507 (166)
Neutral	485 (145)	515 (170)
Positive	475 (147)	524 (175)

brake/not time to cross latency (ms)

Emotion	Urgent	Evaluative
Negative	467 (121)	450 (109)
Neutral	468 (119)	486 (150)
Positive	468 (118)	462 (118)

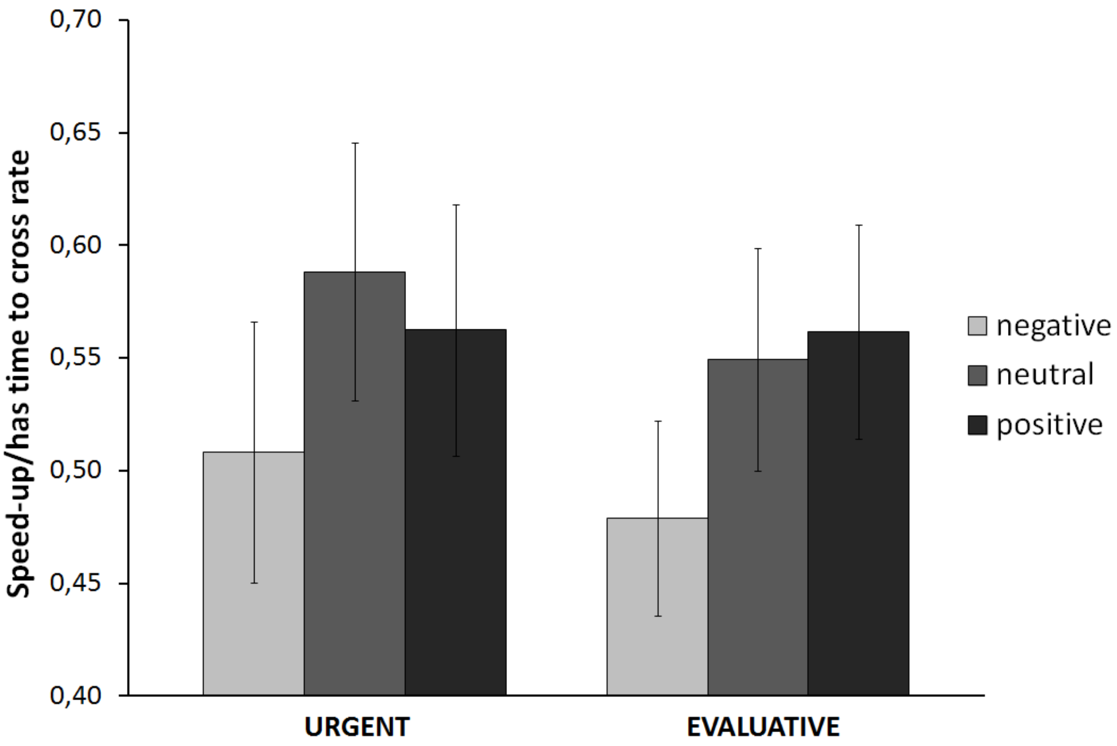

Figure 2. Speed-up rate. Average response rate for “speed-up/time to cross". Vertical bars stand for the standard errors of the mean.

The analysis of median latency response for the speed-up/time to cross showed a main effects of Task, F (1, 23) = 4.90, p = .037, η^2_p = 0.18, and Emotional advertisements, F (2, 46) = 4.49, p = .017, η^2_p = 0.16. Task by Emotional advertisements interaction were not significant, F (2, 46) = 1.30, p = .282, η^2_p = 0.05. According to Holm-Bonferroni comparisons analysis latencies were shorter for the urgent (470 ms) than for the evaluative task (515 ms). Moreover, significantly shorter latencies were produced by negative (478 ms) compared to positive (500 ms) and marginally significant compared to neutral advertisements (500 ms; p = 0.038) (see figure 3). Finally, neither main nor interaction effects were significant for reaction times in brake/not time to cross response (F-values < 1).

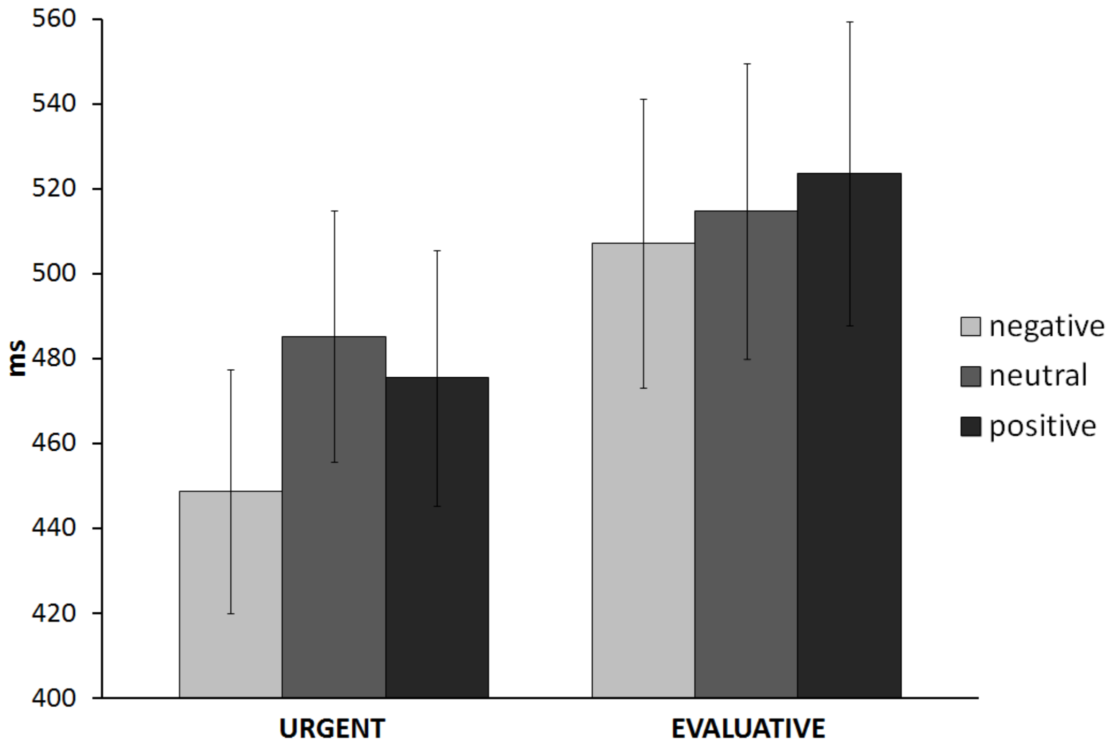

Figure 3. Response latency. Median reaction times for the “speed-up/time to cross” response. Vertical bars stand for the standard errors of the median.

4. Discussion

This study focused on the effects of emotion-laden stimuli (emotional roadside advertisements) on driver decision-making when traffic lights turn yellow, a common dilemma when driving, that involves uncertainty about the possible consequences. We obtained several important results: urgent responses (to speed-up) were faster than the equivalent evaluative response (time to cross), independently of the emotional content of the advertisement displayed. Risk taking tendency, as measured by the speed-up/time to cross rate, was lower after negative advertisements than after positive and neutral ones. Finally, speed-up/time to cross response latency was larger after positive or neutral advertisements than after negative ones.

The difference in reaction times observed between the two categories of driving behavioral responses (i.e. faster response for the urgent behavior) can be explained by the dual systems models of risk perception and decisions-making (Loewenstein et al., 2001; see Megías, Maldonado, Cándido, & Catena, 2011; Slovic et al., 2004, for a detailed discussion on this topic). Considering the speed-up response as an urgent behavior, since even a very short delay increases the likelihood of having a strong negative outcome (crash), urgent behaviors are usually well practiced and automatic, so that many situation–action connections have been created by the experiential system leading to faster behaviors and mostly guided by heuristic rules. In this way, quick responses to critical situations are guaranteed, even at the expense of hampering the rational processing of the situation. On the other hand, the evaluative responses, in our case evaluating "time to cross", are largely controlled by the rational-analytic system which integrates information provided by situational factors identified in the scene to derive a decision, generating in this way slower responses (Megías, Maldonado, Cándido, & Catena, 2011). In addition, according to the rational-analytic system characteristics, the absence of speed up/time to cross rate differences between Evaluative and Urgent behaviors could reflect the lack of useful information to identify risk factors during our simulated scenario (e.g. the distance of other vehicles approaching the intersection).

Our results about emotional modulation indicate that negative advertisements seem to increase safety behaviors, by reducing the tendency to speed-up after the yellow light even when the participant is acting like a mere observer (time to cross). However, when the participant decided to take a risky behavior (i.e. to speed-up/to say there was time to cross after the yellow light) his/her decision was faster (lower reaction times). This safety attitude can be accounted for by several emotion theories about the effects of general affective states on cognitive processes (e.g. associative network theory, Bower (1981), and affect infusion model, Forgas (1995)). These theories propose that stimuli congruent with the emotional state are easier to attend, to recognised, to process, and to retrieve of our memory than incongruent ones. Consequently, a plausible explanation for our results could be that drivers who have seen negative stimuli perceived more negative consequences in risky choice and thus reduced their risk proneness level.. Additionally, according to previous studies, negative emotional stimuli entail faster responses in subsequent tasks, once attention has been disengaged from emotional stimuli (Becker, 2009; Bocanegra & Zeelenberg, 2009; Contreras et al., 2012). However, in our particular case, where a traffic light suddenly turns yellow, the faster response observed only in speed-up/ time to cross could also be explained by considering that the participants have the belief that speeding-up earlier can avoid a possible crash in the next intersection. In any case, more research is needed to disentangle this topic.

From a practical point of view, our results can be useful for the regulation of billboard advertisements for road and safety campaigns (Hoekstra & Wegman, 2011), since the observation of stimuli with negative content could prevent risky behaviors by making drivers more cautious (lower crossing rate at the dilemma zone). However, as has been reported in numerous studies, one of the main problems with emotional stimuli in the road traffic system is that they can cause a strong attentional capture during the time they are displayed (Megías, Maldonado, Catena, Di Stasi, Serrano, & Cándido, 2011; Compton, 2003; Vuilleumier, 2005), causing distractions and a less adequate driving (Crundall et al., 2006; Di Stasi et al., 2010). The integration of our results with these studies suggest that the allocation of billboard advertisements to improve road safety campaigns making drivers more cautious (ColensoBBDO, 2009; DVR, 2010) must be located in positions where the attentional resources requested are lower and there is no risk of being involved in potential dangerous situation, as for example in tollgates, petrol stations, or in places with low-speed traffic flow. At this point, it is important to note the need of future research to generalize our results to situations with bigger time delays between the emotional stimuli and the decision to make.

In summary, it becomes clear that emotions are a key issue in traffic psychology. This research is a new step to better understand the emotional modulation of driving behaviors. Future research should generalize our findings evaluating other segments of the population due to the differential influence of emotional stimuli (Tay & Ozanne, 2002; Vila, 2001) or differences in the driving style in terms of personal characteristics (e.g. risky behaviors are more frequent in young male (Rhodes, Brown, & Edison, 2005; Bymes, Miller, & Schafe, 1999). Furthermore, emotions triggered by specific stimuli on the road should be greater addressed to discern emotional states even in the same valence. For example, in this regard, emotion research has shown that fear increased risk estimates, but anger reduced them (Keltner, Ellsworth, & Edwards, 1993; Lerner & Keltner, 2000; Mesken, 2006). Thus, more research must focus on other factors that could influence decision making in emotional context (gender, age, driving experience, previous mood, risk preference, etc.) with the aim of developing safer road policies and even, devices to increase safety on the road measuring not only well known risk factors such as drug abuse, but also emotional and mood states (angry, frustrations, depression, etc.) associated with less efficient driver performance. Finally, in this study we introduced a point reward system to motivate participants against always deciding to brake or evaluating “no time to cross”. Future studies should investigate the traffic light dilemma, in different scenarios, in which, for example drivers giving a “brake” response would have been also involved in rear-end crash with a similar probability.

5. Conclusion

The relationship between emotions and attention, and how they integrate to modify behavior has grown in the last decade to be an active field in cognitive science (Pessoa, 2008), including in traffic psychology. The goal of this research was to enhance understanding of how emotion-laden stimuli present during driving might influence the driver's behavior at risk potential critical/ambiguous situations, such as a traffic light turning yellow at an intersection. Our results support the differential influence of emotional pictures (positive, negative, and neutral) displayed on central billboard advertisements. They showed that a negative emotion aroused by these roadside advertisements make drivers brake more often than positive and neutral ones, which led them to be more cautious and to cross less often the yellow traffic light. However, when they decided to cross the intersection, the negative advertisements speeded-up their response.

Our findings are especially important for understanding driver behavior in risky situations, in order to improve future transportation policies and they also provide important information for the development of new intelligent and emotional devices aimed to increase wellbeing and human performance, as for example the new advanced emotionally driver support systems (AIDA, 2009, Fukuda, 2008; Jones & Jonsson, 2008).

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CHAPTER IV

How does feedback appealing fear modulate risky driving behavior?

Abstract

The aim of this research was to provide evidences about how driving behavior is concretely modulated by fear appeal. The current study intends to offer new, relevant information on whether the use of negative emotional content is effective in reducing accidents. Participants received negative emotional feedback when performing risky behaviors. The effectiveness of these messages was tested using a driving simulator. Our results demonstrated that the use of negative emotional feedback can be an effective method for reducing the number of accidents; however, it must be applied under the right circumstances. More importantly for our research, the reduction of accidents was accompanied by a set of behavioral changes in driving. These changes in driving style corresponded to a greater abidance for traffic regulation and illustrated a friendlier driving style, which could explain some of the causes behind the reduction of accidents.

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1. Introduction

One of the most frequent debates in the development of health promotion campaigns is about the use of fear appeals in order to reduce the risky behavior (Lewis, Watson, & White, 2008). This issue has special relevance in road safety campaigns where mass media advertisement and rehabilitation programs for traffic offenders often appeal to the fear. Literature shows certain controversy around the effectiveness of such messages (Carey, McDermott, & Sarma, 2013; Griffeth, & Rogers, 1976). Nevertheless, there is a general agreement that under correct circumstances, the use of negative emotional messages may successfully reduce risky driving behavior (Witte, & Allen, 2000).

Road safety research on fear appeals has mainly been operationalised by questionnaires on risk perception, self-reported behavioral intentions and traffic injury statistics (Delhomme et al., 1999; Elliott, 1993; Phillips, Ulleberg, & Vaa, 2011). These variables provide important information on the effectiveness of the manipulation; however, they remain far from explaining the cause behind the reduction of accidents. There is a lack of empirical evidence on how drivers modified their driving style after they were subjected to negative emotional messages.

The aim of this research was to provide the first evidence on how motorcycle driving behavior is concretely modulated by fear appeal. For this purpose, we conducted an emotional manipulation, adhering to factors which have been proved to be effective in road safety research (Lewis, Watson, Tay, & White, 2007). Drivers received negative emotional feedback when demonstrating risky behavior by exposure to images with negative emotional content (traffic accidents). The use of a driving simulator allowed us to obtain objective measures of the effectiveness of the manipulation and to track behavioral changes without the presence of real-life risks.

2. Method

Forty participants from the University of Granada took part in the experiment (31 women; median age: 22.4 years old; range: 18–26). All of them held a valid driver's license (mean: 52 months). The sample was assigned randomly to two groups: Feedback and Control. Both groups were matched in age and sex.

The experiment consisted of three phases: Training, Learning and Transfer. Training and Transfer task were performed on the Honda Riding Trainer simulator (Megías, Maldonado, Cándido, & Catena, 2011). Road scenarios were displayed on a large projection screen (120x90cm) located 185cm from the participants. Learning task were conducted by a standard PC computer. In this task, ninety road images captured from the Honda Riding Trainer simulator were displayed. These images showed situations with medium and high risk level according to a previous parametric study (Megías, López-Riañez, & Cándido, 2013).

In the first phase of the experiment, a training task was employed to inform participants how to operate the simulator. They took approximately 25 minutes to make four circuits. In the learning task, performed a day after, participants were required to make the decision of whether to brake or not (by pressing the buttons on a mouse) in a set of risky situations. In the Feedback group, there was a 50% of probability of receiving negative emotional feedback in the case of no braking (images with negative emotional content selected from IAPS [Vila et al., 2001]). The Control group was never provided with feedback. Each driving image was displayed for 1500ms or until response. Feedback was shown for 1500ms. The task consisted of 180 trials carried out in a random order across participants. Subsequently, the participants performed the transfer phase by making four urban circuits with prefixed routes along which they were presented with hazardous situations.

3. Results

Driver behavior variables recorded by the simulator in the transfer phase were submitted to a unifactorial ANOVA with Group (Feedback and Control) as independent variable. Data in which drivers were stopped (0 km/h) were excluded from the analysis.

An ANOVA on the number of accidents in transfer phase showed more accidents in the Control group (3) than in the Feedback group (1.35), F (1, 38) = 6.36, p < .0159 (table 1).

Table 1. Averages of the driver behavior variables recorded by the simulator in the transfer phase for the Control and Experimental groups.

	Control Group	Feedback Group
Average number of accidents	3	1.35
Average speed	27.62 km/h	23.67 km/h
Average time exceeding speed limit	113 sec	56 sec
Average speed exceeding speed limit	6.61 km/h	3.19 km/h
Average steering wheel angle variance (radians)	0.0073	0.0051
Average throttle variance (0 no throttle/1 full throttle)	0.058	0.035
Average braking force	8.68 kg	7.34 kg

Analysis on the average speed of the drivers showed that there was higher speed in the Control group (27.62 km/h) than in the Feedback group, (23.67 km/h), F (1, 38) = 7.42, p < .0096. Regarding compliance with the established speed limit, the average time exceeding the speed limit was longer in the Control group (113 sec) than in the Feedback one (56 sec), F (1, 38) = 7.81, $p < .0081$, $\eta^2_p = .17$. Moreover, the average speed that driver exceeded the speed limit was higher in the Control group (6.61 km/h) than in the Feedback one (3.19 km/h), F (1, 38) = 11.67, $p < .0015$. Additionally, our results revealed that 23% of the accidents in the control group occurred when drivers exceeded the speed limit, while in the experimental group the percentage dropped to 7%.

Analysis on the steering wheel angle variance (radians: max: +/-0.698) revealed that there was a higher variance in the Control group (0.0073) than in the Feedback group (0.0051), F (1, 38) = 7.68, $p < .0085$. Throttle variance (0: no throttle, 1: full throttle) was greater in the Control group (585.58) than in the Feedback one (359.80), F (1, 38) = 8.31, $p < .0064$,. The average braking force (max: 15kg) was higher in the Control group (8.68 kg) than in the Feedback one (7.34 kg), F (1, 38) = 3.87, $p < .0565$. These sets of variables can be used as relative measures of the driving style where the higher values may indicate more abrupt driving.

4. Discussion

Our results demonstrated that the use of negative emotional feedback in the road safety programs can be effective in reducing the number of accidents. More importantly, in terms of the main objective of this research, our findings illustrated that the reduction of accidents was accompanied by a set of behavioral changes in the driving style. We observed a lower average speed and greater respect for speed limits. This data is of great importance if we take into account that the percentage of accidents exceeding the speed limit decreased by 69.56% in the group which received negative emotional feedback. Moreover, the analyses of steering wheel variance, throttle variance, and average braking force provided evidence for a more even and homogenous driving style. These changes in driving style towards a more 'desirable' way of driving, i.e. complying more closely to traffic regulation and to a friendly driving, could explain many of the causes attributed to the reduction of accidents (Leon & Nahl, 2000; Megías, Maldonado, Catena, & Cándido, 2012).

These findings are in the line with studies affirming that the correct implementation of the negative emotional content can be effective in preventing accidents. However, its use must be always applied with caution and taking into consideration appropriate circumstances (Lewis et al., 2007). They must be directed to the correct target audience (in our case, young people with driving licenses), provoke a high perception of susceptibility (the punished behaviors were their own ones), and to evoke a suitable level of fear (all feedback images had a medium arousal and valence level). In addition, despite the fact that the negative feedback was directed towards a specific behavior (not to brake in a risky situation), its effect modulated driving at a more general level. The study revealed a set of changes in the behavior of drivers which would be on the basis for reducing accidents and must be considered in the design of road safety programs. Future studies should examine the long-term effects of emotional manipulation on driving patterns and should further explore other emotions or positive feedback.

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CHAPTER V

The passenger effect: Risky driving is a function of the driver-passenger emotional relationship

Abstract

This research focused on the influence of imaginary passengers on drivers' estimation of the probability of having an accident in traffic situations. Participants had to imagine riding a motorcycle with either a son or a workmate as passenger. Their task was to assess the risk of accident in a set of traffic scenarios. Risk perception was a function of sex and type of passenger. Women perceived higher risk when the passenger was a son than when a workmate. In contrast, men estimations were rather the same for both passengers. The emotional significance of the consequences of the accident (losing a son vs losing a workmate) modulate the perception of probability of having an accident. Finally, these results could help in designing more effective campaigns promoting road safety.

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1. Introduction

Risk perception is a key factor in driving and safety on the road, as it determines drivers' reactions in many different situations (Fuller, McHugh, & Pender, 2008; Summala, 1988; Wilde, 1988). Two main factors are usually assumed to explain risk perception (Keil, Wallace, Turk, Dixon-Randall, & Nulden, 2000; Mellers & Chang, 1994): the emotional impact derived from the consequences of an accident (e.g., physical impact, pain, damages, etc.)and the probability of the accident. The emotional impact of an accident, as well as its social and economic outcomes, can increase when driving with a passenger. Although the effect of the passenger has been extensively studied (Hu, Xie, Han, & Ma, 2012; Simons-Morton et al., 2011), little is known about the influence of the emotional relationship between driver/rider and passenger on the perception of traffic risky situations. In this paper we compared accident probability that motorcycle riders' estimate for two types of imaginary passengers: a loved one (a son) and a neutral one (a workmate). We hypothesized that riders' ability to detect dangerous traffic situations will be facilitated by loved passengers with regard to emotionally neutral ones.

Theories on risk perception have proposed the probability of the loss will occur and the importance of this potential loss as the two main components directly related to risk perception (Keil et al., 2000; Mellers & Chang, 1994). Research has shown that the emotional meaning rather than its magnitude or probability seems to be the factor that best accounts for risk perception when the outcomes of our actions have a stronger emotional content (Damasio, 1994; Slovic, Finucane, & Peters, 2007). In these cases, the weight of the probability of the loss is lower than for neutral outcomes (Loewenstein, Weber, Hsee, & Welch 2001). Similarly, in gambling behavior, the degree of attraction of a gamble seems rather insensitive to changes in the probability of winning when the outcome has a strong emotional impact (in a range from 0.01 up to 0.99, Rottenstreich & Hsee, 2001). In medical contexts, decisions about cancer are judged riskier than about other diseases with a lower rate of survival, because cancer produces stronger feelings of fear (Slovic, 2006).

In traffic and road safety, research has also focused on how the emotional component of the outcomes modifies drivers risk perception (CAST, 2009; Fuller, 2011; Hole, 2006; Megías, Maldonado, Catena, & Cándido, 2012). In this way, several studies have demonstrated how passengers could play both a protective and a damaging role in risky driving. In general, people drive carefully and take less risks with passengers, except male young drivers with their peers, in which case the probability of accidents and casual fatalities is dramatically much higher (Conner, Smith, & McMillan, 2003; Regan & Mitsopoulos, 2001; Hu, Xie, Han, & Ma, 2012; Simons-Morton et al., 2011). The influence of passengers on drivers' behavior has usually been explained as due to normative social influences (Rolls & Ingham, 1992). It is proposed that young drivers, especially males, have a higher tendency to take risks, driving to higher speed and having less concern of the traffic rules. Thus, the mere presence of peers would also encourage them to behave in a riskier way to gather a greater social support (Matthews & Moran, 1986).

Here, we hypothesize that the emotional value of risky situations might increase when riding with a loved passenger (like a son) in comparison with riding with a peer or a workmate. We suggest that the value of the potential loss can affect both the perception of the risk of having an accident and the estimation of the probability of this accident. However, the influence of the affective relationship between rider and passenger on risk perception and on the estimation of the probability of the accident remains an open question to further research in Traffic Psychology. Accordingly, the main aim was twofold: first, to find out whether the emotional value of the potential loss (a son or a workmate) modifies the perception of the probability of having an accident in riding situations; second, whether the emotional effect is a function of risk level of the situation and rider's sex, given its known effect on risky driving.

2. Method

2.1. Participants

Sixty four participants (32 women and 32 men) agreed to participate in this experiment. After having been informed on their rights according to the Helsinki declaration, they signed the informed consent to take part in the experiment (World Medical Association, 2008). Both sex groups were matched in age (Men: M = 36.25 years old, SD = 15.03, min age = 19, max age = 65; Women: M = 35.03 years old, SD = 14.74, min age = 18, max age = 62). All participants held a valid car and motorcycle driver's license (164 months on average in the case of women and, 178 months for men). Six men and one woman have suffered an accident in the middle-age group, but only two men had ever been involved in a traffic accident in the young group. All participants in the middle-age group were parents except two women and four men.

2.2. Apparatus and stimuli

A set of 84 road pictures obtained from the Honda Riding Trainer (HRT) Simulator (see, Di Stasi et al., 2009, for details on the HRT) were presented to each participant. Each of these pictures (see Figure 1) was selected from a database previously evaluated through a parametric study on risk perception (Megías, López-Riañez, & Cándido, 2013). From this database we selected 28 slides for each level risk group (average risk scores were: 6.68, 3.30, and 0.97, respectively for high, medium and low risk groups, 10 being the highest possible risk and 0 the lowest one). These three levels of risk were used because different risk levels cause dissimilar type of response and reaction times (Megías et al., 2013). For example, medium risk situations are characterized by greater uncertainty, one very influential factor in risk perception (Doya, 2008; Pushkarskaya, Liu, Smithson, & Joseph, 2010).

Figure 1. Three traffic situations used in this experiment, captured from the motorbike HRT simulator and subsequently edited by the authors.

All stimuli were displayed on a 1024x768 screen resolution. Participants were seated at 57 cm from the monitor centre and with a keyboard in front of them. The task was controlled by the E-Prime software package (Schneider, Eschman, & Zuccolotto, 2002).

2.3 Procedure and design

The task of the participants was to evaluate the probability of an accident they perceived in the road pictures on a scale ranging from 0 (no accident at all) to 10 (accident is completely granted), whilst playing the part of a motorcycle driver. They had to respond by using the set of keys arranged horizontally from F1 to F11 in the keyboard. These keys were adapted to the response scale of the experiment by means of stickers, numbered with a digit between 0 and 10. All participants were asked to respond as quickly as possible, which would simulate the urgency of the response in real risky driving situations (Megías, Maldonado, Cándido, & Catena, 2011; Serrano, Di Stasi, Megías, & Catena, 2013).

Each participant completed two 84 trials blocks, counter-balanced across participants. Participants were asked to imagine that they were riding a motorcycle with a passenger both wearing a homologated helmet and observing the speed limits. In one of the blocks (the son passenger condition), the participants had to imagine they were riding home from school with their twelve year old son. In the other block (the workmate passenger condition), they had to imagine that they were a worker returning home from work. In this case, the passenger was a middle-age workmate, to avoid the possible influence of their peer group in young people (Matthews & Moran, 1986).

The same traffic situations were presented in each block, but the trials sequence was randomly selected for each participant. Each trial follows the same sequence: after a fixation point of variable duration (750 - 1200 ms), the picture displaying the traffic situation was presented and the participant had to press the keyboard key that indicated their perceived accident probability (from 0 to 10). After the response or after 4000 ms, a black screen was shown for 1200 ms. The whole experiment lasted for about 15 minutes.

The experimental design was 2 (Passenger) x 2 (Sex) x 3 (Risk level) mixed factorial design with Age and Having children as covariates in order to control a possible effect on estimated accident probability. Sex (men and women) as between-groups variable, and Passenger (son and workmate) and Risk level (low, medium and high risk) as within-subjects variables.

3. Results

Medians of the estimated accident probability scored in a 0-10 integer scale (see Table 1) for each participant was submitted to a (Passenger, 2 x Sex, 2 x Risk level, 3) repeated measures ANCOVA, entering Age and Having children as covariates . There was a significant main effect of risk level, F (2, 120) = 62.13, MSE = 1.74, $p < .0001$. The averages observed for the risk levels (1.34, 3.84 and 7.04, respectively for low, medium and high risk) were close to those obtained in the parametric study (Megías et al., 2013, see above). There was also an interaction effect between Risk and Sex, F (2, 120) = 3.48, MSE = 1.74, $p < .0339$. Finally, passenger significantly interacted with Sex and Risk level, F (2, 120) = 3.27, MSE = 0.13, $p = .0414$. No other main effect or interaction reached the significance level. In the analysis of Passenger x Sex x Risk Level interaction we were especially interested on the effect of passenger (the difference between probabilities for the Son and the Workmate conditions) on each risk level, as a function of sex.

Table 1. Medians of estimated accident probability for each level of the three independent variables (Sex, Passenger and Risk level). Driving situations were scored in a 0-10 integer scale.

		Low Risk	Medium Risk	High Risk
Men group	Son	1.74	3.99	6.95
	Workmate	1.55	3.99	6.89
Women group	Son	1.14	3.94 }*	7.35 }*
	Workmate	0.93	3.44	6.97

*Significant comparisons

In men, the difference between driving with a son and a workmate was not significant independently of the risk level (all p's > .17, see Table 1 and Figure 2). Regarding women, the effect of the passenger was significant for medium and high risk (all *p*'s < 0.01), but not for low risk. Women perceived higher probability of accident when driving with a son than a workmate in medium and high risk situations (see Figure 2).

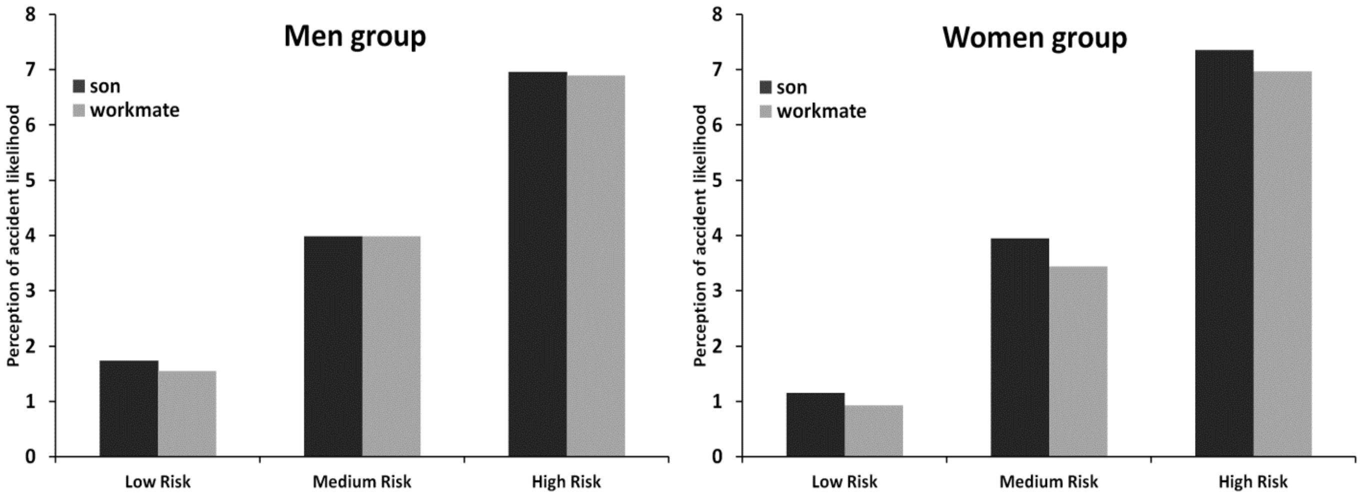

Figure 2. Medians of estimated accident probability for each risk level as a function of sex. Positive values indicate a higher perception of accident probability.

4. Discussion and conclusion

This research focused on the influence of the driver-passenger emotional relationship on drivers' estimation of accident probability in risky driving situations. Given that estimating the probability of having an accident is considered a key factor in the evaluation of perceived risk, our results can add new findings to traffic psychology and risk perception accounts (Slovic et al., 2007; Summala, 2005; Wilde, 1988). Our results showed men's estimation of probability of accident were the same for the two passenger types, but women seem to perceive higher probability of accident when the passenger is a son. Thus, it seems that the emotional value of the link between driver and passenger not only modulates the weight of the loss and consequently the risk perception, as theories of risk perception assume (Slovic et al., 2007; Loewenstein et al., 2001), but it can also modulate more objective estimates as probability of having an accident in a traffic situation.

The effect of the passenger on driver's behavior has usually been explained by social influences. Drivers tend to drive in a more cautious manner when there are passengers, adjusting their driving to the expectations of the passengers (Rolls & Ingham, 1992). However, drivers, especially young males, can behave more risky in response to the peers' pressure (Matthews & Moran, 1986). Our results pointed out that even the evaluation of the probability of having an accident can be affected depending on emotional relationship with the passenger, probably as a result of the high weight attributed to the consequences of having an accident when travelling with a son.

These results also show that men seem rather insensitive to the driver-passenger emotional relationship. In stark contrast, women estimations of accident probabilities when the passenger was a son were higher than for the workmate in those situations with medium or high risk level. Only women were affected by the emotional component associated with the possible loss in case of accident when driving with a son, while they behave similarly to men when it was a work-mate. There is extensive evidence showing sex differences in traffic research because men, especially young men, take higher risks than women, which has raised the cost of their car insurance (Bymes, Miller, & Schafer, 1999; Matthews & Moran, 1986; Rhodes, Brown, & Edison, 2005). Most studies have also shown that men have a lower perception of risk and that they engage in risky activities more frequently than women (Bymes et al.,1999; Rhodes et al., 2005). Our results suggest that women perceived more risk of accidents when driving with a son than a workmate because children may induce a higher emotional valence and arousal in females than males, as observed in studies on the International Affective Picture System

(IAPS) (Lang, Bradley, & Cuthbert, 2005; Spanish norms, Vila et al, 2001), and by research showing differences in childcare implication between women and men (Stephens, 2009; Zamzow & Nichols, 2009). However, it should be noted as a limitation of our study that there can be some individual differences in the connection with children or workmates. Some people might be estranged from their child and be very close to their workmates.

From a theoretical perspective, current models of risk perception and decision-making, for example the affect heuristic (Slovic et al., 2007), claim that very strong emotions associated with behavior outcomes give rise to a more automatic processing mode, neglecting some rational evidences, as the accident probability, in the calculation of perceived risk (Slovic, 1987; Epstein, 1994). However, our results add that, in these cases, changes in the risk evaluation can also be due to the perception of an increase in the probability of adverse outcomes, since these are also a function of the emotional meaning of these outcomes, like driving with a son.

From an applied point of view, one of the most common strategies promoting road safety has been aimed at modifying risk perception (e.g. Rundmo and Iversen, 2004). Road safety campaigns usually link unsafe driving with strong negative emotional content (Dejong, & Atkin, 1995; Lewis, Watson, Tay, & White, 2007; Tay, 2002), for example appealing to the conscience of the children (DGT, 2012; ministerstvo dopravy, 2012), which should increase risk perception and safer driving (Megías, Di Stasi, Maldonado, Catena, & Cándido, 2013; Megías, Maldonado, Catena, Di Stasi, Serrano, & Cándido, 2011). However, our findings suggest that individual variability (e.g. sex) may account for the low impact of these emotional-based road safety campaigns on road accident rates (OECD, 1994; Tay, 2002). In this vein, our study indicates that men do not seem to be affected by the emotional relationship with the passenger. Taken together, these results point out that traffic campaigns targeted to increase road safety have to take into account the sex differences regarding factors associated with the objective assessment of risk.

In summary, our findings suggest that risk perception in driving settings, as measured by the estimation of accident probability, can be modulated by the emotional content of the possible loss, but this modulation depends on socio-demographic factors.

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Experimental Block 2

Urgent and Evaluative Behavior Dissociation

CHAPTER VI

Emotional modulation of urgent and evaluative behaviors in risky driving scenarios

Abstract

This study demonstrated that task features are important factors for the understanding of risk behavior under emotional conditions in driving scenarios. We introduce a distinction between urgent and evaluative behaviors. Urgent behaviors are performed under high time-pressure and, when successful, they will help to avoid high negative outcomes. According to some social psychologists, evaluation is considered a type of value categorization (for example, risk or no risk). Emotional cues in the urgency task make participants slower and less able to discriminate risk from no risk, and prone to positive responses. However, negative emotional pictures speed up the evaluation of risk without affecting the ability to discriminate risk from no risk in a driving scenario.

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1. Introduction

Every day we are faced with situations that involve some risk. Sometimes our responses are urgent, as when we brake because the vehicle ahead has stopped suddenly, when a pedestrian suddenly crosses the street, or when we noticed a traffic light turning to yellow. Urgent behaviors are those that are triggered by the stimulus, performed under heavy time pressure, and can have critical outcomes (e.g. a casualty). In other situations, we just assign a value to the situation (e.g., categorize it as risky or not, positive or negative, threatening or rewarding, Eagly & Chaiken, 1993), but the response does not involve actual casualties, it is not imperative or can be delayed, like when we evaluate the risk as a result of the front car's braking. Both responses seem to involve similar processes: the detection of risk factors in the scene (e.g. a pedestrian in the roadway) and a decision (to stop or not in urgent behaviors and to categorize the situation as risky or not in evaluative ones). It is generally considered, as suggested by the consequentialist point of view (see Lowenstein, Weber, Hsee, & Welch, 2001), that we must first evaluate the risk before making a decision. However, our daily experience is often quite different. Thus, how many times have you thought about the risk of a traffic situation just after you have stopped and the situation has ended?

Recent research on judgment and decision making and attitude change may help us in understanding the differences between urgent and evaluative behaviors in risky situations and its theoretical implications. Most of these propose the existence of two information processing mechanisms, System I and System II, that jointly determine behaviors in risky situations (Damasio, 1994; Epstein, 1994; Gawronski & Bodenhausen, 2006; Kahneman & Frederick, 2002; Loewenstein, Weber, Hsee, & Welch, 2001; Reyna, 2004; Slovic, Finucane, Peters, & MacGregor, 2004).

Most of these dual-process models (Evans, 2008; Sanfey & Chang, 2008; Slovic et al., 2004) agree that System I (affective-experiential) is mostly automatic and unconscious, sensitive to emotions, and based on situation-action connections that have been associated with success in the past. System I is mostly automatic as a consequence of learning experiences, although it also requires less mental effort and awareness than System II (rational-analytic). Hence, System I is believed to be much faster and geared towards immediate action. Moreover, it is useful when urgent behaviors are required, when the context does not contain all the information needed for making a rational decision, or when decisions are complex and few mental resources are available for making rational decisions. On the other hand, System II (i.e., rational-analytic one) is more deliberative, based on logical or statistical rules, verbally oriented (Epstein, 1994), and slower than System I. Furthermore, it is less prone to be affected by emotions (Gawronski & Bodenhausen, 2006; Sanfey & Chang, 2008), although anticipated (expected) emotions linked to the outcome can affect the cognitive evaluation of the situation (Loewenstein et al., 2001), whereas anticipatory emotions (elicited by, for example, incidental affect-laden stimulus) influence mainly System I. Therefore, it seems that evaluative behavior should rely on System II.

Most of the research on the role of the two systems in the control of behavior has focused on the manipulation of contextual (i.e. frame, see Slovic et al., 2004) and emotional factors (i.e. moods, see Pessoa, 2009). However, very little attention has been devoted to uncover if task features modulate the effect of these factors on both systems. This research aimed to examine how incidental emotional cues interact with type of decisions (i.e. urgent versus evaluative behaviors) in risky situations. Previous research has shown how incidental emotions (i.e. task-irrelevant emotions elicited by events or activities preceding the target) influence decision-maker choices (Loewenstein et al., 2001). For example, Chou, Lee, & Ho (2007) found out that risk taking proneness was a function of the transient mood elicited by affect-laden video presentations.

On the other hand, recent research on the effect of incidental emotional pictures in detection and discrimination tasks have shown that negative valence emotional pictures can either speed up or slow down the response to a subsequent target (Buodo, Sarlo, & Palomba, 2002; Most, Chun, Widders, & Zald, 2005; Pereira et al., 2004; Pessoa, 2009; Smith, Most, Newsome, & Zald, 2006). For example, Pereira et al. (2006) have observed both transient and sustained emotional modulation of visual detection of targets after watching task-irrelevant mutilation pictures. They found out that visual detection times were slower after watching negatively-valenced task-irrelevant pictures than after positive or neutral ones. Moreover, brain imaging studies also suggest an interaction between emotional stimuli and detection (Lang et al., 1998, Padmala & Pessoa, 2008).

We suggest that urgent and evaluative behaviors are differentially affected by emotions induced by emotional pictures. Two-systems approaches (Lowenstein et al., 2001) consider that risk evaluation is under the control of the cognitive, rational-analytic system that will integrate information provided by the situation factors to derive a decision. However, urgent behaviors, such as braking while driving, are well practiced behaviors, so that many situation-action connections have been created by the experiential system. According to dual-system models, behaviors controlled by the experiential system can be more easily influenced by transient emotions.

In our experiment, participants looked at target pictures of traffic situations involving either risk or no risk (Figure 1). Thus, they had to either evaluate the riskiness of the situations, an evaluative action, or initiate braking, an urgent action. Affect-laden cues were displayed shortly before the targets. We suggest that the higher negative outcome of a failure to break will promote a soft analysis of the scenes, reducing the ability to discriminate risky from non risky situations and biasing responding toward faster less accurate responses favoring the decision to brake. In contrast to the urgent action of breaking, the evaluation of scene riskiness provides participants an opportunity to behave like mere observers for whom the potential negative outcomes are much less negative. Therefore, risk evaluation should be slower, but discrimination between risky and non risky scenes should be more accurate than for braking from our point of view. Incidental emotions induced by the affect-laden cues would play two different roles. First, out of their emotional content, the offset of the affect-laden cues actually mark the target onset time, increasing the participants’ readiness to respond. Second, affect-laden cues can trigger an emotional reaction that can influence the response to the target.

The main hypothesis of this research was twofold. First, we were looking for differences in the same risky situation as a function of the response requested. It was expected that braking would be quicker, but less accurate than evaluating risk. Second, we also expected a higher influence of incidental emotions in braking than in risk evaluation, as the former response depend more on the System I, affective-experiential, while the latter is controlled by the System II, rational-analytic.

2. Method

2.1. Participants

Thirty eight naive undergraduate students at the Faculty of Psychology of the University of Granada volunteered in exchange for course credits. The eighteen participants in the evaluation task were asked to evaluate the riskiness of traffic situations, while the twenty in the urgent task were asked to brake or not according to the traffic situation. All had normal or corrected to normal vision. After been informed on their rights according to the Helsinki declaration, they signed and informed consent.

2.2. Apparatus and stimuli.

Pictures of traffic target situations were extracted from HRT (Honda Riding Trainer, Figure 1, see Di Stasi et al., 2009, for details on the HRT simulator). After a preliminary parametric study on perceived riskiness with 90 HRT pictures, the eight highest scores (average riskiness = 5.23) were paired with the eight lowest scores (average riskiness = 1.24) that matched the scenarios in overall visual content. Shapiro-Wilks normality test showed that the average risk ratings of the selected traffic situations meet the normality assumption requested by the parametric signal detection theory ($p=.06$ and $p=.10$ for risk and no risk scenes, respectively).

There were 3 emotional cue conditions: negative, neutral, and positive. The 8 cues pictures for each emotional condition were selected from the International Affective Picture System (IAPS) (Lang, Bradley, & Cuthbert, 2005). The average valences of the negative and positive pictures were 1.53 and 7.87 respectively (1: very negative, 9: very positive). The average arousal of negative and positive pictures was similar, 6.675 and 5.642 respectively (1: low arousal, 9: high arousal). The neutral pictures valence and arousal were 5.02 and 2.468, respectively. All cues were presented on a black screen with a resolution of 1024x768 pixels, maintaining the original aspect ratio of the IAPS.

2.3. Procedure

All participants were informed prior to starting the experiment that unpleasant pictures would be displayed and that they were free to leave the experiment whenever they wanted. The experiment had 3 blocks of 80 trials, 20 per each SOA (stimulus onset asynchrony) x Risk condition, plus a previous 20 trials short practice. Each trial had the following sequence (Figure 1): after a variable interval of looking at fixation point (800 to 1200 ms) one emotional cue appeared for 200 ms. Next, a black screen lasted for 200 ms in a random half of the trials (SOA 400) and 600 ms in the other half (SOA 800). This allows examination of the temporal course of emotional modulation. Next, the target traffic situation was displayed. Participants were asked to respond as quickly and accurately as possible, pressing mouse buttons, indicating whether the traffic scene was risky or not (Evaluative Task) or braking or not (Urgent Task). The correspondence between the right and the left mouse button and type of response was balanced across participants. After the response or a maximum time of 1500 ms, a black screen was shown for 1500 ms. The sequence of trials was selected randomly for each participant.

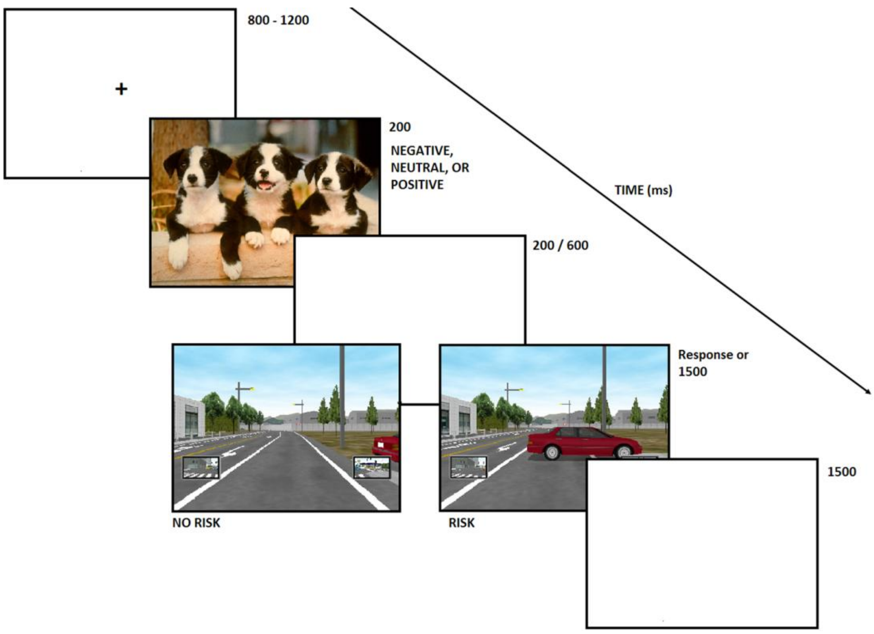

Figure 1. Experimental procedure and parameters.

Participants response bias and discrimination between Risk and No Risk scenes were measured by the c (response bias index) and d' (discrimination index) detection theory parameters (Macmillan & Creelman, 2005). For this analysis we take the risk situations as the signals to be discriminated from noise, the no Risk situations, and the risk/brake and no risk/no brake responses like the "yes" and "no" in typical yes-no signal detection applications.

For the analysis of reaction times and performance indices, the experimental design was a 2 (Task: evaluate or brake, between subjects) x 2 (SOA: 400 and 800 ms, within subjects) x 3 (Emotional cue: negative, neutral, and positive, within subjects) repeated measures. A significance level of 0.05 was set up for all statistical decisions. Partial eta square was used as an index of effects' size.

3. Results

Average of median reaction times were submitted to the repeated measures ANOVA just described. There were main effects of Task, F (1, 36) = 10.02, p = .003, η^2_p = .22, SOA, F (1, 36) = 11.38, p = .002, η^2_p = .24, and the interaction Task by Emotional Cue, F (2, 72) = 6.74, p=.002, η^2_p=.16. Reaction times were faster for Braking (623 ms) than for Evaluation (719 ms), and also for SOA 800 (662 ms) than for SOA 400 (679 ms). Emotional cue affected reaction times both in Evaluation, F (2, 72) = 3.18, p = 0.047, η^2_p = .08, and Braking, F (2, 72) = 4.05, p = .02, η^2_p = .10. According to post-hoc analysis, in the Evaluation task reaction times were faster after negative (697 ms) than after neutral cues (741 ms), F (1, 17) = 5.61, p = .029, η^2_p = .24; however, in the Brake task, reaction times were slower after negative (638 ms) and positive (636 ms) cues than after neutral ones (595 ms), F (1, 19) = 9.41, p = .006, η^2_p = .33 and F (1, 19) = 7.56, p = .013, η^2_p = .28 (see figure 2). No other differences reached significance.

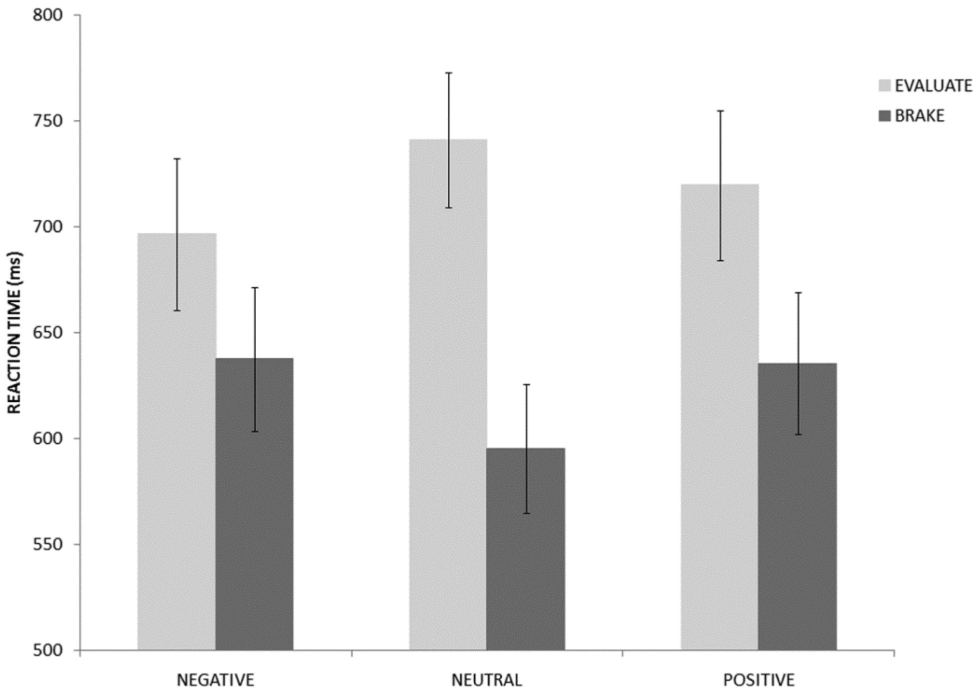

Figure 2. Response Latency. Average reaction times according to task and emotional cue. Vertical bars stand for the standard errors of the mean.

Average discrimination d' index was higher for Evaluate (2.64) than for Brake (2.14) task, *F* (1, 36) = 7.30, *p* = .01, η^2_p = .17. Furthermore, differences in discrimination index were observed in Brake, *F* (2, 38) = 8.30, *p* = .001, η^2_p = .30, but not in Evaluation, *F* (2, 34) < 1. When braking, discrimination index was lower after negative, *F* (1, 19) = 15.11, *p* = .001, η^2_p = .44, and positive cues, *F* (1, 19) = 5.00, *p* = .037, η^2_p = .21, than after neutral ones (see figure 3). Near to significant differences between negative and positive cues were obtained, *F* (1, 19) = 3.64, *p* = .072, η^2_p = .16.

Response bias toward positive responses (risk or brake, according to the task) was lower for Brake (c = -.17) than for Evaluate (c = -.04), *F* (1, 36) = 4.03, *p* = .05, η^2_p = .10 (see figure 3). No other effects were significant.

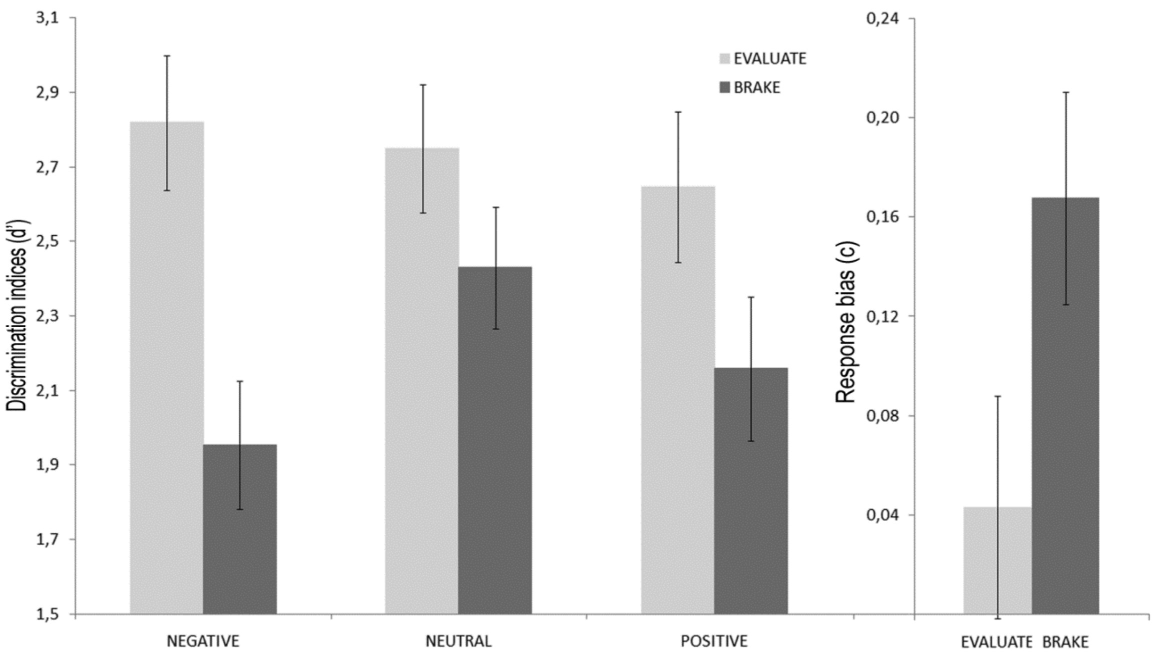

Figure 3. Performance accuracy and response bias. Average discrimination indices for task and emotional condition (left), and average response bias according task (right). Vertical bars stand for the standard errors of the mean.

4. Discussion

The main aim of this work was to examine the impact of incidental emotional cues on urgent and evaluative behaviors into a risky driving scenario. Traffic scenes involving risk and no risk situations were preceded by emotional cues after either short or long SOA. We have obtained several important results: First, braking is considerably faster than riskiness evaluation (96 ms) independent of emotions. Second, negative and positive emotional cues slowed down braking, but negative ones tended to speed up the evaluation. Third, discriminating risk from no risk scenes is largely affected by the task: Braking d' is about 0.5 standard deviation units below the one under evaluation. Moreover, lower d' indices were found after emotional cues in the braking condition. Finally, a response bias toward the positive response (risk or brake) was also found to be larger for braking than for evaluation. In conclusion, when people have to brake in risky situations, the response is faster, with incidental emotional cues either positive or negative impairing the ability to discriminate risk from no risk, slowing down the response to targets, and increasing the trend toward positive (brake) responses. In contrast, risk evaluation is slower, and negative emotional pictures slightly speed up the responses, although they do not affect discrimination or bias the response.

Emotional cues appear to tap into different processes depending on the task features. Its effects on the braking task could be explained if, as indicated before, this response, including simulated braking, is an urgent one, since even a very short delay increases the likelihood of having a strong negative outcome, an accident. This is to say, if the experiential, System I, controls braking, quick responses to urgent situations are guaranteed, even at the expense of hampering the processing of the stimulus. On the other hand, evaluating the risk of a traffic situation is far less compelling than braking, especially when participants are acting as mere observers. The rational-analytic System II combines information provided by the risk factors identified in the scene (for example: the presence of crosswalk or the distance between vehicles), allowing an accurate assessment of the situation. If risk indicators are used to compute a score on the risk-no risk dimension which is used for deciding on riskiness (Quartz, 2009; Weber & Johnson, 2009), it seems that negative pictures, in contrast to neutral and positive ones, speed up the process without impairing the perceptual analysis of the situation.

These results suggest the existence of three main theoretical findings. First of all, braking was much faster than risk evaluation in the same situations. Actually, this result bears out that braking was an urgent behavior and runs against any consequential view (Lowenstein et al., 2001). It is proposed by this view that before an action we must rationally analyze the risk of a situation. Moreover, this finding also supported the assumption that urgent behaviors are more automatic than evaluative ones and that they rely more on the experiential than on the rational processing system.

Secondly, emotional cues had a different impact on each type of behavior. Both negative and positive cues made braking slower, whereas only negative ones tend to speed up the evaluation. This result accords with the existence of different processes depending on the task features and also with the previous assumptions that urgent behaviors, like braking, should be more affected by emotions than evaluative ones. At the same time, it also bears out the assumptions that the experiential system should be more affected by emotions that the rational one (Gawronski & Bodenhausen, 2006; Sanfey & Chang, 2008).

Finally, an important result was the existence of differences in discrimination and a response bias as a function of the emotion induced by the cues and the type of behavior required in a risky situation. When people should only evaluate the riskiness of a specific situation, it seems to be rather accurate and this behavior does not seem to be affected by emotional cues. However, discrimination was less accurate when they have to brake, i.e. an urgent behavior, and it was impaired by negative and positive emotional cues. These findings suggest again the existence of two separate processing modes underlying each type of behavior.

The results obtained in this study have important consequences for risk estimation and drivers training. It is frequent that after looking at an accident in the road, drivers could feel more afraid and change its way of driving afterwards, being more careful. However, when a driver overestimates risk in a given situation and, for example, unexpectedly brakes at a round point, this response bias increases the possibility of accidents for the unaware drivers behind him. In fact, these types of "rear-end collisions" accounts for approximately 29 percent of all crashes (see Lee, LLaneras, Klauer, & Sudweeks, 2007). Another important finding is related to the influence of incidental emotional cues in the driver behavior. While driving, we frequently face affect-laden situations, such as observing an accident or the visualization of some road advertisements. Such incidental emotional cues could impair the speed of response, could also change risk discrimination and give rise to specific response bias in urgent tasks. Therefore, our findings suggest that drivers training programs designed to improve risk discrimination and reduce response bias, especially in traffic situations under emotional conditions, could help to improve drivers' safety.

Beyond the obvious importance of these results, more studies are needed to understand the emotional modulation of these behaviors and the differences between urgent and evaluative behavior in real driving scenarios. It would be necessary to generalize our results to other driving situations and other types of behaviors as speeding up and overtaking other vehicles. In addition, neurophysiologic studies could be useful for supporting the existence of these two separate processing modes for urgent and evaluative behaviors.

5. Conclusion

Incidental emotional cues modulate the two systems involved in human decision making. These modulator effects are strongly linked to the task features. Tasks controlled by System I, especially urgent tasks, are affected by negative and positive emotional cues, making responses faster, but less accurate, while tasks under the control of System II are amended by negative emotional cues, making responses slower, but more accurate.

This study can become an important basis for future research, conducted in more realistic settings, for example, through a motorcycle simulator integrating emotional stimuli in the road (e.g. road advertisement) or including other urgent behaviors (e.g. overtaking a car). These findings could be a starting point for the design of risk prevention programs, for educational training programs or even for the development of new advanced driver assistance systems.

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CHAPTER VII

Driving risk perception vs. Driving risk taking: Influence of the task features

Abstract

There is a general agreement to consider risk perception as a highly predictive factor of risk taking. However, recent research has yielded some contradictory findings about this relationship, especially in situations where an urgent response is required. The aim of this research was a) to explore what distinguish “urgent” from “evaluative” behaviors, and b) to test differentiating features explaining the discrepancies found between risk perception and drivers’ responses. Urgent behaviors, such as braking to avoid a hazard, are decisions triggered by stimuli, performed under time pressure and, in the case of not succeeding, could entail negative consequences. Evaluative behaviors are judgments assigning a value to a situation, such as categorizing a driving situation as risky. Our results showed that urgent and evaluative behaviors lead to different type of responses in similar situations. In line with dual processing models, urgent behaviors would be mostly controlled by the affective-experiential system, leading to faster behaviors mostly guided by heuristic rules; whereas evaluative behaviors would be primarily controlled by the rational–analytic system, guided by normative rules. However, adding urgent task features to the evaluative decisions (time pressure and consequences with a strong emotional value) reduced the found differences between both behaviors. Characteristics of urgent situations create the proper context for the use of heuristics and affect appraisal rather than a rational evaluation. These findings provide evidence to support the importance of the task features in the study of the risk perception-risk taking relationship and they can have important applications to design road safety programs.

The content of this chapter has been submitted as: Megías, A., Cándido, A., Maldonado, A., & Catena, A. (submitted). Risk perception vs. Risk taking: Influence of the task features. *Risk analysis.*

1. Introduction

Risk perception is considered a key factor in determining driving style and risk taking. The most relevant theories on driver behavior have treated risk perception as one of their most important research focus (see Fuller, 2011 for a thorough review). More specifically, a considerable body of research has demonstrated the relationship between risk perception and risk behavior, and their extrapolation to crash record in driving (e.g., Brown & Groeger, 1988; Deery, 1999; Dionne, Fluet, & Desjardins, 2007; Quimby, 1988). However, in spite of the amount of research on this subject, much remains unclear about how risk-taking behavior is related to risk perception. The aim of this study was to provide new information about how the contextual features that characterize the risk evaluation and the subsequent decision making may modulate this relationship.

Although the general view is that perceiving risks acts as a "protective factor", there have also been contradictory findings disputing this relation. Sometimes drivers may engage in risky driving inadvertently due to a distraction or as a result of a lack of experience. Nevertheless, in many instances risk-taking is undertaken with the knowledge that the actions may lead to highly risky situations (e.g. overtaking dangerously or speeding up to cross a yellow traffic light). According to the driving accident reports (e.g. DGT, 2012), the highest percentage of accidents is caused by consciously risky driving behavior. Moreover, drivers themselves perceive risky behaviors such as drinking alcohol, drug use, or rage driving, as major causes of accidents (RACC, 2008). Although drivers know that certain behaviors are more risky than others, many continue carrying them out. Even, in some population groups such as adolescents, perceived risk can be recognized as part of their taking behaviors (Reyna & Farley, 2006). Thereby, as such exceptions illustrate, the relationship between risk-perception and decision-making does not seem to be fully consistent across the literature.

Sitkin and Pablo's study (1992) on the determinants of risk behavior presents one of the most accepted explanations for this question. While it is commonly accepted that risk-taking in driving is the product of a complex behavior where many different variables can influence decision-making (e.g. social influences, emotions or motives; see Megías, Maldonado, Catena, & Cándido, 2012; Wickens, Gordon, & Liu, 1998), Sitkin and Pablo (1992) argued that risky decision-making depends mainly on two factors which interact the other variables: risk perception and risk propensity. Risk propensity is defined as the general tendency of decision-makers to take or avoid risks. This can be conceived as a mediator of risk acceptance, namely, the amount of perceived risk which a driver is disposed to tolerate (Rohrmann, 1998); a common concept to motivational models of driving (e.g. Fuller, 2011; Summala, 1988; Wilde, 1982). According to this view, drivers' motivations can modulate the acceptable perceived risk threshold, resulting in the execution of consciously risky behavior when the balance between costs (e.g. crash) and benefits (e.g. getting quickly to somewhere) is perceived as favorable (Hatfield, & Fernandes, 2009).

Notwithstanding, there are risk situations in which decisions do not seem to adapt to this benefit-risk balance, especially of the kind where urgent responses are needed. Thus, many times the driver is aware of the level of risk in a traffic situation just after he or she has taken an urgent action, such as slamming on the brakes and therefore ending the situation. In order to explain part of this variance not accounted for by classical risk models, Megías, Maldonado, Cándido and Catena (2011) distinguished between urgent and evaluative behaviors. Urgent behaviors are behavioral decisions guided by the stimulus, performed under heavy time pressure and, in the case of not succeeding, entail consequences with a strong emotional value (e.g. breaking to avoid a collision). On the other hand, evaluative behaviors are judgments where the driver attributes a value to a situation, the response may be delayed and it does not involve actual damage (e.g. to evaluate risk) (see Megías et al., 2011; or Megías, Di Stasi, Maldonado, Catena, & Cándido, 2014, for a better understanding). The results of their studies showed that evaluative behaviors are not always linked to urgent ones: urgent behaviors seem to involve faster responses and a response bias toward more cautious responses than evaluative ones. But, what makes these behaviors different? In principle, they must be closely related because decision-making processes are the consequence of previous judgments, as is suggested by the consequentialist approach (Payne, Bettman, & Johnson, 1993).

The aim of this study was twofold: a) to show the differences between risk evaluation and decision-making in risky driving situations; b) to explore if factors such as time pressure and negative emotional consequences could explain, at least in part, the discrepancies found between both risk perception and drivers' responses in risk driving situations. Accordingly, this study focused on the two main features that characterize urgent behaviors: probability of negative consequences with high emotional value and time pressure. Both features seem to be key aspects of urgent decision-making in risky driving situations and distinguishing features regarding evaluative behaviors. In order to test our goal, we added such contextual features, pressure time and emotional negative consequences, to evaluative responses with the purpose of making them more similar to the urgent ones.

2. Method

2.1. Participants

A total of forty undergraduate students at the University of Granada took part in the experiment, volunteering in exchange for course credits (24 female, 16 male, age 18-29 years old, M = 21.62, SD = 2.85). All participants held valid driver's licenses (having held them 32.82 months on average). The participants' ages and the licenses' issue dates were kept within a similar range in order to reduce the influence of these factors on risk perception and driving behavior (Forsyth, Maycock, & Sexton, 1995; Levy, 1990). Participants gave an informed consent and were briefed on their rights according to the Helsinki Declaration (World Medical Association, 2008).

2.2. Apparatus and stimuli

The experiment consisted of one hundred traffic images captured from the Honda Riding Trainer Simulator (see Megías, Maldonado, Catena, Di Stasi, Serrano, & Cándido, 2011, for more details about the simulator). All images (see Figure 1) were selected from a larger set of images previously evaluated on risk perception through a parametric study (Megías, López-Riañez, & Cándido, 2013). Fifty low risk pictures (average risk score between 1 and 10 = 2.13) and 50 high risk pictures (average = 6.54) were chosen for the current experiment. High risky images were picked out in such a way that the best option to avoid the hazard was always brake. The stimuli were displayed on a monitor (1024x768 screen resolution) placed 60 cm away from the participant.

2.3. Procedure

All participants performed five different tasks. One of the tasks required an urgent behavior: decide whether they would brake or not according to the traffic situation displayed. The other four tasks required an evaluative behavior: evaluate whether the traffic situation entailed risk or not. The behavior requested to the participants in the evaluative tasks was always the same (risk evaluation), but the difference lay in the task features. The four evaluative conditions were made adding different combinations of the urgent task features (time pressure and emotional consequences; see Megías et al., 2011) to the evaluative behavior by contextual changes (see table). In the "evaluative task with time pressure", participants had a maximum response time of 850 ms (for the rest of tasks it was 2000 ms). In the "evaluative task with emotional consequences", participants had to imagine that a road safety company had asked them to fill out a survey about road safety. This company would use their answers for the purpose of eliminating black spots on the road in order to prevent accidents, with the consequent emotional charge. Finally, in the "evaluative task with both time pressure and emotional consequences", road safety company context and maximum response time (800 ms) were combined. The five tasks were presented in a counterbalanced order.

Table 1. Behavior, task features and context of the tasks performed by the participants.

Task Name	**Behavior**	**Task features**	**Context**
Urgent	Brake	---	---
Evaluative	Evaluate risk	---	---
Eval. + TP	Evaluate risk	Time pressure	Short time to respond
Eval. + EC	Evaluate risk	Emotional consequences	Survey for road safety company
Eval. + EC + TP	Evaluate risk	Emotional consequences + Time pressure	Survey for road safety company + Short time to respond

Each task was composed of 60 trials (20 different images repeated 3 times each one; 50% of them were high risk situations). The distribution of the images in each task were rotated across the participants. Images could belong to any task, but all of them were displayed the same number of times in each task once the 40 participants finished the experiment. Each trial consisted of the following sequence of events: After a fixation point (750 - 1250 ms), the participants observed a traffic situation where they were required to press one of two buttons on the mouse in order to indicate either "risky situation/brake" or "non risky situation/no brake" (correspondence between mouse buttons and type of response was counterbalanced across participants). After the response or time-out, a black screen was shown for 1000 ms. The experiment lasted for approximately 50 minutes.

2.4. Design and analysis

The experimental design was a unifactorial repeated-measures with Task (5 levels: Urgent; Evalutive; Evalaluative with Emotional Consequences [Eval.+EC]; Evaluative with Time Pressure [Eval.+TP]; and Evaluative with Emotional Consequences and Time Pressure [Eval.+EC+TP]) as within-subject variable. Probability of positive response (brake or risk), reaction times, and performance indices (d' and c) were considered as dependent variables. Post hoc comparisons between the different conditions of the Task variable were only focused on checking differences between Urgent and Evaluative conditions, and on exploring which urgent task features produced these differences (Evaluative condition vs. each one of the Evaluative conditions with urgent task features added [Eval.+EC; Eval.+TP; Eval.+EC+TP]). A significance level of 0.05 was set up for all statistical decisions.

Discrimination index (d') and response bias (c) between Risk and No Risk scenes were calculated by means of the Signal Detection Theory (Macmillan &

Creelman, 2005). A risky situation was considered as the signal to be discriminated from noise (in our case no risky situation), while "risk/brake" and "no risk/no brake" responses were the "yes" and "no" responses in a typical yes-no signal detection application. Extreme hit or false-alarm proportions (H = 1 or FA = 0) were corrected by the loglinear transformation method (Hautus, 1995; Knoke, & Burke, 1980).

3. Results

The repeated measures ANOVA on the means of the probability of giving a positive response (brake or risk) showed a main effect of Task, F (4, 148) = 13.63, MSE = 0.1049, $p < .0001$. Following our first aim, differences between Urgent and Evaluative groups were checked. A post-hoc analysis revealed significant differences between both conditions ($p < .0001$). The probability of braking (0.57) was higher than the probability of evaluating risk (0.43). Regarding the second aim, features task responsible of the differences between Urgent and Evaluative were explored. Post-hoc analysis showed higher probability of evaluating risk in the Eval.+EC+TP condition than in the Evaluative one ($p = .0113$; see figure 1). Thus, differences between Evaluative and Urgent behaviors in this measure seem to be more related to the joint effect of time pressure and emotional consequences.

The ANOVA on mean reaction times revealed a main effect of Task, F (4, 148) = 47.99, MSE = 465449, $p < .0001$. Firstly, post-hoc analysis showed faster reaction times in the Urgent condition than in the Evaluative one ($p < .041$). Secondly, both Eval.+TP and Eval.+ EC +TP conditions had shorter reaction times than the Evaluative one (p's < .0001; see figure 1). In this case, time pressure seem to be the key element that differentiated urgent and evaluative behaviors.

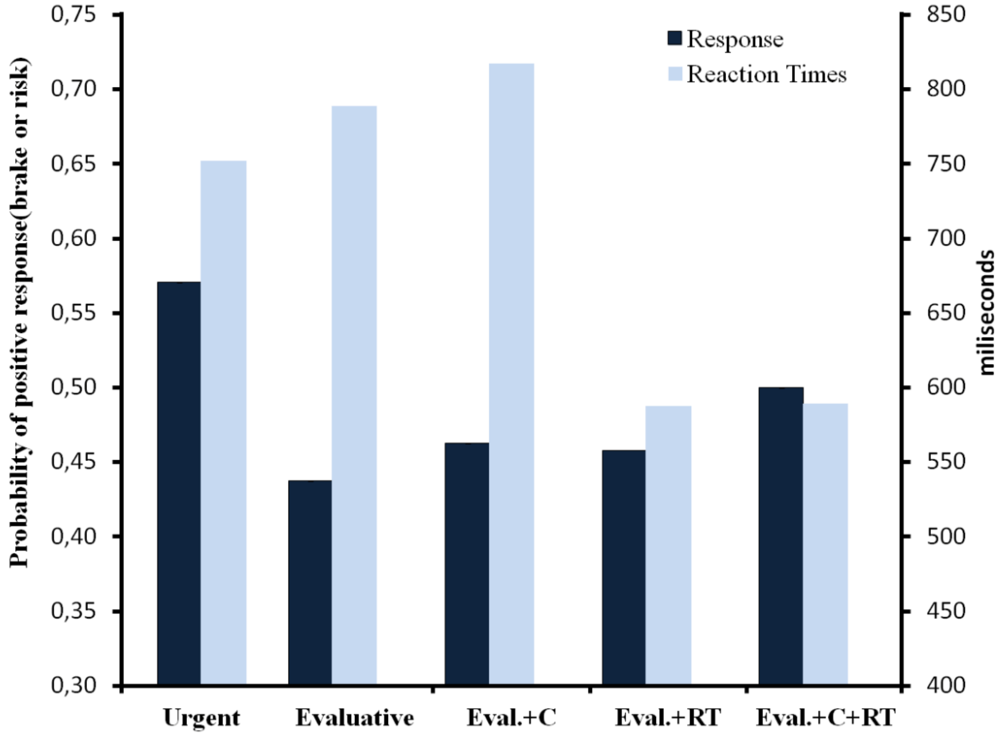

Figure 1. Average probability of positive responses (to brake or to evaluate risk) and average reaction times for each condition of the Task variable.

Means of discriminability index (d') showed a main effect of Task, *F* (4, 148) = 5.09, MSE = 1.1051, *p* < .0001. Post-hoc analysis showed marginal differences between Evaluative and Urgent conditions (*p* = .0717). In addition, we also observed a better discriminability for Evaluative than for Eval.+EC+TP (*p* = .0007; see figure 2). Therefore, emotional consequences and time pressure both were required to find differences between urgent and evaluative behaviors.

Means of response bias (c) showed a main effect of Task, *F* (4, 148) = 13.82, MSE = 1.3752, *p* < .0001. Post-hoc analysis showed a lower response bias for the Urgent condition than for Evaluative one (*p* < .0001). Significant differences were also found between the Evaluative and Eval.+EC+TP (*p* = .0147) and near to significant between the Evaluative and Eval.+EC (*p* = .0613; see figure 2). Thus, emotional consequences seems to be enough to obtain differences in response bias between urgent and evaluative behaviors.

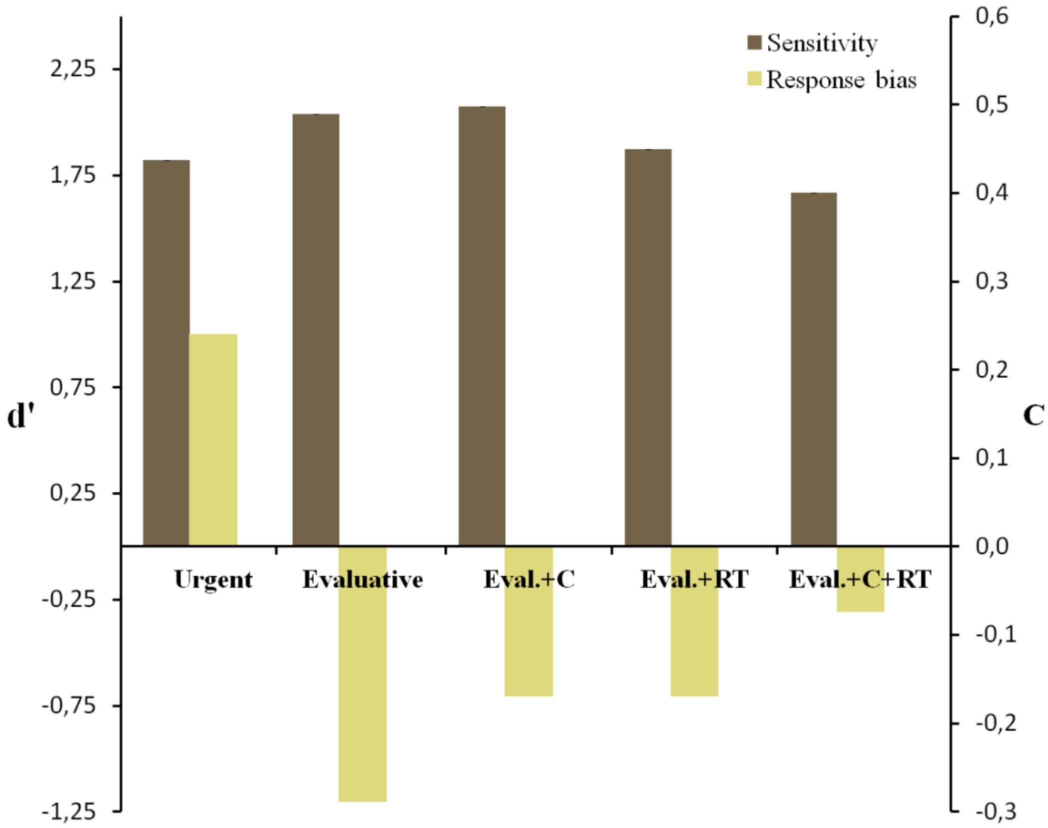

Figure 2. Average discriminability index (d') and average response bias (c) for each condition of the Task variable.

4. Discussion

The first aim of this research was to study the differentiating features of urgent and evaluative behaviors, as there are many examples of driving situations where risk perception does not correspond to the decisions made by drivers, for example risky overtaking, exceeding the speed limit or speeding up when light turn yellow (Megías et al., 2011). The second and main aim was to explore if factors such as time pressure and negative emotional consequences could explain, at least in part, the discrepancies found between risk perception and drivers' responses in risk driving situations.

The results showed firstly, that urgent behaviors (in comparison with evaluative ones) were faster, more cautious, and they had a lower discriminability index as well as a response bias toward positive responses (brake). More importantly, the results suggest that this dissociation could be explained, at least in part, by the two main features which distinguished both tasks, time pressure and emotional factors due to the possibility of negative consequences. It is important to acknowledge that any of the two features or their joint action do not made the evaluative responses exactly equal to urgent ones. However, the higher probability of a positive response and the lower discriminability seems to be related to the joint effects of the time pressure and the emotional consequences, whereas the response bias seems mainly dependent on the emotional consequences. Finally, time pressure appears to be the key factor in reaction time differences.

These findings taken together show that urgent decision-making variance in driving situations cannot be explained solely through previous evaluative judgments of risk perception. Both behaviors do not always involve a direct relationship and their differences could be linked to the features which define each task. Our results suggest that urgent behaviors seem related to time pressure and their emotional consequences. The combination of these two factors worsen the discriminability of the drivers in the risk situation. This deteriorated discriminability could be due to a lack of time to collect the information necessary to make a rational analysis of the situation (analysis which could be accomplished in evaluative behaviors), which lead to a higher number of caution responses in the driver. The absence of in-depth exploration of the situation could be the cause of a bias toward positive responses and the increase, probably more adaptive, of cautious responses (also compromising more false alarms).

Road situations where there are strong temporal pressures and consequences with a high emotional value are scenarios which are widely present in everyday driving and fit with the definition of a risky driving situation. In this type of urgent contexts, a rational benefit-cost analysis is very demanding and requires a too long processing (Gilovich, Griffin, & Kahneman, 2002). Consequently, a more automated process relying on heuristics would be advantageous, producing an earlier reaction to modify driving behavior (Kinnear, Stradling, & Mcvey, 2008). Urgent behavior's task features in our experiment would create an urgent mindset involving a shift from a mainly analytical appraisal of risk (top-down) to an experiential appraisal (bottom-up). From this theoretical perspective, the differences between urgent and evaluative behaviors are in line with dual processing models (automatic vs. controlled; Epstein, 1994; Slovic, Finucane, Peters, & MacGregor, 2004). According to these models, urgent behaviors (e.g. braking in a risky driving situation) would be mostly controlled by the affective-experiential system, leading to faster behaviors mostly guided by heuristic rules. On the other hand, evaluative behaviors (e.g. to evaluate the risk of a situation) would be primarily controlled by the rational–analytic system that integrates information from situational factors by normative and logical rules in order to make decisions (e.g. calculating probabilities). Thus, they requires a greater effort and are markedly slower (Slovic, & Peters, 2006). The results of this experiment suggest that there can be an imbalance between both processing systems as the urgent task features are incorporated (time pressure and emotional consequences). Thus, drivers in need of making an urgent decision are guided by automated processes learned through experience, rather than by rational risk evaluation (e.g. cost-benefit analysis).

To summarize, many existing explanations on the nature of the relationship between risk perception and decision-making have been grounded on cost-benefit models or risk propensity theories. The results of this study suggest that such explanations should note the importance of context task features and their involvement in more automatic or controlled processes. Future neuroimaging or EEG studios could provide brain level evidences about the predominance of one or another system according to the type of responses and the task features.

In terms of real-life applicability, urgent behaviors are well learned and automated responses, mostly due to previous experience where situation–action connections are created (experiential system); therefore, they will be difficult to modify in case of an inadequate learning. Accordingly, teaching how to react on urgent situations from the beginning of driver learning should be an important component of developing safer driving skills. Moreover, many of the evaluative behaviors learned in driving schools seem not to be adapted to urgent situations presented in real-life driving situations. Consequently, the use of simulators during training in driving schools could help drivers acquire driving correct habits more effectively from the beginning of training. In this way, a measure introduced by some governments which have led to an important reduction in crashes is the graduated driver licensing (Ulmer et al., 2003; Simpson, 2003). One of the aims of this method is to give learner drivers under 18 or 21 years old the opportunity to develop their driving skills under the supervision of experienced drivers who already holds drivers licenses (e.g. a relative). New drivers may learn good habits in driving and automate their behaviors, many of them urgent ones, through gradual exposure to more complex or risky situations (Bates, Watson, & King, 2006).

The current research may constitute a key tool in the design of programs to evaluate and control risky behavior in driving. The findings highlight the importance of the task features in the study of driving behavior. They demonstrate that the relationship between risk perception and decision-making can be a function of the task features and must be explained by taking into account dual system models in decision-making. Future research is needed; however, these results provide a good basis to illustrate the importance of heuristics and affect appraisal in driving situations that demand urgent behaviors.

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CHAPTER VIII

Neural mechanisms underlying urgent and evaluative behaviors: an fMRI study on the interaction of automatic and controlled processes

Abstract

Dual-process theories has dominated the study of risk perception and risk-taking over the two last decades. However, there is a lack of objective brain-level evidence supporting the two systems of processing in every-day risk behavior. To address this issue, we propose the dissociation between urgent and evaluative behaviors as evidence of dual processing in risky driving behavior. Our findings showed a dissociation of urgent and evaluative behavior both at the behavioral and at the neural level. fMRI data showed an increase of activation in areas implicated in motor programming, emotional processing, visuomotor integration in urgent behavior compared to evaluative behavior. These results support a more automatic processing of risk in urgent tasks, relied mainly on heuristics and experiential appraisal. Moreover, we observed greater frontal activation in the Urgent task, suggesting the participation of cognitive control in safe behavior. Urgent's task features, characterized by strong time pressure and the possibility for negative consequences, creates a suitable context for the experiential-affective system to guide the decision-making process. The findings of this research are relevant for the study of the neural mechanisms underlying dual process models in risky decision-making, especially because of their proximity to everyday activities.

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1. Introduction

Dual-process theories explaining human decision-making have boomed over the two last decades. A number of models have emerged trying to explain decision-making based on two different processing routes or systems (Damasio, 1994; Epstein, 1994; Kahneman & Frederick, 2005; Lieberman, Gaunt, Gilbert, & Trope, 2002; Slovic, Finucane, Peters, & MacGregor, 2007, among others). Diverse terminologies have been used to characterize the two systems and the proposed models include different features (Evans, 2008). However, the authors generally agree that System 1comprises processes of experiential-affective nature: predominantly automatic, associative, rapid, and undemanding. System 2, on the other hand, is of rational-analytic nature: controlled, deliberative, rule-based, slow, and conscious (Evans, 2008; Kahneman, & Frederick, 2005; Sloman, 1996).

The continuum of automatic and controlled processing has also dominated the study of risk perception and risky decision making (Loewenstein, Weber, Hsee, & Welch, 2001; Slovic et al., 2007). An outstanding amount of literature based on dual processes has explained risk behaviors hardly explicable from a rational and deliberative point of view. However, there is a lack of objective brain-level evidence supporting the two systems of processing in risk behavior. The evidence that exists on this issue comes from artificial tasks especially focused on gambling (Keren & Schul, 2009). Little research has addressed the brain mechanisms involved in dual processing pathways in everyday tasks.

To address this issue, Megías et al., (2011, submitted) proposed the dissociation between urgent and evaluative behaviors as evidence of dual processing in every-day risk behavior. Urgent behaviors are performed under time pressure, triggered by a stimulus, and can lead to negative consequences if the action is unsuccessful. Evaluative behaviors simply consist of an evaluation of the situation, where a response is not imperative and does not involve actual negative consequences. The features characterizing tasks requiring urgent behavior create appropriate conditions for automated processes, determined by stimulus-response connections and enabling fast responses to hazards. On the other hand, tasks requiring evaluative behavior would activate a more controlled mode of processing, carrying out a deeper evaluation of the situation and basing its results on logic rules. For instance, if you are driving and suddenly a ball appears on the road between two stationary cars, what would your reaction be? This is a hazardous situation because a child might come chasing the ball. In this case, experienced drivers most likely do not conduct a slow rational evaluation. Rather, an automated urgent behavior will be triggered by the risk stimulus, in order to avoid hitting a child.

The aim of the current research was to investigate the brain-level mechanisms underlying urgent and evaluative behavior in the context of driving using functional magnetic resonance imaging (fMRI). The study of these behaviors can provide supporting evidence for the existence of two-way processing in risk behavior. Further, it can increase our understanding of the brain systems involved in driving decision making (Callan, Osu, Yamagishi Callan, & Inoue, 2009).

2. Methods

2.1. Participants

Fifty seven volunteers from the University of Granada (M_{age} = 22.24 years old, SD_{age} = 2.7; 39 women) participated in the study in exchange for course credits. All of them had a valid driver's license ($M_{\textit{number of months}}$ = 52 months, SD = 30) and normal or corrected-to-normal vision. The study was conducted in conformity with the declaration of Helsinki (World Medical Association, 2008) and was approved by the Ethical Committee on Human Research of the University of Granada. All participants provided written consent.

2.2. Stimulus material

Stimuli were 140 real traffic pictures taken from the driver's perspective. The pictures were selected from a large and detailed image database depicting risky driving situations. All images met certain statistical criteria aimed to reduce interpersonal variability in the interpretation of the traffic situation and the estimated speed at which a vehicle is traveling in static traffic scenes (Vlakveld, 2011). In particular, all images were evaluated by 40 driving instructors. The selected images were those with standard deviation of speed perception lower than 25% of the average speed perception, and where the best option to avoid the hazard was to brake for at least 70% of the driving instructors. In addition, images were evaluated in relation to the level of risk judged by a non-expert population (40 participants with driving license). The final set of pictures included 70 pictures representing road situations with low risk (average risk score = 1.92; where 0 = no risk, and 7 = high risk) and 70 pictures with medium-high risk (average = 4.34) (see appendix). The risk level of the images was also corroborated a posteriori by the participants of the current study (low risk average: 2.28; medium-high risk: 4.40).

The stimuli were displayed on a screen visible through an angled mirror mounted on the fMRI head-coil. The task was developed and controlled by E-Prime software (Schneider, Eschman, & Zuccolotto, 2002).

2.3. Procedure

Participants performed two tasks: an Evaluative and an Urgent task. Both tasks were identical except for the requested response from the participants. The Evaluative task required participants to evaluate whether the displayed traffic situation entailed risk or not. The Urgent task required participants to decide whether they would brake or not in the displayed traffic situation (see Megías et al. 2011, for more information). The order of tasks was counterbalanced between participants.

Each task comprised 140 trials (70 risky situations and 70 non-risky situations). Participants saw the trials in a random order. Every trial had the following sequence: after a fixation point (750 ms), the traffic situation was presented and the participant was asked to press the button of the MR response pad with his index finger if he thought that the situation entailed risk (vs. no risk in the Evaluative task) or decided to brake (vs. not brake in the Urgent task). After 2000 ms or response execution, a black screen was shown for 3500 ms (see Figure 1). The experiment had a duration of approximately of 30 minutes.

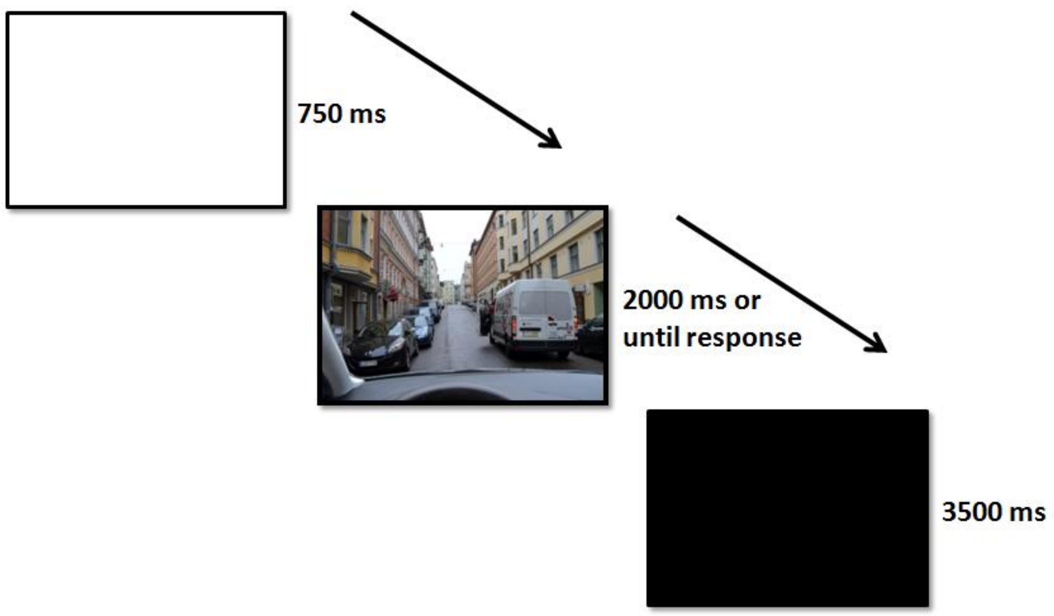

Figure 1. Scheme of experimental procedure.

2.4. fMRI data adquisition

Images were acquired on a Siemens 3T TRIO system at the Mind, Brain and Behavior Research Center, University of Granada, equipped with a 32-channel headcoil. High-resolution structural images were obtained using a T1-weighted MPRAGE sequence (TR = 1900 ms; TE = 2.52 ms; flip angle = 9°). For each volume 176 slices of 1 mm thickness were obtained providing whole brain coverage (voxel size = 1 x 1 x 1 mm^3; FOV = 256 mm; 256 x 256 data acquisition matrix). Functional images were recorded using a T2*-weighted echo-planar sequence with 35 non-contiguous axial slices of 3.5 mm thickness (gap = 4.20 mm) providing whole brain coverage (TR = 2000 ms, TE = 25 ms, flip angle = 80°; voxel size: 3.5 × 3.5 × 3.5 mm^3; FOV = 238 mm; 68x68 data acquisition matrix). Two functional runs were obtained for each participant, one per experimental block (450 volumes each).

2.5. fMRI data analysis

Preprocessing and statistical analysis of the fMRI data were carried out using SPM12 (Wellcome Trust Center for Neuroimaging, London, UK; http://www.fil.ion.ucl.ac.uk/spm/).

The first 5 EPI volumes of each run were discarded to allow magnetization to reach equilibrium. The last volumes of each run after task completion were also discarded. The remaining volumes were motion corrected to the average. The anatomical scans were co-registered to the mean EPI volume using linear rigid body transformation, and segmented to estimate the normalization parameters. The transformation parameters were applied to the set of functional volumes for spatial normalization to the MNI space. Next, functional volumes were re-sampled to a resolution of 3x3x3 mm and spatially smoothed with an isotropic Gaussian kernel of

8 mm full-width-at-half-maximum (FWHM). Before the statistical analysis, functional images were high-pass filtered (128 s).

For each participant we used a design matrix for comparing the two tasks (Urgent-Evaluative). A composition of two gamma functions was used to model the hemodynamic response function. We defined two whole-brain contrasts: Urgent > Evaluative and Urgent<Evaluative.

The resulting individual contrast maps were submitted to single sample t-test analysis to determine locations showing larger activation for the Urgent than for the Evaluative task, and vice versa. We used AlphaSim (1000 runs) to set up the statistical criterion: $p < 0.001$ with at least 132 contiguous voxels, considering the whole brain as the volume of interest. Sex, age, handedness, and counterbalance were included as nuisances.

3. Results

3.1. Behavioral results

The probability of positive response (brake or risk), reaction times, and performance indices (d' and c) were submitted to a repeated measures ANOVAs with Task (Urgent vs. Evaluative) as the single repeated factor. Kolmogorov-Smirnov and Levene’s tests were used to test for normality and homogeneity of variances for each dependent variable. The significance level was set at 0.05 for all statistical decisions.

Averages of the probability of positive response (brake or risk) showed a main effect of Task, F (1, 56) = 37.12, MSE = 0.0044, $p < .0001$. The probability of braking (0.50) was higher than the probability of evaluating risk (0.42). The ANOVA for reaction times also showed a main effect of Task, F (1, 56) = 36.76, MSE = 5230, $p <$

.0001. Reaction times were shorter in the Urgent task (969 ms) than in the Evaluative task (1047 ms) (Figure 2).

Signal Detection Theory response bias (c) and sensitivity indices (d') were used to evaluate response performance (Macmillan, & Creelman, 2005). Risk was considered the signal to be discriminated from noise (non risky situations). We observed significant effects of Task both for the discrimination index (d') and the response bias (c): F (1, 56) = 5.99, MSE = .5012, p = .0176, and F (1, 56) = 2.13, MSE = 0.1798, p = .0009, respectively. Risk discrimination was lower in the Urgent task (1.92) than in the Evaluation task (2.26); there was a response bias toward more cautious responses in the Urgent task (-0.15) than in Evaluative task (-0.35) (Figure 2).

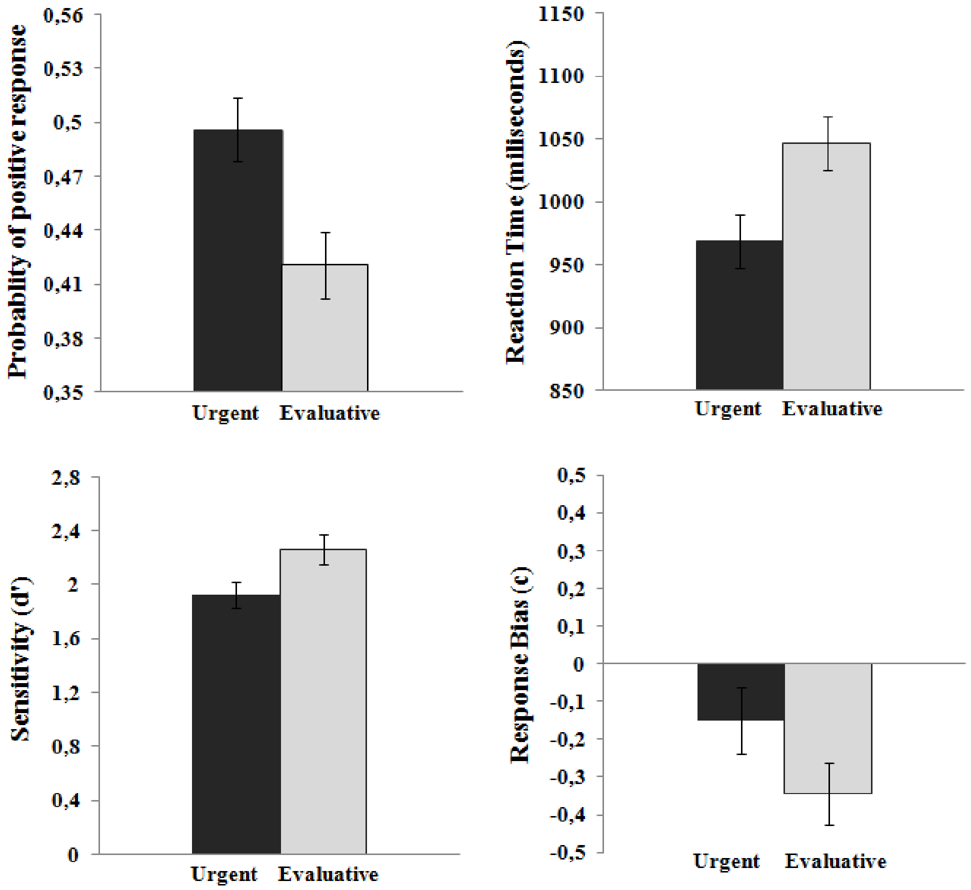

Figure 2. Top panels: average probability of positive responses (to brake or to evaluate risk) and reaction times for each task. Bottom panels: average sensitivity index (d') and response bias (c) for each task.

3.2. Imaging results

Brain areas in which there was a significant modulation of BOLD signal by Task (Urgent vs. Evaluative) are displayed in Table 1 (significance threshold: $p < 0.001$; extended threshold: $k > 132$ voxels).

Table 1. Regions belonging to significant clusters ($p < .0001$) with a cluster size of more than 132 contiguous voxels for Task variable (Urgent vs. Evaluative).

		MNI-coordinates			
Region	Hemisphere	*x*	*y*	*z*	T
Urgent > Evaluative					
Cluster 1 (*k* = 1263)					
Postcentral Gyrus (BA4)	R	42	-19	46	6.25
Superior Temporal Gyrus (BA 22)	R	45	-19	4	5.70
Precentral Gyrus	R	54	-4	16	5.52
Inferior Frontal Gyrus	R	57	5	25	5.42
Superior Temporal Gyrus	R	57	-7	4	5.31
Precentral Gyrus (BA 6)	R	57	-7	31	4.80
Sub-gyral (frontal lobe)	R	21	-13	52	4.52
Medial Frontal Gyrus (BA 6) Supp. motor area	R	12	-16	55	4.11
Superior Temporal Gyrus	R	39	-34	16	3.76
Cluster 2 (*k* = 1809)					
Precentral Gyrus	L	-51	-1	25	5.91
Postcentral Gyrus (BA 43)	L	-54	-7	16	5.79
Superior Temporal Gyrus	L	-54	-13	7	5.54
Sub-Gyral (frontal lobe)	L	-18	-19	46	5.06
Medial Frontal Gyrus Supp Motor Area L	L	-12	-19	52	4.99
Precentral Gyrus (BA4)	L	-15	-31	61	4.99
Medial Frontal Gyrus	L	-12	20	52	4.94
Cingulate Gyrus	L	-15	-34	25	4.76
Superior Frontal Gyrus (BA 9)	L	-12	50	28	4.44
Cluster 3 (*k* = 246)					
Superior Frontal Gyrus	R	12	29	52	4.32
Medial Frontal Gyrus	R	18	32	34	4.10
Sub-Gyral (frontal lobe)	R	27	14	37	3.96

Three significant activation clusters were observed for the contrast Urgent > Evaluative. The first cluster (k = 1263 voxels) peak was located in the right precentral gyrus ($t(48) = 6.25$, $p < 0.0001$, MNI coordinates x: 42, y: -19, z: 46). This cluster encompassed several right hemisphere areas: inferior and medial frontal gyrus, subgyral frontal lobe, postcentral gyrus, supplementary motor area, superior temporal gyrus, and insula. The second cluster (k: 1809 voxels) peak was located in the left postcentral gyrus ($t(48) = 5.91$, $p < 0.0001$, MNI coordinates x: -51, y: -1, z: 25), and encompassed several left hemisphere areas including portions of the inferior, medial, and superior frontal gyrus, subgyral frontal lobe, precentral gyrus, supplementary motor area, middle temporal gyrus, superior temporal gyrus, insula, cingulate gyrus, anterior cingulate. The third cluster (k: 246 voxels; peak voxel: ($t(48) = 4.32$, $p < 0.0001$; MNI coordinates x: 12, y: 29, z: 52) showed higher activation in the superior and medial frontal gyrus, sub-gyral frontal lobe, and anterior cingulate. Finally, when an uncorrected p-value was set up we observed a fourth cluster (k = 65, peak at: x: -9, y: -55, z: -11 , $t(48) = 4.33$, $p < 0.0001$) comprising parts of the culmen and cerebellar lingual in the left anterior lobe of the cerebellum (see Figure 3).

There were no significant clusters in the reverse contrast (Evaluative > Urgent) at the significance threshold. However, a smaller cluster was found in the occipital lobe ($t(48) = 4.33$, $p < 0.0001$; MNI coordinates x: -9, y: -55, z: -11) including portions of the fusiform and gyrus.

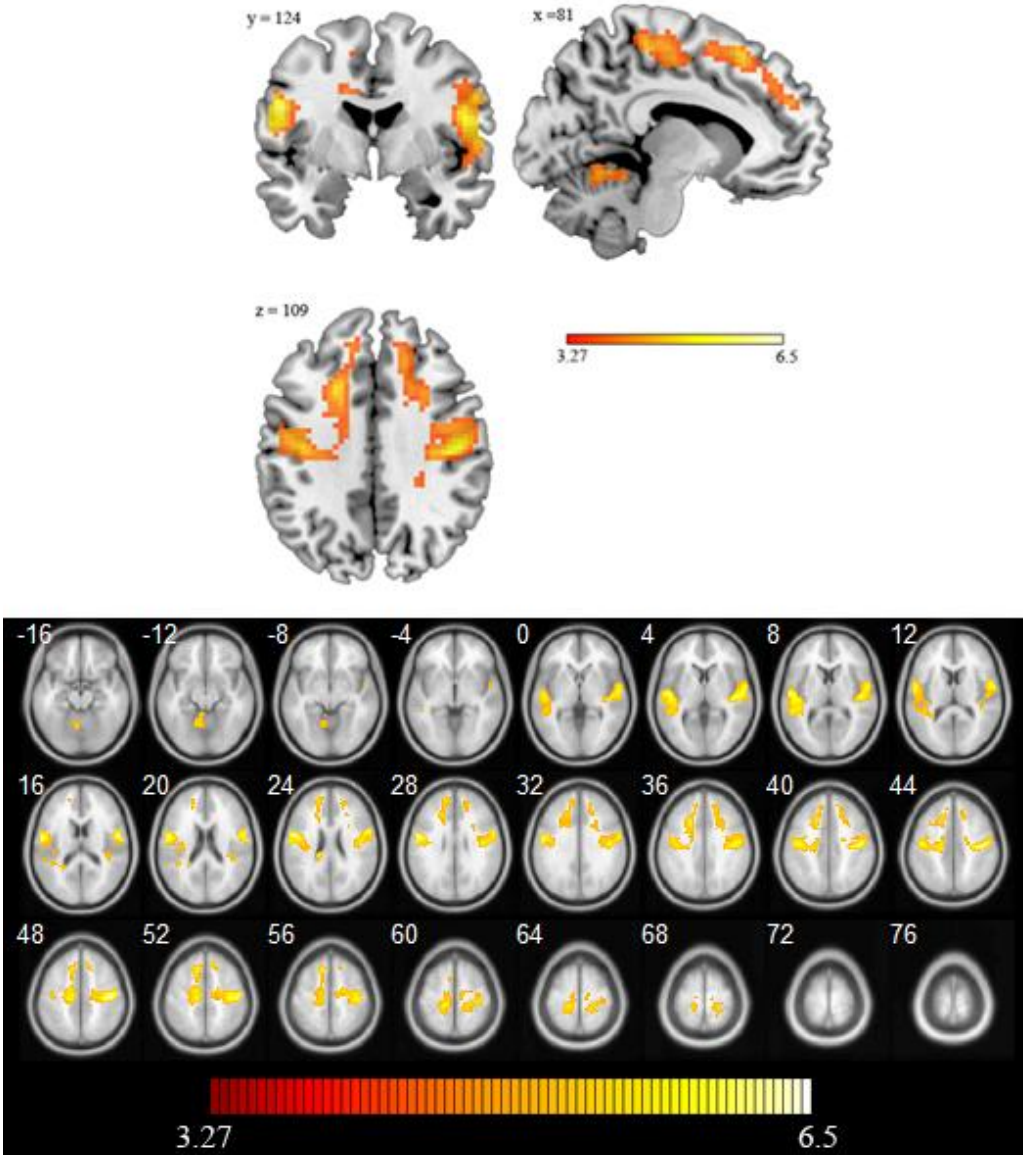

Figure 3. Top panel: Activation map (Urgent task > Evaluative task) in orthogonal projection. Bottom panel: Statistical parametric maps showing enhanced neural activity for the Urgent than for the Evaluative task. Numbers indicate the z coordinate. The color scale showed the range of t-test values.

4. Discussion

The main purpose of this study was to uncover the brain areas differentially involved in evaluative and urgent behavior in risky driving. First, we replicated the behavioral findings reported by Megías et al.'s (2011, in press). Compared to evaluative behavior, urgent behavior showed a higher probability of positive response (brake or risk), shorter reaction times, worse sensitivity to risk, and a more cautious response bias. This behavioral difference was related to differential activation of a set of brain areas commonly linked to behavioral control and motor planning and performance. Our fMRI data showed an increase of activation of multiple brain regions when participants engaged in an urgent behavior compared to an evaluative one (Urgent > Evaluative contrast). Enhanced neural activity was observed bilaterally in the precentral gyrus, supplementary motor area, postcentral gyrus, superior frontal gyrus, medial frontal gyrus, inferior frontal gyrus, sub-gyral frontal lobe, cingulate gyrus, anterior cingulate cortex, insula, and superior temporal gyrus. In the left hemisphere there was higher activation of the middle temporal gyrus, culmen and cerebellar lingual. The Evaluative > Urgent contrast showed differences in the occipital lobe (fusiform gyrus and lingual gyrus).

Below we discuss the neural mechanisms differentiating urgent and evaluative behavior in three sections focusing on motor programming and visuomotor integration, emotional components, and involvement of the frontal lobe.

Motor programming and visuomotor integration of the response to the risk.

Several neuroimaging studies investigated the neural processes involved in driving (e.g. Calhoun, 2007; Callan et al., 2009; Graydon et al., 2004; Lei, 2011; Uchiyama, Ebe, Kozato, Okada, & Sadato, 2003). Some of them have focused on comparing brain activity in driving compared to resting conditions or passive viewing of driving. The latter condition seems similar to our Evaluative task, except that no response is requested when viewing driving passively (Horikawa et al., 2005; Calhoun et al., 2002; Walter et al., 2001). These studies demonstrated that, compared to resting periods, driving is associated with an increase of activation in temporo-parietal, parieto-occipital, and cerebellum areas due to higher demands on visual and motor skills and visuomotor integration. Nevertheless, a comparison between active vs. passive driving revealed that cortical activation associated with visuomotor coordination was shared by both conditions. The differences between active and passive driving were located in the cerebellum, sensorimotor cortex, and precentral gyrus.

In addition, Spiers and Maguire (2007) examined brain activity associated with the driver's specific actions. There was an increased activity in supplementary motor area, parietal, and cerebellar regions while drivers were performing both prepared actions (e.g. starting the car) and unprepared actions (e.g. braking or swerving to avoid a hazard). These findings are consistent with the results of the studies discussed above, suggesting that the cerebellum as well as the premotor areas play an important role in the execution of driving actions in order to generate appropriate motor outputs.

The results of our research share with this set of experiments the activation of motor areas and anterior parietal areas. Precentral gyrus, supplementary motor area, and cerebellum exhibited more activity in the Urgent task than in Evaluative task. Considering that the only difference between the tasks was the type of response required by the participants: an urgent behavioral decision (to brake) vs. an evaluative judgment (to evaluate risk), this can suggest a more active "driving" in the context of the Urgent task compared to the Evaluative task. Thus, motor programming in order to avoid a hazard would be more activated in the Urgent task, although the participants responded by pressing the same button in both tasks. Moreover, the changes in neural activity in the postcentral gyrus and occipital lobe may reflect differences in the visuomotor integration and visual exploration of the environment. These last results are also in line with the differences in discriminability found in the behavioral data.

Emotional components associated with hazard.

The anterior cingulate and insula showed stronger activity for the urgent than for the evaluative task. These brain areas are commonly related to emotional processes (Damasio et al., 2000; Phan,Wager, Taylor, & Liberzon, 2001). Increased activation in both cortices is associated with visceral arousal by emotive stimuli (e.g. threats or hazards) (Critchley, 2005). Anterior cingulate and anterior insula are essential in the bottom-up detection of salient events (Menon & Uddin, 2010). One example is detecting deviant cues in a stream of continuous stimuli (Crottaz-Herbette, Menon, 2006). Therefore, when drivers suddenly confront road hazards (emotive stimuli) during their driving (continuous stream of stimuli), these brain areas will show more activity (see Vlakveld, 2011). Neuroimaging research studying hazard detection in driving is only limited; however, several studies indicated that the insula and the anterior cingulate may be associated with arousal in urgent events. For example, Spiers and Maguire (2007) showed that both brain areas were recruited in actions directed at avoiding collisions. In Callan et al.'s (2009) study, drivers had to anticipate a possible hazard when the view of oncoming traffic was occluded by a truck. Results showed a greater activation in a set of brain areas, including the insula and the anterior cingulate, when the driver had to anticipate the hazard compared to when the uncertainty of the risk had been resolved.

In our experiment, the same hazard stimuli were displayed in both tasks (Urgent and Evaluative). However, the Urgent rather than the Evaluative task exerted stronger time pressure on respondents and entailed the possibility of suffering negative consequences if the hazard was not avoided (Megías et al., 2011). Thus, it is logical to think that hazardous stimuli on the road involve a stronger emotional component in the context of urgency, which could explain the differences of activation in the insula and the anterior cingulate.

Involvement of frontal brain areas in driving.

Compared to evaluative behavior, urgent behavior also increased activity of frontal areas. Neuroscience research has established the involvement of regions of the frontal lobe in risky decision making. Ventromedial prefrontal cortex, dorsolateral prefrontal cortex, orbitofrontal cortex, and inferior and medial frontal gyrus are commonly associated with risky decision-making (e.g. Bjork, Smith, Danube, & Hommer, 2007; Ernst et al., 2002; Minati, Grisoli, Seth, & Critchley, 2012; Vorhold, 2007). Evidences about the functions of these frontal areas have been obtained from different contexts, but mainly using gambling tasks (Bechara, Damasio, Damasio, & Anderson, 1994). It is expected that distinct risky behaviors share neural networks; however, driving is a more complex activity involving multiple cognitive functions absent in gambling tasks (Groeger, 2000). Focusing on driving, Hirth, Davis, Fridriksson, Rorden, and Bonilha (2007) explored the brain areas recruited for hazard detection by displaying videos with hazardous stimuli versus uneventful driving videos. Their results showed that identification of hazards was linked to activation of the right prefrontal cortex. In another interesting study, Beeli, Koeneke, Gasser, and Jancke (2008) demonstrated that the external excitation of the dorsolateral prefrontal cortex (by a transcranial Direct Current Stimulation [tDCS]) led to a less risky driving style. In the anodal stimulation phase participants kept more distance from the car ahead, made fewer speed violations, and reduced their speed and the revolutions per minute of the car engine. A decrease of neural activation in the right lateral prefrontal cortex related to fast driving was also showed by Jäncke, Brunner, and Esslen (2008) using realistic virtual driving scenarios with EEG recording. Accordingly, the prefrontal cortex plays a significant role in the control of risk-taking and inhibitory behavior (Aron, Fletcher, Bullmore, Sahakian & Robbins, 2003; Fecteau et al., 2007).

At the behavioral level, the Urgent task resulted in fewer risky decisions than the Evaluative task in risk evaluations (i.e., participants more often braked than evaluated the situation as risky). Based on the experiments described above, this more cautious attitude in the urgent task could be linked to the increased activation in certain frontal regions. Additionally, higher activity in the medial prefrontal cortex could also be implicated in cognitive aspects of emotional processing of hazardous stimuli or threats (Pessoa, 2009; Phan, Wager, Taylor & Liberzon, 2002). In any case, understanding of the function of the frontal lobe in urgent driving behavior needs further specific research.

Urgent and evaluative neural mechanisms as a function of the task features.

Taken together, evaluative and urgent behaviors seem to depend on different neural mechanisms. Our findings show larger involvement of emotional and motor areas in the Urgent task. Moreover, we observed greater frontal activation in the Urgent task; this could be related to a more cautious response bias (suggesting the participation of cognitive control in safe behavior). Overall, these results could be partially explained by the task features of the Urgent task. Situations with strong temporal pressure, where strong emotional consequences are possible are characteristic of risky driving situations. In such urgent contexts, a more automated process relying on heuristics and experiential appraisal (bottom-up processing) would be more advantageous than a more demanding and slow analytical appraisal of risk (top-down) (Kinnear, Stradling, & Mcvey, 2008; Slovic et al., 2007). Thus, the limited response time to avoid negative consequences would force the participants to carry out more intuitive decisions in the Urgent task than in the Evaluative task. According to dual process models, intuitive decision-making is largely based on System 1 (experiential-affective), whereas reflective decision-making is closer to System 2 (rational-analytic) (Epstein, 1994; Kahneman & Frederick, 2005). From this theoretical perspective, the differences between urgent and evaluative behavior would be in line with the distinction between both systems of processing (Megías et al. 2011).

We suggest that risky decision-making in an urgent context is more automatic, guided by the emotions or feelings associated with the environmental stimuli (i.e., somatic markers). This process is reflected in the increase of activation of the insula and the anterior cingulate cortex (areas implicated in the neural network of somatic markers [Bechara, & Damasio, 2005]). This emotional component automatically triggers motor patterns in order to avoid a hazard. This interpretation is further supported by the neural motor programming and the lower reaction times found in the Urgent task. This view of driving from an emotional approach is in line with the most current motivational theories of driving. According to these theories, during driving the risk is processed from both an analytical (risk as analysis) and emotional (risk as feeling) point of view (Fuller, 2011; Kinnear et al., 2013; Summala, 2007; Vaa, 2007). In summary, risky decision making in urgent context is not only a result of deliberated reasoning mechanisms, but also relies on more automatic mechanisms (experiential-affective system or somatic markers), led by emotional warning signals (Vorhold, 2007).

5. Conclusion

This research aimed to investigate the brain-level mechanisms underlying urgent and evaluative behavior in driving. Our findings showed a dissociation of urgent and evaluative behavior both at the behavioral and at the neural level. Although further research is necessary to clarify more specific mechanisms, our results support a more automatic processing of risk in urgent tasks, guided mainly by an emotional component. Compared to the Evaluative task, the Urgent task is characterized by more time pressure and the possibility for negative consequences. These task features create a suitable context for the experiential-affective system to guide the decision-making process. The findings of this research are relevant for the study of dual process models, especially because of their greater proximity to every-day activities in comparison to previous neuroimaging studies about risky decision-making. Finally, they offer support for models of driving behavior that consider emotion as a fundamental mechanism in driving decision-making.

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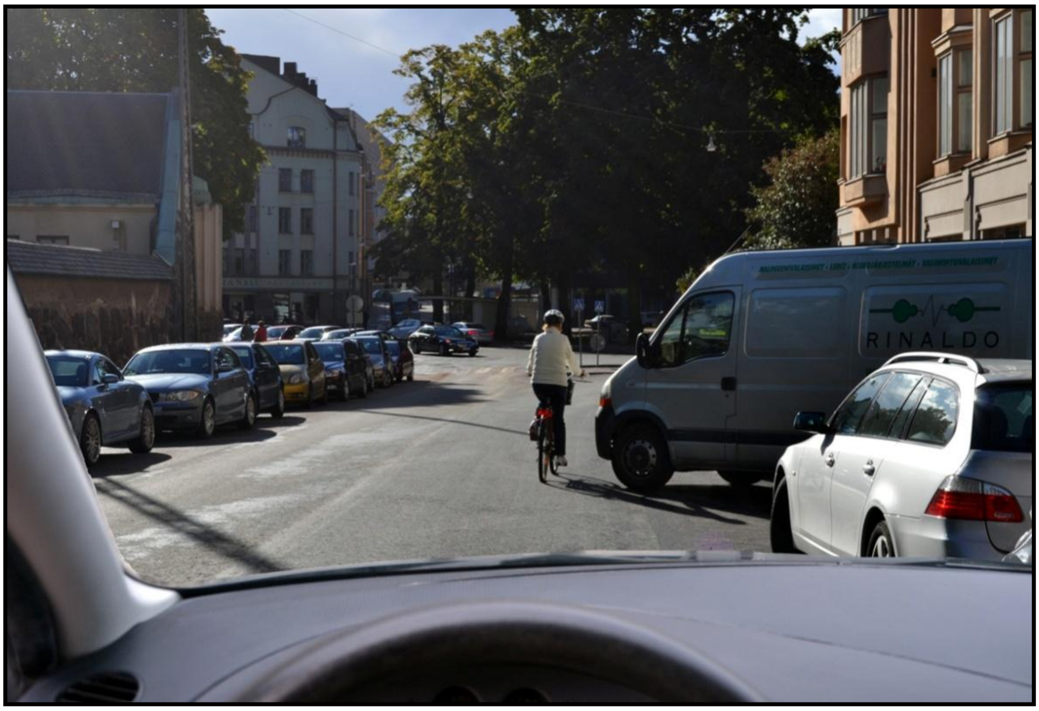
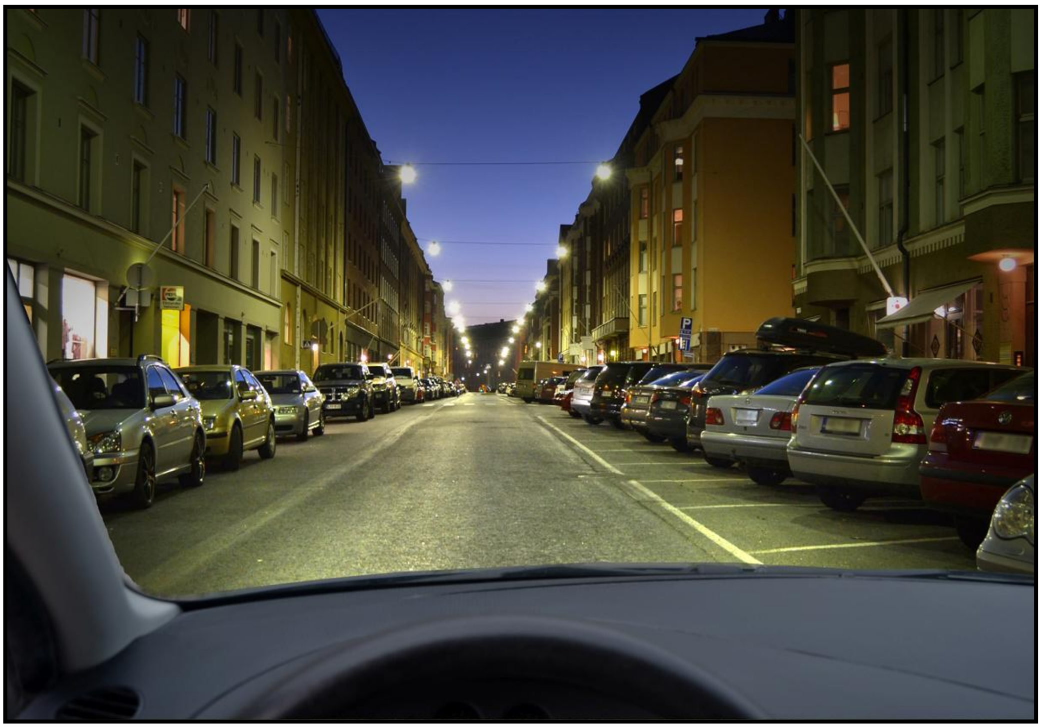
7. Appendix

Examples of risky situations



Examples of non-risky situations



CHAPTER IX

General Discussion

The conceptual framework of this thesis focused on the study of the interaction of emotional and cognitive processing in terms of their influence on driving decision-making in risky driving situations. The study of emotional factor was conducted from two different approaches: a) emotion as a driver's subjective reaction to stimuli with emotional content which may guide or modular driving behavior in risk situations; b) the influence of the task features (understood as a variable of the situational context) on emotional factor involves in risk-taking process in driving.

1. Summary and discussion of the empirical findings from the first experimental block.

The first block of the current thesis aimed to explore the influence of stimuli with emotional content on driving style, with particular attention to drivers' risk behavior and risk perception. Throughout the four experimental studies conducted, we analyzed the influence of emotions as a function of the time of presentation and format of the stimuli. Two experiments were devoted to studying the impact that visual emotional information displayed incidentally while driving may have upon driver's behavior. A third experiment focused on the influence of negative emotional stimuli which were applied as feedback after the driver had driven in a reckless or risky manner. The final study employed emotional content as an implicit factor to the driving task itself, in order to study changes in drivers' estimation of accident probability. The scenarios and variables presented in these experiments were selectively chosen in order to test what advantages and disadvantages they may produce in a real-life driving conditions, and in light of their potential applicability to road safety regulations and training.

The two first mentioned studies focused on the effect of roadside advertisement with emotional content on driving, examining its impact on drivers' willingness to take risks, and how they may modulate the driver's attentional focus. These studies worked on two common risky situations where drivers are required to make an urgent decision: the first refers to braking due to the unexpected appearance of a pedestrian or a vehicle crossing at an intersection, and the second refers to deciding whether to brake at or to run a yellow traffic light which is on the verge of turning red.

The results showed that differences are produced by billboards depending on what emotional content they display. When examining the driver's attention, it became evident that the emotional images, especially the negative ones, captured the attention of the driver more than neutral ones. Negative images produced a greater number of fixations and a greater total fixation time. Moreover, available attentional resources for driving were a function of the temporal position of the billboard. As the driver approached the negative billboard, he spent greater lengths of time observing the displayed image (attentional capture was constantly increasing). However, in the case of the positive billboard, results showed that there was an initial increase of attention on the billboard, after which the attentional capture remained constant.

Behavioral analysis of the response to hazardous situations showed shorter reaction times when billboards had negative valence rather than when they had positive or neutral valence. Significant differences were not found regarding the type of response performed in this first study (braking to avoid a vehicle or pedestrian), due to a clear ceiling effect in the percentage of braking when the situation was risky (99%). In the absence of performance differences, the second experiment comprised a new risky situation involving uncertainty about the possibility of a negative outcome. In this case, participants could make the decision whether to speed-up or brake when approaching a yellow light on the brink of turning red. The results reflected that drivers who had previously viewed negative billboards, braked more often when approaching a yellow light than those who had seen a neutral and positive billboard.

These findings show how roadside advertising appealing to emotion provoke a strong attentional capture, acting as distractors and reducing the attention place on the relevant regions of the road required for a suitable driving (Crundall, Van Loon & Underwood, 2006). However, once the billboards have been passed and the driver's attention returns to the relevant road region, the negative valence may lead to more cautious driving behavior and shorter response times. Stimuli congruent with the affective states are easier to pay attention to, recognise, process, and retrieve from memory than incongruent ones (see Associative network theory, Bower (1981), and Affect infusion model, Forgas (1995), for a better comprehension). Hence, it can be said that drivers who have seen negative stimuli could perceive more negative consequences in risky choices and modify their response bias, thus reducing their proneness to take risks and to shorten their response time when faced with a potentially hazardous situation.

The purpose of advertising billboards is to attract the attention of the largest possible number of people to the billboard's contents. Thus, advertising agencies have an interest in positioning emotional billboards in places where there is a high flow of traffic (e.g. arterial roads), or easily visible places, for instance bends where the billboards lie in line with the driver' sight before they have reached the bend. This type of scenario demands more resources from the drivers and often involves making decisions which entail certain risks (e.g. overtaking another vehicle). It is essential that the driver´s attentional resources are used properly, so that a slow response or an incorrect decision does not result in an accident. However, many countries have no regulations regarding the use of roadside advertisement. In some of countries there are specific rules in place, yet billboards still remain on urban roads (for example in Spain, BOE, 1994). Our findings suggest that roadside advertisements, especially those with a high emotional valence, must be avoided in locations where drivers are exposed to potential risk situations or where there is high demand of resources, such as at bends, intersections, or on roads with large volume of traffic.

On the other hand, nowadays roadside billboards and variable message signs are also used by road safety agencies in order to reduce the number of fatalities and the severity of injuries (Tay, 2002). Messages of this sort are intended to get the driver to be aware of potential hazards on the road. Short and clear messages reprimanding drinking and driving, warning not to exceed speed limit, cautioning to avoid distractions or reiterating the mandatory use of seat belts are common place on our roads. Often, they employ negative emotional contents as the number of traffic casualties. We know that providing emotional messages to drivers may decrease the likelihood of hazardous behaviors. However, an unsuitable message (positioned in an inappropriate location or modality) could lead to an excessive mental workload or be a distraction for the driver. Thus, road safety billboards must be located in places where there is no risk of being involved in potential dangerous situation. For instance, emotional messages in order to road safety could be displayed at tollgates and petrol stations where the vehicle is stationary or, alternatively, through messages on an in-vehicle display (e.g. ADAS) where they can be displayed prior to starting the car.

In this same line of thought, a suitable strategy could consist of using negative emotional feedback after risk behaviors have been carried out and the driver is no longer driving the vehicle. In this way, attentional resources remain available and driving is not impaired. This manipulation would have a similar basis to the point driving license system implemented in many countries, and to some of the interventions commonly used in the rehabilitation programs for traffic offenders, where offenders are shown videos of risky maneuvers or traffic accidents in order to encourage them to be more cautious on the road. In this way, the third study of the thesis focused on exploring the effect of using negative emotional content through this latter method. In our case, drivers received negative emotional feedback by way of exposure to images of traffic accidents after they had demonstrated risky behaviors.

The driver's performance, evaluated by a driving simulator, showed a reduced numbers of accidents and a set of behavioral changes in the driving style after negative emotional feedback was applied. Drivers demonstrated a lower average speed, greater respect for speed limits, and a more steady and homogenous driving style which was characterized by a lower variance of steering wheel angle and throttle, and a lower average braking force. This driving style, closer to the road traffic regulations and recommendations proposed by the national traffic agencies, led to a decrease in the number of accidents.

One of the reasons for drivers repeatedly demonstrate unsafe driving behaviors is the lack of negative consequences for committing unsafe driving (Fuller, 1991). For instance, drivers may make the decision of running a yellow traffic light if they perceive positive consequences (e.g. getting to work or a meeting on time) more frequently than negative consequences (e.g. being involved in or nearly having a collision). Thereby, unsafe driving behavior which is followed by an immediate negative emotional consequences (feedback) will generate associations between these behaviors and their consequences (Cándido, 2000; Feng, & Donmez, 2013). The use of negative emotional feedback both in driving schools and road safety programs may enhance driving performance, promoting safer driving behavior and making drivers aware of unsafe practices. The combined use of simulators and feedback would be a very efficient tool for modifying risky behavior and reducing the obvious problems and risks of training on-roads. Yet, despite the reported benefits, it should also be noted that negative feedback must always be applied with caution and under the appropriate circumstances (Lewis, Watson, Tay, & White, 2007). For example, use of excessive emotional valence may evoke fear, thus disturbing or even impeding the driver (Taylor, Deanem, & Podd, 2002). With this in mind, we should also acknowledge some limitations of our research; future studies should examine longer-term effects of negative valence feedback and the use of other emotions or positive valence feedback. For instance, reductions in the prize of the insurance can be used as feedback of daily driving by recording data system integrated in the vehicle (Feng & Donmez, 2013).

Finally, our fourth study focused on a third way of emotional modulation: it examined the manipulation of emotional content implicit to the context of driving. In this case, the emotion was not present previously (as roadside advertisement) or subsequently (as feedback) after risk behavior, but it was inherent in the driving context itself. The study explored the influence of having an emotional relationship with our passengers on the driver’s estimation of their likeliness to partake in an accident. The results showed that women perceived a higher probability of being in an accident when the passenger was their son than when he was a workmate. However, men's estimation was not affected by this manipulation. These findings lead us to conclude that the presence of an emotional bond between driver and passenger can influence even objective estimations like that of the probability of an accident. This further depended on individual differences such as the sex of the driver.

The results of this last study highlighted the importance of taking into account socio-demographic factors in the development of road safety campaigns. Failure to target the correct audience could explain the low impact of some safety campaigns on road accident rates (OECD, 1994). As we have discussed in previous studies, one of the most common strategies promoting road safety is to link unsafe driving behavior with negative emotional content. However, appealing to negative emotions (e.g. fear) could evoke different responses depending on which audience it addressed. Thus, it is necessary to consider separate strategies for raising awareness in different groups of drivers (Tay, 2002).

2. Summary and discussion of the empirical findings from the second experimental block.

The second part of the thesis dealt with why drivers, in certain contexts, make decisions which do not conform to a rational evaluation of the situation. Decision-making in risky driving situations requires an urgent response of the driver in order to avoid danger (under time pressure). In the case of inappropriate response substantial personal and material damages are possible; these may entail a strong emotional component. Following these characteristics, we determined two different study foci: on the one hand, an urgent behavior consisting of making a decision in a dangerous road situation (in our case, to brake), and, on the other hand, an evaluative behavior compromising an evaluation of the risk that the hazard involves.

The results of our studies showed that urgent behaviors (compared to evaluative ones) had higher probability of performing positive responses (brake/risk), had a lower discriminability of the risk, and showed a response bias toward more cautious behaviors. Moreover, the behavioral decision (braking) was considerably faster than the evaluative judgment (evaluating risk). These differences reflect a lack of contingency between the risk perceived and the decision finally made. In principle, drawing on models of decision-making (Rangel, Camerer & Montague, 2008; see Chapter 1: Introduction, for better comprehension) and consequentialist approaches (Payne, Bettman, & Johnson, 1993), it may be said that any decision should be contingent on a prior evaluation. That is, decision-making processes are the consequence of previous judgments. However, although traffic situations were exactly the same and in theory responses in the urgent task should depend on responses in the evaluative task, we found important differences between the two. In particular, there were differences in the probability of response, the reaction times, the sensitivity to the risk, and the response bias. Reaction times differences are of particular interest if we consider that, following the models mentioned above, the evaluation should have taken a shorter processing time (since drivers must first evaluate the risk before making the brake decision); or, at least, there must be a similar temporal processing if we consider that the risk evaluation in our experiments is a process of risk detection and a subsequent decision-making between two alternatives (risk or no risk). The inconsistency of our findings with respect to the decision-making models may reflect the fact that both tasks could lead to different processing of risk situations.

Starting from this point, our next aim was to attempt to answer two remarkable issues: whether the features characteristic of both tasks may explain the differences in these studies by taking into account the dynamic interaction of cognitive and emotional systems proposed by the dual-process theories (Damasio, 1994; Kahneman, 2011; Reyna, 2004; Slovic, Finucane, Peters, & MacGregor, 2007); and, if this was the case, whether this differential processing is reflected at the level of the brain.

By adding negative consequences with high emotional value and time pressure (the main contextual features which characterize urgent decision-making) to evaluative behaviors, we observed that these features explained, in part, the higher probability of positive responses and the lower discriminability in urgent behaviors. In addition, differences in response bias seemed to depend on the emotional consequences, and the shorter latencies of response on time pressure. We found that, given the limited time in which it was possible to brake in order to avoid an imminent danger, drivers would demonstrate faster responses, thus not having sufficient time to collect all the information necessary to make a rational analysis of the situation (an analysis which could be accomplished in evaluative behavior). This absence of an in-depth exploration of the situation would lead to a deteriorated discriminability of the risk. In this way, a good adaptive strategy for the driver would be to change the response bias in favour of greater caution.

This type of processing would be especially functional in cases where fast answers are required, the context provides limited information, or decisions are complex and the driver has few mental resources available. In essence, these are some of the traits that characterize decision-making in risky driving situations. In such urgent contexts, a rational analysis (e.g. a benefit-cost analysis assessing the different possible alternatives) may be excessively demanding and require too long a processing time (Gilovich, Griffin, & Kahneman, 2002). This allows us to justify that drivers when facing dangers on the road, are oftentimes guided more by automated processes as they rely on heuristics, rather than on more demanding analytic inference processes (Kinnear, Stradling, & Mcvey, 2008).

Based on these results and drawing upon dual process theories developed in the decision-making research (Kahneman & Frederick, 2005; Slovic et al, 2007), we propose that in urgent behaviors there may be a greater influence of the system which relies on experiential-affective processing, while evaluative behaviors are guided mainly by the rational-analytical system. In this regard, it seems reasonable to assume that urgent behavior's task features can induce an urgent mindset, which would imply an imbalance between the two systems, as one of them -the fast and automatic (bottom-up)- is prioritized over the more rational one (top-down). Thus, drivers in need of making an urgent decision are guided by automated processes learned through experience. If risk behavior is explainable according to cognitive (computation of probabilities) and affective (emotions, feelings) factors present in the interaction between the experiential-affective and rational-analytic systems, and if we assume that the predominance of one system over the other is a function of the task features, then it can be presumed that all of this should also be observed at the level of the brain.

In this way, the last experiment presented in this thesis reflected different brain-level mechanisms underlying urgent and evaluative behaviors. Urgent behaviors showed increased activity in comparison to evaluative ones in emotional areas (anterior cingulate cortex and insula), motor areas (precentral gyrus, supplementary motor area, and cerebellum), and parts of the superior, middle and inferior frontal gyrus.

Anterior cingulate and insula are regions involved in the detection of salient emotional stimuli. When drivers detect a hazard on the road, emotional components are activated in their brain. In an urgent context, there is more time pressure and greater probability to experience negative consequences. These factors imply a greater role of emotions in the urgent task than in the evaluative one, where participants act as mere observers of risk situation. This conception of the urgent task as requiring more active contribution from the participants in comparison with the evaluative task, could also explain why there was an increased level of brain activity in areas involving in motor programming. The greater frontal activation could be linked to the more cautious response bias observed in the behavioral data. This suggests that cognitive control is active in decision-making processes in order to ensure safe behavior. The prefrontal cortex has an important role in the control of risk-taking, as numerous studies on decision-making in risk situations have reported (Aron, Fletcher, Bullmore, Sahakian &

Robbins, 2003; Bechara, Damasio, Damasio, & Lee, 1999; Beeli, Koeneke, Gasser and Jancke, 2008).

To summarize, urgent and evaluative behaviors involve differences on behavioral and neural levels. Results support the view that there is more automatic processing of decision-making when drivers are faced with risks during urgent tasks, being guided mainly by an emotional component. These findings may be relevant in the study of decision-making from the point of view of dual process models. They provide valuable new information about the neural basis of driving behavior in risky situations and may help us explain the influence of emotion on cognitive processes in settings closer to daily living activities. Further research is needed in order to generalize our observations. Personal and motivational factors during driving must be take into account in future studies. Moreover, our findings must be studied in more realistic and complex road environments, for example, through high fidelity driving simulators or on-road experiments with instrumented vehicles.

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CHAPTER X

Conclusion

The main objective of the current thesis was to study the interaction between cognitive and emotional processes, and to explore its effect on drivers' behavior in risky situations. While driving, our perception of risk, as well as the subsequent decision-making processes, are essential for carrying out appropriate and safe driving. In a risk situation, a wrong decision may lead to serious, at times fatal, consequences. This research has provided important results about the role which emotional factor have on decision-making and cognitive processes in drivers' behavior.

The first block of our research explored the influence that stimuli with an emotional content have on driving as a function of the format and the time at which they were presented. Our findings showed that negative emotional content leads to higher risk perception and a higher estimation of accident probability. In turn, this provoked a response bias towards more cautious behavior. However, we observed different results depending on the situation, time and format of the presentation. Emotional stimuli viewed incidentally while driving, for instance on roadside billboards, captured the drivers' attention and reduced the attentional resources placed on the relevant road regions to drive. Such distractions impair driving, and may be cause of accidents if they are presented at the same time that drivers are confronted by risk situations or it is need to make decisions requiring high cognitive workload or complex motor skills. It is, for this reason, that we recommend removing roadside advertisements which appeal to emotions, and the use of negative emotional billboards or variable message signs for road safety only in places where resources demanded by the driving situation are low. In addition, we found that the influence of affect-laden stimuli depended on the individual characteristics of drivers (e.g. sex, age). Thus, emotional content should be tailored to the target population group which, in the case of roadside billboards, may be unfeasible. In light of these problems, it seems more appropriate to introduce emotional content in the interest of road safety by other strategies. For instance, it may be done through the use of negative emotional feedback on undesired driving behavior. Our results showed that the correct implementation of negative emotional feedback may lead to a more 'desirable' driving style which was closer to the traffic agencies' recommendations, thus reducing the number of risk behaviors carried out by drivers. Thereby, emotional content may be adapted to individual needs, it may be applied in a such a way that it does not produce distractions and, furthermore, its use in conjunction with driving simulators may be an ideal method in order to avoid the risks inherent in training in real environments.

The second part of the thesis focused on exploring why drivers in certain situations engaged in risky behaviors which did not conform to a rational analysis, showing a significant gap between perceived risk and decisions taken by the driver. Our results demonstrated that emotional factors play a fundamental role in directing drivers to choose among alternatives responses in risk situations. Urgent behaviors (risk-taking) and evaluative behaviors (risk perception) led to distinct responses in similar situation, and this behavioral dissociation was accompanied by differences in the underlying brain mechanisms. These findings seem to support the view that there is a more automatic processing of risks when responding to urgent tasks. When faced with making an urgent decision, drivers mostly rely on an experiential processing system, as it is guided by emotional components. In contrast, evaluative behaviors are primarily controlled by a more rational system, guided by normative rules. The nature of the relationship between risk perception and decision-making suggests that it is important to take into account the context's task features and their involvement in more automatic or controlled processes. Urgent task features, such as the presence of time pressure and the prospect of negative consequences, create a suitable context for the use of heuristics and affect appraisal, rather than a rational evaluation which is guided by normative rules.

To summarize, taken together, the results of our studies demonstrate that emotion plays a crucial role in influencing decision-making and risk perception in driving. Emotions are a fundamental part of attentional processes, directing attention to different purposes. Furthermore, they are a primary motivational system for our actions, and they influence learning processes as they are basis of automatic behavior which is guided by stimulus-response associations. Further research should attempt to investigate how emotion interacts with cognitive processes more concretely, and how the level of control which emotions wield over driving decisions is determined. The study of emotion-cognition interaction is a highly important issue for the future of the road safety research. The inclusion of the emotional factors in transport policies, in the design of Advanced Driver Assistance Systems, or in the evaluation, prevention and creation of behavior control programs may help to improve road safety and prevent further grave consequences associated with risky driving situations.