TESIS DOCTORAL

MECANISMOS DE CONTROL COGNITIVO Y EMOCIONAL: PROCESOS CONSCIENTES Y NO CONSCIENTES

Doctoranda: **Mª Asunción Panadero Sanchis**

Director: **Pío Tudela Garmendia**

Programa Oficial de Posgrado en Diseños y Aplicaciones en Psicología y Salud (P33.56.1)

Universidad de Granada

NOVIEMBRE 2015

Editor: Universidad de Granada. Tesis Doctorales
Autora: María Asunción Panadero Sanchís
ISBN: 978-84-9125-555-0
URI: http://hdl.handle.net/10481/42777

El doctorando Mª Asunción Panadero Sanchis y el director de la tesis Pío Tudela Garmendia, 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.

Firmado en Granada a día 5 de Noviembre de 2015

Pío Tudela Garmendia   Mª Asunción Panadero Sanchis

:

AGRADECIMIENTOS

…Cuento en mi vida con personas de un valor incalculable….

Como no agradecer a todas aquellas personas que me han acompañado a lo largo de todo este largo y duro proceso. No puedo olvidar a aquellos y aquellas que me han brindado su apoyo, que me han arrastrado a la calle, a los que yo he arrastrado a la calle, a los que me han hecho reír, cuando lo que me apetecía era llorar o gritar. En fin a todos los que, cuando lean esto, ya sabrán quienes son.

Tampoco puedo olvidar a todos aquellos compañeros y compañeras que me han regalado su tiempo y sus conocimientos y que me han ayudado en lo que he necesitado para que esta tesis sea lo que es hoy.

Sin embargo, aunque han sido muchos y muchas, y no me gustaría olvidar a nadie, debo destacar a algunas de esas personas, que son tan parte de esta tesis como yo misma, o incluso más, porque sin ellas esto no habría sido posible.

Pio, bueno, la verdad es que tengo tanto que agradecerte que no se ni por dónde empezar. Hace ya unos años que nos embarcamos juntos en esto y nunca has dejado de creer en mi ni de darme tu apoyo. Gracias por tu infinita paciencia, por tu ayuda, por tu escucha, en momentos difíciles. Para mí ha significado mucho. Gracias por tus infinitos conocimientos, que han dado esta tesis la forma que tiene. Sin ti no habría sido posible. Gracias por tu tiempo y por tu trabajo, de un valor incalculable y por dedicarle a esto tanto o más que yo. Para mí siempre serás más que mi director de tesis, ¡Muchas gracias!

Gracias a mi familia que son las personas que han hecho que hoy por hoy sea como soy y que no me rinda bajo ninguna circunstancia y que termine siempre lo que he empezado. Gracias mamá por soportar mis malos humores y mis locuras transitorias.

Has sabido entender que eran producto de lo externo y las has capeado como solo tú sabes hacerlo. ¡Te quiero!

Como no poner en un lugar privilegiado a quien, aunque no de sangre, ha sido mi hermana durante todos estos años. Como digo, mi hermana, mi amiga, mi compañera de piso durante más de 6 años. Ella ha vivido de cerca esta etapa de mi vida. Cuantos días de aguantarme despotricar, de oír que no lo iba a conseguir, de verme llegar tarde del laboratorio de pasar participantes, y de verme desesperar cuando tenía que tirar muchos de ellos por lo malditos parpadeos. Cuantos momentos de risas (sobre todo los desayunos), momentos que hacían que todo fuera más llevadero y que no me dejara arrastrar por la desesperación en determinadas situaciones. Sabes que te quiero ¡Gracias!

Conchi querida, ¿qué te digo que no te haya dicho ya? Esta tesis es tan tuya como mía, lo sabes. No hay palabras ni combinaciones de letras que expresen bien lo que te agradezco todo lo que has hecho por mí durante todo este tiempo. Créeme cuando te digo que sin ti esto no habría salido nunca a flote. Además de por todo esto, gracias por los cafés en Psicología primero y luego en Farmacia, oliendo a tostada quemadilla, con ese sueño profundo que solo da el laboratorio, con esa luz tenue. Gracias por hacerme remontar cada vez que flaqueaba (han sido tantas…). ¡Gracias por todo!

Kitty, en fin, yo sé que no necesito escribirte nada porque me lees la mente, pero aun así déjame decirte que esos momentos por todos los rincones de Granada destrozándonos el hígado no han tenido precio. Y tampoco nuestras charlas hasta las mil de la mañana sobre toda clase de temas y en muchas ocasiones sobre esas tontería que tú y yo compartimos y que nadie más entiende. ¡Te quiero!

Marifé, amore tú sabes lo que yo te quiero y lo que te agradezco todos los momentos que hemos pasado. No sabes hasta qué punto me han salvado en momentos difíciles.

Quique, cómo no agradecerte los momentos frikis que me han hecho desconectar siempre que lo he necesitado, por nuestros cafés en ese sitio que nunca me acuerdo de cómo se llama y al que nunca se llegar por mí misma. Gracias por las noches de cervezas y tapas y algún que otro gin tonic. ¡Gracias por soportarme cuando ni yo misma me soportaba!

Toñi, gracias por estar ahí cuando te he necesitado. Por sacarme y por rescatarme y por darme alguna que otra colleja mental cuando me ponían inaguantable y, por no rendirte y esperar hasta que estuve preparada para decir basta.

Eduardo, gracias también por todas nuestras charlas y discusiones sobre la verdad de la ciencia en psicología. Algún día llegaremos a alguna conclusión lógica. Gracias por "reírte" de mis neuras y quitarles importancia y por darme siempre buenos consejos.

Gracias a todos aquellos compañeros y compañeras que han dedicado tiempo a escuchar mis problemas y mis dudas en los momentos que más los he necesitado. El que alguien te dedique tiempo siempre es algo que valoro por encima de muchas cosas.

Gracias a mi familia del teatro. Vosotros hacéis que mi mente se evada de todo hasta el punto del reseteo. Por supuesto, como no, gracias a mis niñas y a nuestros viernes que ya se han convertido en tradición.

Gracias a mi gente de los caballos, por hace que disfrute además de mi afición, de buenos momentos entre muy buena gente. Os quiero

¡Gracias a todos!

INDICES

FIGURAS

Capítulo 1

INTRODUCCIÓN

1.- CONTEXTUALIZACION HISTORICA

1.1. *Antecedentes previos*

A partir del siglo XIX es cuando empezamos a encontrarnos grandes conceptualizaciones de la atención como: mecanismo selectivo, asignación de capacidad y lo que va a llevar a toda una línea de estudio dentro de la cual se va a encuadrar nuestra investigación, que es la distinción entre un tipo de atención más voluntaria y controlada, a la cual se le atribuye la necesidad de consciencia y otro tipo de atención, en la que el individuo tiene menos control, denominada automática y que por ende se ha asumido que no necesita de la consciencia, aunque tampoco ésta la perjudica. La idea recurrente es la necesidad de distinguir aquellos estímulos sobre los que no se atiende y aquellos sobre los que sí, y que por tanto son conscientes. Así Wilhelm Wundt distingue entre percepción y apercepción, siendo esta última la que está constituida por aquellos estímulos que se encuentran en el foco de la consciencia, debido a un proceso de focalización atencional, de manera que la atención se empieza a concebir como una actividad interna que determina los grados de consciencia de la información percibida.

El control cognitivo puede definirse como una función que nos permite alcanzar con éxito nuestras metas, mediante la adaptación flexible de nuestro comportamiento al medio, potenciando acciones que se dirigen hacia nuestras metas y/o conteniéndolas para evitar resultados no deseados. Para que esto se lleve a cabo es necesaria la coordinación de múltiples sistemas. Así la memoria es necesaria para mantener nuestra meta, la atención para seleccionar la información relevante de entre toda la información irrelevante del medio y la percepción, para procesar dicha información. El control cognitivo atencional es crucial para nuestro comportamiento, ya que sin él, ninguna de nuestras actividades de la vida diaria podrían llevarse a cabo.

Para poder llegar a comprender bien el punto en el que esta tesis está enmarcada hay que hacer un repaso a cerca de cómo se ha llegado a la definición de control tal y como hoy en día se conoce. Dado que el tema principal de este trabajo es el interés en mostrar la existencia de procesos de control no conscientes debemos detenernos y echar un ojo a las distinciones que, a lo largo de la historia de la Psicología cognitiva, se han hecho entre procesamiento controlado-consciente y procesamiento automático-no consciente.

Si observamos cualquier actividad de las que realizamos todos los días (lavarnos los dientes, vestirnos, ir hacia el trabajo, levantarnos de la cama, etc) y "prestamos atención" a cada una de ellas, nos daremos cuenta de que la mayoría son para nosotros actividades que podríamos considerar automáticas. Por efecto de la práctica hemos llegado a dominar tanto cada uno de los pasos que realizamos para llegar a la consecución de cada una de estas tareas, que simplemente ya no somos conscientes de ellos a menos que les pongamos atención de manera voluntaria. Sin embargo, cuando tenemos que enfrentarnos por ejemplo a una situación novedosa para nosotros, enseguida nos damos cuenta de la necesidad de poner el máximo de nuestros recursos atencionales sobre dicha tarea para poder llevarla a cabo lo mejor posible. Es por esta razón por la que se ha asociado consistentemente el control voluntario con la consciencia.

En la psicología moderna, la primera aportación acerca de la distinción entre estos dos tipos de procesamiento fue realizada por Posner y Snyder en 1975. Hasta este momento la línea que diferenciaba ambos procesos era bastante difusa, de manera que lo que estos autores pretendieron fue dilucidar con más claridad las diferencias entre ambos tipos de procesamiento. Para ellos un proceso automático era aquel que ocurría sin atención, sin consciencia y sin provocar ninguna interferencia sobre cualquier otra tarea que se estuviera realizando de manera simultánea. En estos casos el procesamiento que se realizaría sobre la información sería en paralelo, a diferencia de aquellas situaciones en las que se requieren procesos controlados y conscientes y que estarían guiadas por un procesamiento serial, de manera que para que no se produjera una interferencias las tareas tendrían que llevarse a cabo una detrás de otra.

Se ha considerado que la práctica sistemática de una tarea lleva al aprendizaje de ésta, y es mediante ese aprendizaje que se consigue la automatización de las mismas, por lo que pueden ser realizadas a la vez que podemos dirigir nuestra atención a otra cosa (Shiffrin & Schneider, 1977; Schneider & Shiffrin, 1977). Sin embargo, existe una contrapartida: una vez que una acción se ha automatizado hasta este punto, se pierde flexibilidad en cuando a ejecución se refiere, por lo que cuando queremos introducir un cambio en la ejecución de dicha tarea y modificar esa acción practicada masivamente, debemos realizar un gran esfuerzo que lleva a la consecución de numerosos errores (Schneider & Shiffrin, 1977). Es esto lo que ocurre con el conocido como efecto Stroop. En este caso compite una tarea muy bien aprendida como es la lectura de una palabra, con otra que es novedosa y que requiere de más esfuerzo como es el nombramiento del color de la tinta en la que está escrita dicha palabra. Así cuando la palabra nombra el mismo color en el que está impresa la competencia entre la tarea automática *lectura* y la tarea controlada *nombrar el color* será menor que si la palabra nombra otro color diferente al que está impresa (Stroop, 1935). En el primer caso hablaríamos de una condición congruente, mientras que en el segundo caso hablaríamos de una condición incongruente.

De la misma manera que con las tareas automáticas, se han tratado de tipificar las situaciones en las que se requiere de control consciente. Norman y Shallice (1980), proponen cinco situaciones claves en las que es necesario del control consciente con el fin de maximizar la eficacia de la ejecución. Estas serían: *situaciones novedosas*, *situaciones que entrañan peligro o riesgo para el individuo*, *situaciones difíciles*, *situaciones en las que se ha cometido un error* y por último, la ya mencionada *situación en la que es preciso inhibir una respuesta automática que es inapropiada o inútil para la consecución de las metas actuales de la persona*.

1.2. *Dos modelos clásicos que pretenden explicar cómo la atención modula el procesamiento controlado y el procesamiento automático: Modelo de Norman y Shallice (1980) y Teoría de las Redes Atencionales de Posner y Snyder (1990).*

Surge cada vez más la necesidad de explicar el papel que la atención tiene en el control de la acción, ya sea una acción externa o una acción interna en la que solo intervenga el procesamiento cognitivo. Y no solo la necesidad de explicar el control de la acción en general, sino de diferenciar y abordar el cómo la atención modula las acciones automáticas y aquellas que están sujetas a un control deliberado y consciente.

1.2.1 Modelo de Norman y Shallice

Su principal objetivo a la hora de formular un modelo de la atención es explicar cómo ésta va a influir en el control de las acciones, tanto las que son realizadas de manera automática como las que se llevan a cabo bajo control voluntario. El marco teórico que ellos proponen se basa en una serie de esquemas activos que se organizan como parte de una secuencia de acción determinada. Estos esquemas permanecerán a la espera del set de acción apropiado, de manera que una vez que dicho set se produzca estos esquemas puedan ser seleccionados con el fin de controlar la acción. Norman y Shallice van a tomar el término automático en el sentido de aquellas acciones que no van a generar interferencia con otras tareas. Mientras que para ellos existen en general cinco categorías de acciones que si necesitarían control voluntario y por lo tanto la consciencia, y que serían las que hemos mencionado con anterioridad. En estas situaciones la aplicación no controlada de un esquema puede llevar a la comisión de errores o a una situación que no es deseable.

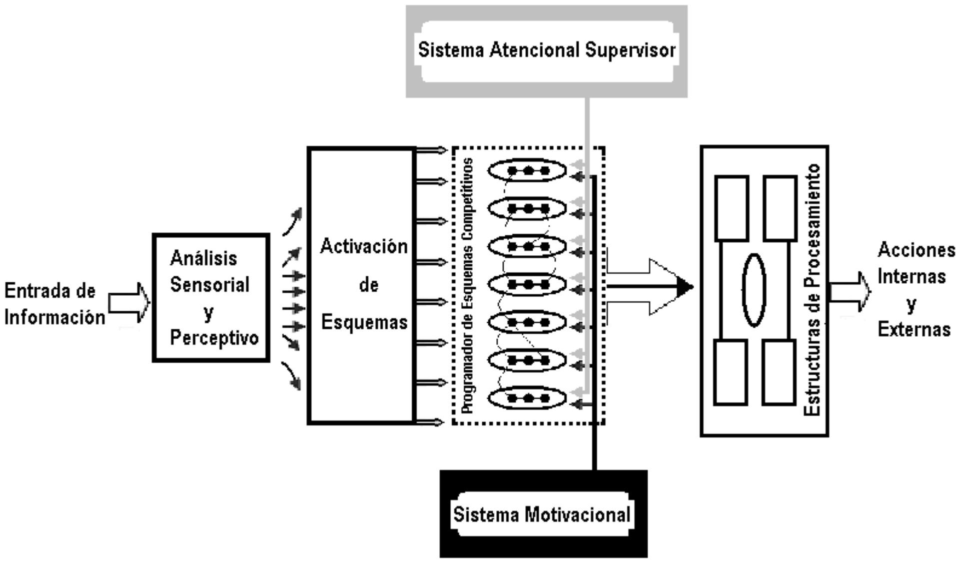


Figura 1.1. Modelo de Control Ejecutivo de Norman y Shallice

El aspecto central del modelo se basa en que todo el comportamiento humano está mediatizado por esquemas mentales, que son los que van a interpretar las señales que llegan al sistema de procesamiento de la información y los que van a seleccionar la respuesta adecuada en cada momento. Ante la pregunta de cómo esos esquemas interaccionan entre sí y como se llega a la elección de la respuesta apropiada a cada situación, proponen dos mecanismos fundamentales: el *contention scheduling* (CS) y el *Sistema Atencional Supervisor* (SAS).

a) Contention Scheduling:

Como hemos comentado anteriormente el eje central del modelo de Norman y Shallice es la existencia de esquemas de acción que deberán ser activados para que dicha acción se lleve a cabo. Para ellos el mecanismo de CS sería aquel que evalúa la relevancia relativa de cada uno de los esquemas y por tanto, va a gestionar el comportamiento en función de dicha evaluación evitando así la competición en la selección de esquemas o favoreciendo la cooperación entre los mismos para potenciar una determinada acción. Podríamos resumir el funcionamiento de este sistema como la evaluación del valor de una serie de sets de esquemas que están compitiendo entre sí, con el fin de decidir cuál de ellos es el más adecuado en función de la acción que se quiere llevar a cabo.

Este sistema funciona especialmente bien cuando tratamos con acciones rutinarias complejas. De esta forma un estímulo ambiental va a desencadenar una conducta. Para que dicha conducta sea la apropiada en cada caso será necesario un sistema de inhibición recíproca, de manera que el esquema de acción más activo será aquel que prevalezca, mientras los demás se mantienen inactivos temporalmente, Como ya hemos dicho, este sistema será especialmente útil en el caso de que nos enfrentemos con acciones muy rutinarias y bien especificadas. En ausencia de alguna estimulación ambiental este sistema quedará inactivo o latente.

Pero, ¿qué ocurre cuando se presenta un estímulo o una situación para la que no hay una acción rutinaria especificada o ésta no es apropiada? Es en estos casos, cuando se necesita de un sistema que module y controle al CS y que favorezca la toma de decisiones o la inhibición de la respuesta rutinaria inapropiada. Es ahí donde entra en escena el Sistema Atencional Supervisor (SAS).

b) El SAS:

El SAS va a estar activo y en pleno funcionamiento en cualquiera de las cinco situaciones que se han mencionado anteriormente como generadoras de la necesidad de control cognitivo y atencional. Este sistema puede modificar las fuerzas de acción rivales dando más preponderancia a unas o a otras en función de las demandas de la nueva situación.

Asímismo, ante aquellas situaciones que no generan un modelo de acción determinado, el SAS puede generar uno que se adecue a dicha situación. De esta manera podemos decir que el SAS puede inhibir una respuesta automática y perseverante, así como puede generar conductas nuevas ante aquellas situaciones que no elicitan secuencias de acción rutinarias.

La acción de control del SAS sería, por tanto, indirecta ya que éste solo controla y regula los niveles de activación o inhibición de los esquemas y no su selección en sí. Es decir, este sistema aumentaría o disminuiría deliberadamente el valor que un esquema determinado posee, según la acción que se realice o las demandas de la tarea. Pero sería el CS el encargado de seleccionarlo para aplicarlo a la acción. A la influencia que el SAS ejerce sobre los niveles de activación de los esquemas de acción de CS hay que añadirle además los factores motivacionales de cada individuo. La motivación sería un factor que iría actuando de manera lenta y progresiva a lo largo del tiempo sobre el CS para dirigir dichas estructuras a la consecución de una meta más a largo plazo, mediante la activación de los esquemas relevantes y la selección de los correspondientes.

1.2.2 La Teoría Atencional de Posner y Petersen (1990)

Al igual que Norman y Shallice, Posner intenta dar cuenta de todos los aspectos fundamentales de la atención mediante ka propuesta de una teoría integradora (Posner y Boies, 1971; Posner y Petersen, 1990; Posner y Rothbart, 1991; Posner y Dehaene, 1994). En un primer momento, para Posner y Boies (1971) la atención tenía tres componentes fundamentales, necesarios para entender como ésta influía en las acciones: el primero de esos componentes era la *alerta*, entendida como un estado de vigilancia o de atención sostenida que se mantenía durante un periodo largo de tiempo para poder realizar una determinada tarea o actividad. El segundo componente hacía referencia a la *selección de información.* Por último el tercer componente hace referencia a la *capacidad de procesamiento*.

Posteriormente, a medida que estudiaron la relación entre estas funciones con las estructuras cerebrales que las sustentan, la teoría fue evolucionando hasta llegar a la formulación de aquella que postula la existencia de varias redes atencionales separadas pero relacionadas entre sí, que serían: la Red Atencional de Vigilancia o Alerta, la Red Atencional Posterior o de orientación y la Red Atencional Anterior o del Control Ejecutivo.

a) Red Atencional de Vigilancia o Alerta

Esta es la red encargada de que el sistema atencional se mantenga con un nivel de activación y de ejecución óptimo durante la realización de una tarea que es el que va a permitir que se puedan llevar a cabo las distintas actividades y tareas de la vida con eficacia. Esta red no solo va a encargarse de este tipo de alerta que podría considerarse tónica y mantenida durante periodos largos de tiempo, sino que también tiene la función de mantener un tipo de alerta más física y de corta duración ante la presencia de una señal de aviso que indique la presencia inminente, de un estímulo esperado. Todo esto es muy útil a la hora de acelerar la respuesta del organismo ante determinadas situaciones, pero también tiene un inconveniente y es que al ganar en rapidez se pierde un poco en precisión y se aumenta la comisión de errores y/o anticipaciones, por tanto solo nos prepara para la acción pero no mejora el nivel del procesamiento de los estímulos (Posner, Klein, Summers y Buggie, 1973; Posner, 1978).

Tradicionalmente se han utilizado metodologías diferentes para estudiar ambos tipos de alerta. En el caso del estudio de la ***alerta fásica***, el paradigma tradicional consiste en la presentación de una señal de aviso justo antes de la aparición de un estímulo objetivo al cual hay que responder, que como ya hemos comentado anteriormente produce un estado de preparación para la detección del dicho estímulo, y mejora el TR en la respuesta a éste, no porque aporte más información acerca de sus características, sino porque facilita la respuesta de orientación hacia el mismo y por tanto facilita su percepción.

Con respecto a la ***alerta tónica***, los estudios que se han realizado han estado marcados por las fluctuaciones que en ésta se producen a lo largo del día (ritmos circadianos), y por las variables que influyen en dichos cambios (temperatura corporal, secreción de cortisol, etc). Las tareas utilizadas en dichos estudios comparten las características de ser largas y aburridas con el fin de poder medir las fluctuaciones en atención sostenida. Se ha visto que el rendimiento en estas tareas y el TR son mejores durante las horas más tempranas de la mañana, mientras que dicho rendimiento va cayendo a lo largo del día para volver a aumentar durante la noche (Posner, 1975).

Estudios de lesión y neuroimagen han situado esta red lateralizada en el hemisferio derecho en estructuras que incluirían el córtex frontal y parietal derecho, donde se reciben innumerables proyecciones noradrenérgicas procedentes de Locus Coeruleus (Aston-Jones y Cohen, 2005). Otros estudios de neuroimágen (Sturn y Willmes, 2001) han ampliado esta información mostrando que numerosas áreas talámicas también intervienen, tanto en estados de alerta fásica, como en estados de alerta tónica o vigilancia.

b) Red Atencional Posterior o de Orientación

Sería aquella encargada de dirigir la atención hacia un determinado estímulo que bien posee características peculiares que lo hacen único, es nuevo o bien aparece de manera abrupta (Ruz y Lupiáñez, 2002). De esta manera se prioriza un imput sensorial bien por su modalidad o por su localización (Posner y Petersen 1990). Se ha observado un efecto de facilitación en la percepción cuando la atención está orientada hacia un determinado estímulo, aunque esta señal no prediga el lugar exacto en el que dicho estímulo va a aparecer (Posner, 1980; Posner y Cohen, 1984). Para el estudio del efecto de orientación se han utilizado tareas de *señalización* (Posner, Inhoff, Friedrich y Cohen, 1987). Durante este tipo de tareas, para producir el efecto de orientación, se utilizan dos tipos de señales, que pueden bien indicar dónde va a aparecer el estímulo objetivo (Marrocco y Davidson, 1998), o bien aparecer en el mismo sitio que el estímulo objetivo: el primer tipo de señales, serían las llamadas ***centrales.*** Este tipo de señales, en líneas generales son predictivas, es decir, van a dar información del lugar en el que va a aparecer el estímulo objetivo, por lo que la persona va a poner orientar su atención hacia ese lugar. El segundo tipo de señales, serían las ***periféricas.*** En este caso, aunque la señal aparece en un posible lugar de aparición del estímulo objetivo, no son predictivas (el estímulo aparecerá en la posición que indica la señal el 50% de las veces).

Numerosos estudios en humanos y monos han mostrado que los moduladores de la Norepinefrina afecta a la alerta pero no a la orientación, si bien al contrario, aquellas drogas moduladoras del neurotransmisor acetilcolina, afecta al efecto de orientación pero no al de alerta, sugiriéndose así la existencia de una independencia clara entre ambos procesos (Fernández-Duque y Posner, 1977). Pese a esta independencia, ambos procesos pueden funcionar a la vez y potenciar sus efectos, ya que en la vida diaria la mayoría de las situaciones de aviso arrojan información acera del cuándo y del dónde va a ocurrir algo (Fan et al., 2009).

Neuroanatómicamente situamos esta red en estructuras tales como el córtex parietal posterior, los núcleos pulvinar y reticular del Tálamo y los colículos superiores. Actualmente, los estudios de neuroimagen arrojan datos a favor de la intervención en procesos de orientación de áreas frontales (Frontal Eye Field) y de áreas posteriores (Corbetta, et al., 1998; Thompson et al., 2005), situadas en el surco intraparietal. En lo que respecta a las áreas parietales, se ha visto su implicación en diversas formas de procesamiento. Determinadas áreas están más especializadas en procesamiento motor, traducido en el movimiento directo de los ojos hacia la señal, mientras que otras zonas se especializarían más en un tipo de procesamiento más sensorial, en el que la orientación de la atención no sería tan claramente visible, pero sin embargo estaría igualmente presente. Este sistema constituye un mecanismo más dorsal que se activa por ejemplo cuando se presenta una flecha que hace de señal y que va a predecir el lugar de aparición del target (señal central). La función que se le ha atribuido a este sistema es la de un rápido control estratégico sobre la atención.

Cuando la señal es periférica y no predice el lugar de aparición del objetivo, puede ocurrir que la atención se oriente hacia un lugar y que el estímulo no aparezca ahí, por lo que deba haber un cambio en la orientación de la atención. Ese cambio se asocia con activación del la unión temporo-parietal y del cortex frontal ventral y se asocia con la interrupción de la señal para que se pueda producir ese cambio atencional. Esto formaría parte de un sistema más ventral, que se activaría, no tras la señal como el dorsal, sino tras el estímulo objetivo y se identificaría como una parte de la red encargada de procesar los sucesos sensoriales.

c) Red Atencional Anterior o de Control Ejecutivo

Esta red se ha asociado a la gestión del control voluntario de la acción en aquellas situaciones novedosas, en resolución de conflicto tanto entre estímulos como entre respuestas, en situaciones que requieren de algún tipo de planificación o estrategia, etc (Posner y Raichle, 1994). Otra de las funciones que se le ha atribuido a esta red es la de detección consciente de los estímulos (Posner y Raichle, 1994) a la vez que procesos de memoria de trabajo (Posner y Dehaene, 1994) y en situaciones de recompensa (Hampton y O´Doherty, 2007).

Lejos de considerar a esta red como una subparte de otros sistemas que regulan estos procesos, Posner y Petersen (1990) consideraron a esta red como un sistema que englobaba procesos de focalización atencional, así como de regulación de las demás redes de procesamiento. En su revisión más actual (Petersen y Posner,

2012) este sistema tendría como función principal la regulación top-down, por lo que estaría estrechamente relacionada con el control ejecutivo, el cual ha sido asociado al procesamiento consciente de la información.

Estos autores ponen el énfasis en una estructura cerebral que para ellos es clave en el funcionamiento de esta red: el cortex cingulado anterior (ACC). Sin embargo, el papel del ACC en lo que se refiere al control ejecutivo es una cuestión que aún se debate entre dos grandes teorías. Una de ellas considera esta estructura clave en la monitorización del conflicto, en constante comunicación con áreas frontales laterales que serían las encargadas de resolver dicho conflicto (Botvinick et al., 2001; Carter y Krug, 2012). La otra gran teoría es la que va a favor de la existencia de dos redes diferentes de control top-down (Dosenbach et al., 2008). A estos sistemas llegarían tres tipos de señales con el fin de aplicar mecanismos de control: la primera de ellas es la que llega de las instrucciones iniciales que se da en una determinada tarea, y que son las que especifican cuales son las demandas de ésta. La segunda haría referencia a la actividad que hay que mantener a lo largo de toda la tarea con el fin de no perder los parámetros de ésta y de no desviarse de las demandas iniciales. Por última, la tercera señal vendría del feedback de ejecución, el cual da información de si se está cumpliendo o no las demandas de la tarea. Dosenbach et al. (2008) encuentran que el frontal lateral y las regiones parietales se centran más en el primer tipo de señal, mientras que las zonas frontales más mediales y el ACC estarían más centrados en el mantenimiento de las demandas de la tarea.

Como puede apreciarse, ambos modelos contemplan la necesidad de que en el cerebro debe existir un mecanismo de control voluntario que dirija las acciones hacia la consecución de unos determinados objetivos. Cabe destacar la gran relevancia posterior que ha tenido el modelo de Norman y Shallice en la elaboración de teorías posteriores, como la Teoría Atencional de Posner y Petersen (1990), así como modelos en otros campos, como puede ser el modelo de la memoria de trabajo de Baddeley. El modelo del Control Ejecutivo describe cómo ha de funcionar el sistema de control y como se llevan a cabo diversos procesos atencionales. Posteriormente, se añaden los mecanismos neurales que llevan a cabo dichos procesos. Así, tanto el SAS de Norman y Shallice y la Red Atencional Anterior de Posner comparten tanto funciones como estructuras cerebrales.

Por otra parte ambos modelos hacen hincapié en que dicho control se realiza mediante el procesamiento consciente de la información y de los estímulos, pues solo de esta manera el sistema sería capaz de ejercer ese control voluntario. En este caso la consciencia se entiende como un contenido y la definimos como la capacidad de caer en la cuenta de algo o de percatarnos de lo que nos rodea. Utilizando la terminología extraída de estudios de lesión con pacientes humanos, nos estaríamos refiriendo al procesamiento explícito de la información, en contraposición al procesamiento implícito, que sería el equivalente al procesamiento no consciente, más característico de los procesos automáticos. De esta manera podemos decir que todo proceso automático es implícito, aunque no todo proceso implícito tiene que ser automático.

2. **CONTEXTO RECIENTE EN EL QUE SE ENMARCA NUESTRA INVESTIGACIÓN**

En los modelos tradicionales se destaca como punto clave la existencia de un mecanismo que ante determinadas situaciones demandantes, va a ejercer su acción de control para ajustar la ejecución del individuo a las demandas de esta situación, de manera que esa ejecución sea lo más precisa y ajustada posible.

Sin embargo empieza a surgir la problemática de conocer realmente, no solo la influencia que el control va a tener sobre la acción, sino el cómo ese proceso de control se lleva a cabo, de manera que se pueda tener una teoría del control completa que no caiga en la tentación explicaciones homunculares, en las que un determinado mecanismo cerebral "sabe" cuándo intervenir. Es decir, una buena teoría del control, dad una situación determinada, debe poder explicar y predecir si va a ser necesaria o no la aplicación de procesos de control. Es ciertamente comprensible que no siempre vamos a saber antes de comenzar la realización de una tarea, que vamos a necesitar del uso de procesos de control. Sin embargo existen situaciones

A este respecto, Kahneman (1973) argumenta que es el hecho de intentar realizar una tarea que resulta difícil lo que hace que se demanden recursos cognitivos. Prueba de esto son los resultados obtenidos con la tarea Stroop, en la cual los participantes muestran mayor interferencia en los dos primeros ensayos de cada bloque, mientras que dicha interferencia disminuye a medida que se va avanzando en la serie de ensayos (Henik, Bibi, Yanai y Tzelgov, 1997). Otro de los aspectos que tenemos que tener en cuenta es el hecho de explicar, una vez que el control cognitivo está siendo aplicado, cómo se va a modular sus influencia para hacerlo más eficiente, ya que se ha documentado extensamente que los ajustes que se hacen en el proceso de control cognitivo, ocurren on-line, mientras la tarea está siendo llevada a cabo. Así por ejemplo, justo después de la comisión de un error se observa un aumento, tanto del tiempo de reacción como de la precisión de respuesta (Laming, 1968; Rabbitt, 1966). Por último, otro punto crucial que debe tener en cuenta toda teoría del control es conocer aquellos procesos que van a marcar cuándo y cómo el control cognitivo deja de aplicarse. Como se ha podido observar, la práctica lleva a la automatización de las acciones (Anderson, 1982; Shiffring y Schneider, 1977). Este fenómeno va a hacer que la necesidad de control disminuya, por tanto debe haber un elemento evaluador que determine cuándo puede retirarse en control sin que haya un perjuicio en la ejecución de la tarea.

En resumen, podemos decir que para que el control cognitivo se lleve a cabo de manera eficaz y eficiente, deben haber dos dimensiones a tener en cuenta: Una ***dimensión reguladora*** que será la que dé cuenta de la aplicación de procesos top-down, y una ***dimensión evaluadora*** que será la que monitorice el procesamiento de la información teniendo en cuenta en todo momento las demandas actuales de la tarea.

2.1. *La Hipótesis de Monitorización del Conflicto (Botvinick, Braver, Barch, Carter, & Cohen, 2001).*

De acuerdo con lo expuesto, Botvinick, Braver, Barch, Carter y Cohen (2001) desarrollaron una teoría del control que intentaba dar cuenta de todos estos aspectos que acabamos de comentar, en la que se presta especial atención a la dimensión evaluativa del control cognitivo. Ellos proponen la existencia de un mecanismo de *monitorización del conflicto*, que se encargará de evaluar y monitorizar cuando se produce un conflicto durante el procesamiento de la información. Su principal función es la de traducir esa información, en ajustes compensatorios de control. De esta manera, primero se evalúa la situación y posteriormente se manda dicha información a aquellos centros responsables de ejercer los procesos de control, que a su vez se encargarán de proyectar esa información a los centros necesarios para potenciar su influencia en el procesamiento.

La estructura que principalmente se encarga de la ***monitorización del conflicto*** es el Cortex Cingulado Anterior (ACC), que detecta y evalúa la información que puede ser conflictiva. Esta estructura está conectada con estructuras más prefrontales, como el Cortex Prefrontal Dorsolateral (DLPFC), a las que manda la información para que se implementen las ***estrategias de control*** propiamente dichas.

Esta hipótesis se ha formulado como resultado de la múltiple evidencia de la participación del ACC cuando ocurre una situación de conflicto, números estudios que han estudiado el papel de dicha estructura en la cognición. Estos estudios han sido realizados utilizando una gran variedad de metodologías, entre las cuales se incluyen los estudios de lesión, los registros mono-neuronales y las técnicas de registro de la actividad cerebral, como pueden ser los potenciales evocados asociados a un evento (ERPs) y en años más recientes los de resonancia magnética funcional (fMRI), siendo estos últimos los que mayor cuerpo de datos han arrojado. La mayoría de los resultados que se han obtenido utilizando estas metodologías apuntan hacia la participación esencial del ACC en la detección del conflicto.

A continuación, vamos a realizar un repaso de los principales datos que existen a este respecto.

2.2 *Evidencias a favor de la Teoría de Monitorización del Conflicto.*

En líneas generales, cuando nos enfrentamos a la revisión de estudios acerca del rol del ACC en la detección del conflicto, nos encontramos con la posibilidad de clasificar los estudios en tres categorías diferenciadas: la primera es la que incluye los estudios que tratan de la necesidad de **inhibir una respuesta** que es muy prominente pero totalmente innecesaria para el objetivo de la tarea.
La tarea más frecuente que se ha usado en estos estudios ha sido la tarea Stroop (Stroop, 1935; McCleod, 1991). Usando esta tarea, el primero que observó activación en el ACC usando como técnica de imagen Tomografía por emisión de positrones (PET) fue Pardo (Pardo, Janer y Raichle, 1990). Lo que observaron fue una mayor

activación en el ACC durante la ejecución de la condición incongruente en comparación con la condición congruente. Este resultado ha sido replicado en estudios similares, usando fMRI (Carter, Cohen y Mintun, 1995, Van Veen y Carter, 2006), siendo también esa activación del ACC en la condición incongruente mayor que la activación en la condición neutra (Bench et al. 1993; Carter et al., 1995). Pero no solo se han obtenido estos datos usando la tarea Stroop, sino también usando otras tareas en las que se requiere que se inhiba una respuesta automática. Un ejemplo es un estudio en el que se le pide a los participantes que nombren una serie de letras B, J, Q e Y. Posteriormente se le pide a esos mismos participantes que respondan a las letras siguiendo una serie de reglas simples. Por ejemplo cuando aparezca la J deben responder F (Taylor, Kornblum, Minoshima, Oliver y Koeppe, 1994). En esta segunda condición, en la que los participantes deben inhibir la lectura automática de las letras, se ve una mayor activación del ACC.

Otro tipo de estudios que pueden enmarcarse dentro de esta categoría y también han mostrado un incremento en la activación del ACC, son aquellos que se han realizado usando tareas go-no go. Casey, Castellanos, F.X., Giedd, Marsh, Hamburguer, Schubert, Vauss, Vaituzis, Dickstein, Sarfatti y Rapoport, 1997 realizaron estudios de este tipo usando fMRI. En este estudio los participantes respondían presionando una tecla cada vez que se presentaba una letra, excepto cuando esa letra era una X. Para que el hecho de presionar la tecla se convirtiera en una respuesta prepotente, en la mayoría de los ensayos no aparecía la X. Cuando comparaban la activación del ACC durante esta tarea con la activación del ACC en una condición control en la cual nunca aparecían las Xs, se observó una mayor activación en la condición experimental del ACC, sobre todo cuando aparecía la X. Para generalizar podemos decir que en todas estas situaciones se da una competición entre vías de procesamiento que llevan a una respuesta correcta, pero que son débiles y aquellas vías de procesamiento que llevan a una respuesta incorrecta y que son prepotentes. Es lo que comúnmente se conoce como *conflicto de crosstalk.*

El segundo grupo de estudios acerca de la activación del ACC y que pueden constituir otra categoría es aquel que hace referencia a la **selección de una respuesta** de entre un grupo de posibilidades entre las cuales no destaca ninguna como más obvia que las demás para la correcta consecución de la tarea. En este caso, el estímulo que se presenta, por si solo no da información ni especifica cual es la respuesta correcta. Un ejemplo de este tipo de tareas son las tareas denominadas de *generar* versus *repetir*. Pettersen, Fox, Posner, Mintun y Raichle (1988, 1989), llevaron a cabo una serie de experimentos usando PET en los cuales se les pedía a los participantes que generaran un verbo que identificara una acción apropiada a un objeto cuyo nombre se les había presentado previamente. En otra condición, los participantes simplemente tenían que leer o repetir el nombre sin generar ningún verbo. En este tipo de estudios se observa una mayor activación del ACC en la condición de generar en comparación con la activación en la condición repetir. Estos estudios han sido replicados por otros autores (ver Barch, Sabb, Braver y Noll, 2000), incluso si la generación del verbo se hace en silencio (Warburton et al., 1996; Wise et al., 1991).

Otro ejemplo de este tipo de tareas, son las tareas de fluidez verbal, en las cuales los participantes deben decir una serie palabras que empiecen por una letra determinada. En estos estudios también se observa una mayor activación del ACC cuando los participantes tienen que realizar esta tarea, en comparación a cuando simplemente tienen que repetir una palabra que oyen (Frith, Friston, Liddle y Frackowiak, 1991a) o en comparación a cuando tienen que realizar una tarea de decisión léxica (Frith, Friston, Liddle y Frackowiak, 1991b).

También se han realizado estudios con fMRI usando tareas de fluidez verbal en silencio (Yetkin et al., 1995), así como usando tareas de fluidez semántica, en los que los participantes deben generar una serie de nombres correspondientes a una determinada categoría (Yetkins et al., 1995). Ambos tipos de fluidez, la léxica y la semántica, han mostrado la producción de una mayor activación en el ACC.

Las conclusiones que podemos sacar de este tipo de estudios es que, dado que todo el abanico de respuestas pueden llevar a la consecución de la tarea, el cerebro activa en paralelo múltiples vías de procesamiento que son incompatibles entre sí, produciendo lo que antes hemos llamado un conflicto de crosstalk, esta vez en el espacio de tiempo entre la presentación del estímulo y la ejecución de la respuesta.

Por último, vamos a hablar del tercer grupo de estudios que se han llevado a cabo para comprobar el papel del ACC en el proceso de monitorización del conflicto. Estos serían los estudios que evalúan la **comisión de errores.** La particularidad que presentan estos estudios es que en lugar de usas técnicas de imagen propiamente dichas, usa en su mayoría técnicas electrofisiológicas, en concreto los potenciales evocados (ERPs) (Rugg y Coles, 1995). Estos estudias han mostrado que tras la comisión de un error en tareas de velocidad de respuesta, se observa la aparición de un potencial negativo, al que se ha llamado *Negatividad asociada al error* (ERN) (Falkenstein, Hohnsbein y Hoorman, 1995). Esta negatividad ocurre 100-150 ms después de que se produzca la respuesta, e incluso puede producirse antes de que se produzca esa repuesta errónea, si la persona es consciente de que va a cometer un error, como se ha observado en estudios en los que se registra este potencial asociado a una respuesta electromiográfica de la mano que no corresponde a la respuesta correcta que tiene que dar el participante (Ghering, Coles, Meyer y Donchin, 1990).

Dehaen, Posner y Tucker, (1994) observaron este potencial en sus estudios, en los cuales por una parte piden a los participantes que pulsando una tecla lo más rápidamente posible, digan si un número (que puede estar representado en su forma numérica o escrito en palabra) es mayor o menos que 5, y por otra parte les piden que digan si una serie de palabras que se les presentan son animales. Cuando los participantes cometían un error y se daban cuenta de ello, se observaba esta negatividad.

Este negatividad ha sido consistentemente, asociada a regiones frontales mediales. Mediante el uso de extracción de dipolos se ha asociado la generación de esta negatividad al ACC (Dehaen et al.

1994). Es importante apuntar que junto a los estudios de estimación de dipolos, de los cuales se han extraído estas conclusiones, se han realizado estudios usando fMRI con el fin de observar si realmente es el ACC la estructura implicada en la detección consciente de un error (Kiehl, Liddle, & Hopfinger, 2000; Menon, Adleman, White, Glover, & Reiss, 2001). Kiehl, Liddle, & Hopfinger, (2000) usaron una combinación de ERPs y fMRI con el fin de observar los correlatos neurales, tanto de respuestas correctas (rechazos correctos y aciertos) como de las respuestas incorrectas (errores), durante la realización de una tarea go/no go. Al analizar las respuestas incorrectas observaron una gran activación del ACC rostral, así como del cortex frontal lateral izquierdo. Estas áreas solo se activaron ante los errores y no ante las respuestas correctas, lo cual sugiere que dichas áreas forman parte de un sistema cerebral integral de detección del error.

De toda esta revisión de estudios podemos extraer la conclusión de que el ACC es clave en la detección consciente del conflicto. Solo cuando el cerebro se percata de que existe una situación donde existe una competición entre respuestas automáticas o respuestas que requieren más control, o cuando se dan varias posibilidades que compiten en igualdad de condiciones o cuando se ha detectado la comisión de un error, el ACC interviene monitorizando esa situación de conflicto y mandando señales al DLPFC que, en el primer caso inhibirá la respuesta automática más fuerte pero incorrecta y potenciará la respuesta más débil pero a la vez correcta, mientras que en el segundo caso dará más activación a una de las respuestas destacándola por encima de las demás, de manera que se pueda usar para la tarea, por último en el tercer caso tras la comisión de un error se pondrán en marcha estrategias de control para evitar que ese error vuelva a ocurrir, como por ejemplo aumentar la velocidad de respuesta. Es más, existen estudios con fMRI, que muestran una doble disociación en la actividad de estas dos estructuras (McDonald, Cohen, Stenger y Carter, 2000). Estos autores usaron una variante de la tarea Stroop con el fin de demostrar la doble disociación entre el ACC, cuya función para ellos era la de evaluación de la situación y el DLPFC, que para ellos tenía funciones de mantenimiento de la atención en las demandas de la tarea. En la tarea daban una instrucción antes de cada ensayo que bien podía ser leer la palabra (más automático) o bien podía ser nombra el color de la tinta (se requiere mayor control). Posteriormente, tras un periodo de tiempo presentaban el target. Esta estrategia hacía que se separan por un lado los procesos estratégicos que estarían ligados a las instrucciones (requieren mantenimiento de la atención en las demandas de la tarea), y por otro lado aquellos procesos que están ligados a la respuesta (que serían más evaluativos). Lo que observaron fue una activación en el DLPFC ligada a las instrucciones, pero solo a las que hacían referencia a nombrar el color y no a las que se referían a leer la palabra, mientras que no se observó activación del ACC ligada a las instrucciones. Esa mayor activación del DLPFC ligada a la instrucción de nombrar el color, se tradujo en un menor efecto Stroop ante la presentación de un target incongruente. Por otro lado, se observó una mayor activación del ACC derecho para aquellos ensayos incongruentes en comparación con los ensayos congruentes. Esa activación era mayor cuanto mayor era la interferencia tipo Stroop. Así se pudo ver que el DLPFC izquierdo se activaba de manera selectiva durante el periodo de preparación, mientras que el ACC derecho se activaba de manera selectiva durante el periodo de respuesta, por lo que se puede deducir que ambas estructuras poseen un rol complementario dentro de una red neural encargada del control cognitivo.

Uno de los puntos fuertes de la Teoría de Monitorización del conflicto es que da explicación a múltiples fenómenos que han sido estudiados en psicología cognitiva. Un claro ejemplo de esos fenómenos son los efectos de ajustes en el control. En el siguiente apartado vamos a describir estos efectos y la explicación que da esta teoría de ellos.

3. EFECTOS DE ADAPTACIÓN AL CONFLICTO

Una prueba más de la existencia de un sistema que actúa evaluando el conflicto y mandando información a centros que se encargan de su resolución son las pruebas que arrojan los estudios donde se han podido observar cambios y fluctuaciones en el control, asociadas a variaciones en la ejecución o a cambios en las demandas de la tarea. Estas fluctuaciones se les ha dado el nombre genérico de *Ajustes de Control*. A continuación vamos a hacer un repaso por los efectos de ajuste en el control más comúnmente observados en la literatura. Posteriormente pasaremos a describir como la Teoría de la Monitorización del Conflicto, trata de dar cuenta de cada uno de estos efectos.

3.1 *Efectos secuenciales: Efecto Gratton.*

Un **efecto secuencial** puede definirse como el cambio en el tiempo de reacción (RT) de la respuesta de un ensayo debido a la naturaleza del ensayo precedente. Este efecto, ya conocido antes de que se formulara la hipótesis de monitorización del conflicto, descrita con anterioridad, fue observado por Cratton, Coles y Donchin (1992) en un estudio realizado con una modificación de la tarea de flancos de Eriksen (Eriksen y Eriksen, 1974). En esta tarea se pide a los participantes que digan, mediante la presión de dos teclas, la dirección hacia la que apunta una flecha que aparece en el centro de la pantalla. Esta flecha está flanqueada a derecha e izquierda por otras dos flechas que pueden apuntar, bien en la misma dirección que la flecha target (ensayos congruentes), bien en la dirección contraria (ensayos incongruentes). Si tenemos en cuenta la secuencia que compondrían dos ensayos se obtienen cuatro posibilidades: ensayos congruentes que están precedidos por otro ensayos congruente (CC), ensayos congruentes que están precedidos por un ensayo incongruente (IC), ensayos incongruentes que están precedidos por un ensayo congruente (CI) y por último, ensayos incongruente que están precedidos por otro ensayo incongruente (II). El efecto que estos autores observaron se produce de manera más prominente en los ensayos incongruentes, de manera que ellos compararon la condición CI y la condición II: Lo que se observa es una reducción del RT en la condición II en comparación con la condición CI. Asimismo el RT se ve incrementado en la condición IC en comparación con la condición CC. A esta reducción del RT es a lo que llamaron ***Efecto Gratton***.

La explicación que la teoría de Monitorización del Conflicto da a este efecto es que en un ensayo incongruente el sistema necesita recopilar recursos de control para la resolución del conflicto que estos ensayos general, lo cual prepara al sistema para resolver futuras situaciones de conflicto. Por tanto, si lo que sigue es otro ensayo incongruente, el sistema se encontrará altamente preparado para resolver esa situación de conflicto, lo que se traducirá en una menor interferencia y en una disminución del RT. Por el contrario, si el ensayo que sigue es congruente, situación que se resuelve de manera automática, el sistema se encontrara demasiado preparado para el control, por lo que volver a una respuesta automática tendrá un coste y se observará un enlentecimiento de la respuesta. De la misma manera podemos explicar el caso de los ensayos congruentes. Como ya hemos mencionado los ensayos congruentes no suponen ningún tipo de conflicto al sistema y se resuelven de manera automática. Por tanto, si un ensayo congruente va seguido de otro ensayo congruente, este último experimentará una facilitación que hará que el RT aún sea menor. Si por el contrario va seguido de un ensayo incongruente el RT aumentará de manera considerable, pues el sistema no está en absoluto preparado para la resolución del conflicto.

Otra de las predicciones que hace la Teoría de la Monitorización del conflicto en lo que se refiere a estos efectos, es que una mayor activación en el ACC se traducirá en un consiguiente incremento de activación en el DLPFC., que es el responsable de implementar las estrategias de resolución del conflicto y por tanto sería el encargado de realizar los ajustes de control en función de cada secuencia de ensayos Kerns et al. (2004) realizaron estudios de fMRI en los que usaban la tarea Stroop. Eliminaron las repeticiones de estímulos entre ensayos con objeto de comprobar si se seguían produciendo los efectos secuenciales y observaron una mayor que una activación del ACC en un ensayo se traducía en una mayor activación del DLPFC en el siguiente, obteniendo como predice la hipótesis un menos RT en ensayos II en comparación con ensayos CI, así como una menor actividad del ACC en los primeros en comparación con los segundos.. A su vez observaron que la actividad del DLPFC se incrementaba en aquellos ensayos en los que mayor ajuste de control se había producido, confirmando así tanto comportamentalmente como anatómicamente la Hipótesis de Monitorización del Conflicto.

3.2. *Efectos de la frecuencia del tipo de ensayo: Efecto de proporción de congruencia (PCE), Efecto de compatibilidad específico del ítem (ISCE) y Efecto de compatibilidad específico del contexto (CSCE).*

Los efectos de ajuste en el control no solo se han observado al estudiar los efectos secuenciales. Se ha observado que la frecuencia real o relativa de la incongruencia, produce una reducción del RT en ensayos incongruentes, sólo cuando dicha frecuencia es alta.

3.2.1. ***Efecto de proporción de congruencia (PCE)***

Cuando hablamos de este efecto, nos referimos a una disminución de la interferencia en ensayos que implican conflicto, cuando la proporción de ensayos incongruentes es elevada en comparación con cuando esta proporción de ensayos incongruentes es baja. Asimismo, los ensayos no conflictivos se procesan más rápido cuando los ensayos incongruentes son infrecuentes en comparación con cuando la proporción de ensayos incongruentes es alta (Logan y Zbrodoff, 1979; Logan et al., 1984).

Este efecto se ha podido observar en numerosos estudios que usan la tarea Stroop. Logan y Zbrodoff (1979) llevaron a cabo un estudio en el que usaron una variante de la tarea Stroo en la que los participantes tenían que decir la posición de una palabra (ARRIBA y ABAJO), que podía presentarse por encima o por debajo de un punto de fijación. O bien tenían que decir el significado de esas dos palabras. En ambas tareas los ensayos podían ser compatibles (ARRIBA presentado por encima del punto de fijación, ABAJO presentado por debajo del mismo) o bien podían ser incompatibles (ARRIBA presentado por debajo del punto de fijación y ABAJO presentado por encima). Estos autores variaron la proporción de ensayos compatibles e incompatibles (20% de incompatibles para la condición de baja incongruencia y 80% de incompatibles para la condición de alta). Lo que observaron fue que en la tarea donde tenían que decir el significado de la palabra, cuando los participantes estaban en la condición de baja incongruencia procesaban de manera más rápida los ensayos compatibles, mientras que cuando estaban en la condición de alta, lo que obtenían la facilitación eran los ensayos incompatibles. Otros estudios confirman estos resultados usando la tarea Stroop o variantes (Cheesman y Merikle, 1986; Lindsay y Jacoby, 1994; Logan, 1980; West y Baylis, 1998; Kane y Engle, 2003 experimento 4). En todos estos estudios la manipulación que se realiza de la proporción de congruencia es a un nivel global de lista, donde se varía el número total de ensayos incongruentes y de ensayos congruente.

La explicación que da la Teoría de la monitorización del conflicto sobre este efecto es que ante una situación en la que la incongruencia y por tanto el conflicto es frecuente, hace que el sistema de control esté mejor preparado para enfrentarse a futuras situaciones de conflicto, por lo que cuando se presente un ensayo incongruente se procesará más rápidamente y habrá una menos diferencia en lo que se refiere a RT entre ensayos incongruentes y congruentes. Los participantes generarían expectativas acerca de qué tipo de ensayo va a ocurrir a continuación, desarrollando estrategias de control de manera proactiva (Braver et al., 2007). Cuando un participante espera que aparezca un ensayo congruente, como ocurriría en aquellos bloques de ensayos donde los proporción de congruentes es mayor, desarrollarán la estrategia de leer la palabra. Esta estrategia hará que se facilite el procesamiento de los ensayos congruentes, empeorando por tanto el procesamiento de los incongruentes, lo que se traduciría en mayor efecto Stroop. Por el contrario, cuando el participante se encuentra en un bloque donde la proporción de ensayos incongruentes es mayor, hará un doble esfuerzo por evitar el procesamiento del significado de la palabra, lo que hará que empeore su percepción de ensayos congruentes, pero mejorará sustancialmente la percepción de aquellos ensayos que sean incongruentes, disminuyendo significativamente la interferencia de tipo Stroop. La base neural de esta explicación es que el ACC detectaría esa situación de conflicto frecuente, de modo que el DLPFC estaría altamente preparado para implementar la resolución de ese conflicto. Este sistema, al encontrarse activo y facilitado, estaría mejor preparado para resolver una futura situación de conflicto y por tanto se ve esa disminución de la interferencia.

3.2.2. ***Efecto de proporción de congruencia específico del ítem (ISPCE).***

Esiste un grupo de autores, sin embargo que proponen que el efecto de proporción de congruencia no ocurre a nivel de lista, sino que actúa a nivel de ítem propiamente dicho. De acuerdo con estos autores la adaptación al conflicto no necesita de una gran secuencia de ensayos o de una manipulación a nivel de bloque para poder observare, si no que dichos ajustes se van produciendo ya ensayo a ensayo. Jacoby, Lindsay & Hessels (2003) obtuvieron este efecto usando de Nuevo la tarea Stroop. Eligieron un conjunto de seis colores y sus correspondientes 6 nombres de color. Para generar la condición de ítems mayoritariamente congruentes (MC) los nombres de palabras de uno de los conjuntos fueron presentadas en su color correspondiente un 80% de las veces y en otro color diferente un 20%. Las palabras del otro conjunto revirtieron este orden con el fin de producir ítems mayoritariamente incongruentes (MI). La proporción de congruencia global se mantenía al 50% de congruentes y 50% de incongruentes, lo cual evita que los participantes desarrollen estrategias generales para adaptarse al conflicto. Lo que Jacoby et al. encuentran es que los ítems MC mostraban un mayor efecto Stroop que los MI. La proporción relativa de incongruencia que se asociaba a cada uno de los ítems ajustaba el sistema, produciendo un mayor efecto de control en aquellos ensayos incongruentes en los que el ítem era MI.

Según la Teoría de monitorización del conflicto el cerebro debe detectar que hay más ensayos incongruentes que congruentes para poder desarrollar una estrategia de control acorde a esa situación y así resolver mejor una nueva incongruencia. Sin embargo, en los estudios de Jacoby et al. el cerebro no puede generar una estrategia global en relación con el porcentaje de congruencia, pues a nivel global de tarea el porcentaje de congruentes e incongruentes es el mismo. Es necesario una actualización on-line de la situación para que se pueda dar ese beneficio con una proporción de incongruencia que está asociado a un ítem. Para estos autores el ISPCE estaría reflejando un control rápido dirigido por el estímulo. Una especie de "control automático". Según esta perspectiva cada ítem individualmente se asocia con el filtro atencional que más frecuentemente se debe emplear para ese tipo de ítem a lo largo de toda la sesión experimental. De esta manera, por ejemplo los ítems MC quedarían asociados con un filtro atencional que filtre de manera muy débil la lectura de la palabra, mientras que los ítems MI quedarían asociados a un filtro que filtre de manera fuerte la información de la palabra (Jacoby et al., 1999). Por tanto, cuando un determinado ítem aparece en la pantalla, inmediatamente de forma reflja activará el filtro atencional que se haya asociado al tipo de ítem que es y ese filtro rápidamente ajusta los mecanismos atencionales para proporcionar control on-line sobre el procesamiento de dicho ítem Stroop. En conclusión, en lo que se refiere a la tarea Stroop usada por Jacoby et al. (2003), la influencia de la palabra actuaría a un nivel de ítem, siendo ese ítem el que actúa de clave contextual para selecciona un set atencional u otro en función de las demandas de la tarea.

Existe una visión alternativa que explicaría este efecto como el resultado de un aprendizaje asociativo específico para cada ítem que se centra en la frecuencia con la que una palabra determinada y un determinado color se asocian a lo largo de un diseño experimental (Jacoby et al., 2003). De ese modo los participantes aprenden a responder más rápido a aquellos pares de palabra-color que son más frecuentes en comparación con aquellos pares que no lo son tanto (Logan, 1988). Los ensayos MC repetirán de forma más frecuente ítems específicamente congruentes y de manera infrecuente ítems específicamente incongruentes. Al contrario sucedería con los MI, por lo que los participantes estarían respondiendo a la asociación más frecuente para cada ítem (Schmindt y Besner, 2007 y 2008; Atalay y Misirlisoy, 2012).

Con el fin de tener en cuenta estos resultados y tomar en cuenta el control automático, Blais, Robidoux, Risko, & Besner (2007) desarrollaron un modelo computacional que modifica el modelo de Botvinick et al. En este modelo, el DLPFC ejercería los procesos de control a nivel de un ítem particular, en vez de a un nivel de lista más general. Posteriormente Blais y Bunge (2010) realizaron un estudio en el que usaron un diseño casi idéntico al del estudio de Bugg, Jacoby y Toth (2008), mientras registraban la actividad cerebral con fMRI. A parte de replicar los efectos comportamentales aportando de nuevo evidencia a favor del control cognitivo a nivel de ítem, obtuvieron que el ACC y el DLPFC, que son estructuras tradicionalmente asociadas al control de tipo top-down (Botvinick et al., 2001), se activaban de manera selectiva ante condiciones en las que actuaban procesos de control específicos del ítem. Sin embargo, dicha activación no se daba cuando la proporción de congruencia relativa al ítem era del 50%, lo cual aporta evidencias a favor de la existencia de mecanismos de control automáticos, que están siendo llevados a cabo por estructuras frontales que se han asociado a control consciente y voluntario.

3.2.3. *Context-Specific Compatibility Effect*

La tercera forma que se usa para manipular el porcentaje de congruencia y que también ha contribuido a aclarar la distinción entre control automático y aprendizaje asociativo es la del contexto. En este caso el porcentaje de congruencia se varía en diferentes contextos en los cuales se presentan los mismos ítems. La lógica que sigue esta manipulación es la siguiente: si como ocurre en el ISPCE un ítem puede por sí mismo servir de estímulo para alicitar procesos de control automáticos on-line que inciden directamente sobre los filtros atencionales a usar, según las demandas de la tarea, entonces un determinado contexto que se asocia a un determinado ítem, como por ejemplo puede ser la localización espacial en la que aparece, podrá servir de señal también a la hora de ajustar los procesos rápidamente seleccionando el filtro atencional que corresponda a las demandas actuales de la tarea. Crump et al. (2006) diseñaron un estudio en el que utilizaban una versión de la tarea Stroop en la que se presentaba una palabra que iba seguida de un parche de color que podía presentarse o bien por encima de un punto de fijación o bien por debajo de este. La tarea de los participantes era responder al parche de color, que podía ser congruente o incongruente con respecto a la palabra (prime). La localización del parche de color (arriba o abajo del punto de fijación) era lo que definía el contexto para la manipulación del porcentaje de ensayos congruentes. Así aquellos parches de color que aparecían arriba eran asociados con un porcentaje de congruencia alto (75% de ensayos congruentes), mientras que aquellos que aparecían por debajo estaban asociados a un porcentaje de incongruencia alto (75% de incongruentes). En este tipo de manipulaciones, el porcentaje de congruencia a nivel de lista se mantiene al 50/50. Lo que se obtuvo fue un menor efecto Stroop cuando el contexto era mayoritariamente incongruente (MI), mientras que dicho efecto Stroop se incrementaba en el contexto mayoritariamente congruente (MC). Otros estudios usan como contexto el tipo de letra en el cual aparecen escritas las palabras, en lugar de utilizar la localización espacial (Bugg et al., 2008) obteniendo los mismos resultados.

De nuevo aquí surge la duda de si este efecto es debido a procesos de control automático o a los efectos de aprendizaje debido a la frecuencia de un tipo u otro de ensayos o ítems. Para intentar desentramar esta cuestión Crump y Miliken (2009) realizaron un estudio en el que manipularon el porcentaje de congruencia, tanto a nivel de contexto como a nivel de ítem. En el primer experimento usaron la misma variante de tarea Stroop en la que se presentaban palabras (primes) y parches de color (targets). En este diseño había dos localizaciones (arriba y abajo del punto de fijación) que eran 100% predictivas solo para un subconjunto de palabras-parches de color. A este subconjunto lo llamaron *context probes.* Por lo tanto, el contexto localización no era predictivo para el resto de ítems. A estos los llamo *transfer ítems.* Esta manipulación evitaba que los *transfer probes* se beneficiaran de la variable frecuencia, pues cada *transfer ítem* aparecía el mismo número de veces. La hipótesis que tenían estos autores es que si el CSCE solo se debe a procesos de aprendizaje que se desarrollan por la presentación de un ítem de manera frecuente, no podremos observarlo en los *transfer probes,* si no solo en los *context probes.* Por el contrario, si el CSCE se debe a modulaciónes que proceden de las características del contexto, sí que se observará este efecto, tanto en los *context probes* como en los *transfer probes*. Es más. Lo participantes aprenderán a aplicar determinados parámetros de atención selectiva para controlar la ejecución de la tarea en los *context probes*, y transferirán ese aprendizaje a la ejecución en los *transfer probes*. Este efecto de transferencia que requiere de la experiencia de los participantes con los *context probes* se potenciará con la práctica y será menos visible al principio de la sesión. Efectivamente observaron CSCE en los *transfer probes*. Pese a que estos ítems se presentaban con la misma frecuencia, sufrieron las influencias del contexto, mostrando un mayor efecto Stroop cuando se presentaban en el contexto MC en comparación con los que presentaban en el contexto MI. Este efecto de transferencia supone evidencia clara la existencia de ajustes en el control que se producen de manera rápida, on-line y automáticamente generados por el contexto, puesto que los procesos que se han ido aplicando para los *context probes*, en una situación totalmente predictiva, se han trasferido de manera automática a los *transfer probes*, que se presentan en una situación en la que los participantes no pueden predecir ni anticipar el tipo de estrategia que deben utilizar.

Aunque por motivos de interés en esta tesis nos estamos basando en los estudios que utilizan la tarea Stroop o alguna variante de esta, similares resultados en la manipulación del porcentaje de congruencia se han obtenido con otro tipo de paradigmas, como por ejemplo la Tarea de Flancos (Eriksen y Eriksen, 1974), tanto en las manipulaciones de este porcentaje a nivel de lista, como de ítem o de contesto (Corballis y Gratton, 2003; Lehle y Hübner, 2008).

4. ACLARANDO EL CONCEPTO DE CONSCIENCIA

Como hemos visto al estudiar los fenómenos de adaptación al conflicto, el cerebro es capaz de procesar ciertos aspectos de la información a unos niveles complejos sin que la persona sea consciente de dicho procesamiento, lo que nos lleva a plantearnos más específicamente la cuestión de la existencia de procesos de control no conscientes. El interés por el estudio de dichos procesos se remonta a los comienzos de la Psicología Experimental. Una de las primeras estrategias que se usaron para estudiar estos procesos experimentalmente, fue la degradación de un estímulo hasta que la persona era incapaz de percibirlo. Otra de las estrategias era disminuir cada vez más el tiempo de presentación de dicho estímulo, de modo que llegara un momento en el que se presentaba lo suficientemente rápido para que la persona no pudiera percibirlo. Al valor crítico de intensidad o de tiempo de exposición de un estímulo por debajo del cual una persona es incapaz de percibir dicho estímulo, se le llamó ***umbral de consciencia***. Este umbral puede ser de dos tipos: podemos hablar de *umbral subjetivo de consciencia*, cuando nos referimos a la condición mínima de estimulación necesaria para que una persona tenga experiencia de percibir un determinado estímulo. De la misma manera hablamos de umbral objetivo de consciencia cuando nos referimos a la condición mínima de estimulación por debajo de la cual una persona ejecuta una tarea al azar.

Podría decirse que las medidas de umbral objetivo y umbral subjetivo forman parte de un continuo de percepción, en el que el umbral objetivo marcaría el punto en el que tenemos la total certeza de que una persona no es consciente de lo que se le está presentando y donde el umbral subjetivo sería el punto en el que estando más próximos a la percepción consciente, la persona siente que no es capaz de percibir aquello que se le está presentando. Cabe resaltar la importancia que en investigación tiene el umbral subjetivo de consciencia, pues es el que define el término de consciencia propiamente dicho. Aquellos estímulos que se sitúan por debajo del umbral subjetivo no son reportables por la persona, como ocurre en determinadas patologías neuropsicológicas como el *neglect* o el *blindsight*. Sin embargo, aunque no existe reportabilidad, la ejecución de pacientes con estos déficits en tareas de detección está por encima del azar.

A nivel teórico, Dehaen y Changeoux (2005) desarrollaron un modelo neural de espacio de trabajo en el que postulan que las proyecciones colinérgicas que parten del bulbo raquídeo en sentido ascendente, mandan señales neuro-moduladoras al tálamo y la corteza. Para que esas señales puedan ser enviadas, debe existir un estado de vigilancia óptimo. Se ha observado que un buen estado de vigilancia correlaciona con actividades en el bulbo raquídeo y en el tálamo y posteriormente en el córtex, cobrando importancia las conexiones funcionales entre el cortex prefrontal y ACC (Balkin, et al., 2002). Como vemos estas estructuras corticales son las mismas que se asocian al control cognitivo, por lo que esto apoyaría la necesidad de la consciencia para que estos procesos puedan llevarse a cabo.

En base a este modelo teórico Dehaene, Changeux, Naccache, Sackur y Sergent (2006) desarrollaron una nueva tipología conceptual para clasificar y diferenciar diferentes tipos de procesamiento estimular. Según ellos habría tres tipos: ***consciente*** sería aquel tipo de procesamiento que permite que la persona pueda reportar lo que está percibiendo. Para que se de este tipo de procesamiento es necesario y fundamental que se activen las proyecciones frontales, que comunican las estructuras subcorticales con la corteza cerebral.

Por otra parte ***pre-consciente*** sería aquello que aún no llegando en un principio a ser consciente, podría serlo si se dirige la atención hacia el estímulo. Numerosos ejemplos de procesamiento pre-consciente se ha encontrado en la literatura y en la historia de la Psicología. De esta manera, es en esto en lo que se basaba la terapia psicológica de Freud, que pretendía que la persona atendiera a aspectos de su psique que se mantienen a un nivel inconsciente, pero que con las técnicas adecuadas puede salir a la luz y ser tratado. Otros ejemplos son el parpadeo atencional, la ceguera por inatención o la ceguera al cambio.

Por último ellos se utilizaban el término ***subliminal*** para hacer referencia a aquello que aunque la persona le preste atención la información no llega a acceder a la consciencia, porque de alguna manera el procesamiento queda interrumpido y no puede darse la reverberación de las proyecciones frontales. Un claro ejemplo de este fenómeno sería el proceso de enmascaramiento. En dicho proceso el estímulo se presenta o bien demasiado rápido como para que la persona no sea capaz de procesarlo, o bien degradado hasta un punto en el que el procesamiento no es posible o bien seguido de otro estímulo que actúa de máscara y que impide que el procesamiento del primer estímulo pueda llevarse a cabo. Este tipo de experimentos se han realizado manipulando también el porcentaje de congruencia, a fin de observar si se producen efectos de adaptación al conflicto a nivel no consciente. De esta manera, los participantes no pueden ser conscientes de la relación de conflicto existente entre el prime y el target y por tanto no pueden establecer ninguna estrategia deliberada para adaptarse al conflicto (Klapp, 2007 experimentos 2 y 3). Lo que estos estudios muestran es que incluso así, los participantes presentan efectos de adaptación al conflicto. No se puede equiparar el término consciencia con el término percepción, de manera que ser consciente de algo es percibir ese algo, puesto que la percepción incluye multitud de procesos de los que la persona no es consciente. El resultado de percibir requiere de una serie de procesos previos que no van a acceder a la consciencia, de modo que sin ellos no habrá percepción.

Una vez que se han estimado los valores de umbral perceptivo, se usan dichos valores como tiempo de presentación de los estímulos de la fase experimental.. Numerosos estudios muestran que el valor crítico de tiempo de presentación de un estímulo, por debajo del cual éste ya no es conscientemente percibido se sitúan en torno a los 30 ms (Greenwald, Klinger, & Liu, 1989; Daza et al., 2002; Klapp, 2007, Ortells, Marí-Beffa, & Plaza-Ayllón, 2012).

Mediante el uso de este tipo de experimentos, usando valores tanto de umbral objetivo como de umbral subjetivo, se ha podido comprobar que las personas son capaces de discriminar numerosos aspectos de los estímulos de manera no consciente, llegando incluso a ser capaces de discriminar el significado de las palabras (Ruz, Madrid, Lupiáñez y Tudela, 2003) y la expresión emocional de las caras.

5. NUESTRA INVESTIGACIÓN

El objetivo principal de nuestra investigación es aportar evidencia a favor de la existencia, de procesos de control no conscientes. Con este fin realizamos dos series experimentales en las que se registró la actividad cerebral usando potenciales corticales evocados (ERPs), con objeto de estudiar la temporalidad de los procesos. Consideramos muy importante el uso de este tipo de técnicas para estudiar los procesos de adaptación al conflicto de manera no consciente, pues nos pueden dar información sobre los mecanismos cerebrales que van a estar actuando a la hora de resolver ese tipo de conflicto, así como el momento en el que dicho proceso está ocurriendo, cosa que hasta ahora no ha sido descrita en la literatura sobre esta temática. Nuestro objetivo a este respecto es ver si realmente se producen efectos de adaptación al conflicto no consciente, y si se producen, ver si dicha adaptación implica los mismos mecanismos cerebrales, o similares, a los que están implicados en el control consciente. Por tanto, este tipo de medidas proporcionan información adicional sobre cómo el cerebro está respondiendo ante los estímulos previos (primes), que en nuestro caso estarán enmascarados, así como sobre la respuesta hacia el objetivo. También esperamos obtener información acerca de la relación de congruencia entre ambos, primes y objetivo, y del procesamiento de la manipulación de la proporción de la congruencia. (Desender y Van den Bussche, 2012).

La primera serie experimental consta de un experimento en el cual usamos una variante de la tarea Stroop y seguimos un paradigma de enmascaramiento, mientras se registraba la actividad cerebral. El objetivo de este estudio fue doble: por una parte quisimos estudiar el efecto Stroop en condiciones de enmascaramiento y ver cómo influye la manipulación de la proporción de congruencia cuando ésta se asocia a un determinado contexto, que en nuestro caso fueron dos tipos de máscaras utilizadas para evitar que se produjera el procesamiento consciente de los primes. Por otro lado quisimos observar el curso temporal de activación neural que se producía al procesar la proporción de congruencia y la relación de congruencia entre la palabra que designa color y el objetivo.

Usamos un conjunto de ensayos en los cuales enmascaramos una palabra que designaba un color. Previamente creamos una expectativa sobre la aparición de dicha palabra calibrando de manera individual el umbral subjetivo por debajo del cual el participante informaba no percibir dicha palabra, partiendo de una condición en que la misma era plenamente visible. Así pretendimos mantener constante la expectativa del prime pese a que éste permanecía enmascarado. Se ha demostrado que mantener dicha expectativa puede generar un priming semántico subliminal entre el prime y el objetivo (Martens, Ansorge & Kiefer, 2011). Manipulamos, a su vez, el porcentaje de congruencia a nivel de ítem, manteniendo la proporción de ensayos congruentes e incongruentes a nivel de lista al 50/50 y asociamos las distintas proporciones de congruencia con cada uno de los tipos de máscara, de manera que sistemáticamente una máscara creaba un contexto de más incongruencia que la otra.

En la segunda serie experimental nos propusimos comparar el conflicto cognitivo con el emocional, manipulando las principales variables relacionadas tanto con el conflicto (congruencia) como con la adaptación al conflicto (congruencia previa y porcentaje de congruencia). Para este fin utilizamos la tarea de categorización de caras (Egner y Hirsch, 2005b), en la cual los participantes debía clasificar una serie de caras en función del género (tarea no emocional) o en función de la expresión emocional de las caras (tarea emocional). En el primer experimento, superpuesta a la cara, aparecía una palabra que podría ser congruente o incongruente con el género (tarea no emocional) o con la expresión de las caras (tarea emocional). En este experimento los participantes tuvieron acceso consciente a los estímulos, tanto palabras como caras. En el segundo experimento las palabras aparecieron enmascaradas previamente a la presentación de las caras, replicando en gran parte el procedimiento del experimento de la primera serie.

Capítulo 2

SERIE EXPERIMENTAL I:

Unconscious context-specific proportion congruency effect in a stroop-like task

El contenido de este capítulo ha sido publicado como Panadero, A., Castellanos, M. C., & Tudela, P. (2015). Unconscious context-specific proportion congruency effect in a stroop-like task. *Consciousness and cognition*, *31*, 35-45.

Abstract

Cognitive control is a central topic of interest in psychology and cognitive neuroscience and has traditionally been associated with consciousness. However, recent research suggests that cognitive control may be unconscious in character. The main purpose of our study was to further explore this area of research focusing on the possibly unconscious nature of the conflict adaptation effect, specifically the *context-specific proportion congruency effect* (CSPCE), by using a masked Stroop-like task where the proportion of congruency was associated to various masks. We used electrophysiological measures to analyze the neural cor- relates of the CSPCE. Results showed evidence of an unconscious CSPCE in reaction times (RTs) and the N2 and P3 components. In addition, the P2 component evoked by both target and masks indicated that the proportion of congruency was processed earlier than the con- gruency between the color word and the ink color of the target. Taken together, our results provided evidence pointing to an unconscious CSPCE.

1. Introduction

In a Stroop task, participants have to name the ink color of color words (Stroop, 1935, experiment 2). In a more recent version of the task, two different conditions are usually presented: congruent and incongruent. In the congruent condition, the ink color matches the color name of the word (e.g., RED in red ink). In the incongruent condition, by contrast, the ink color is different from the color name of the word (e.g., BLUE in red ink). To perform the task in the incongruent condition, participants must avoid the automatic process of reading the word and name the color of the ink in which the word is printed by using control strategies. In the congruent condition, the ink color matches the color name of the word, so avoidance of the automatic reading process is not necessary. Consequently, reaction times (RTs) are longer in the incongruent condition than in the congruent one. This additional time is known as *Stroop interference* or *Stroop effect*.

Stroop interference is affected by the relative proportion of congruent and incongruent trials. Behavioral studies have shown a reduction in RTs in incongruent trials presented in a context of low congruency (Logan & Zbrodoff, 1979). In other words, when the proportion of incongruent trials is higher than that of congruent trials, the Stroop effect is smaller than in situations in which the proportion of congruent trials is predominant. It seems as if frequent experience with conflicting stimuli or response features facilitates the resolution of interference. In general terms, this facilitation is known as the *conflict adaptation effect* (Botvinick, Braver, Barch, Carter, & Cohen, 2001).

Over the years, this improvement in control has been attributed to different factors. The main ones are the overall proportion of congruency at the list level (*proportion of congruency effect*, PCE) and a more specific and online processing of the information either at the item level (*item-specific proportion congruency effect,* ISPCE) or at the context level (*context-specific proportion congruency effect,* CSPCE). Proponents of the PCE (Logan, Zbrodoff, & Williamson, 1984) argue that in a Stroop task subjects become aware of the contingency between the color and the word and adapt their strategies to attend to the word when the proportion of congruent trials is higher than that of incongruent ones and ignore the word when the proportion of congruent and incongruent trials is reversed. Consequently, the Stroop effect is larger when the proportion of congruent trials is predominant because the color word is likely to be attended to in incongruent trials. By contrast, when the proportion of congruent trials is lower than that of incongruent trials, the Stroop effect is smaller than in the previous case because the color word is mostly ignored in incongruent trials. According to this approach, the proportion of congruent items influences performance at a list-wide level by switching participants' attention to one of the two dimensions depending on which one is relevant for the task.

At computational and neural levels of analysis, Botvinick et al. (2001; see also Botvinick, Cohen, & Carter, 2004; McDonald, Cohen, Strenger, & Carter, 2000) implemented these ideas in what they termed the *conflict-monitoring hypothesis.* According to these authors, the Stroop task is just a particular case of conflict resolved by the interplay of a set of neural structures. The dorsal anterior cingulate cortex (dACC) acts as a detection mechanism that responds to the occurrence of a conflict situation (i.e., an incongruent trial in a Stroop task). The conflict signal triggers strategic adjustments in the dorsolateral prefrontal cor- tex (DLPFC) and other posterior and subcortical structures that serve to prevent conflict in subsequent performance. Accord- ingly, in a list where incongruent trials outnumber congruent ones, strategic adjustment mechanisms will be highly operative, thus minimizing the influence of the color word on performance and reducing the Stroop effect. For the purposes of the pres- ent study, it should be underlined that PCE proponents understand control as a strategic and conscious process.

Proponents of the ISPCE contend that the proportion congruency effect acts at the item level. Jacoby, Lindsay, and Hessels (2003) chose six colors and their corresponding color words and divided them into two sets of equal size. To produce mostly congruent (MC) items, words in one set were presented in their congruent colors in eighty percent of trials and in another color from that set in the remaining twenty percent of trials. These rates were reversed in words from the other color set to produce mostly incongruent (MI) items. The proportion of congruency at the list level was fifty percent. This manipulation of proportions prevents subjects from developing a general list-level strategy because the proportion of congruent and incon- gruent items is the same. However, Jacoby et al. found that MC items showed a larger Stroop effect than MI items. From a computational approach, Blais, Robidoux, Risko, and Besner (2007) showed that Botvinick's *conflict-monitoring model* could not explain the ISPCE and proposed a modified model according to which the DLPFC exerts control at the specific item level rather than at the general list level. Results similar to those of Jacoby et al. were obtained by Crump, Gong, and Milliken (2006) in a situation in which the likelihood of congruency was associated to a task-irrelevant location context rather than to a particular color word. According to these authors, the ISPCE belongs to a larger class of effects known as *context-specific proportion congruency effect* (CSPCE) that is driven by the relationship between the context and the likelihood of congruency. In recent years, the CSPCE has been reported in a range of Stroop-like effects (Bugg, Jacoby, & Toth, 2008; Crump, Vaquero, & Milliken, 2008; for a review, see Bugg & Crump, 2012) and in different types of contexts, including social categories (Cañadas, Rodríguez-Bailón, Milliken, & Lupiáñez, 2012). An interesting characteristic of the CSPCE is that the type of control involved cannot be assumed to be a strategic, deliberate and conscious process. Instead, this type of control seems to be automatic (Jacoby et al., 2003) and unconscious. In fact, the effect has been shown to be independent of participants' awareness of the proportion of congruency manipulation (Crump et al., 2008).

The main purpose of the present research was to further explore the likely unconscious character of the conflict adaptation effect in a Stroop task by asking subjects to name the color of a color patch that was preceded by a masked color word. We used two masks (one previous to the color word and one following the color word) and calibrated the duration of the color word individually for each participant until it was unnoticed. Under similar masking conditions to ours, this variable has been used in some studies in which the proportion of congruency was manipulated in an effort to find qualitative differences between conscious and unconscious processes (Daza, Ortells, & Fox, 2002; Merikle & Joordens, 1997). In those experiments, the usual Stroop effect was observed under masked color word conditions. Yet, the effect was reversed when the color word was easily seen, as participants exhibited faster RTs in incongruent trials than in congruent ones. The PCE effect has also been explored under masked conditions in other experiments. Klapp (2007, Experiment 3) used a spatial Stroop-like task involving successively presented arrows pointing in either the same direction (i.e., compatible condition) or the opposite direction (i.e., incompatible condition). The first arrow was presented for 32 ms and was immediately followed by the mask and the second arrow, so that the first arrow was unnoticed to the subjects. Results revealed a significant interaction. Specifically, the difference in RTs between compatible and incompatible conditions was greater when the arrows pointed in the same direction than when they pointed in opposite directions. However, in Klapp's experiment (2007), participants received feedback for incorrect responses, which makes it difficult to interpret his results. A possible explanation could be that subjects adapted their responses to conscious error rates rather than to the unconscious frequency of congruent and incongruent trials. Heinemann, Kunde, and Kiesel (2009) explored the CSPCE under masked conditions using a task in which subjects had to categorize target numbers as being larger or smaller than five. The target was preceded by a masked number (i.e., the prime) that could be congruent or incongruent with the target. At the beginning of each trial, a colored rectangle was presented as background simultaneously with the fixation cross. The color of the rectangle was associated with a particular congruency context that could be either 80% or 20%. Results showed that the difference in RTs between congruent and incongruent trials was significantly higher in the 80% than in the 20% congruent trial condition but only when subjects were able to see the prime; no differences were observed when they could not see it. (Heinemann et al., 2009). The authors concluded that the CSPCE requires conscious representation of the conflicting information, namely prime, target and context (Kunde, Reuss, & Kiessel, 2012).

It seems that the unconscious conflict adaptation effect has not been clearly established. First, studies of the PCE under unconscious conflict conditions are difficult to interpret due to the presence of confounding factors. Second, the CSPCE seems to occur only when the conflicting information is consciously perceived. We considered that it would be interesting to explore the conflict adaptation effect by associating the proportion of congruent and incongruent trials to different masks and using electrophysiological recordings at the same time to study the brain response to both conflict adaptation and the proportion of congruency.

We partly followed a procedure developed by Blais, Tudela, and Bunge (2007) and used two different types of masks. One type of mask was associated with mostly congruent trials and a second type of mask was associated with mostly incongruent trials. Each mask appeared an equal number of times within each block. Yet, one mask was followed by 33% congruent and 66% incongruent color words the other mask was followed by the opposite proportion of congruent and incongruent trials. Thus, the total number of congruent and incongruent trials was kept the same in each block.

The use of brain activity-related measures to study the unconscious conflict adaptation effect has been highly recommended (Desender & Van den Bussche, 2012). Such measures can provide additional information about the brain response not only to targets and masked primes but also to the processing of the congruency relation between prime and target and of the proportion of congruency. In an influential study, Dehaene et al. (2003), Dehaene, Sergent, and Changeux (2003) used functional magnetic resonance imaging (fMRI) and a Stroop-like task in which subjects were asked to decide whether target numbers were larger or smaller than five. Targets were always preceded by another number (i.e., the prime) that could be congruent with the target (i.e., both numbers greater or smaller than five) or incongruent (i.e., one number larger and the other one smaller than five). In addition, the numbers could be either visible or made invisible by masking. They found that normal subjects showed a clear activation of the anterior cingulate cortex (ACC) when the prime could be consciously pro- cessed; by contrast, no ACC activation was observed when the prime was masked. Interestingly, they also observed impaired conscious priming but normal subliminal priming in patients with schizophrenia who exhibited a hypoactivation of the ACC. These authors concluded that subliminal conflicts are resolved without ACC involvement. It seems logical to conclude that if the control structures of the brain do not play a role in subliminal priming, they are not likely to participate in conflict adaptation effects. However, in a recent experiment using fMRI, Blais and Bunge (2010) found that many of the regions involved in cognitive control in the Stroop task, including the ACC and DLPFC, were operative at a local item level.

In the literature on electroencephalography (EEG), ACC activation has been associated with the N2 component, a negative deflection in the averaged event-related potential (ERP) wave with a fronto-central scalp distribution that peaks around 250–350 ms after stimulus presentation (Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004). Consistent with the role of the ACC in the conflict-monitoring theory, the amplitude of this component has been found to be more negative in incompatible trials compared to compatible trials (Clayson & Larson, 2011; Wendt & Luna-Rodríguez, 2009). Moreover, the P3 component, a positive deflection in the averaged waveform with a central–

parietal distribution that occurs 350–500 ms after stimulus presentation, has been associated with response conflict and has been found to be more positive in incongruent trials compared to congruent trials (Clayson & Larson, 2011; Frünholz, Godde, Finke, & Herrmann, 2011). Research conducted by Clayson and Larson (2011) is of particular interest for the present study. In a flanker task, these authors studied the sequential effect of the previous trial on the N2 and P3 components as a function of its congruency (Gratton, Coles, & Donchin, 1992). This effect is considered to reflect conflict adaptation and seems to be closely related to the proportion con- gruency effect (Botvinick et al., 2001). Clayson and Larson's results showed that in both components (i.e., N2 and P3), the difference in amplitude between an incongruent and a congruent trial was lower when the previous trial was incongruent than when it was congruent. As for the ISPCE effect, Shedden, Milliken, Walter, and Monteiro (2012) analyzed various ERPs in a recent study and failed to find a scalp signature directly related to the conflict adaptation effect both in a global–local task and in a standard Stroop task. However, these authors observed that subjects distinguished the proportion congruency cat- egory before the congruency of the specific stimulus as early as 100 ms post-stimulus onset in the global–local identification task and 150 ms in the Stroop task.

To the extent that unconscious conflict adaptation may also involve the activation of control structures in the brain, we expected to find a conflict adaptation effect in a late (i.e., N2 or P3) event-related component in our experiment. In a recent experiment, Jiang, van Gaal, Bailey, Chen and Zhang (2013) reported an unconscious block-wise proportion congruency effect (PCE) in N2 and P3 amplitudes using a meta-contrast masked priming task. However, to our knowledge, no unconscious ISPCE or CSPCE has been observed yet. On the other hand, if proportion congruency is processed earlier than the congruency of the specific stimulus, as reported by Shedden et al. (2012), we should expect a similar effect in our experiment since participants are usually unaware of the proportion of congruency manipulation even under regular non-masked conditions.

In summary, the goals of our current research were to explore the Stroop effect under unconscious conditions and to observe how the proportion of congruency modulates this effect when it is associated to a particular context. We also intended to study the time course of neural activation related to processing of the proportion of congruency, the congruency between the color word and the color of the target, and the interaction between item congruency and proportion of congruency that defines the CSPCE. We focused on analyzing the unconscious situation by using an extended set of color-word masked trials. However, we tried to maintain an expectation of the presence of a color word between masks by calibrating the duration of the color word individually for each participant until it was unnoticed and by including a trial block in which the color word could be easily seen at the end of each session. It has been recently reported (Martens, Ansorge, & Kiefer, 2011) that subliminal semantic priming can be modulated by attentional task set. In this experiment we tried to keep the Stroop task set constant while the processing of the color word remained unconscious.

2. Material and methods

2.1. Participants

Twenty-nine students of the University of Granada (21 females and 8 males) participated in a two-session experiment. Sessions were separated by a one-week interval. Participants reported having normal or corrected-to-normal vision and were not aware of the purpose of the experiment. Mean age was 23 years (SD = 4.26). Participants received course credit in exchange for their participation and signed a consent form approved by the local Ethics Committee.

2.2. Stimuli and apparatus

Three different types of stimuli were presented: three colored prime words, two different masks and three colored rect-angles as targets. The color words were GRIS (GREY), ROJO (RED) or AZUL (BLUE), and the masks could be either @@@@ (visual angle: 4.581º wide by 0.802º high) or #### (visual angle: 6.867º wide by 0.802º high). Each mask was associated with a different percentage of congruency condition. Words and masks were presented in 18 Courier New letter font in white on a black background; words subtended a visual angle 3.437º wide and 0.802º high. Targets were colored rectangles with a visual angle 8.008º wide and 2.864º high. They could appear in gray, red or blue in the center of the screen. All stimuli were presented on the

17-in. color screen of a PC at a viewing distance of about 50 cm. The PC was connected to a Macintosh com- puter to record ERPs. The entire task was created and displayed using E-Prime 1.2 Professional software (Schneider, Eschman, & Zuccolotto, 2002).

2.3. Procedure and design

2.3.1. Procedure

The experiment consisted of two sessions separated by a one-week interval. Both sessions had the same structure. Each session had two parts: a threshold setting stage followed by an experimental section. The awareness threshold was deter- mined for each participant as follows: first, a cross served as a fixation point and was presented in the center of the screen for 1000 ms. Next, a color word immediately preceded and followed by the same mask appeared. The preceding mask was dis- played for 109 ms and the following mask was displayed for 689 ms. At the beginning, the word was presented for 100 ms, a time interval that participants could easily perceive. Participants had to report whether or not they were able to see the word. If the answer was ‘‘yes’’, the presentation time of the word was shortened in 10 ms steps (equivalent to one refresh rate of the computer screen). If the answer was ‘‘no’’, the presentation time of the word was kept constant and the procedure was repeated until the answer remained ‘‘no’’ for three consecutive trials. The presentation time obtained was set as the awareness time threshold for the particular subject. The second part of each session consisted of four seventy-two masked trial blocks with the following event sequence: a fixation point appeared for 1000 ms and was followed by the first mask, which lasted 109 ms. Next, one of the three color words was presented for the time determined in the previous part of the experimental session and was followed by the same mask, which lasted 689 ms. The stimulus-onset asynchrony (SOA) value between the second presentation of the mask and the target stimuli was 1000 ms. The target stimuli were color rectangles in either grey, red or blue ink, which were displayed until the participant responded by pressing the 1, 2 or 3 num- ber keys of a Qwerty keyboard for gray, red and blue, respectively. Participants' response was followed by an intertrial inter- val that varied randomly between 1000 and 1500 ms (see Fig. 2.1A).

After the four masked blocks, all subjects performed an additional block where the word was presented for 100 ms. The main purpose of this unmasked block was to make subjects aware that a color word was presented between the two masks, thus maintaining the expectation of a word between masks as part of the task set throughout the experiment.[1] At the beginning of the entire procedure we instructed participants to concentrate on the mask and respond as fast as possible to the color of the rectangle.

[1] Since the main purpose of this experiment was to explore unconscious conflict adaptation, we used an extended number of masked trials but did not use the same number of unmasked trials to avoid discouraging participants. Therefore, data from the two unmasked blocks are not reported.

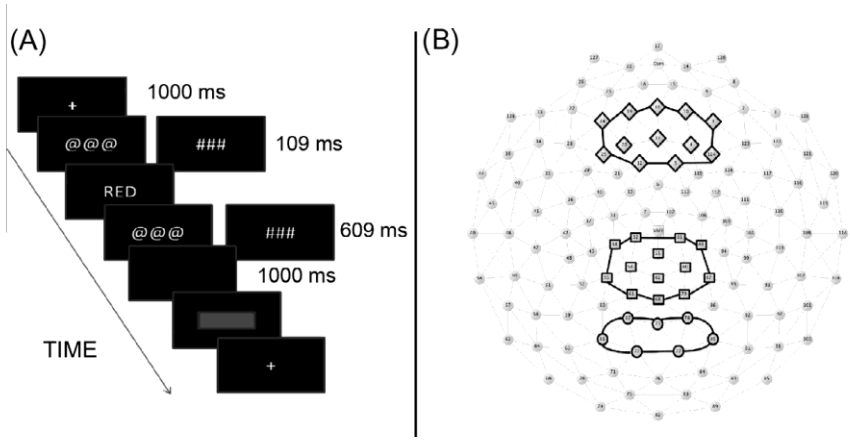


Figure 2.1. *(A) Sequence of events in an incongruent trial. Words have been translated to English. (B) Groups of electrodes selected for P2 (circles), P3 (squares) and N2 (rhombuses) components. Topographies of the average temporal windows of analysis show the maximum level of amplitude for each group of electrodes.*

2.3.2. Design

Within each block of 72 masked trials two independent variables were manipulated, namely congruency (congruent vs. incongruent trials) and percentage of congruency (33% vs. 66%). Each percentage was associated with a particular mask (#### or @@@@). In our 33% condition, 12 trials were incongruent and 24 were congruent. On the other hand in the 66% condition, 24 trials were incongruent and 12 were congruent. Thus, the number of congruent and incongruent trials remained the same within each block and each mask appeared an equal number of times but was associated with a different percentage of congruency.

2.4. EEG recording and data analysis

Participants were seated in front of the computer monitor in an electrically shielded room. They were instructed to avoid eye blinking and moving during stimulus presentation and response. The EEG was recorded using a high-density 128-channel Geodesic Sensor Net (Tucker, 1993). The head coverage included sensors lateral to and below both eyes to mon- itor horizontal and vertical eye movements. The EEG net was connected to an AC-coupled, high-input impedance amplifier (200 MX). At the beginning of the recording session, the impedance of each channel was measured and kept under 50 kX, as recommended for Electrical Geodesics high-input impedance amplifiers. Amplified analog voltages (0.1–100 Hz band pass) were digitized at 250 Hz (12-Bit A/D converter and 0.02 lV minimum resolvable voltage). All channels were referenced to the Cz electrode during the recording and were algebraically re-referenced to the average off-line.[2]

The continuous EEG was filtered offline using a 30 Hz low-pass filter. Next, it was segmented in epochs of 200 ms before and 600 ms after target onset. A 200 ms segment previous to the target presentation was used to calculate the baseline. The epochs were submitted to software processing in order to identify artifacts. Segments with eye movements, eye blinks (i.e., electro-oculogram channel differences greater than 70 lV), more than 20% of bad

[2] Following the suggestion made by one reviewer, we also re-referenced all channels to a linked mastoid reference. The outcome of the data analysis using this reference is presented in the results section.

channels or incorrect responses were not included in the ERPs. Data from consistent bad channels were later replaced using a spherical interpolation algorithm (Perrin, Pernier, Bertrand, & Echallier, 1989). A minimum criterion of 30 artifact-free trials per participant and condition was established to maintain an acceptable signal-to-noise ratio. A final grand average was obtained for each condition by pooling subjects' averages in each experimental condition. Eight group-average ERP waveforms were constructed according to session (*first* vs. *second*), congruency percentage (*33%* vs. *66%*), and current congruency (*congruent* vs. *incongruent*). Conditions were equated in number of trials, $F < 1$.

To facilitate the selection of spatiotemporal windows for amplitude analyses, the topographic maps provided by the Net Station Viewer (EGI, 2008) were used as a guide. Topographic map views display samples as representations of the scalp projected onto disk-shaped maps (also referred to as *scalp maps*) where amplitudes are represented by colors. In such views, the amplitudes between sensors are interpolated, which allows the entire surface of the head to be depicted, thus providing a view of the voltage distribution (i.e., topographies) over the scalp for each experimental condition as a function of time. As shown in Fig. 2.1B, visual analysis of the scalp maps revealed two main focuses of activity in the ERPs: a posterior focus, which included seven parieto-occipital electrodes (shown as circles) and remained for 205–275 ms after target presentation, and a second more central focus, which included thirteen parietal electrodes (shown as squares) and remained for 360–400 ms after the presentation of the target. These two topographies corresponded to the P2 and P3 components. Voltage analysis was performed on a 40 ms window centered at the P2 peak (240 ms) of the grand average waveform for the posterior location and on a 20 ms window centered at the P3 peak (380 ms) for the central location. Using a mastoid reference, the scalp maps revealed an additional focus of activity in the ERPs: a frontal focus, which included twelve electrodes (shown as rhombuses) centered on the midline and remained for 260–300 ms after target presentation. This topography corresponded to a N2 component. Voltage analysis was performed on a 40 ms window centered at the N2 peak (280 ms) of the grand average waveform.[3] Trials that did not meet the criteria regarding the amount of artifacts and bad channels were eliminated for each participant. Mean amplitude voltages averaged over the selected channels and time windows were submitted to repeated-measures ANOVAs with Session, Congruency Percentage and Congruency as factors. The same ANOVA was used with subjects' accuracy and RTs.

[3] After analyzing this twelve-channel focus using a mastoid reference, we also analyzed the N2 component of the twelve channels using an average reference. Results are presented in the corresponding section

3. Results

3.1. Behavioral results

3.1.1. Threshold setting

The average presentation time of the masked words at threshold value was 15.97 ms (SD = ± 5.53 ms) in the first session and 16.66 ms (SD = ± 8.03 ms) in the second session. A comparison between these two threshold values showed no significant differences between sessions, $t = .586$, $p = .562$.

3.1.2. RT analysis

Overall accuracy was very high (99%) and no difference in accuracy was observed between experimental conditions. Only correct responses were considered in the RT and ERPs analyses. RTs shorter than 300 ms or longer than 1000 ms were excluded as outliers (3%).

No significant main effects were found in the analysis of RTs; however, the interaction between Congruency Percentage and Congruency was significant, $F(1, 27) = 5.014$, $p < .05$ (see Fig. 2A). Planned comparisons showed that, when the propor- tion of incongruent trials was low (33%), responses to incongruent trials (mean = 525 ms, SD = ± 43.5 ms) were slower than responses to congruent trials (mean = 515 ms, SD = ± 49 ms), $F(1, 27) = 4.8$, $p < .05$. By contrast, no difference in RTs was observed between congruent and incongruent trials (mean = 522.25 ms, SD = ± 41.75 ms) when the proportion of incongruent trials was high (66%),

$F(1, 27) = .02$, $p > .1$. Thus, the expected conflict adaptation effect was found in RT measures.

As some authors have argued that the proportion congruency effect is related to the conflict adaptation sequential effect (e.g., Botvinick et al., 2001), we further analyzed RT data including the congruency or incongruency of the previous trial as a new independent variable. No significant effects were found.

3.2. Electrophysiological data

3.2.1. Target analysis

As mentioned above, inspection of the scalp topographies revealed a P2 positive polarity lasting from 205 to 275 ms after target presentation over a set of parieto-occipital electrodes. As shown in Fig. 2B, waveforms for the percentage of congruency conditions showed a difference in amplitude that peaked around 240 ms. A window of 80 ms around this peak was analyzed.

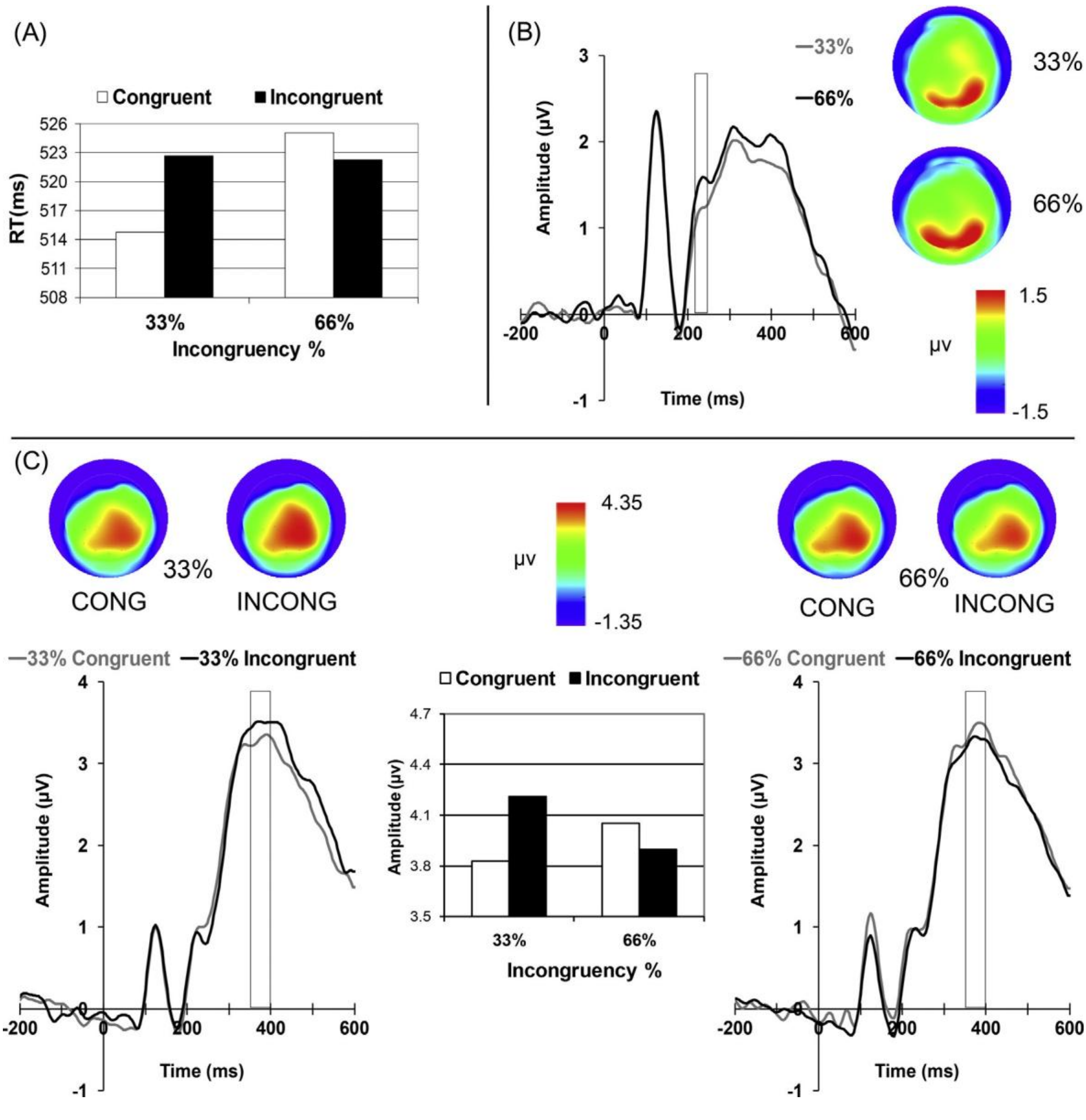


Figure 2.2. *(A) Interaction of Incongruency percentage x Congruency effect on RT. (B) Waves and topographies of the main effect of Incongruency percentage on the P2 amplitude. (C) Waves and topographies corresponding to the interaction of Incongruency percentage x Congruency on the P3 amplitude. The 33% effect on Congruency appears on the left (33% congruent in gray and 33% incongruent in black) while the 66% effect on Congruency appears on the right (66% congruent in gray and 66% incongruent in black). In the center we present the amplitude table for this interaction.*

The amplitude in the 66% incongruent trial condition (mean 66% = 1.459, SD = ± 2.046) was higher than the amplitude in the 33% incongruent trial condition (mean 33% = 1.239, SD = ± 2.042). This difference was found to be significant, $F(1, 27) = 7.206$, $p < .05$. No effect of the congruency variable was found in this time window. This main effect of the percent- age of congruency was not significant when a linked mastoid reference was used.

A second, later positive polarity (P3) was identified between 360 and 400 ms at a more central position encompassing thirteen electrodes. An amplitude analysis of this window showed no significant main effect but revealed a significant inter- action between congruency percentage and congruency, $F(1, 27) = 9.622$, $p < .01$. As shown in Fig. 2C, the amplitude was higher in incongruent trials (mean 33% I = 4.209, SD = ± 2.168) than in congruent trials (mean 33% C = 3.825, SD = ± 2.118) when the percentage of incongruent trials was low (33%), and this difference was significant, $F(1, 27) = 6.508$, $p < .05$. By contrast, this trend was reversed when the percentage of incongruent trials was high (66%); in this case, the amplitude was higher in incongruent trials (mean 66% I = 3.897, SD = ± 2.003) than in congruent trials (mean 66% C = 4.052, SD = ± 2.189), although this difference did not reach significance, $F > .1$.

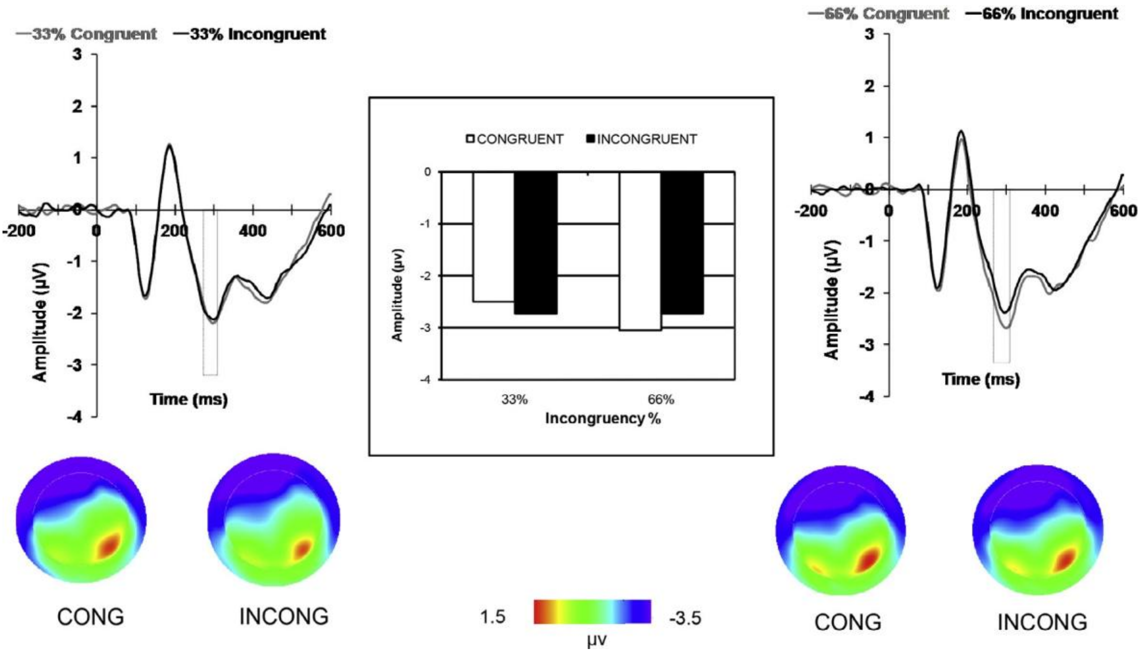


Figure 2.3. *Waves and topographies corresponding to the interaction of Incongruency percentage x Congruency on the N2 amplitude. The 33% effect on Congruency appears on the left (33% congruent in gray and 33% incongruent in black) while the 66% effect on Congruency appears on the right (66% congruent in gray and 66% incongruent in black). In the center we present the amplitude table for this interaction.*

This interaction was also significant when a mastoid reference was used, $F(1, 27) = 4.403$, $p < .045$. It was mainly produced by a significant decrease in amplitude in incongruent items from the 33% condition (mean = 4.72, SD = ±.438) to the 66% condition (mean = 4.31, SD = ±.382), $F(1,27) = 4.403$, $p < .05$. Thus, we also found a conflict adaptation effect in this amplitude measure.

A significant frontal effect on N2 (see Fig. 2.3) was found when an average reference was used as revealed by the interaction between percentage of congruency and congruency $F(1, 27) = 4.227$, $p < .05$. Only the comparison between the 33% condition (mean = -2.50, SD = ±.64) and the 66% condition (mean = -3.05, SD = ± 1.11) for congruent items was significant $F(1, 27) = 8.194$, $p < .01$. Using a mastoid reference, the analysis revealed a marginally significant interaction between percentage of congruency and congruency, $F(1, 27) = 3.170$, $p < .086$. Only the comparison between the 33% condition (mean = -2.86, SD = ±.81) and the 66% condition (mean = -3.67, SD = ± 1.66) for congruent items was significant, $F(1,27) = 5.13$, $p < .032$.

3.2.2. Mask analysis

Throughout the experiment, each mask was systematically associated with a particular percentage of congruency in order to determine the extent to which the brain was registering this association. Therefore, we further analyzed the ERPs associated with the presentation of the mask following the color word. It should be kept in mind that, given the close proximity between the color word and the mask, the processing of such stimuli was likely to overlap, making it impossible to attribute the ERP waveform only to the mask. Consequently, our intention with this analysis was to determine whether or not the brain had differentially registered the association between each mask (or word-mask compound) and its corresponding pro- portion of congruency.[4]

[4] From now on we shall refer only to the mask.

The scalp maps indicated one main focus of posterior activity related to the mask that included the same group of parieto-occipital electrodes analyzed for the target. Using a baseline of 200 ms before the second mask presentation, we analyzed two temporal windows: a window between 210 and 250 ms, peaking around 230 ms, and a window between 270 and 345 ms, peaking around 300 ms. In the first temporal window, a main effect of congruency percentage was found to be significant, $F(1,) = 8.38$, $p < .01$, showing a higher positive deflection in the mostly incongruent condition (mean = 1.92, SD = ± 2.055) compared to the mostly congruent condition (mean = 1.67, SD = ± 2.085). We also found an interaction close to significance between session and congruency percentage, $F(1, 27) = 3.93$, $p = .057$. Planned comparisons showed a significant difference in amplitude between both levels of congruency percentage only in the second session, with higher results in the mostly incongruent condition (mean = 2.160, SD = ± 2.14) compared to the mostly congruent condition (mean = 1.765, SD = ± 2.145), $F(1, 27) = 12.507$, $p < .01$.

4. Discussion

The main purpose of the present research was to explore whether or not the proportion of congruency modulated the Stroop effect when the color words were masked. Both RT and ERP measures provided an affirmative answer to this question. RTs in congruent and incongruent trials significantly changed depending on the percentage of incongruent trials. When this percentage was low, congruent trials were responded to faster than incongruent trials; by contrast, when the percentage of incongruent trials was high, no significant differences in RTs were found between these two conditions. In the ERPs, the amplitude of both the N2 and the P3 components showed a significant interaction between the proportion of congruency and the congruency between the color word and the color of the target.

We applied a subjective threshold of awareness determined by presentation time. Below this threshold, subjects were unable to perceive the color word. In fact, mean presentation time was 15.97 ms in the first session of the experiment and 16.66 ms in the second session, with no significant differences in threshold values between both. These presentation times were similar or even lower than those generally used in other masking experiments (Daza et al., 2002; Greenwald, Klinger, & Liu, 1989; Klapp, 2007, Ortells, Marí-Beffa, & Plaza-Ayllón, 2002). As mentioned above, the CSPCE has been found to be independent of subjects' awareness of the proportion of congruency even in situations where no masking procedure was used (Crump et al., 2008). In the present study, subjects were unaware of the congruency relation between the masked color word and the color of the patch they had to name; in addition, the percentage of congruent and incongruent trials was the same within each block of trials. Under these conditions, awareness of the proportion of congruency associated with each mask seems very unlikely. After the experiment, when subjects were asked if they had been able to process any color words, the general answer was ''no'' and none were able to establish any relationship between the masks and the proportion of congruency. Moreover, all subjects reported the same difficulty across blocks regardless of the mask type. Based on these results, we can conclude that the context-specific proportion congruency effect (CSPCE) was obtained at least under conditions in which participants were subjectively unaware of the congruency relation between a color word and a color patch in a modified Stroop task. Whether or not this effect can also be obtained under objective thresholds of consciousness requires further study. Nevertheless, the fact that the CSPCE was obtained under subjective threshold conditions should not be underestimated. The subjective threshold is likely to be the main point to determine awareness and provides relevant information about cognitive processing outside the realm of consciousness, as shown by research on various neuropsychological deficits, such as blindsight (Weiskrantz, 2009) or spatial neglect (see Driver & Vuilleumier, 2001).

The analysis of the event-related potentials associated with the target provided additional information to the RT results. First, our main finding was related to a P3 (or P300) component that peaked around 380 ms and showed the expected inter- action between percentage of congruency and congruency that characterizes the CSPCE. The amplitude of incongruent trials was significantly higher than that of congruent trials in the mostly congruent condition; by contrast, this difference in amplitude disappeared in the mostly incongruent condition. This interaction between percentage of congruency and congruency was obtained using an average and a mastoid reference. The P3 component has been associated with response conflict and reported to be more positive in incongruent compared to congruent trials (Clayson & Larson, 2011; Frünholz et al., 2011). Although this component has also been associated with conscious processing (Dehaene & Changeux, 2011), our results show that it may be affected by the unconscious processing of both the proportion of congruency and the congruency between the color word and the color of the target. An influential though highly controversial interpretation of the P300 component (Donchin & Coles, 1988) is that this component is a manifestation of activity occurring whenever an individual's environ- mental context must be updated. Our results fit well with this view and provide the additional information that this ''context updating'' need not be conscious. In our study, each mask set the context for a different proportion of congruency to influ- ence the congruency effect between the color word and the color of the target. It has been argued that the CSPCE requires conscious representation of conflicting information, namely the prime, target and context (Kunde et al., 2012). However, our results indicate that a conscious representation of the prime is not a necessary condition for the CSPCE to take place.

Second, a significant interaction between percentage of congruency and congruency in a frontal N2 when an average ref- erence was used and the mastoid reference analysis yielded a marginally significant interaction. Therefore, this component also showed evidence that the proportion of congruency associated to the corresponding mask modulated the congruency between the color-word and the target.

Third, at least in the average-reference analysis, a relatively early P2 component around 240 ms showed a difference in amplitude as a function of the proportion of incongruent trials. Specifically, the amplitude of mostly incongruent trials was higher than that of mostly congruent trials. The proportion of congruency seems to have already been processed at this point within the wavelength and thus to set the stage for a later appearance of the CSPCE.

In summary, the present research revealed that the CSPCE was clearly present in the P3 and N2 components. Both components have been associated with the operation of control structures such as the ACC and DLPFC (Frünholz et al., 2011; Ridderinkhof et al., 2004). It has been demonstrated that these structures play a role in conflict adaptation at a local item level (Blais & Bunge, 2010). Our results add further support to the findings of Blais and Bunge. They suggest that, at least under the conditions of the present research, these control structures can operate even when participants are unaware of the relationship between the color word and the color of the target and the relationship between the masks and the proportion of congruency.

Finally, the analysis of the waveform associated with the mask yielded a significant effect of proportion of congruency on the posterior P2. Specifically, the response to the mask associated with mostly incongruent trials had greater amplitude than the response to the mask associated with the mostly congruent trials. Interestingly, this P2 difference in amplitude increased across sessions, reaching significance in the second session. Thus, it seems that the building of an association between a given mask and a particular percentage of congruency takes place across trials and implies some kind of implicit or unconscious learning. In fact, Wong, Bernat, Snodgrass, and Shevrin (2004) have reported effects of associative learning on the P2 component.

Taken together, our results show that, even though subjects were unconscious of the congruency relation between the masked color word and the color of the target and of the proportion of congruency associated with each mask, the brain responded sensitively to both variables and to their interaction, giving rise to the CSPCE. The presentation of the mask probably set the context that modulated the congruency effect produced by the relationship between the color word and the color of the target. The interaction between percentage of congruency and experimental session found in the P2 of the mask waveform suggests that the building of an association between a given mask and a particular percentage of congruency takes place across trials and implies some kind of implicit or unconscious learning. However, the CSPCE seems to be a within-trial process where the context activated by the mask modulates the congruency response. This account of the CSPCE is consistent with the explanation of the item-specific proportion congruency effect (ISPCE) provided by Shedden et al. (2012). According to these authors, control processes can be implemented rapidly (i.e., online) based on a previously experienced conflict in a particular context.

It should be kept in mind that throughout the present experiment great care was taken to ensure that the expectation of a color word between the two masks remained activated. In other words, subjects were generally conscious that a color word was being presented between the masks, although they were not conscious of which exact color word was presented in each trial. Attentional modulation of subliminal semantic processes by task set has recently been reported (Martens et al., 2011; see also Kiefer, Adams, & Zovko, 2012). The general expectation of the presence of a color word between masks may have contributed to sensitizing subjects about the semantic representation of the colors used in our task even though they were not aware of the particular color word presented in each trial. This explanation may account for the congruency effect between the color word and the color of the target but cannot explain the relationship between the masks and the proportion of congruency. In this case, the relationship could not have been conscious; instead, it appears to have been built through practice and remained unconscious all along the experiment. However, such relationship exhibited a clear effect both on RT and ERP measures. In addition, the CSPCE observed in our experiment did not seem to be attributable to sequential effects, as no significant effects were found when we included the congruency of the previous trial as a variable in the analysis of our RT data.

Overall, our results lend support to the currently widely held view that the classical division between automatic and controlled processes (Posner & Snyder, 1975; Schneider & Shiffrin, 1977; Shiffring & Schneider, 1977) is in need of a thorough revision (Bugg & Hutchison, 2013; Crump et al., 2008; Shedden et al., 2012). According to this division, *controlled* and *automatic* are conceptualized as categories belonging to a general and disjunctive classification of processes that makes it contradictory even to talk about *automatic control*. Each category is defined by a set of characteristics. For example, automatic processes are considered to be fast, stimulus-driven, resource-free and to occur in the absence of awareness of the stimuli that elicit them. By contrast, controlled processes are thought to be slow, subject to volition, resource demanding and open to conscious inspection. This way of classifying cognitive processes is incompatible with our results, which show control adaptation in a situation where subjects are unaware of the relationship between a mask and a proportion of congruency and of the congruency relation between a color word and the color of the target. By contrast, an influential model of control processes (Norman & Shallice, 1986; see also Shallice & Cooper, 2011) allows for a more flexible relationship between two main components: (1) a *contention scheduling* mechanism composed of a set of automatic schemas resulting from experience and learning that maintain cooperative or competitive relations among themselves, with the most active schema taking con- trol of a particular situation; and (2) a *supervisory attentional system* (SAS) responsible for conscious control that comes into play in situations where routine schemas cannot be relied upon. According to this way of thinking, contention scheduling and the SAS are not ways of classifying cognitive processes. Instead, they are conceptualized as two different systems that may act cooperatively to achieve cognitive control. Under this view, it makes perfect sense to talk about *automatic control when* a particular schema exerts control as a result of learning. In our study, as a consequence of the association between a mask and a particular proportion of congruency, an unconscious control schema was generated; this schema was able to act in the presence of that particular mask, thus modulating the Stroop effect, which in turn took place without awareness of the color word. In addition, as in the Norman and Shallice model, we found that the relationship between contention scheduling and the SAS is cooperative rather than disjunctive, allowing the flexible attentional top-down influence of the conscious task set, that remained constant in our experiment, on unconscious processing as recently elaborated by Kiefer et al. (2012).

5. Conclusions

Our results provide evidence of the unconscious character of cognitive control when a masked Stroop-like paradigm is used. The early P2 component showed amplitude differences as a function of percentage of congruency, displaying larger amplitude for mostly incongruent than for mostly congruent trials. This seems to be evidence of a type of implicit learning across trials given that, when masks were analyzed, the P2 tended to be higher in the second session compared to the first one.

The interaction between the percentage of congruency and the congruency between the color word and the color of the target observed in the N2 and P3 component and RTs provided evidence of the expected CSPCE even when subjects were unaware of two main relationships in the experimental task: the relationship between the color word and the color of the target, and the relationship between the masks and the proportion of congruency.

Acknowledgments

We thank María Ruz and our reviewers for their careful reading of our manuscript and their many insightful comments and suggestions.

This research was supported by the Spannish Ministerio de Educación y Cultura with a Grant (FPU-AP2007-00313) to the first author and a research Grant P09-HUM-5422 from the Andalusian Autonomous Government to Pío Tudela..

Capítulo 3

SERIE EXPERIMENTAL II:

Comparing conflict adaptation in cognitive and emotional conflict

1. Introduction

As well as in real life activities, when performing an experimental task in which there is competition between the task-relevant and task-irrelevant information, humans need to implement control mechanisms (see Norman & Shallice, 1986; Fan & Posner, 2004). How these control mechanisms are implemented and how our brain identifies this kind of competing information and puts into action strategies to avoid irrelevant information is a question that has been studied for over the years. For this purpose, the *stimulus-response compatibility tasks* (Kornblum, Hasbroucq, & Osman, 1990) have been frequently used. A well known variant of this type of tasks is the Stroop task (Stroop, 1935; Macleod, 1991) in which participants have to name the ink color of color words. There are two conditions: congruent and incongruent. In the congruent condition, the ink color matches the color name of the word (e.g., RED in red ink). In the incongruent condition, by contrast, the ink color is different from the color name of the word (e.g., BLUE in red ink). To perform the task in the incongruent condition, participants must avoid the automatic process of reading the word and name the color of the ink in which the word is printed by using control strategies. In the congruent condition, the ink color matches the color name of the word, so avoidance of the automatic reading process is not necessary. Consequently, reaction times (RTs) are longer in the incongruent condition than in the congruent one. This additional time is known as *Stroop interference* or *Stroop effect*.

On the other hand, when a sequence of trials within a block is considered, a *conflict adaptation effect* appears (Gratton, Coles & Donchin, 1992) as a reduction in interference in a current incongruent trial when it is preceded by another incongruent trial. This effect has been found across different conflict tasks, including Stroop (e.g., Egner & Hirsch, 2005), Simon (Hommel, Proctor & Vu, 2004) and flanker tasks (e.g., Nieuwenhuis, Stins, Posthuma, Polderman, Boomsma & De Geus, 2006); it seems to be domain-specific, as it does not transfer across different tasks that are performed sequentially (Egner, 2008; Funes, Lupiáñez, & Humphreys, 2010).

In computational and neural terms, Botvinick, Braver, Barch, Carter & Cohen (2001) advanced an explanation of both, the Stroop and the conflict adaptation effects, in what they termed the *conflict-monitoring hypothesis.* According to these authors, the Stroop effect is just a particular case of conflict resolved by the interplay of a set of neural structures. The dorsal anterior cingulate cortex (dACC) acts as a detection mechanism that responds to the occurrence of a conflict situation (i.e., an incongruent trial in a Stroop task). In addition, this conflict signal triggers strategic adjustments in the dorsolateral prefrontal cortex (DLPFC) that amplifies cortical responses to reduce conflict. On the other hand, the conflict adaptation effect is considered to result from the activation of the DLPFC that serve to prevent conflict in subsequent performance. Thus, according to the conflict monitoring hypothesis, when an incongruent trial is presented dACC detects the conflict situation triggering signals to DLPFC that implements strategies to resolve this situation. If a subsequent incongruent trial is presented, the DLPFC is now prepared for the resolution of the conflict, which translates in faster RT in the current incongruent trial. Experiments using functional magnetic resonance (fMRI) have lent support to this *conflict-monitoring hypothesis* (Botvinick, Cohen, & Carter, 2004; Kerns, Cohen, McDonald III, Cho, Stenger & Carter, 2004; McDonald, 2000).

However conflict not only exists in the cognitive but also in the emotional domain. Many tasks have been adapted in order to study the emotional conflict resolution processes (Bishop, Duncan, Brett, & Lawrence, 2004; Bush, Luu, & Posner, 2000; Compton, 2003; Shin, Whalen, Pitman, Bush, Macklin, Lasko et al., 2001; Whalen, Bush, Mcnally, Wilhem, McInerney, Jenike & Rauch, 1998). For example, in the emotional counting Stroop task (Whalen et al., 1998), participants have to report the number of words that appear on a screen, regardless of the word meaning. Control trials contain emotionally neutral words (e.g., 'cabinet' written three times), while interference trials contain emotional words (e.g., 'murder' written three times). As a general finding, interference (emotional) words tend to show greater interference effect (longer RT) when compared with control (non-emotional) words. Similar results have been found in emotional Stroop tasks where subjects have to name the ink color of words the meaning of which may be emotional or non-emotional. As in the previous task, emotional words produce longer RT than non-emotional words (e.g. Watts, McKenna, Sharrock & Trezise, 1986).

A common characteristic of these tasks is that emotional information acts as distracter rather than target, because target information is always cognitive. Thus they may be suited to provide information about the interference produced on the control of a cognitive activity (either counting or color naming) by emotional information, but they do not provide direct information on emotional control. To achieve this information, emotional stimuli should be included as targets. Recently, attempts have been made to study both, cognitive and emotional, control mechanisms within the same task in order to equate the cognitive and affective type of conflict. The face-word Stroop task (Egner, Etkin, Gale, & Hirsch, 2008; Etkin, Egner, Peraza, Kandel, & Hirsch, 2006) may be considered a good example. In the emotional version of this task, subjects have to name the emotion displayed by either a male or female face while an emotional word is presented across the face such that the meaning of the word and the emotion of the face may be either congruent or incongruent. In the cognitive version of the task, subjects have to respond to the gender (male or female) of the faces disregarding the meaning of the word (male or female), printed across the face, that may be congruent or incongruent with the face gender. Results show that in both versions of the task the incongruent condition creates conflict (emotional or cognitive), reflected in slower RT in incongruent relative to congruent trials. Other researchers (Alguacil, Tudela, & Ruz, 2013; Ochsner, Hughes, Robertson, Cooper, & Gabrieli, 2008) have employed a variant of the Eriksen flanker task (Eriksen & Eriksen, 1974) in which a word was presented as target at the center of the screen and flanked by another two words above and below. In the emotional version, participants had to respond to the valence of the target (positive or negative); in the cognitive version they had to indicate the target's semantic category. In either version, the flanker words could be congruent or incongruent with the target. As in the Stroop task also in the flanker task the incongruent trials produced both, cognitive and emotional conflict (slower RT).

Regarding neural mechanisms underlying cognitive and affective conflict, an influential review of experiments, using imaging techniques, on cognitive and emotional versions of the Stroop task (Bush, Luu, & Posner, 2000) suggested a segregation of functions within the anterior cingulated cortex (ACC); the dorsal part would be mainly involved in cognitive control while the ventral ACC (vACC) would be engaged when emotional control is needed. This hypothesis was based in experimental evidence where cognitive and emotional control was studied in experiments in which, as pointed out above, emotional information acted as distracter for cognitive responses. More recently, the neural substrate of cognitive and affective conflict has been jointly explored within the same experiment using fMRI (Egner, et al., 2008; Ochsner, et al., 2008). Their results partially modified Bush et al.' hypothesis so that emotional conflict seems to recruit vACC and rostral medial prefrontal cortex (RMPC) while cognitive conflict appears under control of the DLPFC.

Although fMRI studies have provided important information about brain mechanisms involved in conflict resolution, the timing of the different processes involved cannot be studied with precision. Event-related potential (ERP) recordings, on the other hand, can provide critical temporal information for precise analysis of the timing of different types of conflict. To date, at least one experiment have studied the ERPs associated to cognitive and emotional conflict jointly in the same experiment and using the same kind of material and task settings across conditions (Alguacil, et al., 2013). In this experiment participants performed a flanker task in which they had to focus on a central target and indicate its semantic category (cognitive version) or its valence (affective version). Targets were flanked by congruent or incongruent words in both versions. Results showed differences in the wave amplitude as a function of the cognitive or emotional nature of the task in the late ERP components but none in the early components. They found conflict adaptation effects in N170 component with larger amplitudes for incongruent trials preceded by a previous incongruent trial. This pattern was the same for both, emotional and non-emotional task, showing that conflict had been processed at a very early stage of information processing. They also found that the N2 and the first part of the P3 were exclusively modulated by cognitive conflict, whereas the last section of the P3 deflection was only involved in affective conflict processing. The authors argued in favor of the existence of early common mechanisms, equivalent for cognitive and affective materials, and later task-specific conflict processing mechanisms.

The N170 is an early potential that reflects perceptual processing in the visual cortices. It has been associated with perceptual discrimination and object categorization processes (Hillyard, 2009; Luck et al., 2000) and can be modulated by attention (see Aranda, Madrid, Tudela, & Ruz, 2010; Ruz & Nobre, 2008a). ERP studies using both emotional and non-emotional conflict tasks have shown larger N170 amplitudes for incongruent than for congruent trials in both types of conflict (Zhu, Zhang, Wu, Luo & Luo, 2010). This experiment used a version of the face-categorization task similar to that introduced by Egner et al. (2008). When participants were asked to identify the emotional expression of the face, the incongruent condition evoked a more negative N170 component than in the congruent condition. In contrast, when subjects were asked to identify the emotional meaning of the word, the pattern of results reversed. These results provide evidence that the N170 may be modulated by emotional conflict

The N2 component, that is strongly associated with cognitive control, is a negative deflection that takes place around 200 ms after stimulus onset with a fronto-central topography. The amplitude of this component is usually larger for incongruent than for congruent trials (Koop, Rist, & Mattler, 1996; Van Veen & Carter, 2002). This result seems to reflect the implementation of control mechanisms and has been replicated several times (Folstein & Van Petten, 2008; Van Veen & Carter, 2002). As mentioned before, the study of emotional conflict has been limited to the influence of irrelevant emotional material on the resolution of cognitive conflict. In this type of situation, the presence of irrelevant emotional material has also generated an N2 of larger amplitude compared to a control condition (Kanske & Kotz, 2010, 2011). However in the experiment by Alguacil et al. (2013) where the valence of the stimuli was relevant to performance, no effect on the N2 component was found in the emotional task though both, the previous and current congruency variables, significantly modulated this component in the cognitive task.

As to the P3 component, a positive deflection in the averaged waveform with a central-parietal distribution occurring 350-500 ms after stimulus presentation, it has been associated with stimulus selection and categorization and with the implementation of the required response (Luck, 2005). It has been argued (Polich, 2007) that in conflict situations the P3 may be generated by inhibitory processes involved in avoiding irrelevant and competing information , as well as in focusing attentional resources on the relevant elements of the task. As a matter of fact, Clayson & Larson (2011) found a more positive P3 for incongruent than congruent trials (see also Frünholz, Godde, Finke & Herrmann, 2011). Clayson & Larson's (2011) research is also relevant to the present investigation because they studied the conflict adaptation effect in a flanker task and found that in both, the N2 and P3 components, the amplitude of an incongruent trial was reduced when the previous trial was incongruent compared to congruent.

As the electrophysiological evidence about the relationship between emotional and cognitive conflict is scant, in the present experiment we tried to compare, jointly in the same experiment and using the same kind of material and task settings across conditions, the ERPs associated with these two types of conflict, as well as with the conflict adaptation effects associated with both types of conflicting situations. For this purpose we used a face-categorization task (Egner y Hirsch, 2005b; Gale; and Hirsch, 2007), in which we varied the source of conflict between non-emotional and emotional stimulus representations, while keeping task-relevant stimulus characteristics constant. The task-relevant information for both tasks was a set of male and female faces expressing either happiness or fear (Ekman & Friesen, 1976). For the non-emotional task, subjects had to respond to the gender of the face while ignoring gender labels appearing across the faces. For the emotional task subjects had now to respond to the emotion expressed by the face ignoring a congruent or incongruent emotional label across the faces. During the entire experiment we recorded continuously the EEG of the participants.

2. Material and methods

2.1. Participants:

Twenty four participants (16 female and 8 male) students of the University of Granada participated in a one-session experiment. They reported to have normal o corrected-to-normal vision, and they were not aware of the purpose of the experiment. The mean age was 25 years (SD= 6.30). All of them gave their verbal consent to participate in the experiment and signed a consent form approved by the local Ethics Committee. Credits were given for participation.

2.2 Stimuli and apparatus

The stimulus set consisted of 5 male and 5 female faces with an expression of fear or happiness (11.42º high and 10.28º wide of visual angle). In the non-emotional task faces were presented with either the word HOMBRE (man) (0.573º high and 4.581º wide of visual angle) or MUJER (woman) (0.573º high and 3.437º wide of visual angle) printed in red ink, producing gender-congruent and incongruent stimuli (see Fig 1. A.). In the emotional version the same face stimuli were presented with either the word ALEGRIA (happiness) (0.573º high and 4.581º wide of visual angle) or MIEDO (fear) (0.573º high and 3.437º wide of visual angle). All stimuli were presented on a 17 inch color screen of a PC computer at a viewing distance of about 50 centimeters. The PC was connected to a Macintosh computer for the registration of the ERPs. The entire task was created and displayed using the E-Prime 1.2 Professional software (Schneider, Eschman & Zuccolotto, 2002)

2.3. Procedure and design

2.3.1. Procedure

As mentioned before the task had two versions being the structure of the task the same for each version. First a fixation point appeared at the center of the screen with a duration varying randomly between 500 and 1000 ms. Then, the target stimulus was presented during 1000 ms or until the participant gave a response. Finally we displayed an inter-trial interval (ITI) varying between 1000 and 1500 ms (see Fig. 3.1).

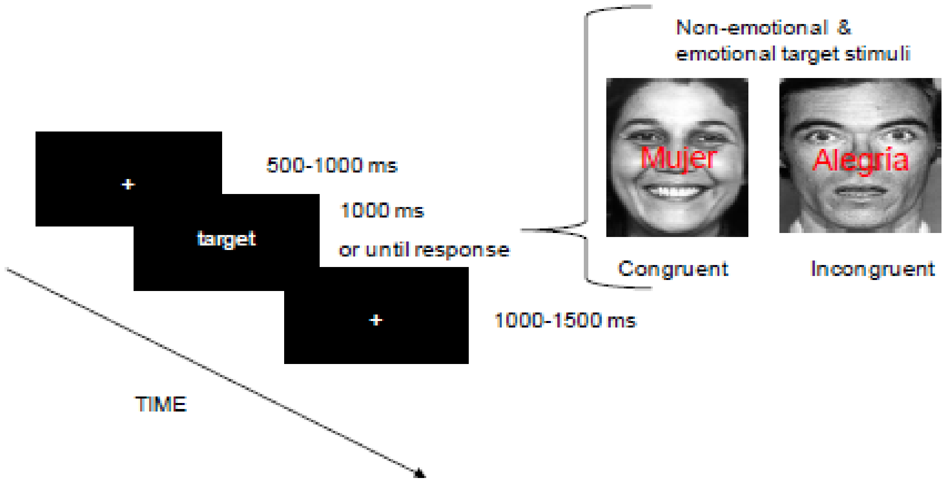


Figure 3.1. *Sequence of a non-emotional congruent and emotional incongruent trial.*

Participants used a computer Qwerty keyboard to answer. They were asked to respond to the gender of the face (*hombre* or *mujer*) in the cognitive version and to the emotion of the face (*alegría* or *miedo*) in the emotional version of the task. In every trial the face was displayed in the center of the screen with an overlapping word placed over the nose of the face. The meaning of the word could be congruent or incongruent either with the gender of the face (non-emotional version) or with the emotion displayed by the face (emotional version). Participants were encouraged to focus on the face and disregard the words as much as possible. They were repeatedly told to respond based upon the face and to ignore the word.

For each version of the task we conducted 10 practice trials and four blocks of 160 trials each. During the practice trials participants received feedback of their performance. Answer keys, blocks and the starting version of the task were counterbalance across participants.

2.3.2. Design

Within each 160 trials block of each version of the task, two independent variables were manipulated: current trial congruency (congruent vs incongruent) and previous trial congruency (congruent vs incongruent) A 2 (previous trial congruency) x 2 (current trial congruency) repeated measures ANOVA was conducted. Task version was manipulated between blocks and the order of presentation was counterbalanced per participants.

2.4. EEG recording and analysis:

Participants were seated in front of the computer monitor in an electrically shielded room. They were instructed to avoid eye blinking and moving during stimulus presentation and response. The EEG was recorded using a high-density 128-channel Geodesic Sensor Net (Tucker et al., 1994). The head coverage included sensors lateral to and below both eyes to monitor horizontal and vertical eye movements. The EEG net was connected to an AC-coupled, high-input impedance amplifier (200 MΩ). At the beginning of the recording session, the impedance of each channel was measured and kept under 50 kΩ, as recommended for Electrical Geodesics high-input impedance amplifiers. Amplified analog voltages (0.1–100 Hz band pass) were digitized at 250 Hz (12-Bit A/D converter and 0.02 μV minimum resolvable voltage). All channels were referenced to the Cz electrode during the recording and were algebraically re-referenced to the average off-line.

The continuous EEG was filtered offline using a 30 Hz low-pass filter. Next, it was segmented in epochs of 200-700 ms relative to the target onset. A 200 ms segment previous to the target presentation was used to calculate the baseline. The epochs were submitted to software processing in order to identify artifacts. Segments with eye movements, eye blinks (i.e., electro-oculogram channel differences greater than 70 μV), more than 20% of bad channels or incorrect responses were not included in the ERPs. Data from consistent bad channels were later replaced using a spherical interpolation algorithm (Perrin, Pernier, Bertrand, & Echallier, 1989). A minimum criterion of 30 artifact-free trials per participant and condition was established to maintain an acceptable signal-to-noise ratio. Trials that did not meet the criteria regarding the amount of artifacts and bad channels were eliminated for each participant. A final grand average was obtained for each condition by pooling subjects' averages in each experimental condition. Eight group-average ERP waveforms were constructed according to task (*emotional* vs. *non-emotional*), previous trial congruency (*congruent* vs. *incongruent*) and current congruency (*congruent* vs. *incongruent*). Conditions were equated in number of trials, $F < 1$.

To facilitate the selection of spatiotemporal windows for amplitude analyses, the topographic maps provided by the Net Station Viewer (EGI, 2008) were used as a guide. Topographic map views display samples as representations of the scalp projected onto disk-shaped maps (also referred to as *scalp maps*) where amplitudes are represented by colors. In such views, the amplitudes between sensors are interpolated, which allows the entire surface of the head to be depicted, thus providing a view of the voltage distribution (i.e., topographies) over the scalp for each experimental condition as a function of time. As shown in Figure 3.2 visual analysis of the scalp maps revealed two main focuses of activity in the ERPs: a bilateral group of electrodes starting at 160 ms and lasting for 200 ms, including 14 electrodes, seven to each side (shown in discontinuous line). A centro-parietal focus including 14 electrodes was also found, starting at 247 ms and lasting for 500 ms after target presentation, which included fourteen electrodes (shown in continuous line).

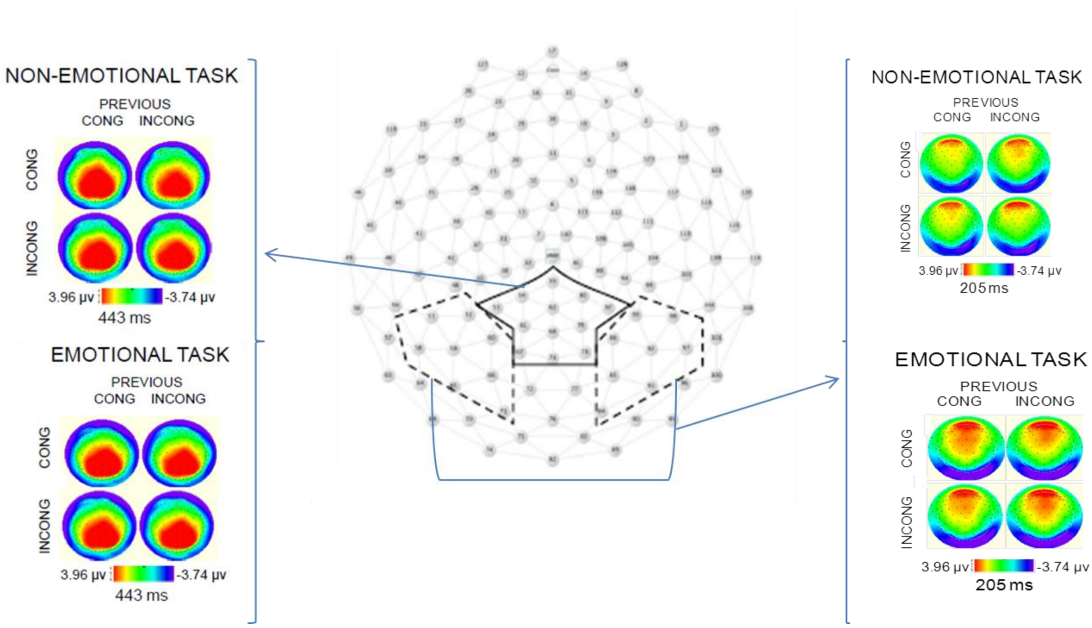


Figure 3.2. *Group of electrodes selected for the analysis and topographies showing amplitude differences in non-emotional and emotional tasks.*

Latencies and mean amplitude voltages averaged over the selected channels were submitted to repeated-measures analyses of variance. For the bilateral group of electrodes we conducted a repeated-measures ANOVA including Hemisphere (*left* vs *right*), Task (*non-emotional* vs *emotional*), Previous trial congruency (*congruent* vs *incongruent*) and Current trial congruency (*congruent* vs *incongruent*). For the centro-parietal group of electrodes a repeated-measures ANOVA with Task (*non-emotional* vs *emotional*), Previous trial congruency (*congruent* vs *incongruent*) and Current trial congruency (*congruent* vs *incongruent*) as factors was carried out.

3. Results.

3.1. Behavioral analysis

Overall accuracy was very high, being error percentage less than 1% and no difference in accuracy among experimental conditions was found. Only correct responses were considered in the RT and the ERPs analyses. RTs shorter than 300 ms and higher than 1000 ms were excluded as outliers. First trial of each block was removed in the analysis of sequential effects. To avoid the influence of repetition priming, we also excluded of the analysis those trials that were complete repetition (same face, same expression, same word) of the previous trial (14%).

3.1.1. RT analysis

The ANOVA showed larger RT for the emotional (Mean= 603.75 ms, SD= ±62.3 ms) than for the non-emotional task (Mean=

523 ms, SD= ±48.73 ms), $F(1,23) = 147.59$, $p < .01$, and for incongruent (Mean= 572.25 ms, SD= ±58.93 ms) than for congruent trials (Mean= 554.5 ms, SD= ±52.34 ms), $F(1, 23) = 31.38$, $p < .01$.

As can be seen in Fig. 3.3, we also found a significant interaction of Task x Congruency $F(1,23) = 6.57$, $p < .05$.

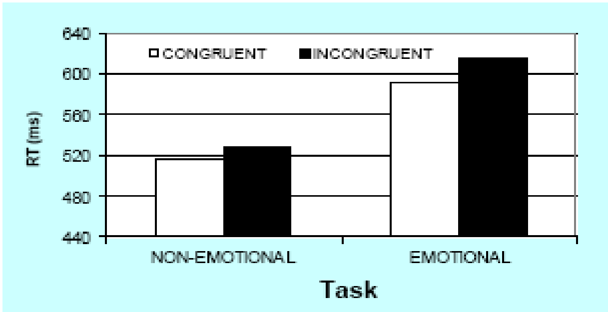


Figure 3.3. *Behavioral results: interaction effect Task x Current Trial Congruency*

Planned comparisons showed significant congruency effect in both the non-emotional ($F(1, 23) = 25.36$, $p < .01$) and the emotional ($F(1, 23) = 22.24$, $p < .01$) versions of the task, but this effect was larger in the emotional (congruent Mean = 582, SD = 56.96, incongruent Mean = 615.5, SD = 67.64) than in the non-emotional (congruent Mean = 517, SD = 47.73, incongruent Mean = 529, SD = 49.73) version.

No significant main effect of the Previous Trial Congruency variable appeared, and no interaction of this with any other variable was found either.

3.2. Electrophysiological analysis

Separate analyses were carried out on the two different groups of electrodes shown in Figure 2 namely, the bilateral group of seven electrodes on each side of the head and the fourteen electrode central group. For each group we analyzed the latency and amplitude of the ERP components of our interest. Given the significant main effect due to the type of task found in our RT data, latency analyses were particularly appropriate to ascertain whether or not the difference in time found in the behavioral measure had an effect on the ERP components.

3.2.1. Bilateral group of electrodes

Figure 3.4 shows the average waves for the two seven electrode groups corresponding to the left and right hemispheres. On each side the waves for the congruent and incongruent conditions are displayed as a function of the Previous congruent variable. No reference is made to the type of task because, as will be shown below, no effect of this variable on the analyzed components was found. In this group of electrodes, our interest centered on the P1 and N170 components.

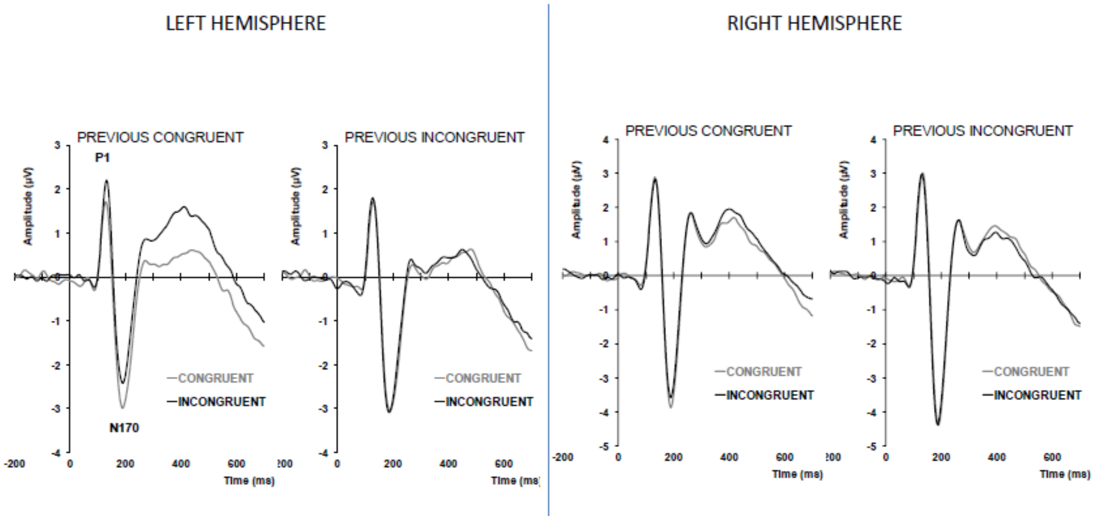


Figure 3.4. *Average waves of the congruent and incongruent trials when previous trial was congruent or incongruent for the left hemisphere (in the left) and right hemisphere (in the right)****.***

3.2.1.1. P1

Voltage analysis for this component was performed on a 20 ms window centered on the first positive peak at 150 ms.

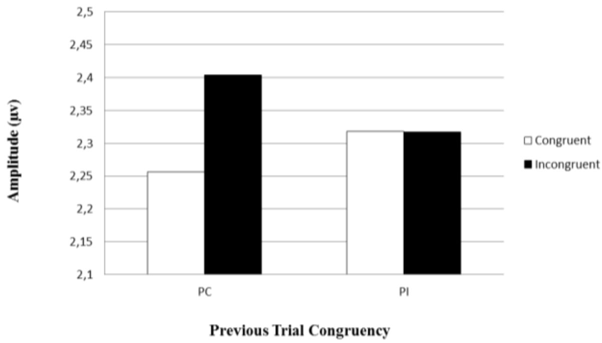
Latency analysis

No main or interaction effects were found in the latency analysis for this component.

Amplitude analysis

This analysis showed a main effect of Hemisphere, F(1,239= 7.077, p< .05, with larger positive voltage in right electrodes (Mean= 2.984, SD= ± 2.491) than in left electrodes (Mean= 1.664, SD= ± 2.010). In addition a close to significance interaction of

Previous trial congruency * Current trial congruency was also found F(1,23)= 3.0255, p= .095.



Z

Figure 3.5. *Averages representation of the interaction effect Previous Trial Congruency x Current Trial Congruency*

Planned comparisons showed a tendency for the Stroop effect to be larger when the previous trial was congruent than when it was incongruent, F(1, 23)= 3.7345, p= .0657 with higher amplitudes of incongruent trials (Mean= 2.404, SD= ± 2.290) compared to congruent trials (Mean= 2.256, SD= ± 2.405). No difference between congruent and incongruent trials appeared when the previous trial was incongruent. The cognitive vs emotional nature of the task did not show an effect or interact with any other factor.

3.2.1.2. N170

We analyzed this component on a 40 ms window centered on a negative peak at 200 ms.

Latency analysis

Again, no main or interaction effects were found analyzing the latency of this component.

Amplitude analysis

This analysis showed a significant main effect of Hemisphere F(1,23)= 5.9336, p< .05. Amplitude of right hemisphere (Mena= -5.030, SD= ±3.054) was more negative than amplitude for left hemisphere (Mean= -3.688, SD= ±2.135).

We also found a significant main effect of Previous trial congruency F(1,23)= 4.5885, p< .05. The amplitude for the previous incongruent trial (Mean= -4.430, SD= ±2.757) was more negative than amplitude for the previous congruent trial (Mean= -4.288, SD= ±2.679). No other significant effect appeared.

3.2.2. Centro-parietal group of electrodes.

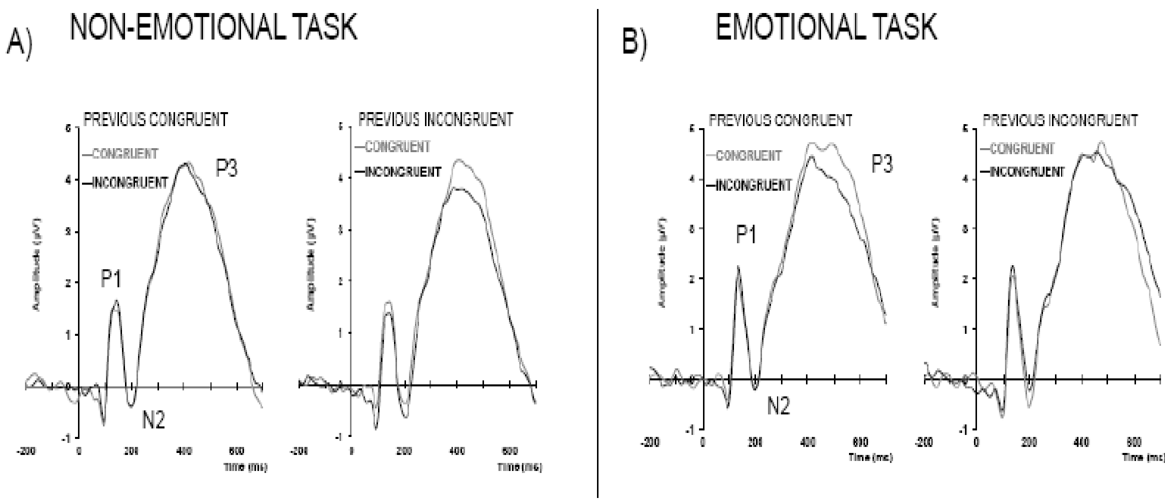


Figure 3.6. *Average waves of the congruent and incongruent trials for the non-emotional (A) and emotional (B) tasks and for the previous congruent (left) and previous incongruent (right) trials.*

3.2.2.1. N2

For this component we selected a 40 ms window centered on a posterior negativity peaking at 200 ms.

Latency analysis

No main or interaction effects were found in the latency analysis.

Amplitude analysis

Amplitude analysis for the N2 component showed a close to significance main effect of the task variable $F(1,23)= 3.2014$, $p= .086$; the emotional task (Mean= -0.958, SD= ± 2.029) showed less negativity than the non-emotional task (Mean= -1.430, SD= ± 2.317). Also a close to significance main effect of previous congruency appeared, $F(1,23)= 3.1422$, $p= .089$, with less negativity for the previous congruent (Mean = -1.123, SD = ± 2.204) than for the previous incongruent (Mean = -1.265, SD = ± 2.175) condition.

A significant interaction effect between Task x Congruency was found , $F(1, 23)= 6.3945$, $p<.05$

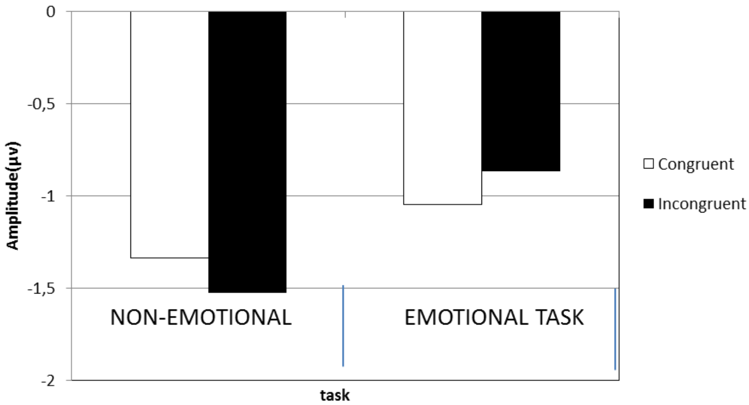


Figure 3.7. *Graphic representation of the interaction effect between Task x Current Trial Congruency.*

As can be seen in Fig. 3.7, in the non-emotional task the difference between congruent (Mean= -1.336, SD= ± 2.398) and incongruent trials (Mean= -1.524, SD= ± 2.254) was significant $F(1,23) = 4.7750$, $p < .05$ while no significant difference between congruent (Mean= -1.047, SD= ± 2.106) and incongruent trials (Mean= -0.869, SD= ± 1.967) was found in the emotional task. The grater negativity of incongruent trials in the non-emotional task compared with emotional task was also significant $F(1,23) = 5.6048$, $p < .05$.

We also found a significant second order interaction effect between Task x Previous Trial congruency x Current Trial Congruency $F(1,23) = 6.7584$, $p < .05$ (see Figure 3.8)

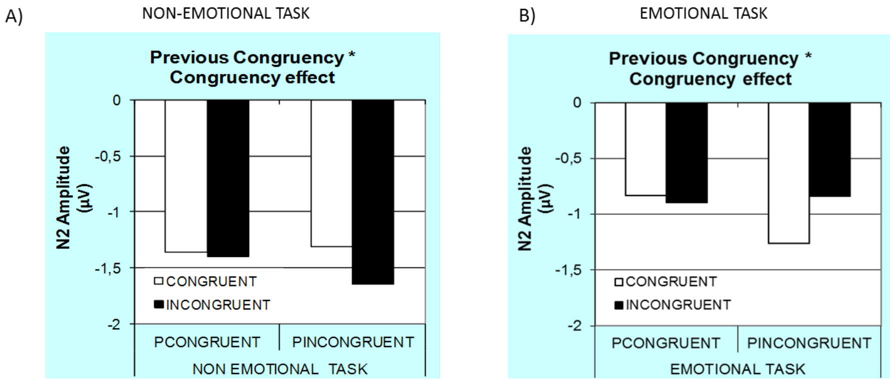


Figure 3.8*. N2 Average amplitude of the congruent and incongruent trials for the non-emotional (A) and emotional (B) tasks and for the previous congruent (left) and incongruen trials (right).*

Planned comparison showed that in the non-emotional task incongruent trials (Mean= -1.648, SD= ± 2.199) were more negative than congruent trials (Mean= -1.312, SD= ± 2.506) when previous trial was incongruent $F(1,23)= 7.598$, $p<.05$, but no difference between congruent (Mean= -1.361, SD= ± 2.338) and incongruent trials (Mean= -1.400, SD= ± 2.348) was found when previous trial was congruent. This pattern of results was different for the emotional task where congruent trials (Mean= -1.259 , SD= ±2.258) were more negative than incongruent trials when previous trial was incongruent (Mean= -0.840, SD= ±1.960) $F(1,23)= 14.09$, $p< .01$, but no differences between congruent (Mean= -0.834, SD= ± 2.179) and incongruent trials (Mean= -0,898, SD= ± 2.058) appeared when previous trial was congruent.

3.2.2.2. P3

This component was defined on a 20 ms window centered on a 420 ms positive peak.

Latency analysis

No significant main or interaction effects were found when we analyzed the P3 latencies.

Amplitude analysis

Looking at P3 amplitudes we found a significant main effect of congruency, showing more positive amplitude for congruent trials (Mean = 4.894 µv, SD = ± 3.052) than for incongruent trials (Mean = 4.668 µv, SD = ± 3.131), $F(1, 23)= 6.036$, $p< .05$. The analysis also showed a significant second order interaction Task x Previous Congruency x Congruency $F(1, 23)= 5,14$, $p< .05$. (see Fig 3.9)

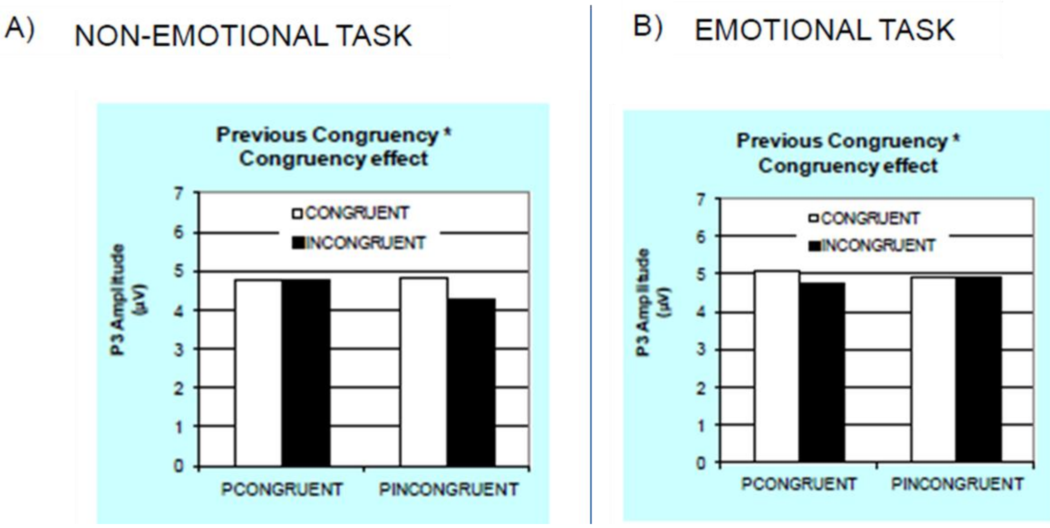


Figure 3.9. *P3 average amplitude of the congruent and incongruent trials for the non-emotional (A) and emotional (B) tasks and for the previous congruent (left) and previous incongruent (right) trials.*

In the non-emotional task, planned comparisons showed significantly less amplitude for incongruent trials (Mean= 4.26; SD= ± 2.948) compared with congruent trials (Mean= 4.801, SD= ±

3.081) when they were preceded by an incongruent trial $F(1,23) = 11.12$, $p < .01$. Also the difference in amplitude between incongruent trials following an incongruent trial and those following a congruent one was significant $F(1,23) = 4.5712$, $p < .05$. No other significant difference was found either in the non emotional or the emotional tasks.

4. Discussion

The main purpose of the present experiment was to further understand the relationship between emotional and cognitive conflict using a face-word Stroop task where both, emotional as well as cognitive conflict, were included in the same task. By recording the scalp electrical activity of the subjects while they were performing the task we also tried to study the brain processes associated with the two types of conflicts.

Our RT data showed that the task employed was adequate to create conflict situations so that responses during incongruent trials took longer than responses during congruent trials in both the cognitive and emotional versions of the task. Our results for the cognitive conflict situation replicates the familiar Stroop effect found in a wide series of experiments (see Mac Leod, 1991). Also our emotional conflict results support previous research using an emotional Stroop task (vg. Mckenna & Sharma, 1995; Etkin, Egner, Peraza, Kandel & Hirsch, 2006) or emotional counting Stroop task (Bush., Whalen., Rosen., Jenike., McInerney., & Rauch., 1998; Hayward., Goodwin., & Harmer., 2004), though, as said above, in these experiments emotional information acted as distracter rather than target. We used emotional information as target and examined emotional and cognitive conflict jointly in the same experiment. In agreement with similar previous research (Alguacil et al., 2013; Egner et al., 2008) we found a significant Stroop effect for both, the non-emotional and the emotional versions of the task, though this effect was higher in the emotional than cognitive version. One possible explanation for this difference may be related to the fact that the RT of the emotional version was significantly longer than the RT of the cognitive version of the task. It appears that identifying a male or a female face is relatively easy compared with discriminating the emotional expression of those faces; while identifying the face gender may be based on global characteristics of the face, discriminating its emotional expression may require to focus attention on specific facial features like eyes, nose and mouth. In fact, influential models of face perception (Bruce & Young, 1986; Haxby & Gobini, 2011) consider gender, as a permanent characteristic, to be part of a face identity (core system according to Haxby & Gobini, 2011) that is processed at early stages of face perception. However emotional facial expression, being a changeable characteristic, requires additional information and is processed at later stages of face perception (extended system for Haxby and Gobini, 2011). This line of reasoning is further supported by the behavioral results reported by Egner et al. (2008); using a task similar to ours, also found larger RT for the emotional than for the non-emotional task. On the other hand, Alguacil et al. (2013) found no difference between the two types of tasks, using words instead of faces. Therefore it is likely that the difference in our data may be due to the type of stimuli on which the response was made. In any case, if the emotional version of the task turns out to be more difficult, as it is the case in the present experiment, is not surprising that it also gives way to a greater Stroop effect compared to the cognitive version of the task.

Our RT data did not show any effect due to the Previous trial congruency variable, though this variable did influence our ERP data. Why conflict adaptation was not present in our RT data is difficult to explain. Alguacil et al. (2013) and Oschner et al. (2008) did not find conflict adaptation in their behavioral data either. Alguacil et al. (2013) pointed to the complexity of the task as a possible explanation, but Egner et al. (2007), using faces in a task similar to ours, reported a conflict adaptation effect in both, the emotional and non-emotional tasks. Further research is needed on this issue.

Despite the large difference in RT between the emotional and cognitive tasks, in our ERP data no component in either group of electrodes showed differences in latency due to the emotional or cognitive characteristics of the task. It appears that the difference found in the RT data may be due to differences in later components related either to response preparation, to response execution or both. Nevertheless, neither the latency of the early components, P1 and N170, nor that of the components mainly related to conflict, N2 and P3, changed as a function of the emotional or cognitive nature of the task.

In the posterior bilateral set of electrodes, the P1 component showed a significant difference in amplitude depending upon the laterality of the electrode location; the amplitude of electrodes on the right side was larger than the amplitude of electrodes on the left side of the head. This result is in agreement with the well-known cerebral dominance of the right hemisphere for face processing (see Kanwisher and Barton, 2011). In addition, our data on P1 provide some indication of conflict adaptation, since the Stroop effect decreased when previous trial was incongruent relative to previous congruent trial. However, this tendency was only close to significance.

The amplitude of the N170 component replicated the findings on P1 concerning laterality; voltage values were more negative for electrodes on the right than for electrodes on the left side of the head. This result is in agreement with to the view that the right lateralized N170 may be considered an electrophysiological marker of face processing (Eimer, 2011). In the present experiment, the N170 also appeared sensitive to Previous congruency, as the amplitude were more negative for previous incongruent than for previous congruent trials. However no sign of the interaction between Previous and Current congruency, and consequently of conflict adaptation, appeared on this component.

Taken together, the results of the this experiment did not replicate the clear-cut findings of Alguacil et al. (2013) with respect to the early, P1 and N170, components. These authors found conflict adaptation effects for both tasks on these two early components and, following conflict monitoring theory (Botvinick et al., 2001), related the effect on P1 to conflict detection and the effect on N170 to control implementation. The main difference between our procedure and that of Alguacil et al. lies on the type of stimuli used, as they employed words instead of faces. It is difficult, however, to ascertain how this difference may have generated different results.

In the present experiment the N2 component of interest had a central and posterior topography and appeared relatively early, picking around 200 ms. This posterior N2, also called N2c (Pritchard, Shappell and Brant, 1991), has been related to stimulus classification rather than cognitive control (Folstein and Van Petten, 2008). However in our experiment the posterior N2 was clearly modulated by conflict resolution and previous congruency. In the cognitive version of the task the N2 displayed negative amplitude larger for incongruent than congruent trials in agreement with previous results showing N2 modulations when attention is focused on targets avoiding irrelevant information (Luck, 2005). These modulations appear related to the response, by monitoring the inappropriate responses that in conflicting situations may compete with the correct one (Folstein and Van Petten, 2008). Also in the cognitive task we found a significant modulation of this component as a function of previous congruency, so that the more negative amplitude for incongruent compared with congruent trials was largest when they followed an incongruent trial. In contrast, conflict adaptation showed a different pattern in our emotional task since, after an incongruent trial, the N2 amplitude was significantly shorter for incongruent than for congruent trials. These results show a clear dissociation on N2 conflict adaptation between the emotional and the non-emotional tasks.

There is no agreement regarding the way that conflict adaptation should be reflected on N2 in cognitive tasks. Clayson and Larson (2011) using a modified Eriksen flanker task, in which participants had to identify the direction of a central arrow pointing to the right or to the left, reported a decrease of N2 for incongruent trials following another incongruent trial. On the other hand, we found more negative amplitude for incongruent compared with congruent trials when they followed an incongruent trial. There is a difference in difficulty between our task and the Eriksen flanker tasks, employed by Clayson and Larson, that may explain the diversity of results. If we assume that the N2 component is related to focusing attention on targets and avoiding irrelevant information (Luck, 2005), responding to the gender or emotion of a face appears more attention demanding than responding to the direction of a pointing arrow. It is reasonable to assume that the amount of attention focusing induced by an incongruent trial on the following trial may depend upon the difficulty of the task, being greater for high demanding tasks. As a result, an incongruent trial following another incongruent trial may receive more attention, shown in a greater N2, than a congruent trial in a high demanding task while it may not need additional attention in a low demanding task. Though this explanation is clearly ad hoc, it provides an interesting prediction about conflict adaptation being dependent upon the difficulty of the task, at least in cognitive tasks.

Concerning the emotional version of the task, our results showed N2 amplitude significantly shorter for incongruent than for congruent trials after an incongruent trial. This is likely the first time that conflict adaptation on N2 is reported in an emotional Stroop task in which participants had to perform explicit affective evaluations on the stimuli; in fact, Alguacil et al. (2013) did not observe any N2 modulation in their affective task when they asked their subject to evaluate the emotional meaning of words. As mentioned above, experiments showing emotional conflict on N2 have generally asked their subjects to respond according to the cognitive nature of target stimuli displayed upon an emotional background (Kanske & Kotz, 2010, 2011).

It is not easy to explain why in our experiment emotional conflict adaptation on N2 appears as amplitude shorter for incongruent than for congruent trials. According to the *conflict-monitoring hypothesis* we would expect a control reduction in an incongruent relative to a congruent trial as a consequence of being preceded by another incongruent trial. If N2 amplitude were directly related to control, then our data would lend support to a reduction of control for incongruent compared with congruent trials after an incongruent trial, but only in our emotional task, not in the cognitive task. Thus, it appears that the conflict adaptation hypothesis cannot explain our results for both, our cognitive and emotional task. It is also possible that our results provide supporting evidence for neuronal mechanisms different for cognitive than for emotional control; Egner et al. (2008), using fMRI and the same task as we have used, reported two distinct neuronal control circuits: a lateral prefrontal system, in charge of resolving cognitive conflict, that was associated with enhance processing of task relevant stimuli, and a rostral anterior cingulate system, resolving emotional conflict, and associated with decreased amygdalar responses to emotional distracters. These two mechanisms could explain our N2 results for both, the cognitive and emotional tasks. In the cognitive task, the N2 amplitude larger for incongruent than congruent trials, would be mainly related to the working of the lateral prefrontal system, enhancing task relevant stimuli. In the emotional task, the N2 amplitude, shorter for incongruent than congruent trials, would mainly reflect a decreased in amygdalar responses to the emotion of the face. Further research is needed to replicate our findings and to ascertain the different factors that may influence N2 amplitude in emotional and non-emotional conflict situations. In a relevant review on cognitive control and the N2 component, it was concluded that even the N2c may need subdivisions (Folstein and Van Petten, 2008). If, in addition, emotional control is taken in account, the need for research on N2 is further increased.

With reference to the P3 component, we found again a second order interaction between Previous congruency and Congruency that was different for the non-emotional than for the emotional task. A significant conflict adaptation effect appeared in the non-emotional task but no significant difference was found in the emotional task. In the non-emotional version, conflict adaptation appeared as a decrease in P3 amplitude of incongruent trials following an incongruent trial compared with incongruent following a congruent trials. These results replicate those reported by Clayson and Larson (2011). However Alguacil et al. (2013) did not find conflict adaptation in any of the three different windows defined on P3.

It has been suggested that the P3 component in conflict situations is related to control operations such as the allocation of attentional resources and inhibition of conflicting responses (Polich, 2006). Our P3 results in the non-emotional task lend support to the *conflict-monitoring hypothesis* that would predict a reduction in P3 amplitude for incongruent trials following an incongruent trial compared to incongruent following congruent trials. According to this hypothesis, conflict adaptation results from activation of the DLPFC that serve to prevent conflict in subsequent performance. Thus, when an incongruent trial is presented, dACC detects the conflict situation triggering signals to DLPFC that implements strategies to resolve this situation. If a subsequent incongruent trial is presented, the DLPFC is now prepared for the resolution of the conflict, investing less attentional resources than in the previous incongruent trial. Therefore our data also support a possible relationship between P3 amplitude and the control activity of the DLPFC, at least in non-emotional conflict situations. Egner et al. (2008) found a relation between DLPFC activation and the resolution of conflict, cognitive as well as emotional. However, in our emotional task we were unable to find any differences on P3.

As a consequence, it is likely that the relationship between DLPFC activity and P3 amplitude is multifaceted and need further research.

In sum, the present experiment provides evidence of conflict adaptation on ERP components closely related to control namely, the N2 and P3 components. To our knowledge, this experiment and the one by Alguacil et al. (2013) are the only ones conducting a direct comparison of the time course of cognitive and emotional conflict processing using EEG recordings in a task including an explicit evaluation of both types of materials. Curiously enough, Alguacil et al. found scalp signatures of conflict adaptation on the early P1 and N170 components, where we were unable to find them. In contrast, we found such scalp signatures on N2 and P3, where Alguacil et al. (2013) did not. The main difference between the two experiments have to do with the task and kind of stimuli employed; Alguacil et al., used an Eriksen flanker task with only words as stimuli, while we have utilized a Stroop task with words and faces. Further research will hopefully shed light upon these discrepancies.

Capítulo 4

SERIE EXPERIMENTAL II:

Unconscious CSPCE in cognitive and emotional conflict: An ERPs study

1. Introduction

Cognitive control processes have been a central topic in cognitive neuroscience research. As in real life, many experimental tasks require selection of relevant information to achieve an accurate performance. Cognitive control plays a role when the task environment contains both relevant and irrelevant task information. Stroop task (Stroop, 1935 experiment 2) provides an example of this situation. In this task participants have to name the ink color in which color words are printed. Two different conditions are usually presented: congruent and incongruent. In the congruent condition, the ink color matches the color name of the word (e.g., RED in red ink). In the incongruent condition, by contrast, the ink color is different from the color name of the word (e.g., BLUE in red ink). To perform the task in the incongruent condition, participants, by using control strategies, must avoid the automatic process of reading the word and have to name the color of the ink in which the word is printed. In the congruent condition, the ink color matches the color name of the word, so avoidance of the automatic reading process is not necessary. Consequently, reaction times (RTs) are longer in the incongruent condition than in the congruent one. This cost of time is known as *Stroop interference*.

Stroop interference can be affected by the relative proportion of congruent and incongruent trials (Logan & Zbrodoff, 1979; Lowe & Mitterer, 1982; West & Baylis, 1998). That is, when the proportion of incongruent trials is high, the Stroop effect is smaller than in situations in which the proportion of congruent trials is predominant. It seems as if frequent experience with conflicting stimuli or response features facilitates the resolution of interference. In general terms, a kind of facilitation like this is known as a *Conflict adaptation effect (CAE)* (Botvinick, Braver, Barch, Carter, & Cohen, 2001). Several factors responsible of this effect have been advanced. The main ones are the overall proportion of congruency at the list level (*proportion of congruency effect*, PCE) (Logan, Zbrodoff, & Williamson, 1984) or a more specific and online processing of the information either at the item level (*item-specific proportion congruency effect,* ISPCE) (Jacoby, Lindsay and Hessels 2003) or at the context level (*context-specific proportion congruency effect,* CSPCE) (Bugg, Jacoby, & Toth, 2008; Crump, Vaquero, & Milliken, 2008; for a review, see Bugg & Crump, 2012).

Proponents of the PCE (Logan, et al., 1984) argue that in a Stroop task subjects become aware of the contingency between the color and the word and adapt their strategies to attend the word when the proportion of congruent trials is higher than that of incongruent ones and ignore the word when the proportion of congruent and incongruent trials is reversed. Consequently, the Stroop effect is larger when the proportion of congruent trials is predominant because the color word is likely to be attended to in incongruent trials as well. By contrast, when the proportion of congruent trials is lower than that of incongruent trials, the Stroop effect is smaller than in the previous case because the color word is mostly ignored in incongruent trials. According to this approach, the proportion of congruent items influences performance at a list-wide level by switching participants' attention to one of the two dimensions depending on which one is relevant for the task.

Proponents of the ISPCE contend that the proportion congruency effect acts at the item level. Jacoby et al. (2003) chose six colors and their corresponding color words and divided them into two sets of equal size. To produce mostly congruent (MC) items, words in one set were presented in their congruent colors in eighty percent of trials and in another color from that set in the remaining twenty percent of trials. These rates were reversed in words from the other color set to produce mostly incongruent (MI) items. The proportion of congruency at the list level was fifty percent. This manipulation of proportions prevents subjects from developing a general list-level strategy because the proportion of congruent and incongruent items is the same. However, Jacoby et al. found that MC items showed a larger Stroop effect than MI items. Results similar to those of Jacoby et al. were obtained by Crump, Gong and Milliken (2006) in a situation in which the likelihood of congruency was associated to a task-irrelevant location context rather than to a particular color word. According to these authors, the ISPCE belongs to a larger class of effects known as *context-specific proportion congruency effect* (CSPCE) that is driven by the relationship between the context and the likelihood of congruency. In recent years, the CSPCE has been reported in a range of Stroop-like effects (Bugg, Jacoby, & Toth, 2008; Crump, Vaquero, & Milliken, 2008; for a review, see Bugg & Crump, 2012) and in different types of contexts, including social categories (Cañadas, Rodríguez-Bailón, Milliken, & Lupiáñez, 2012).

A second example of conflict adaptation has to do with sequential effects. Gratton, Coles and Donchin (1992) first studied these effects using the Eriksen flanker task. They found that RT decreased for current incongruent trials when they followed another incongruent trial compared with when they followed a congruent trial. On the other hand RT increased for congruent following incongruent trials compared with congruent following congruent ones. This result, known as Gratton effect, has been found across different conflict tasks, including Stroop (e.g., Egner & Hirsch, 2005), Simon (Hommel, Proctor & Vu, 2004) and flanker tasks (e.g., Nieuwenhuis, Stins, Posthuma, Polderman, Boomsma & De Geus, 2006); it seems to be domain-specific, as it does not transfer across different tasks that are performed sequentially (Egner, 2008; Funes, Lupiáñez, & Humphreys, 2010). The most generally accepted explanation for this effect is that participants detect conflict on incongruent trials and decrease attention to the word on the following trial in order to avoid further conflict. As a result, the Stroop effect will be smaller. In contrast, on congruent trials there is no conflict, so attention will not be as constrained on the following trial. Hence, the word can interfere more strongly and the Stroop effect will be larger. Due to these processes, a Gratton effect will emerge, that is, an interaction between congruency on the current trial and congruency on the previous trial.

At computational and neural levels of analysis, Botvinick et al. (2001); (see also Botvinick, Cohen, & Carter, 2004; MacDonald, 2000) advanced a common explanation for both, the PCE and the Gratton effects, in what they termed the *conflict-monitoring* *hypothesis.* According to these authors, the Stroop task is just a particular case of conflict resolved by the interplay of a set of neural structures. The dorsal anterior cingulate cortex (dACC) acts as a detection mechanism that responds to the occurrence of a conflict situation (i.e., an incongruent trial in a Stroop task). The conflict signal triggers strategic adjustments in the dorsolateral prefrontal cortex (DLPFC) and other posterior and subcortical structures that serve to prevent conflict in subsequent performance. Accordingly, in a list where incongruent trials outnumber congruent ones, strategic adjustment mechanisms will be highly operative, thus minimizing the influence of the color word on performance and reducing the Stroop effect. For the Gratton effect the explanation is similar. When an incongruent trial is presented, dACC detects the conflict situation triggering signals to DLPFC that implements strategies to resolve this situation. If a subsequent incongruent trial is presented, the DLPFC is now prepared for the resolution of the conflict, which translates in faster RT in the current incongruent trial. Experiments using functional magnetic resonance (fMRI) have lent support to this *conflict-monitoring hypothesis* (Botvinick, Cohen, & Carter, 2004; Kerns, Cohen, McDonald III, Cho, Stenger & Carter, 2004; McDonald, 2000). Nevertheless, from a computational approach, Blais, Robidoux, Risko and Besner, (2007) showed that Botvinick's *conflict-monitoring model* could not explain the ISPCE and proposed a modified model according to which the DLPFC exerts control at the specific item level rather than at the general list level. Likewise, in a recent experiment using fMRI, Blais and Bunge (2010) found that many of the regions involved in cognitive control in the Stroop task, including the ACC and DLPFC, were operative at a local item level.

Conflict not only exists in the cognitive but also in the emotional domain. Many tasks have been adapted in order to study the conscious emotional conflict resolution processes (Bishop, Duncan, Brett, & Lawrence, 2004; Bush, Luu, & Posner, 2000; Compton, 2003; Shin, Whalen, Pitman, Bush, Macklin, Lasko et al., 2001; Whalen, Bush, Mcnally, Wilhem, McInerney, Jenike & Rauch, 1998). For example, in the emotional counting Stroop task (Whalen et al., 1998), participants have to report the number of words that appear on a screen, regardless of the word meaning. Control trials contain emotionally neutral words (e.g., 'cabinet' written three times), while interference trials contain emotional words (e.g., 'murder' written three times). As a general finding, emotional words tend to show greater interference effect (longer RT) when compared with neutral (non-emotional) words. Similar results have been found in emotional Stroop tasks where subjects have to name the ink color of words the meaning of which may be emotional or non-emotional. As in the previous task, emotional words produce longer RT than non-emotional words (e.g. Watts, McKenna, Sharrock & Trezise, 1986).

A common characteristic to these tasks is that emotional information acts as distracter rather than target, because targets are always cognitive. Thus they may be suited to provide information about the interference produced on the control of a cognitive activity (either counting or color naming) by emotional information, but they do not provide direct information on emotional control. To achieve this information, emotional stimuli should be included as targets. Recently, attempts have been made to study both, cognitive and emotional, control mechanisms within the same task in order to equate the cognitive and affective type of conflict. The face-word Stroop task (Egner, Etkin, Gale, & Hirsch, 2008; Etkin, Egner, Peraza, Kandel, & Hirsch, 2006, Panadero & Tudela, submitted) may be considered a good example. In the emotional version of this task, subjects have to name the emotion displayed by either a male or female face while an emotional word is presented across the face such that the meaning of the word and the emotion of the face may be either congruent or incongruent. In the cognitive version of the task, subjects have to respond to the gender (male or female) of the faces disregarding the meaning of the word (male or female) printed across the face that may be congruent or incongruent with the face gender. Results show that in both versions of the task the incongruent condition creates conflict (emotional or cognitive), reflected in slower RT in incongruent relative to congruent trials. Other researchers (Alguacil, Tudela, & Ruz, 2013; Ochsner, Hughes, Robertson, Cooper, & Gabrieli, 2008) have employed a variant of the Eriksen flanker task (Eriksen & Eriksen, 1974) in which a word was presented as target at the center of the screen and flanked by another two words above and below. In the emotional version, participants had to respond to the valence of the target (positive or negative); in the cognitive version they had to indicate the target's semantic category. In either version, the flanker words could be congruent or incongruent with the target. As in the Stroop task, also in the flanker task the incongruent trials create both, cognitive and emotional conflict (slower RT).

Regarding neural mechanisms underlying cognitive and affective conflict, an influential review of experiments, using imaging techniques, on cognitive and emotional versions of the Stroop task (Bush, Luu, & Posner, 2000) suggested a segregation of functions within the anterior cingulated cortex (ACC); the dorsal part would be mainly involved in cognitive control while the ventral ACC (vACC) would be engaged when emotional control is needed. This hypothesis was based in experimental evidence where cognitive and emotional control was studied in experiments in which, as pointed out above, emotional information acted as distracter for cognitive responses. More recently, the neural substrate of cognitive and affective conflict has been jointly explored within the same experiment using fMRI (Egner, et al., 2008; Ochsner, et al., 2008). Their results partially modified Bush et al.' hypothesis so that emotional conflict seems to recruit vACC and rostral medial prefrontal cortex (RMPC) while cognitive conflict appears under control of the DLPFC.

To date, few experiments have studied the ERPs associated to cognitive and emotional conflict jointly in the same experiment and using the same kind of material and task settings across conditions (Alguacil, et al., 2013, Panadero & Tudela, to be submitted). In the Alguacil et al. experiment, participants performed a flanker task in which they had to focus on a central target and indicate its semantic category (cognitive version) or its valence (affective version). Targets were flanked by congruent or incongruent words in both versions. Results showed differences in the wave amplitude as a function of the cognitive or emotional nature of the task in the late ERP components but none in the early components. They found conflict adaptation effects in N170 component with larger amplitudes for incongruent trials preceded by a previous incongruent trial. This pattern was the same for both, emotional and non-emotional task, showing that conflict had been processed in a very early stage of information processing. They also found that the N2 and the first part of the P3 were exclusively modulated by cognitive conflict, whereas the last section of the P3 deflection was only involved in affective conflict processing. The authors argued in favor of the existence of early common mechanisms, equivalent for cognitive and affective materials, and later task-specific conflict processing.

In contrast, Panadero and Tudela (to be submitted), using faces instead of words as stimuli, did not find conflict adaptation in the N170 potential, but did find it in both, the N2 and P3 potentials; in the N2 potential there was a dissociation between the cognitive and the emotional tasks; in the former, the N2 component for incongruent trials increased in negativity when they were preceded by another incongruent trial, while in the latter, the N2 component decreased in negativity under the same circumstances. In addition, they found evidence of conflict adaptation in the P3 component only for the cognitive, but not for the emotional, task. Panadero and Tudela argued that their results might provide electrophysiological support for neural mechanisms of control different for non-emotional and emotional situations. In the present experiment we tried to further explore the relationship between cognitive and emotional conflict and their underlying neural mechanisms.

A common characteristic of the experiments mentioned so far, is that they have studied conflict, either cognitive or emotional, in situations where participants were well aware of the stimuli presented and most of the relationships among them. As a result, theories such as the conflict monitoring hypothesis understand control as a conscious and strategic process. Few experiments have studied the possible unconscious nature of conflict adaptation processes. Klapp (2007, Experiment 3) explored the PCE under masked conditions using a masked arrow paradigm. He used a spatial Stroop-like task involving successively presented arrows pointing in either the same (compatible condition) or opposite direction (incompatible condition). The first arrow was presented for 32 ms and immediately followed by the mask together with the second arrow so that the first arrow was unnoticed to the subjects. The results yield a significant interaction so that the difference in RT between compatible and incompatible conditions was higher when the arrows pointed in the same rather than when they pointed in the opposite directions. However, in Klapp's experiment (2007) participants received feedback for incorrect responses, which makes it difficult to interpret his results. It may be that subjects' responses adapted to the conscious error rates rather than to the unconscious frequency of congruent and incongruent trials. Heinemann, Kunde and Kiesel (2009) explored the CSPCE under masked conditions using a task in which subjects had to categorize target numbers as being larger or smaller than five. A masked number (i.e., the prime), that could be congruent or incongruent with the target, preceded the target. At the beginning of each trial, a colored rectangle was presented as background simultaneously with the fixation cross. The color of the rectangle was associated with a particular congruency context that could be either 80% or 20%. Results showed that the difference in RTs between congruent and incongruent trials was significantly higher in the 80% than in the 20% congruent trial condition but only when subjects were able to see the prime; no differences were observed when they could not see it. (Heinemann et al., 2009). The authors concluded that the CSPCE requires conscious representation of the conflicting information, namely prime, target and context (Kunde, Reuss, & Kiesel, 2012).

Recently, Panadero, Castellanos and Tudela (2015) reported evidence for the unconscious nature of the conflict adaptation effect, specifically the context-specific proportion congruency effect (CSPCE). Following in part a procedure introduced by Blais, Tudela and Bunge (2007), they used a masked Stroop-like task where two different proportions of congruency were associated to two dissimilar masks. In addition they used electrophysiological measures in an attempt to trace the time course of each trial neural processing. Their results provided clear evidence of unconscious CSPCE not only in the RT but in the N2 and P3 components as well; a significant interaction between the percentage of congruency and the congruency between the color word and the color of the target, appeared in the three dependent variables, showing less

Stroop effect when the proportion of incongruent trials associated with one of the masks was 66%, than when the proportion of incongruent trials associated with the other mask was 33%.

In relation to emotional conflict, to our knowledge, no evidence of unconscious CSPCE has been provided so far. Thus, the main purpose of the present experiment was to study both, unconscious cognitive and emotional conflict, and in particular the possible existence of unconscious CSPCE in emotional conflict, in a task similar to that employed by Panadero and Tudela (submitted). We used a face-categorization task (Egner y Hirsch, 2005b; Gale; and Hirsch, 2007), in which we varied the source of conflict between non-emotional and emotional stimulus representations, while keeping task-relevant stimulus characteristics constant. The task-relevant information for both tasks was a set of male and female faces expressing either happiness or fear. For the cognitive task, subjects had to respond to the gender of the face while ignoring gender labels appearing across the faces. For the emotional task subjects had now to respond to the emotion expressed by the face ignoring a congruent or incongruent emotional label across the faces. To insure the unconscious processing of the labels, we followed a procedure similar to that employed by Panadero, Castellanos and Tudela (2015). Thus, the labels were preceded and followed by masks in both, the cognitive and emotional, tasks. In turn, each mask was associated to a particular proportion of incongruent trials. During the entire experiment we recorded continuously the EEG of the participants.

In summary, we tried to explore the emotional and non-emotional conflict effects under unconscious conditions and to observe how the proportion of congruency modulates these effects when it is associated to a particular context. We also took into account the effect of previous trial congruency to see how the CSPCE and the Gratton effects might interact. We focused on analyzing the unconscious situation but we tried to maintain an expectation of the presence of a prime word between masks by calibrating the duration of this word individually for each participant until it was unnoticed. It has been recently reported (Martens, Ansorge, & Kiefer, 2011) that subliminal semantic priming can be modulated by attentional task set. In this experiment we tried to keep the task set constant while the processing of the prime word remained unconscious.

2. Material and methods

2.1. Participants

Twenty-four students of the University of Granada (23 females and 1 male) participated in a one-session experiment. A group of twelve participants conducted a non-emotional version of the task and another group of twelve participants conducted an emotional version of the same task. Participants reported having normal or corrected-to-normal vision and were not aware of the purpose of the experiment. Mean age was 21.67 years (SD = ±2.37). Participants received course credit in exchange for their participation and signed a consent form approved by the local Ethics Committee.

2.2. Stimuli and Apparatus:

Three different types of stimuli were presented: twelve face pictures (6 men and 6 women, three of them were happy and three were angry), two different masks and two kinds of words. For the non-emotional version the words were MASCULINO (4.581º wide and 0.573º high) and FEMENINO (3.8º wide and 0.573º high). In turn, for the emotional version the words were ASUSTADO (3.347º wide and 0.573º high) and CONTENTO (3.347º wide and 0.573º high). Masks could be either @@@@@@@@@ (4,581º wide and 0,802º high of visual angle) or ######### (6,867º wide and 0,802º high of visual angle), each one associated with a different percentage of incongruency and, counterbalanced per participants; for odd participants @@@@@@@@@ was associated to a 66% and ######### to a 33% incongruency percentage. This was reversed for even participants. Words and masks were presented in 18 Courier New letter in white color on a black background.

Targets were face pictures of about 10.28º wide and 11.42º high of visual angle; they appeared in the center of the screen. All stimuli were presented on a 17 inch color screen of a PC computer at a viewing distance of about 50 centimeters. The PC was connected to a Macintosh computer for the registration of the ERPs. The entire task was created and displayed using the E-Prime 1.2 Professional software (Schneider, Eschman & Zuccolotto, 2002).

2.3. Procedure and design

2.3.1 Procedure

The experimental session had two parts: a threshold setting, followed by an experimental section. In the first part, the awareness threshold for the words was determined for each participant in the following way. First a cross served as a fixation point and was presented in the center of the screen for 1000 ms. Then a word that could be ASUSTADO or CONTENTO for the emotional task and MASCULINO or FEMENINO for the non-emotional task, appeared immediately preceded and followed by the same mask. The preceding mask lasted for 109 ms and the following 689 ms. At the beginning the word was presented for 100 ms, a time interval that participants could easily perceive. They had to report whether or not they were able to see the word. If the answer was affirmative we decreased the presentation time of the word in 10 ms steps (equivalent to one refresh rate of the computer screen). If it was negative, we kept the presentation time of the word constant and repeated the procedure until the answer remained negative for three consecutive trials. The obtained presentation time was kept as the awareness time threshold for the particular subject. The second part of the session consisted of eight masked blocks with seventy-two trial each with the following event sequence: A fixation point appeared during 1000 ms and was followed by the first mask lasting 109 ms. Then one word was presented for the time determined in the previous part of the experimental session and followed by the same mask now lasting 689 ms. The SOA value between the second presentation of the mask and the target stimuli was 1000 ms. These target stimuli were face pictures of scared or happy men or women and were displayed during 1500 ms. Participants responded by pressing z or n in a Qwerty keyboard. Keys were counterbalance per participant. The subject response was followed by an inter-trial interval that varied randomly between 1000 and 1500 ms (see Fig. 4.1.A).

In the non-emotional task participants had to respond to the gender of the face and in the emotional task they had to respond to the emotion of the faces. At the beginning of the entire procedure we instructed the participants to concentrate on the task and try to respond as fast as possible to the target. After the experimental session every participant had to respond to three questions to ensure they were not aware of the association between the incongruency percentage and the mask.

2.3.2. Design

Within each block of 72 masked trials three within-subject independent variables were manipulated: Incongruency percentage (33% vs 66%), Previous trial congruency (congruent vs incongruent) and Current trial congruency (congruent vs incongruent). In the 33% incongruency mask condition, 24 trials were congruent and 12 incongruent. In the 66% incongruency mask condition, 12 trials were congruent and 24 incongruent. Thus within each block the number of congruent and incongruent trials remained the same and each mask appeared an equal number of times but associated with a different percentage of incongruency.

Finnally, an additional between-subject variable was manipulated: Task (emotional vs non-emotional).

2.4. EEG recording and data analysis:

Participants were seated in front of the computer monitor in an electrically shielded room. They were instructed to avoid eye blinks and movements during target presentation and response. EEG was recorded using a high-density 128-channel Geodesic Sensor Net (Tucker et al., 1994). The head coverage included sensors lateral to and below both eyes to monitor horizontal and vertical eye movements. The EEG net was connected to an AC-coupled, high-input impedance amplifier (200 MΩ). At the beginning of the recording session, impedance for each channel was measured and kept under 50 kΩ, as recommended for Electrical Geodesics high-input impedance amplifiers. Amplified analog voltages (0.1–100 Hz band pass) were digitized at 250 Hz (12 bits A/D converter and 0.02 µV minimum resolvable voltage). All channels were referenced to the Cz electrode during the recording and were algebraically re-referenced off-line to the average.

The continuous EEG was filtered offline using a 30 Hz low-pass filter. After that it was segmented in epochs of 200 ms before and 600 ms after target onset. A 200 ms segment previous to the target presentation was used to calculate the baseline. The epochs were submitted to software processing for identification of artifacts. Segments with eye movements, eye-blinks (electro-oculogram channel differences greater than 70 µV), more than 20% of bad channels or corresponding to incorrect responses were not included in the ERPs. Data from consistent bad channels were later replaced using a spherical interpolation algorithm (Perrin, Pernier, Bertrand, & Echallier, 1989). A minimum criterion of 30 artifact-free trials per participant and condition was established to maintain an acceptable signal-to-noise ratio. A final grand-average was obtained per condition by pooling the subject's averages in each experimental condition.

To facilitate the selection of spatio-temporal windows for amplitude analyses, the topographic maps provided by the Net Station Viewer (EGI, 2008) were used as a guide. A topographic map view displays samples as representations of the scalp projected onto disk-shaped maps (also referred to as *scalp maps*) where amplitudes are represented by colours. However, in the topographic map view the amplitudes between sensors are interpolated, which allows the entire surface of the head to be depicted thus providing a view of the voltage distribution (topographies) over the scalp for each experimental condition as a function of time. Visual analysis of the scalp maps provided four focuses of the EEG, one bilateral including fourteen electrodes (showed in triangles in Figure 4.1B) lasting from 180 to 220 ms, another posterior, including seven parieto-occipital electrodes (shown in circles in Figure 1B), lasting from 205 to 275 ms after target presentation, a third, more central focus, including thirteen parietal electrodes (shown in squares in Figure 3.1B) lasting from 360 to 400 ms after the presentation of the target, and a frontal focus of twelve electrodes (showed in rhombuses in Figure 1B) lasting from 260-300 ms .

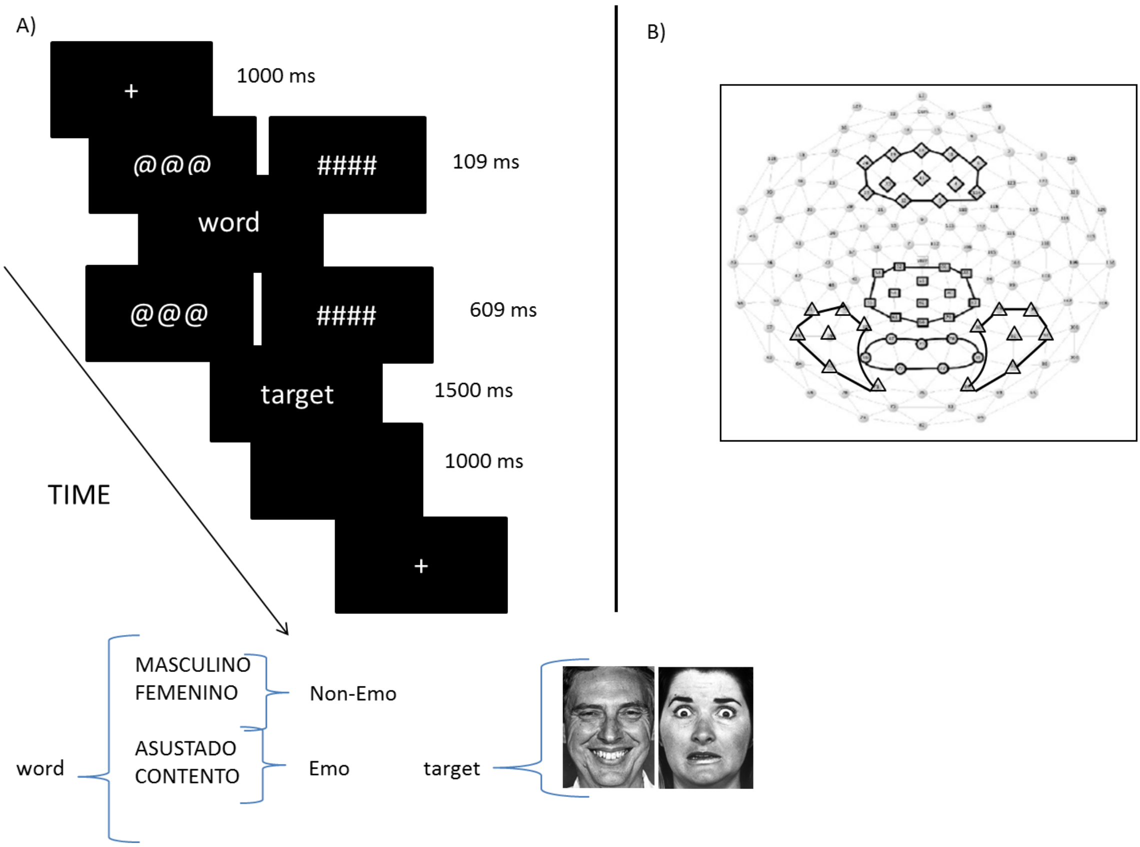


Figure 4.1. *(A) Trial sequence of events. (B) Groups of electrodes selected for N170 (triangles), P2 (circles), P3 (squares) and N2 (rhombuses) components.*

Latencies and voltage analyses were performed on a 40 ms window centered at the N170 (200 ms) of the grand-average waveform for the bilateral location, on a 70 ms window centered at the P2 peak (240 ms) for the posterior location, on a 40 ms window centered at the P3 peak (380 ms) for the central location, and on a 40 ms window centered at the N2 peak (280 ms) for the frontal location. For each participant, trials that did not meet the criteria regarding the amount of artefacts and bad channels were removed. Mean amplitude voltages averaged over the selected channels and time windows were submitted to repeated-measures ANOVAs with Task, between-subject,, and Incongruency Percentage, Previous trial congruency and Congruency, within-subjects, as factors. The same ANOVA was used with subjects' accuracy and RT.

3. Results

3.1 Behavioral results

Overall accuracy was very high (99%) and no significant differences in accuracy was observed between experimental conditions and tasks. Only correct responses were considered in the RT and ERPs analyses. RTs shorter than 300 ms or longer than 1000 ms and post-error trials were excluded (3%).

3.1.1. Threshold setting

The average presentation time of the masked words at threshold value was 20.75 ms (SD= ±2.70 ms) in the non-emotional group and 19.75 (SD= ±4.71 ms) in the emotional group. A comparison between these two threshold values showed no significant differences between groups $t > .1$

3.1.2. RT analysis.

A significant main effect of task was found in the RT analysis $F(1,22)= 6.7229$, $p < .05$, showing larger RT for the emotional task (Mean= 631 ms, SD= ±65.173) than for the non-emotional task (Mean= 567 ms, SD= ±54.069). We also found a significant interaction of Incongruency percentage x Current trial congruency $F(1,22)= 4.7949$, $p< .05$. (see Fig. 4.2.)

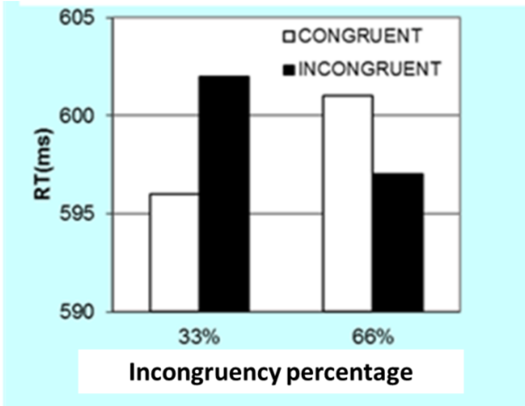


Figure. 4.2. *Interaction effect Incongruency percentage x Current trial congruency in the RT.*

Planned comparisons showed a close to significance difference between congruent and incongruent trials when incongruency percentage was low (33%), $F(1,22)= 4.2536$, $p= .051$ with larger RT for incongruent trials (Mean= 602, SD= ±73.137) than for congruent trials (Mean= 596, SD= ±64.984). On the other hand no significant differences between congruent (Mean= 601, SD= ±66.088) and incongruent trials (Mean= 597, SD= ±67.723) were found when incongruency percentage is high (66%).

A significant second order interaction Incongruency percentage x Previous trial congruency x Current trial congruency $F(1,22)= 4.4971$, $p< .05$ showed the expected Gratton effect when incongruency percentage was low (33%) (see Fig. 4.3.).

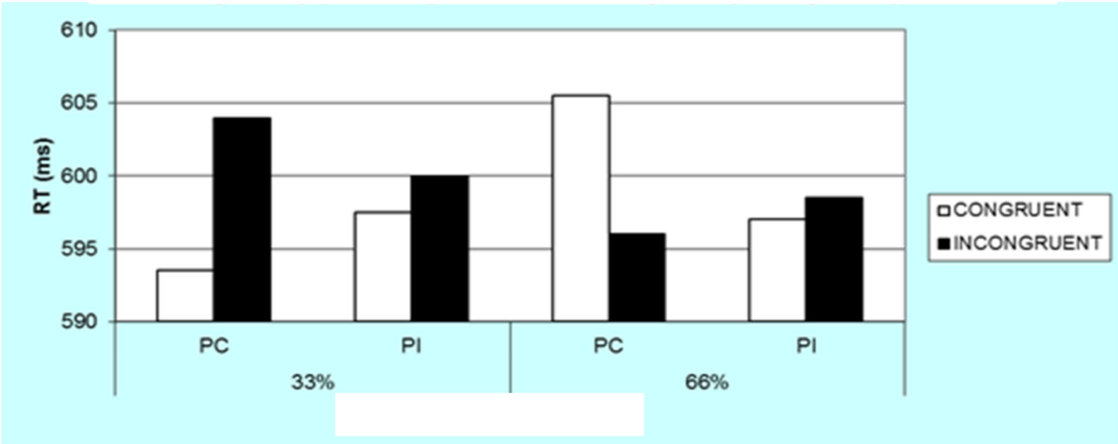


Figure 4.3. *Interaction effect Incongruency percentage x Previous trial congruency x Current trial congruency in the RT.*

As planned comparisons showed, when incongruency percentage was low (33%) a close to significant difference between congruent and incongruent trials was found if they were preceded by a congruent trial $F(1,22)= 4.1902$, $p= .052$, showing larger RT for incongruent (Mean= 604, SD= ±73.127) than for congruent trials (Mean= 568, SD= ±54.887). No significant differences between congruent (Mean= 598, SD= ±66.227) and incongruent (Mean= 600, SD= ±74.673) trials were found when preceded by an incongruent trial.

Reversed pattern of results were found in a high incongruency context (66%). In this case congruent trials preceded by a congruent trial (Mean= 605, SD= ±66.298) showed larger RT than incongruent trials preceded by congruent trials (Mean= 596, SD= ±65.039) $F(1,22)= 5.521$, $p< .05$ but these differences disappeared when congruent (Mean= 597, SD= ±67.008) and incongruent trials (Mean= 598, SD= ±71.685) were preceded by an incongruent trial.

3.2.EEG analysis

3.2.1. Target analysis

3.2.1.1.N170 ***(bilateral group of electrodes)***

Latency analysis

The analysis was conducted on a 40 ms window centered on a negative peak at 200 ms. A close to significance interaction effect was found between Incongruency percentage x Current trial congruency F(1,22)=3,556, p= .072 (see Fig. 4.4).

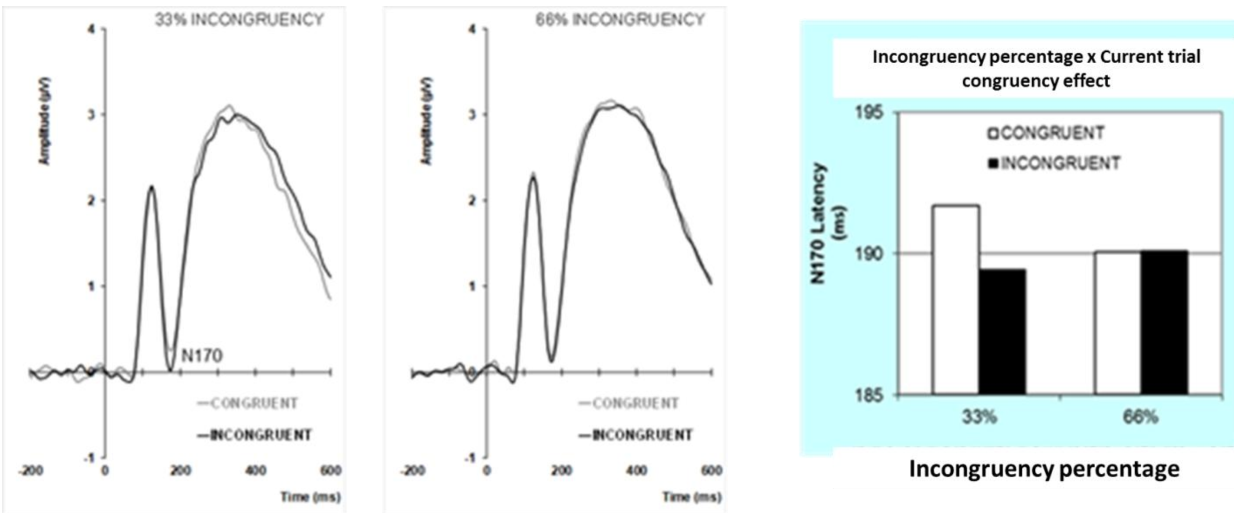


Figure 4.4*. Waves and graphic representation of the latency interaction effect Incongruency percentage x Current trial congruency effect in N170 latency.*

Planned comparisons showed only a significant difference between congruent trials (Mean= 191.698, SD= ±11.192) and incongruent trial (Mean= 189.411, SD= ±9.819) in a low incongruency context (33%) F(1,22)= 6.49, p< .05. Likewise an additional close to significance interaction between Previous trial congruency and Current trial congruency appeared, F(1,22)= 3.295, p= .083 (see Fig. 4.5)

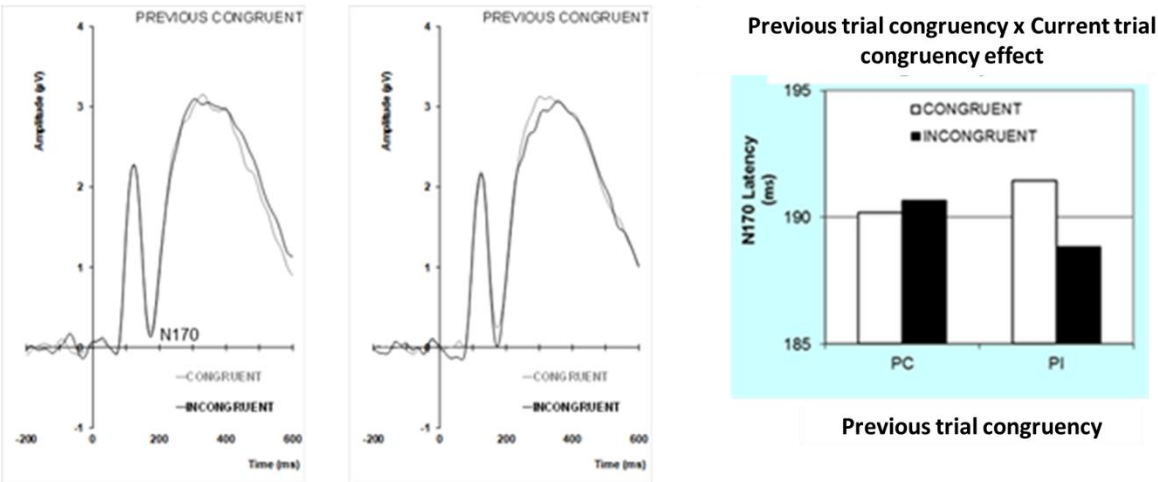


Figure 4.5. *Waves and graphic representation of the interaction effect Previous Congruency x Congruency in N170 latency*.

Only the difference between congruent (Mean= 191.438, SD= ±10.852) and incongruent trials (Mean= 188.839, SD= ±8.971) when previous trial was incongruent turned up significant F(1, 22)= 5.45, p<.05. No other significant difference was found. However, this interaction was modulated by Incongruency percentage as shown by a close to significant second order interaction, F(1,22)= 3.7714, p= .065. As can be seen in Figure 4.6, the difference between congruent (Mean= 192.448, SD= ±11.425) and incongruent trials (Mean= 187.563, SD= ±8.030) when previous trial was incongruent was significant F(1,22)= 6.91, p< .05, when the incongruency context was low (33%). Also in this low incongruency context we found that the incongruent following another incongruent trial (Mean=187.563, SD= ±8.030) peacked earlier than incongruents following a trial (Mean= 191,260, SD= ±11.110), F(1, 22)= 5.652, p< .05.

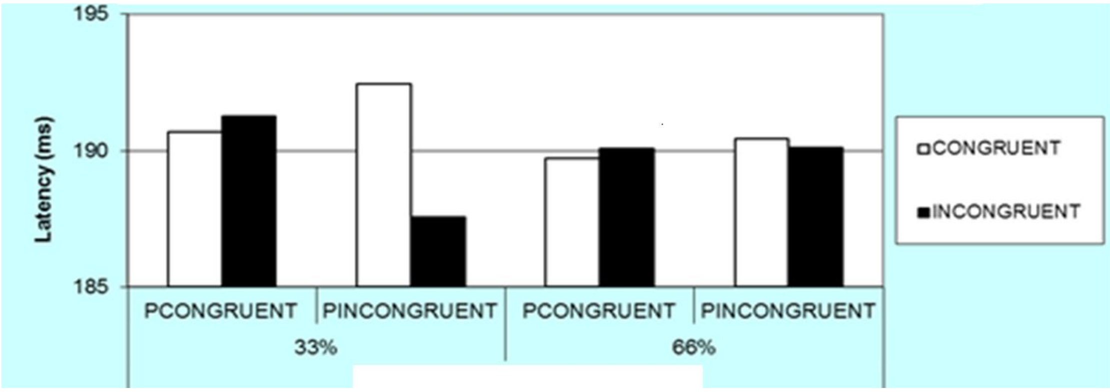


Figure 4.6*. Graphic representation of the interaction effect Incongruency percentage x Previous trial congruency x Current trial congruency for the N170 latency.*

Finally an additionally significant second order interactions was found between Task x Incongruency percentage x Current trial congruency F(1,22)= 5.1354, p< .05 (see Fig.6). This interaction was due to a significant F(1,22)= 4.64, p< .05 decrease in latency for previous congruent trials when the incongruency context was high (66%) (Mean= 188.135, SD= ±9.950) compared to when it was low (33%) (Mean= 190.260, SD= ±9.856) only for the non-emotional task (See Figure 4.7).

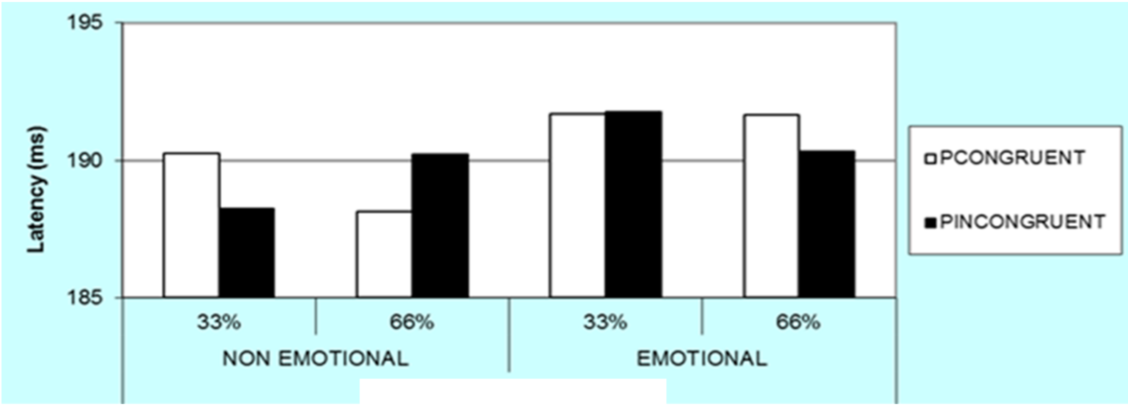


Figure 4.7. *Graphic representation of the interaction effect Task x Incongruency percentage x Previous trial congruency in the N170 latency.*

Amplitude analysis

Voltage analysis showed an significant interaction between Task and Hemisphere $F(1,22)= 13.501$, $p< .01$. In the right hemisphere, the difference in amplitude between the non-emotional (Mean= -1,152, SD= ±3,475) and the emotional task (Mean= 1,019, SD= ±1.85) was close to significance, $F(1,22) = 3,635$, $p = .07$. But there were no difference between non-emotional and emotional tasks in the left hemisphere.

We also found a significant second order interaction effect, hemisphere x Incongruency percentage x Current trial congruency $F(1,22)= 4.3916$, $p< .05$. The only close to significance effect was found in the left hemisphere and was due to a decrease in negativity for incongruent trials in a high incongruency (66%) (Mean= -0,051, SD= ± 2,130) compared with a low incongruency (33%) (Mean= -0.232, SD= ± 2,245) context. No other effect reached significance.

3.2.1.1. P2 *(Posterior group of electrodes)*

Inspection of the scalp topographies revealed a P2 positive polarity (see Fig. 4.8) lasting from 205 to 275 ms after target presentation over a set of parieto-occipital electrodes (circles in Fig. 4.1B).

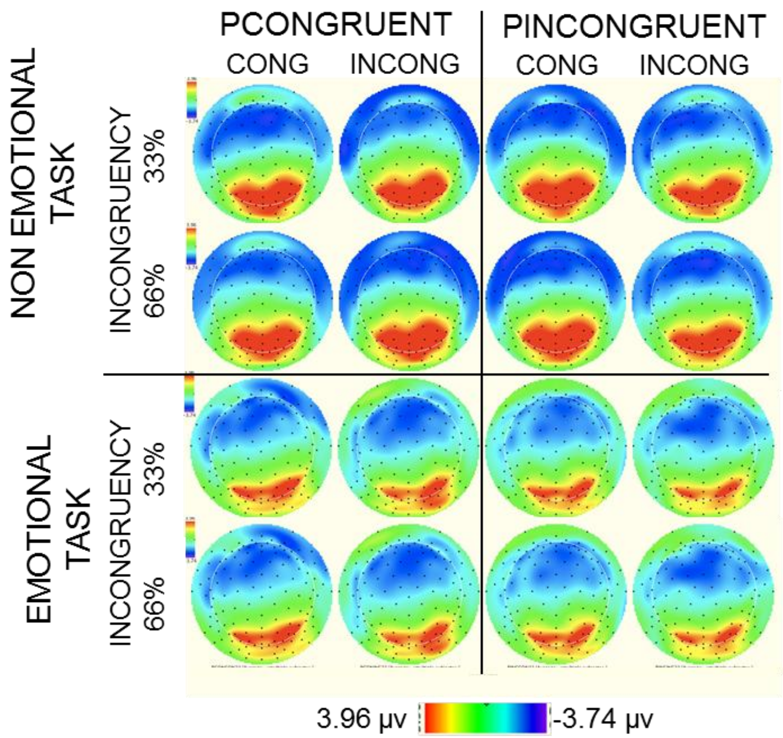


Figure 4.8. *Topographies corresponding to P2 peak (240 ms)*

Latency analysis

A significant interaction between Task and Incongruency percentage appeared, F (1,22) = 4,74, $p < 0.5$. Only the difference in the emotional task between the 33% (Mean = 223,39 , SD = 8,09) and 66% (Mean = 220,06 , SD = 9,87) conditions approached significance, $F(1,22) = 4,21$, $p = 0.052$. A three-way interaction Task x Previous trial congruency x Current trial congruency was also significant, $F(1,22) = 4,74$, $p < 0.05$. Planned comparisons showed that only in the emotional task there was a marginally significant increase in latency ($F1,22) = 3.564$, $p= 0.07$ for the incongruent trials following another incongruent trial (Mean = 222,64 SD = 10,42) compared to incongruent trials following a congruent trial (Mean = 220,33, SD = 8,15).

Amplitude analysis

Waveforms analysis sowed peak amplitudes around 240 ms, and amplitudes were analyzed using adaptive means in windows of 70 ms around the appropriate peak. The amplitude in the 66% incongruent trial condition (mean 66% = 3,998, SD = ± 3,277) was higher than the amplitude in the 33% incongruent trial condition (mean 33% = 3,803, SD = ± 3,291). This difference was found significant, $F(1,22) = 4.688$, $p < .05$.

A significant second order interaction Task x Previous trial congruency x Congruency was also found $F(1,22)= 6.3213$, $p< .05$. (see Fig 4.9.).

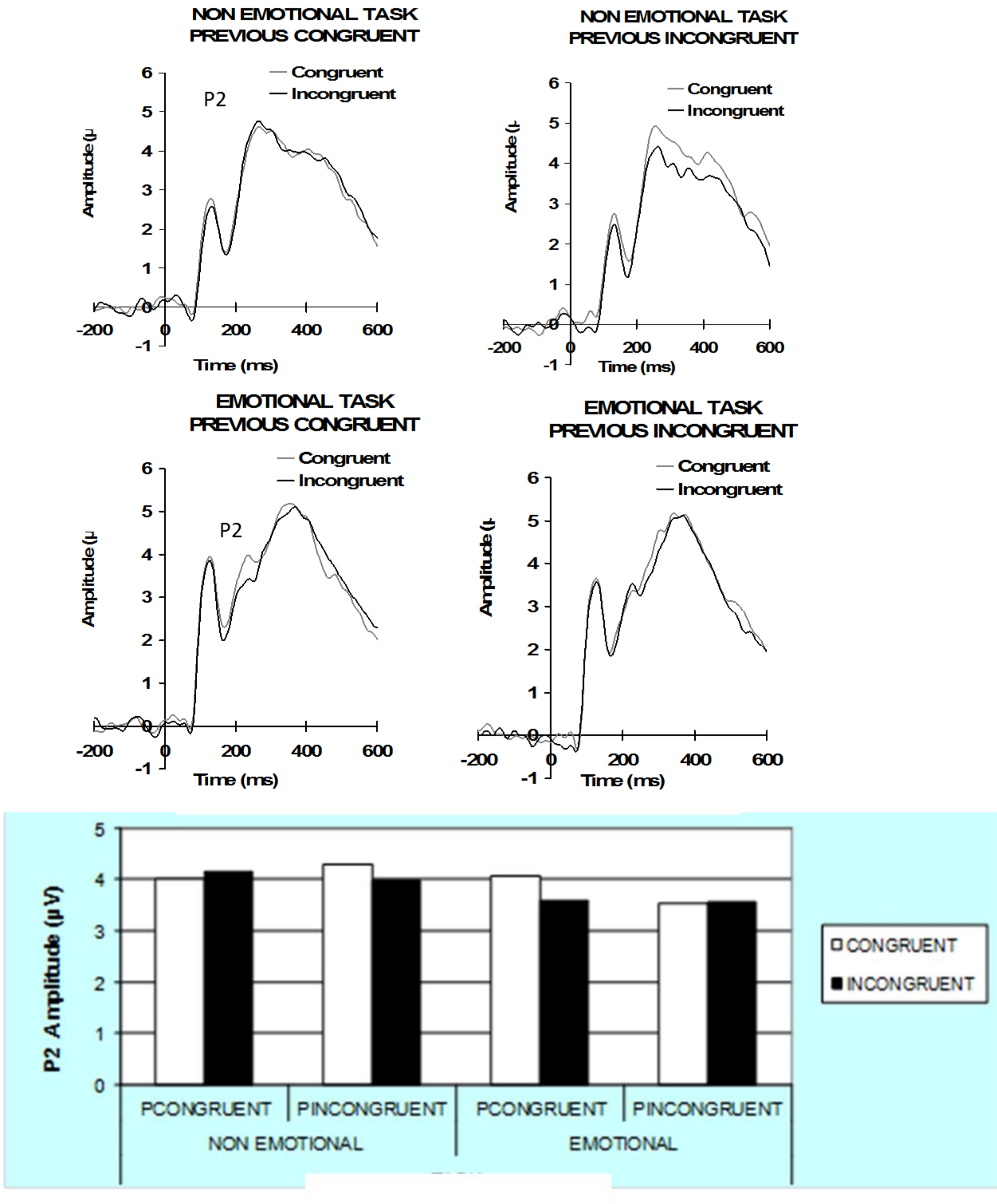


Figure 4.9. *Waves and graphic representations of the interaction effect Task x Previous trial congruency x Current trial congruency for the P2 amplitude.*

As can be seen, in the non-emotional task, though it was only marginally significant, incongruent trials (Mean= 3,982, SD= ± 3,721) showed less amplitude than congruent trials (Mean= 4,305, SD= ± 3,757) when they were preceded by an incongruent trial. $F(1,22)= 3.508$, $p= .074$. On the other hand, in the emotional task this pattern of results is produced when previous trial is congruent (Mean= 3,603, SD= ± 2,949) (Mean= 4,059, SD= ± 2,805) $F(1,22)= 4.644$, $p< .05$.

3.2.1.3. N2 *(frontal group of electrodes)*

Inspection of the scalp topographies showed a negative polarity over a frontal set of electrodes (rhombuses in Fig. 3.1B) in a window from 260 ms to 300 ms centered at 280 ms over a set of frontal (see Figure 4.10).

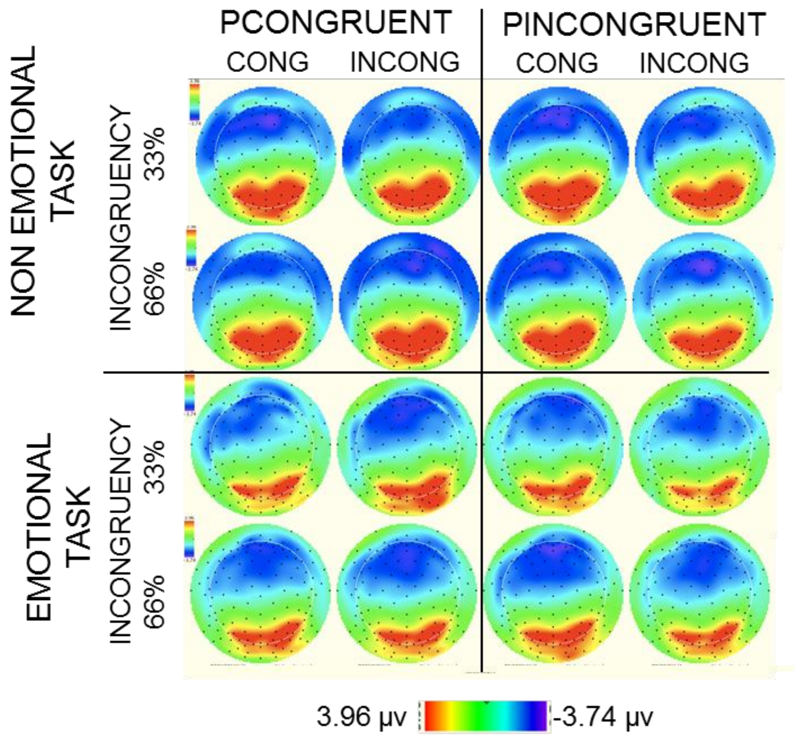


Figure 4.10.: *Topographies corresponding to the N2 component.*

Latency analysis

No main or interaction effects were found.

Amplitudes analysis

No significant main effects were found. But a significant interaction effect between Previous trial congruency and Current trial congruency $F(1,22)= 4.7570$, $p< .05$ (see Fig. 4.11) turned up.

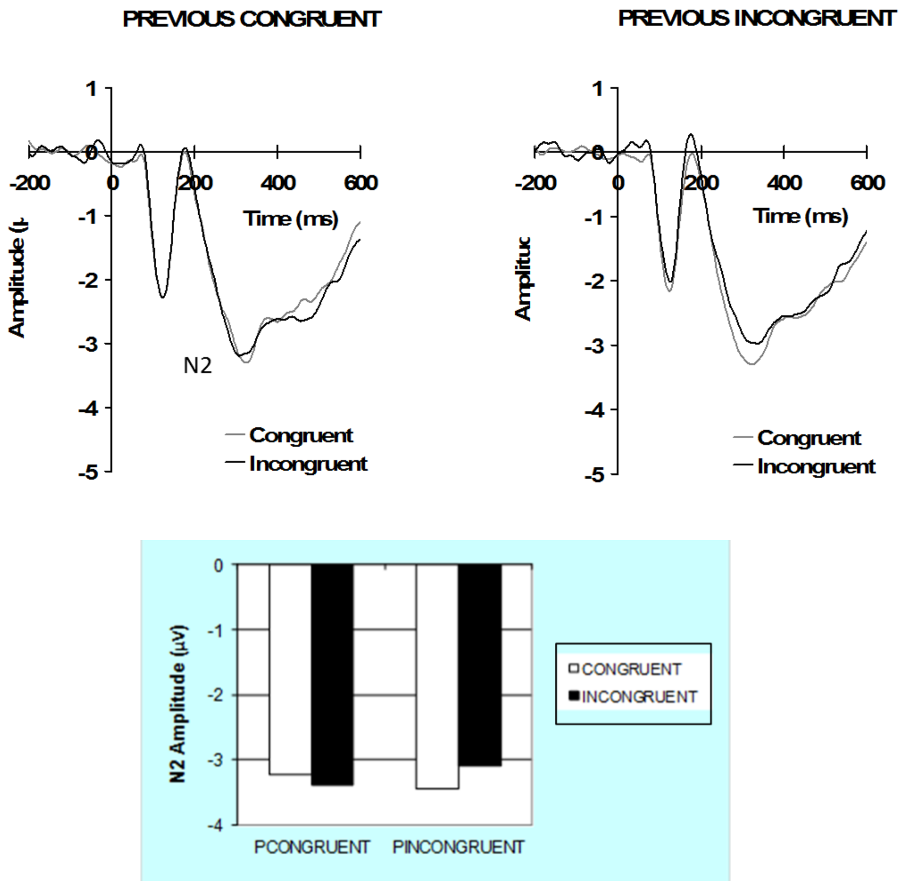


Figure 4.11*. Waves and graphic representations of the Interaction effect Previous trial congruency x Current trial congruency for the N2 amplitude.*

Planned comparisons showed a significant difference in amplitude for congruent (Mean= -3.448, SD= ± 2.075) and incongruent trials (Mean= -3.097, SD= ± 2.152) when previous trial was incongruent $F(1,22)= 5.1552$, $p< .05$ compared with when previous trial was congruent (Mean= -3.237, SD= ± 2.118, for incongruent), (Mean= -3.378, SD= ± 2.210, for congruent). In addition, incongruent trials showed a close to significance less negative when previous trial was incongruent than when previous trial was congruent F(1,22)= 4.0597, p= .057.

3.2.1.4. P3 *(central group of electrodes)*

Inspection of the scalp topographies showed a positive polarity over a centro-parietal set of electrodes (squares in Fig. 1.B) in a window from 360 ms to 400 ms centered at 380 ms (see Fig 4.12).

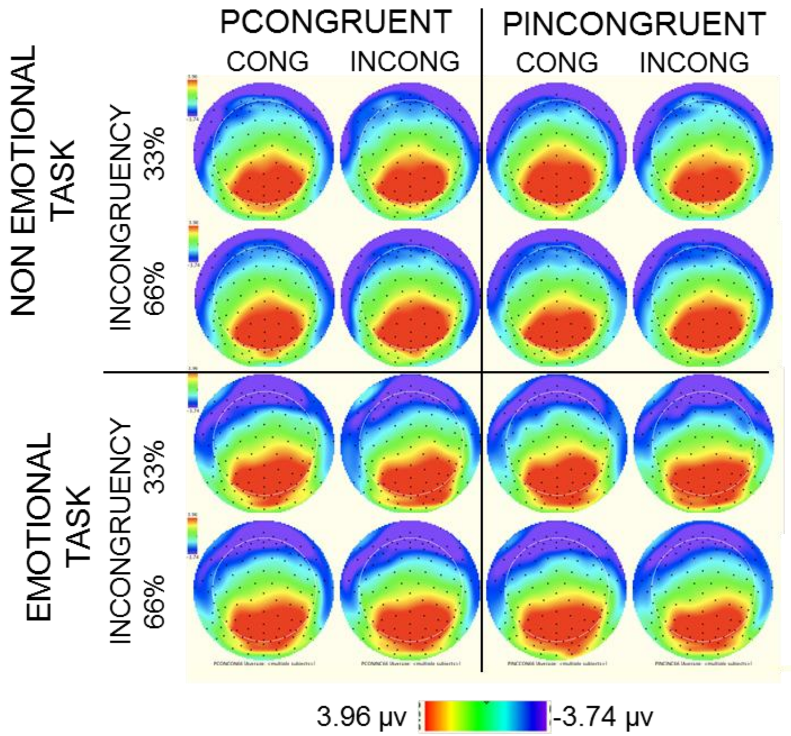


Figure 4.12. *Topographies corresponding to P3 peak (380 ms)*

Latency analysis

No significant main or interaction effects were found.

Amplitude analysis

A significant main effect of Current trial congruency was found for the P3 component F(1,22)= 4.5237, p< .05 with less positivity for incongruent trials (Mean= 4,749, SD= ± 2.180) compared with congruent trials (Mean= 4,903, SD= ± 2.187). We also found a close to significance interaction effect between Previous trial congruency and Current trial congruency F(1,22)= 3.6828, p= .068 (See Fig. 4.13).

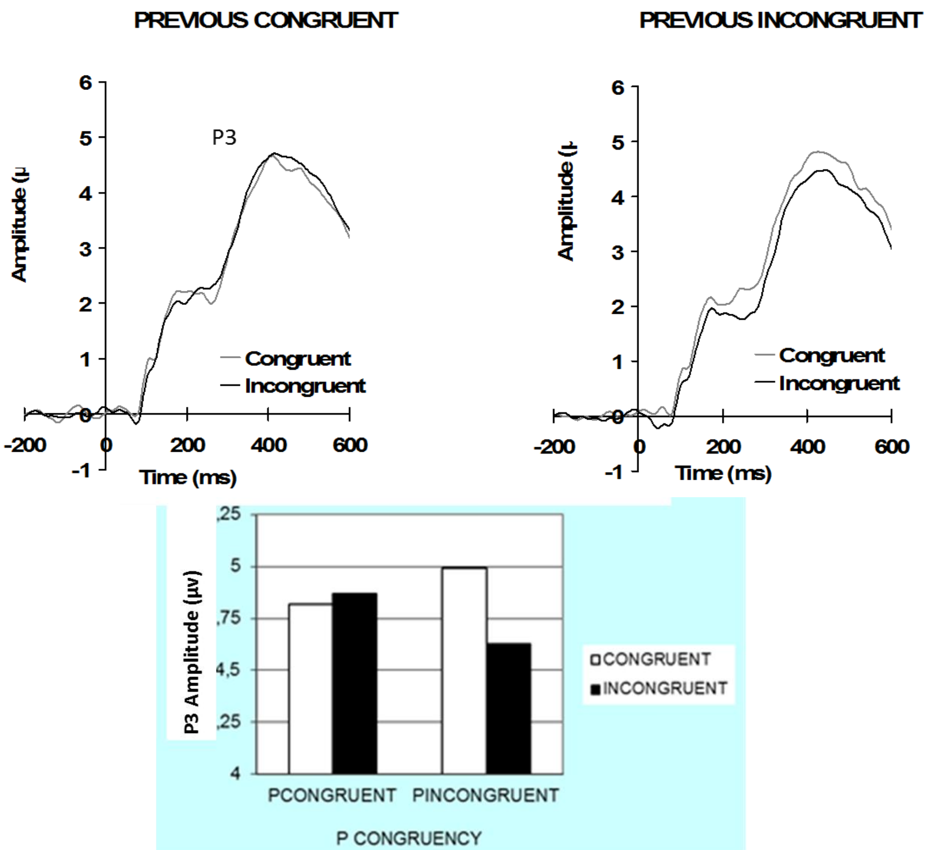


Figure 4.13*. Waves and Graphic representations of the close to significance interaction effect Previous trial congruency x Current trial congruency for the P3 amplitude.*

Planned comparisons showed significant differences between congruent (Mean= 4.990, SD= ± 2.202) and incongruent trials (Mean= 4.627, SD= ± 2.203) when they were preceded by another incongruent trial $F(1,22)= 6.1521$, $p< .05$. No significant differences were found when previous trial was congruent. We also found a significant third order interaction Task x Incongruency percentage x Previous trial congruency x Current trial congruency effect $F(1,22)= 4.848$, $p< .05$. To analyze this interaction effect we took emotional and non-emotional tasks separately. Analyzing the emotional task we found a close to significance second order interaction Incongruency percentage x Previous trial congruency Current trial congruency effect $F(1,11)= 4.2901$, $p= .062$ (see Fig. 4.14 y 4.15).

Planned comparisons showed a significant difference between congruent (Mean= 5,061, SD= ± 2.419) and incongruent trial (Mean= 4.546, SD= ± 2.527) when previous trial was incongruent, in the high incongruency context (66%), $F(1,11)= 8.766$, $p< .05$. In addition, the difference in amplitude between incongruent following congruent (Mean= 5,089, SD= ± 2.431) and incongruent following incongruent trials was also significant $F(1,11)= 6.4295$, $p< .05$. However no significant difference appeared in low incongruency context (33%)

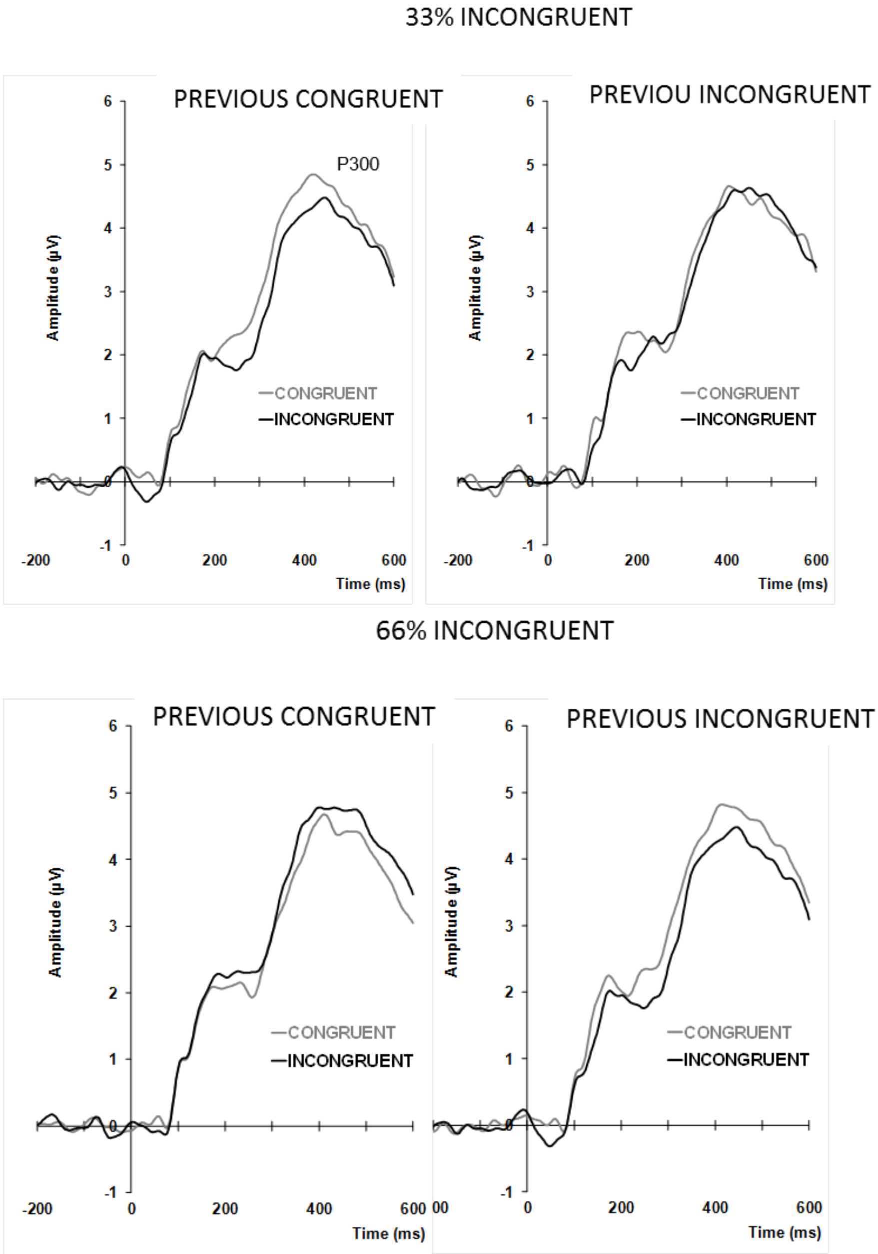


Figure 4.14*. Waves of the second order interaction effect Incongruency percentage x Previous trial congruency x Current trial congruency in emotional task for P3 amplitude.*

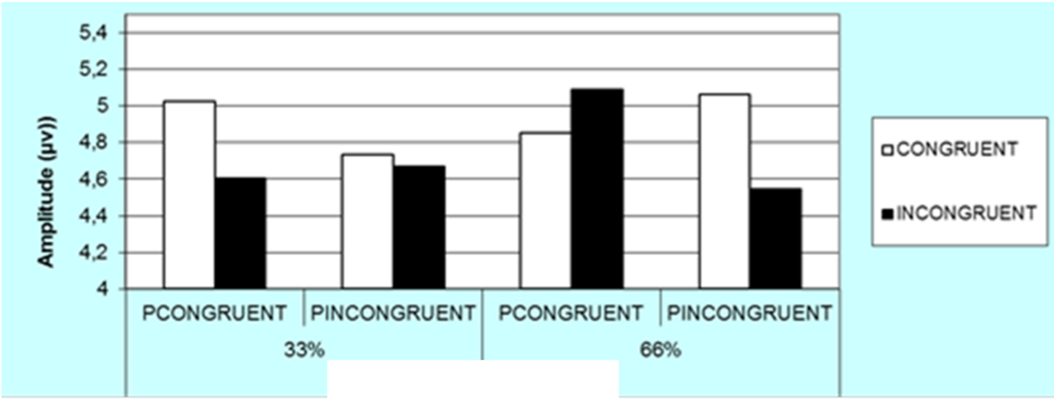


Figure 4.15. *Graphic representation of the second order interaction effect Incongruency percentage x Previous trial congruency x Current trial congruency in emotional task for P3 amplitude.*

On the other hand, in the non-emotional task, we found a close to significance interaction effect Previous trial congruency and Current trial congruency F(1,22)= 3.9167, p= .073 (See Fig. 4.16)

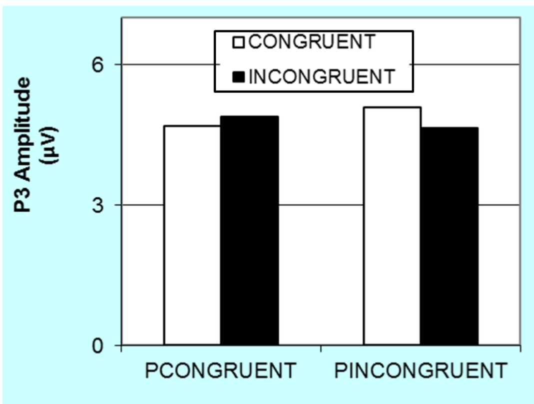


Figure 4.16*. Interaction effect Previous trial congruency x Current trial congruency in P3 amplitudes for the Non-Emotional task for P3 amplitude.*

Planned comparisons showed significant differences between congruent (Mean = 4,90, SD = 2,50) and incongruent trials

(Mean = 4,65, SD = 1,92) only when previous trial was incongruent $F(1,11)= 6.5858$, $p<.05$.

4. Discussion

The main purpose of this experiment was to study the cognitive and emotional conflict effects under unconscious conditions and to observe how the proportion of incongruency modulates these effects when it is associated to a particular context. Thus, we tried to replicate the results of Panadero et al. (2015), concerning the CSPCE, in a different Stroop-like cognitive task in which participants had to identify the gender of male or females faces. At the same time, we were interested in testing the similarities and/or differences of a hypothetical CSPCE related to emotional control, using the same Stroop-like face categorization task but, in this case, asking the participants to identify the emotion expressed either happy or frighten faces. In addition, we also analyzed the possible effect due to the congruent or incongruent character of the previous trials, in an attempt to shed some light on the likely relationship between this variable and proportion of incongruency. To insure the unconscious nature of Stroop conflict, the labels indicating either the gender or the emotion of faces were presented before the faces and double masked by a preceding and following set of characters. This set, in turn, was associated to and different for each proportion of incongruency.

We employed a subjective-threshold criterion of awareness determined by word presentation time. Below this threshold participants reported to be unable to perceive the words. In fact, the mean presentation time was 20.75 ms in the non-emotional group and 19.75 in the emotional group, with no significant difference in threshold value between the two. These presentation times are similar than those used in other masking experiments (Greenwald, Klinger, & Liu, 1989; Klapp, 2007; Panadero et al., 2015; Ortells, Marí-Beffa & Plaza-Ayllón, 2012). Additionally, when subjects were asked after the experiment if they had been able to process any word, the general answer was negative and none could establish any relation between the masks and the proportion of incongruency. Even more, all subjects reported equal difficulty across blocks independently of the mask type. Hence, it seems safe to conclude that, under subjective threshold conditions, our participants were unaware of the prime words and of the relationship between masks and proportion of incongruency.

Our RT data showed that the emotional task was significantly slower than the non-emotional task. These results agree with Egner et al. (2008) and Panadero & Tudela (to be submitted), who used a face categorization task and reported the same difference as well. However Alguacil et al. (2013) and Oschner et al. (2008), using words in an Eriksen flankers task, did not find difference in RT between cognitive and emotional tasks. Therefore it is likely that these discrepant results may be due to the type of stimuli on which the response is made. It appears that identifying a male or a female face is relatively easy compared with discriminating the emotional expression of those faces; while identifying the face gender may be based on global characteristics of the face, discriminating its emotional expression may require to focus attention on specific facial features like eyes, nose and mouth. In fact, influential models of face perception (Bruce & Young, 1986; Haxby & Gobini, 2011) consider gender to be part of a face identity (core system according to Haxby & Gobini, 2011) because it is a permanent characteristic and hence is processed at early stages of face perception. However emotional facial expression, being a changeable characteristic, requires additional information and is processed at later stages of face perception (extended system for Haxby and Gobini, 2011).

We also found the significant interaction between Incongruency percentage and Congruency characteristic of conflict adaptation; in a context of low incongruency (33%), incongruent were slower than congruent trials but, in a context of high incongruency (66%), incongruent tended to be faster than congruent trials. These results replicate those obtained by Panadero et al. (2015), who used a color-word-color patch cognitive Stroop task, and extends their results to emotional conflict as well, since the significant interaction in our data did not appear modulated by the type of task. Therefore our results may be considered an additional demonstration of unconscious cognitive CSPCE, and, to our knowledge, the first demonstration of unconscious emotional CSPCE. Previous research (Crump, Vaquero & Milliken, 2008; Blais, Harris, Guerrero, & Bunge, 2012) had shown that CSPCE might be independent of subjects' awareness of the incongruency proportion in situations where no masking procedure had been used. In the present research, by means of masking, subjects were made unaware of the congruency relation between the masked word and either the gender or the emotion of faces. In addition within each block of trials the percentage of congruent and incongruent trials was the same. Under these conditions, awareness of the proportion of incongruency associated with each mask seems very unlikely.

In the present experiment, Previous trial congruency produced an effect that was modulated by Incongruency percentage. The Stroop effect decreased in size from the condition where the previous trial was congruent to the condition where the previous trial was incongruent, but this decrement occurred only in the low incongruency context (33%). In the high incongruency context (66%), when the previous trial was congruent a reversed Stroop effect appeared, where congruent were slower than incongruent trials; on the other hand, when the previous trial was incongruent, no difference between congruent and incongruent trials turned up. If we assume that the manipulation of both variables, Previous trial congruency and Incongruency percentage, influence the Stroop effect in the same way, both tend to decreasing it (Botvinick et al., 2001), it is reasonable to suppose that the effect of one variable, say Previous trial congruency, may more clearly show up in a context where the effect of the other variable, say Incongruency percentage, is relatively weak, as it is the case in the 33% incongruency condition. However in a context where the Stroop effect is already reduced, as it is the case in he 66% incongruency context, the effect of Previous trial congruency in bound to be faint, because there is little room for the Stroop effect to be further reduced. In addition, the inverted Stroop effect, found when the previous trial was congruent in the 66% condition, may easily be due to the unlikely presentation of two consecutive congruent trials in a context where the dominant expectation favors an incongruent trial. It is interesting to note that the above mentioned effects were independent of the type of task; no difference was modulated by the conflict cognitive or emotional nature. Nevertheless, our second order significant interaction between Previous trial congruency, Incongruency percentage and Current Congruency is an intriguing result in need of further replication.

With respect to our electrophysiological results, we found significant effects in both, latency and amplitude, of the N170 component. The N170 latencies showed close to significance interactions of Congruency with Incongruency percentage as well as with Previous trial congruency. However these effects were clarified by a second order interaction among the three variables. As can be seen in Figure 6, only in the low incongruency context (33%) appeared a significant decrease in N170 latency for incongruent trials when they were preceded by an incongruent compared with a preceding congruent trial. This Gratton effect resembles that found in RT and indicates again that the effect of a previous congruent or incongruent trial depends upon the incongruency context; in our experiment, when the incongruency context was high (66%) no significant effect appeared. Similar to our RT results, these effects were independent of task type. However the type of task did showed up interacting with Previous trial congruency and Incongruency percentage; only for the non-emotional task, previous congruent trials produced shorter latencies in the high (66%) than in the low (33%) incongruency context.

Nontheless this interaction provides little information about the main purpose of the present experiment since the Stroop effect was not involved in it.

Amplitude analysis for the N170 mainly showed lateralization effects. On the one hand, only in the right hemisphere the non-emotional tended to show larger negativity than the emotional task. On the other hand, only in the left hemisphere there were indications of conflict adaptation since the negativity of the incongruent trials tended to change as a function of the type of previous trial, this negativity was shorter after an incongruent than after a congruent trial. This result agrees, but only in part, with that reported by Alguacil et al. (2013). They found conflict adaptation on the N170 independent of hemisphere and with voltage values more negative for incongruent trials following identical trials than for those following a congruent trial. In our experiment, conflict adaptation was lateralized and the direction of change for incongruent trials was opposite to that found by Alguacil et al. It seems that the direction of change induced by the type of previous trial on incongruent trials negativity is not clear. We will take over this issue after analyzing the remaining ERP components.

In sum, the analysis of the N170 component provided interesting information with respect to the aims of the present research. As in the RT analysis, unconscious conflict adaptation was found in the N170 latencies but depending upon the incongruency context. It was present in a context of mostly congruent trials but not in a context of mostly incongruent trials. In turn, N170 amplitude analysis showed conflict adaptation only in the left hemisphere but the negativity of incongruent trials decreased, rather than increased, after an identical trial compared with after a congruent one.

In the latencies of the P2 component, conflict adaptation appeared close to significance only for the emotional task but latency for incongruent trials tended to increase instead of decrease when they were preceded by an identical trial compared to when they were preceded by a congruent trial. The amplitude analysis replicated previous results by Panadero et al. (2015) showing a significant main effect of Incongruency percentage; the amplitude of the mostly incongruent trial condition was higher than the amplitude of the mostly congruent trial condition. In addition, a different effect of Previous trial congruency showed up depending upon type of task. In the non-emotional task, a close to significance reversed Stroop effect appeared under the previous incongruent trial condition while in the emotional task the reversed Stroop effect was significant and appeared under the previous congruent trial condition.. In sum, the only consistent result found in the P2 component was the main effect of Incongruency proportion replicating previous results by Panadero et al. (2015). The remaining results look rather unstable; though the type of task seems to modulate conflict adaptation, the way it appears to do it does not follow any known or understandable pattern of data.

In contrast with the just mentioned results, our data concerning N2 showed a clear unconscious conflict adaptation effect that was independent of both, type of task and percentage of incongruency. Interestingly, the adaptation effect showed a decrease in negativity for incongruent trials from the previous congruent to the previous incongruent trial condition. This result agrees with Clayson and Larson (2011) who, using a modified Eriksen flanker task in which participants had to identify the direction of a central arrow pointing to the right or to the left, reported a decrease of the N2 amplitude for incongruent trials following another incongruent trial compared to those following a congruent one. Likewise Panadero and Tudela (to be submitted), in an experiment using the same tasks than in the present experiment, found less negativity for incongruent than for congruent trials in the N2 amplitude but only in the emotional task, in the cognitive task the effect was reversed and the negativity was larger for incongruent than for congruent trials. Consequently, whether conflict adaptation should show up as a decrease in negativity for incongruent trials as a function of the type of the previous trial, or not, may depend on variables such as type of task. To what extent this line of reasoning may also be extended to our results in the N170 amplitude will need further investigation.

The P3 amplitude showed a significant third order interaction with different patterns of results for the emotional and non-emotional tasks. In the emotional task there was a significant Gratton effect but only in the context of high incongruency (66%). We found no effect in the low incongruency (33) context. In the non emotional task, the Gratton effect was significant and independent of incongruency context. The results for the emotional task show a modulation of the Gratton effect by the type of context opposite to the way in which RT and the N170 latencies were modulated by the same variable. In the RT and N170 latencies, the Gratton effect appeared in a context of low incongruency (33%) while in the P3 it appeared in a context of high congruency (66%). Though this difference is not easy to explain, may be related to the characteristics of the P3 amplitude providing room for greater differences between congruent and incongruent trials than it was the case for RT. Thus, the Stroop effect would have a greater range for change in the P3 amplitude than in RT. On the other hand, it is well known that the P3 amplitude is inversely related to the probability of task-defined stimulus class (Kutas, McCarthy, & Donchin, 1977). Consequently, in our experiment, the greater the probability of an incongruent trial, the shorter the P3 amplitude for these trials would be. Thus, the 66% percentage of incongruency context would tend to decrease the P3 amplitude of incongruent and increase the amplitude of congruent trials. In addition, a previous incongruent trial would tend to further decrease the amplitude of incongruent trials, resulting in a significant Gratton effect when the incongruency context is high (66%). On the contrary, the 33% incongruency context would tend to decrease the amplitude of congruent and increase the amplitude of incongruent trials, while the effect of a previous incongruent trial would tend to decrease the amplitude of the incongruent trials. In this context the P3 amplitude of incongruent trials would undergo the influence of two tendencies that are opposite to each other. As a result, predictions about what to expect in P3 amplitude in the 33%

incongruency context are almost impossible. The fact that the above-discussed two-way interaction only appears in the emotional task, may be related to the greater difficulty of this task, as indicated by our RT data. As P3 amplitude is known to increase with task difficulty (Isreal, Chesney, Wickens, & Donchin, 1980), it may be the case that only the emotional task provided the appropriate amplitude background for the complexities of the two-way interaction to show up. In any case, the significant three-way interaction found in the present experiment under masking conditions, is in itself a valuable empirical finding that deserves further investigation.

In summary, the present experiment clearly demonstrated unconscious conflict adaptation in the RT measures, as well as in several ERP components like N170 latencies, and N2 and P3 amplitudes. These results replicate those reported by Panadero et al. (2015), though in the Panadero et al. experiment the type of conflict investigated was only cognitive and conflict adaptation was induced by the manipulation of context incongruency but not by previous congruency. In this experiment context incongruency interacted with the type (congruent or incongruent) of previous trial and also with the type (cognitive or emotional) of task. So, a contribution of this experiment that deserves to be pointed out is the wide interplay of variables able to modulate the Stroop effect and the conflict adaptation effect. Finally, it should not be overlooked that all the effects reported in this experiment took place in a situation in which participants were unaware of the labels associated with the faces and of the relations between masks and incongruency percentage. We may conclude that in this experiment unconscious conflict adaptation has been demonstrated for both, cognitive and emotional, types of conflict.

Capítulo 5

DISCUSIÓN GENERAL

En términos generales, el objetivo principal de esta tesis ha sido estudiar los procesos de adaptación al conflicto: el efecto de proporción de congruencia asociada a un determinado contexto (CSPCE) y el efecto asociado a la secuencia de ensayos, conocido como *efecto Gratton*. Hemos estudiado estos efectos en situaciones fundamentalmente de no consciencia, observando el curso de la actividad neural asociada a dichos procesos. Además hemos querido estudiar las semejanzas o diferencias de las estrategias de resolución de conflicto, tanto cognitivo como emocional, mediante el análisis del registro de la actividad eléctrica del cerebro.

Con este fin, se diseñaron dos series experimentales. La primera serie constaba de un solo experimento cuyo propósito principal fue estudiar los procesos de control cognitivo a nivel no consciente, así como ver la modulación que sufrían dichos procesos de control al manipular la proporción de incongruencia, cuando ésta se asociaba a un determinado contexto. Para ello se utilizó una variante del paradigma clásico de Stroop (Stroop, 1935), en el cual se enmascaraba la palabra de color usando dos tipos de máscaras que se asociaban sistemáticamente con una proporción de incongruencia alta (66%) o una proporción de incongruencia baja (33%). Procuramos mantener activa la expectativa de presentación de dicha palabra de color, mediante la calibración del tiempo de presentación de dicha palabra para cada participante. Durante todo el procedimiento se registró la actividad eléctrica cerebral usando técnicas electrofisiológicas de alta densidad, concretamente potenciales corticales evocados (ERP). Los resultados del primer experimento mostraron evidencia a favor del carácter no consciente de los procesos de control cognitivo asociados a la tarea Stroop, y de la existencia de CSPCE a nivel no consciente, como se desprende del análisis del tiempo de reacción (RT) y de diferentes componentes de la actividad eléctrica del cerebro (ERPs). Así a nivel de RT se observó una disminución del efecto Stroop en aquellas situaciones en las que la proporción de incongruencia era más alta (66%), lo cual es un claro efecto de adaptación al conflicto (Logan, et al., 1984; Jacoby et al., 2003; Crump, Gong y Milliken, 2006) que, en este caso, se produjo en condiciones de no consciencia de la palabra previa que designaba al color. Este efecto se reflejó a su vez en los potenciales corticales N2 y P3 cuya amplitud varió también en función de la proporción de incongruencia. A su vez, el análisis del componente P2 mostró evidencia a favor de la existencia de un proceso de aprendizaje implícito de la asociación de las máscaras con sus respectivos porcentajes de incongruencia a lo largo del experimento

En la segunda serie experimental, compuesta por dos experimentos, ampliamos nuestros objetivos para estudiar además del control cognitivo, el control emocional. En el primer experimento se estudió el control consciente mientras que en el segundo experimento estudiamos el control inconsciente. El paradigma común a los dos experimentos de esta serie fue una variante de la tarea de categorización de caras (Egner, Etkin, Gale, & Hirsch, 2008; Etkin, Egner, Peraza, Kandel, & Hirsch, 2006), en la cual los participantes debían clasificar una serie de caras en función del género de estas (en la versión cognitiva) o bien en función de la emoción que expresaban (en la versión emocional). El objeto de elegir este paradigma fue igualar la tarea para el estudio de ambos tipos de conflicto al mismo tiempo que diferenciar las respuestas sobre el estímulo objetivo que en un caso eran de carácter cognitivo y en el otro emocional. En el primer experimento de la serie el efecto de adaptación al conflicto se estudió mediante el análisis de la influencia de la congruencia previa pero no se manipuló la proporción de incongruencia. De esta forma quisimos estudiar, utilizando potenciales corticales, la situación analizada mediante fMRI por Egner et al. (2008) y compararlos con los resultados de Alguacil et al. (2013) que, utilizando potenciales corticales, habían estudiado conjuntamente el control cognitivo y emocional empleando una tarea de flancos de Eriksen. Los resultados comportamentales replicaron los obtenidos anteriormente, tanto para el conflicto cognitivo (McCleod, 1991), como para el conflicto emocional (Mckenna& Sharma, 1995; Etkin, Egner, Peraza, Kandel& Hirsch, 2006; Bush., Whalen., Rosen., Jenike., McInerney., & Rauch., 1998; Hayward., Goodwin., & Harmer., 2004), como para ambos conjuntamente (Alguacil, et al., 2013; Egner et al., 2008). Con respecto a los potenciales corticales analizados, encontramos un efecto de adaptación al conflicto en N2 y P3, mostrando el N2 una disociación entre conflicto cognitivo y emocional que comentaremos más adelante.

En el segundo experimento de la segunda serie utilizamos la misma tarea que en el experimento anterior pero introdujimos dos cambios fundamentales. El primero consistió en estudiar la adaptación al conflicto manipulando también el porcentaje de incongruencia, cuyo efecto habíamos demostrado en el experimento de la primera serie. Como en este experimento, asociamos el porcentaje de incongruencia al tipo de máscara que se utilizó para impedir el procesamiento consciente de las palabras que etiquetaban el género o la emoción de las caras. De esta forma el segundo cambio introducido respecto al experimento anterior en la serie fue el enmascaramiento de dichas palabras. Los resultados comportamentales mostraron de nuevo un CSPCE inconsciente, independientemente del tipo de tarea. También mostraron una interacción entre porcentaje de incongruencia, congruencia previa y efecto Stroop, de forma que solamente en el contexto de baja incongruencia se mostró el efecto Gratton. Con respecto a los potenciales corticales analizados, efectos de adaptación al conflicto aparecieron no sólo en las latencias sino también en las amplitudes tanto del N170 como del N2 y P3. El comentario de estos efectos se retomará más adelante. El P2 replicó el resultado del primer experimento mostrando una sensibilidad diferencial al porcentaje de incongruencia.

Las principales aportaciones de esta tesis están relacionadas fundamentalmente con dos aspectos principales: los efectos de adaptación al conflicto y el procesamiento no consciente de los procesos relacionados con esos efectos.

El efecto de adaptación al conflicto

Con respecto a los efectos de adaptación al conflicto, los resultados han puesto de manifiesto que tanto la manipulación del porcentaje de incongruencia como la manipulación de la congruencia del ensayo previo son variables que modulan el efecto

Stroop, reflejando esta modulación tanto en las medidas comportamentales como en las medidas relacionadas con algunos componentes de los potenciales corticales evocados.

Los resultados comportamentales han mostrado un efecto significativo de adaptación al conflicto en dos de los tres experimentos de la tesis. En la primera serie experimental el efecto fue producido por la manipulación de la proporción de incongruencia y en el tercero fue producido por la variable anterior y además por la congruencia previa. Curiosamente en los dos experimentos en los que se ha encontrado adaptación al conflicto, la presentación de las palabras estímulo-previo estaban enmascaradas. Dicho con otras palabras el efecto de adaptación al conflicto ha aparecido en situaciones de procesamiento no consciente de los estímulos previos. Dentro de las limitaciones de nuestros conocimientos, esta es la primera vez que se demuestra un CSPCE no consciente, cognitivo en el primer experimento y tanto cognitivo como emocional en el tercer experimento. A nivel consciente estos efectos han sido ampliamente establecidos para el conflicto cognitivo (Crump, Gong, y Milliken, 2006; Crump, Vaquero & Milliken, 2008; Jacoby, Lindsay, and Hessels, 2003; Logan, Zbrodoff, & Williamson, 1984), y también, aunque en menor medida para el conflicto emocional (Alguacil et al.; 2013; Egner et al., 2008, Zhu, Zhang, Wu, Luo y Luo, 2010). En nuestro segundo experimento, no obtuvimos dicho efecto ni cognitivo ni emocional, aunque los potenciales corticales evidenciaron la presencia de un efecto de adaptación al conflicto. Nuestro tercer experimento mostró una interacción de segundo orden que reflejaba la modulación conjunta del efecto Stroop por el porcentaje de incongruencia y por la congruencia previa, de modo que el efecto Gratton se localizó en el contexto de baja incongruencia pero no en el de alta incongruencia. Si suponemos, como suele ocurrir, que las dos variables manipuladas tienden a afectar al TR de la misma forma, este resultado puede deberse a que la probabilidad de que aparezca el efecto Gratton sea mayor en un contexto en el que el efecto del porcentaje de ensayos incongruentes sea menor, como se ha explicado en la discusión del tercer experimento.

En relación con los potenciales corticales analizados, nuestros resultados presentan una consistencia sistemática en los tres experimentos, mostrando efecto de adaptación al conflicto tanto en N2 como en P3. El N2 presentó una topografía frontal en los experimentos primero y tercero, y una topografía parietal posterior en el segundo. La adaptación al conflicto cognitivo presentó una disminución en la negatividad de los ensayos incongruentes respecto a la de los congruentes en el primer experimento y un aumento de su negatividad en el segundo; en el tercer experimento, independientemente del tipo de conflicto, la negatividad del N2 se redujo en la misma dirección que en el experimento primero. En cuanto al conflicto emocional, sólo en el segundo experimento la negatividad de los ensayos incongruentes presentó una disminución con respecto a la de los congruentes. Cabe la posibilidad de que la direccional del cambio inducido en los ensayos incongruentes como resultado de la adaptación al conflicto dependa del tipo de conflicto. Así parecen sugerirlo los resultados de nuestro segundo experimento, sin embargo, Clayson y Larson (2011) encontraron un decremento de la negatividad en una situación de conflicto cognitivo. En consecuencia, parece que el problema de la direccionalidad del cambio que cabe esperar en el N2 como resultado de la adaptación al conflicto, necesita mayor investigación.

En el componente P3 la adaptación al conflicto, tanto cognitivo como emocional, siempre se manifestó como una disminución en la positividad de los ensayos incongruentes con respecto a los congruente. En el primer experimento, que sólo estudió el conflicto cognitivo, se encontró un efecto significativo de adaptación al conflicto. En el segundo experimento, el efecto de adaptación al conflicto solamente apareció significativo en la tarea non-emocional. Finalmente en el tercero, presentó un patrón de resultados diferente dependiendo del tipo de tarea. En la no emocional se encontró un efecto de la congruencia previa cercano a la significatividad que era independiente del porcentaje de incongruencia. En la tarea emocional, se encontró un efecto Gratton significativo, pero únicamente cuando el contexto era de alta incongruencia. Curiosamente este patrón, que implicaba al porcentaje de incongruencia, a la congruencia previa y al efecto Stroop, era diferente al presentado por la interacción de estas mismas variables en el tiempo de reacción y en las latencias del N170 del tercer experimento. En estos dos últimos casos el efecto Gratton apareció cuando el contexto era de baja incongruencia y fue independiente del tipo de tarea. No resulta fácil explicar esta discrepancia de resultados. El razonamiento avanzado anteriormente respecto al efecto encontrado en el tiempo de reacción se apoya principalmente en el limitado rango de variación del efecto Stroop que parece razonable esperar cuando se mide en tiempo de reacción. En el caso del P3, es más difícil establecer el rango de variación del efecto Stroop aunque podemos razonar de la siguiente manera.

Por una parte a nivel teórico, este componente ha sido relacionado con la "*adaptación al contexto*" (Donchin & Coles, 1988) y con la asignación de recursos cognitivos a una tarea (Isreal, Chesney, Wickens, & Donchin, 1980), de forma que la amplitud del P3 aumenta cuando la tarea es difícil y necesita mayor asignación de recursos. Por otra parte a nivel empírico, sabemos que la amplitud del P3 es sensible a la probabilidad del objetivo (Duncan-Johnson y Donchin (1977), sobre todo a la probabilidad de la clase de estímulos definidos por la tarea (Kutas, McCarthy, & Donchin, 1977), de forma que su amplitud es inversamente proporcional a dicha probabilidad.

En nuestro experimento podemos asumir que la tarea emocional es más difícil que la no emocional y por tanto necesita mayor cantidad de recursos. Este supuesto está fundamentado en el hecho de que tanto en el segundo como en el tercer experimento hemos obtenido un efecto principal de tarea en el TR, de forma que la tarea emocional ha sido mas lenta que la no emocional. Podemos por tanto asumir que la amplitud del P3 va a poder aumentar (Isreal, Chesney, Wickens, & Donchin, 1980) y, en consecuencia, tener mayor rango de variación en la tarea emocional que en la no emocional. Por otra parte, el contexto de alta incongruencia (66%)

introduce una alta probabilidad de ensayos incongruentes que va a disminuir la amplitud de los ensayos incongruentes y a aumentar la de los congruentes (Kutas, McCarthy, & Donchin, 1977) permitiendo que los ensayos previos incongruentes produzcan su efecto de adaptación al conflicto, disminuyendo aún más la amplitud del P3 de los ensayos incongruentes. Sin embargo, el contexto de baja incongruencia (33%) introduce una alta probabilidad de ensayos congruentes que va a disminuir la amplitud del P3 de estos ensayos y a aumentar la de los ensayos incongruentes. En este caso, el efecto de un ensayo previo incongruente influirá sobre la amplitud del P3 de estos ensayos en sentido opuesto a la influencia del contexto.

Dicho con otras palabras, la tarea emocional exige más recursos que la no emocional aumentando la amplitud del P3 de esta tarea y proporcionando un margen de reducción de su amplitud a la influencia de las otras dos variables. La aparición de la máscara asociada al alto porcentaje de incongruencia introduce un contexto de alta probabilidad de ensayos incongruentes que va a disminuir la amplitud del P3 de esos ensayos por ser los más probables y a aumentar la amplitud del P3 de los ensayos congruentes por ser los menos probables. Finalmente, la expectativa inmediata provocada por un ensayo previo incongruente disminuirá aún más la amplitud del P3 para los ensayos incongruentes. Como consecuencia de la interacción de estos factores, el *efecto Gratton* aparece significativo en el contexto de incongruencia alta. En un contexto de incongruencia baja (33%), la probabilidad más alta está asociada con los ensayos congruentes que influirá reduciendo la amplitud del

P3 asociado con estos ensayos y aumentando la amplitud del P3 de los ensayos incongruentes. En esta situación la influencia de un ensayo previo incongruente actuará sobre los ensayos incongruentes disminuyendo la amplitud de su P3, es decir, en sentido opuesto a la influencia del contexto. En estas condiciones resulta muy difícil predecir las amplitudes finales del P3 de los ensayos congruentes e incongruentes a la hora de poder producir un efecto Stroop. De hecho en nuestro experimento no encontramos ningún resultado significativo en el contexto de baja incongruencia.

Aunque este razonamiento no carece de fundamento, puede resultar bastante especulativo, por lo que merece la pena resaltar el valor que tiene en sí mismo el resultado empírico que hemos obtenido en el tercer experimento, único en el que se ha podido analizar conjuntamente el efecto de la proporción de incongruencia y de la congruencia previa sobre el efecto Stroop. En tres ocasiones, en el TR, latencias del N170 y amplitud del P3 hemos encontrado significativa la interacción de segundo orden entre porcentaje de incongruencia, congruencia previa y la congruencia del ensayo actual, aunque con patrones de resultados diferentes. Creemos que esta interacción de segundo orden, así como la de tercer orden, que implicó también al tipo de tarea y que apareció en la amplitud del P3, constituyen una aportación novedosa de nuestra investigación que obliga a repensar la forma en que estas variables modulan el efecto Stroop. La aportación tiene aún más valor si tomamos en consideración que estos resultados han aparecido en una situación experimental en la que los estímulos previos habían sido enmascarados.

Por lo que respecta a los resultados encontrados en los potenciales corticales más tempranos, la información que nos han proporcionado ha sido considerablemente más escasa. En el segundo experimento, no se encontró efecto alguno en las latencias del P1 ni del N170, y el análisis de las amplitudes sólo puso de relieve una aproximación a la significatividad del efecto Gratton en el P1. A su vez, en el tercer experimento solamente las latencias del N170 mostraron la interacción de segundo orden a la que hemos aludido anteriormente y cuyo patrón de resultados era similar al encontrado en el TR, es decir el *efecto Gratton* se encontró en el contexto de baja frecuencia (33%) pero no en el de alta frecuencia (66%). Dado que el efecto se ha encontrado en las latencias, hemos preferido explicar esta interacción de segundo orden en los mismos términos que nuestra explicación en el caso del TR y que no hace al caso repetir ahora.

Más importante resulta recalcar la diferencia entre nuestros resultados y los encontrados por Alguacil et al. (2013) que encontraron un claro efecto de la congruencia previa en el efecto Stroop tanto en la amplitud del P1 como en la del N170; en ambos casos un ensayo previo incongruente modificaba el efecto Stroop. Este efecto de la congruencia previa en el efecto Stroop, presentó la forma de una reducción de la positividad del P1 y de un incremento en la negatividad del N170 para los ensayos incongruentes respecto a los congruentes cuando aparecían precedidos por un ensayo incongruente, lo que añade complicación al punto, discutido anteriormente, sobre la forma que la influencia de la congruencia previa se manifiesta en los componentes negativos de los potenciales corticales evocados. Por otra parte, la principal diferencia entre nuestro experimento y el de Alguacil et al. reside en el tipo de estímulos y en la tarea utilizada. Alguacil et al., utilizaron palabras en una tarea Eriksen de flancos, mientras que nosotros hemos utilizado caras en una tarea Stroop. La razón por la que estas diferencias producen resultados discrepantes en los componentes tempranos no es evidente y necesita más investigación.

Finalmente merece la pena resaltar los resultados encontrados en el componente P2 en relación con el porcentaje de incongruencia. Tanto en el primero como en el tercer experimento, en los que las palabras previas al objetivo fueron enmascaradas y las máscaras se asociaron a diferentes porcentajes de incongruencia, obtuvimos un efecto principal de esta variable de forma que la amplitud del P2 para la condición de 66% de ensayos incongruentes presentó mayor amplitud que para la condición de 33% de ensayos incongruentes. Este resultado parece robusto e indica que, a lo largo de la tarea, la asociación entre las diferentes máscaras y sus correspondientes porcentajes de incongruencia se va fortaleciendo a pesar de que la relación de congruencia o incongruencia entre el estímulo previo y el objetivo no es procesada conscientemente. La sensibilidad del componente P2 a esta asociación sugiere que este componente puede constituir un índice adecuado de aprendizaje implícito.

El procesamiento no consciente

Quizás la aportación más novedosa de esta tesis doctoral reside en el hecho de que los efectos de adaptación al conflicto, que hemos comentado en el apartado anterior, se han obtenido en condiciones de enmascaramiento de los estímulos previos. Mediante una cuidadosa sesión previa de cálculo de umbral, se estableció para cada participante el tiempo de presentación del estímulo previo que lo hacía imperceptible de forma consciente. De hecho, los tiempos que se determinaron mediante este procedimiento fueron similares a los utilizados en otros experimentos interesados en estudiar el procesamiento no consciente mediante enmascaramiento (Daza, M. T., Ortells, J. J., & Fox, E. (2002); Greenwald, Klinger, & Liu, 1989; Klapp, 2007, Ortells, Marí-Beffa, & Plaza-Ayllón, 2002). Además, al final de la sesión experimental, se preguntó a los participantes si habían sido conscientes de alguna palabra o de la relación entre las máscaras y el porcentaje de incongruencia. En ambos casos las respuestas fueron negativas.

El procedimiento que utilizamos fue un procedimiento descendiente encaminado a establecer el umbral subjetivo de consciencia, es decir el tiempo de presentación del estímulo previo en el que el participante comienza a decir de forma consistente que no percibe la palabra enmascarada. Puede decirse, por tanto, que nuestro procedimiento estableció el umbral subjetivo de consciencia de la palabra y que el valor de nuestros resultados encuentra en este hecho uno de los límites de su extensión. El estudio de estos mismos problemas en condiciones de umbral objetivo de consciencia de las palabras es tarea para futuras investigaciones. No obstante el valor de nuestra aportación no merece ser subestimado por varias razones.

En primer lugar, el umbral subjetivo tiene una extraordinaria importancia para el funcionamiento cotidiano de las personas. Esta afirmación está avalada por numerosos síndromes neuropsicológicos, como la "*vista ciega*" (*blindsight*) (Weiskrantz, 2009), y la *heminegligencia espacial* (*spatial neglect*) (Driver & Vuilleumier, 2001), que no sólo han mostrado la existencia de procesamiento cognitivo en el *escotoma* o en la mitad del espacio visual afectado, sino que las personas que padecen este tipo de problemas son inconscientes de los estímulos que provocan ese procesamiento e incapaces de iniciar una acción intencional dirigida a los mismos. Precisamente en estas situaciones, que podríamos calificar de umbral subjetivo de consciencia, lo que más interesa a la investigación neuropsicológica es conocer qué y cuánto procesamiento cognitivo puede tener lugar en las zonas del cerebro afectadas con el fin de poder plantear estrategias terapéuticas. De forma parecida, en la psicología experimental parece cada vez más urgente investigar el tipo de procesamiento que puede darse en situaciones de umbral subjetivo para poder valorar, entre otros temas, hasta qué punto *control* y *consciencia* son procesos que van necesariamente asociados o no. Nuestros resultados han mostrado de forma clara que no están necesariamente asociados.

En segundo lugar, si tomamos como referencia la clasificación de formas de procesamiento no consciente propuesta por Dehaene, Changeux, Naccache, Sackur, & Sergent, (2006), el procesamiento inducido en nuestros experimentos por el enmascaramiento de las palabras previas, puede clasificarse de *subliminal*, ya que no se evitó que los participantes atendieran a los estímulos presentados (máscara y objetivo) sino que solamente se impidió el procesamiento de las palabras mediante enmascaramiento. Además cuidamos que los participantes mantuvieran la expectativa de la presencia de una palabra entre las máscaras. En estas condiciones, Dehaene et al. (2006) han caracterizado el procesamiento subliminal que tiene lugar de la siguiente forma:

- *No puede comunicarse mediante el lenguaje*. Esa característica se cumple en nuestros experimentos ya que los participantes expresamente dijeron que no habían visto las palabras enmascaradas ni captado la relación entre máscaras y porcentaje de incongruencia.
- *El nivel de procesamiento depende de la atención y de la expectativa (set) de tarea.* Como ya hemos dicho anteriormente, nuestra situación experimental se planteó precisamente para maximizar el procesamiento de las palabras enmascaradas sin que llegaran a ser conscientemente percibidas.
- *La activación neuronal puede alcanzar el nivel semántico*. Como se sigue del punto anterior, buscamos expresamente que esto fuera posible y los resultados han demostrado que lo conseguimos.
- *La facilitación (priming) que se consigue es de corta duración*. En nuestros experimentos la asincronía entre la presentación de la segunda máscara y el estímulo objetivo (SOA) fue de un segundo, y el SOA entre comienzo de la palabra previa y el objetivo, superior a un segundo. Este intervalo no puede considerarse corto, por lo que nuestros resultados muestran que la

facilitación semántica que estímulos subliminares pueden llegar a producir no siempre es de corta duración.

- *No existe una actividad frontoparietal durable*. Nuestros resultados demuestran lo contrario. Como sugieren los mapas topográficos y se puede ver en las ondas correspondientes a los distintos potenciales corticales analizados en los experimentos primero y tercero, tanto el componente N2 frontal como el P3 centroparietal presentan una duración semejante a la que suele encontrarse en condiciones de procesamiento consciente de los estímulos. Si comparamos los resultados encontrados en los experimentos en los que se han enmascarado las palabras previas con el segundo experimento, en el que no existió enmascaramiento de ningún tipo, es precisamente en el primero y tercero en los que aparecieron efectos significativos en un N2 frontal, mientras que la topografía del N2 en el segundo experimento no fue frontal sino posterior. Por otra parte, la topografía y duración del componente P3 no apareció diferente entre los tres experimentos. De hecho, si comparamos el experimento segundo con el tercero, que presentan grandes similitudes pero en este último se enmascararon las palabras previas y en el segundo las palabras se pudieron procesar conscientemente, sorprende la sensibilidad de los potenciales corticales en el experimento de enmascaramiento. Aparecieron efectos de latencia que no estuvieron presentes en el segundo experimento, e interacciones de segundo y tercer orden que tampoco estuvieron presentes en el segundo experimento. Mas bien, esta comparación de experimentos sugiere que el hecho de ser consciente de las palabras disminuye la sensibilidad de los potenciales evocados por la relación entre las palabras no enmascaradas y los estímulos objetivo.

Finalmente, en relación con el CSPCE se ha argumentado que para que se produzca el efecto es necesaria la representación consciente de todos los elementos que intervienen en el conflicto: el estímulo previo (prime), el objetivo y el contexto (Kunde, Reuss, & Kiessel (2012). Nuestros resultados, tanto en el primer experimento como en el tercero han demostrado que estas restricciones no son necesarias y que el CSPCE puede tener lugar sin representación consciente del estímulo previo (prime) y sin consciencia de la relación entre el contexto y el porcentaje de incongruencia asociado al mismo.

Conclusiones

Durante mucho tiempo, la distinción entre procesos automáticos y procesos controlados (Posner & Snyder, 1975; Schneider & Shiffrin, 1977; Shiffring & Schneider, 1977) ha dirigido la investigación psicológica y ha sido ampliamente aceptada como marco general de referencia de dicha investigación. Esta división ha funcionado como una clasificación disjunta en la que cada una de las dos clases de procesos presentaba unas características definitorias. Por ejemplo, los procesos automáticos se consideraban rápidos, dirigidos por los estímulos, libres de la necesidad de recursos atencionales e inconscientes. A su vez, los procesos de control se consideraban lentos, dependientes de la voluntad del sujeto, necesitados de recursos atencionales y conscientes. En un contexto teórico como este, resulta una contradicción en los propios términos hablar de *control automático*.

Nuestros resultados ponen seriamente en tela de juicio esta distinción de los procesos psicológicos. En este punto nuestra crítica se une a la de autores que previamente han puesto en guardia sobre lo inadecuada que puede resultar esta división (Bugg & Hutchison, 2013; Crump, Vaquero, & Milliken, 2008; Shedden et al., 2012). A lo largo de esta investigación hemos visto que la consciencia no es necesaria para el funcionamiento de los mecanismos de control y que los mecanismos de control pueden deberse a procesos de aprendizaje, que una vez establecidos, se ponen en funcionamiento ante la presencia de un estímulo desencadenante. Concretamente, hemos comprobado que la asociación de una determinada máscara con un determinado porcentaje de incongruencia acaba determinando el contexto que da lugar al CSPCE.

Nuestros resultados encuentran un marco de referencia teórico más adecuado en modelos de control como el propuesto por Norman y Shallice (1986; Shallice & Cooper, 2011) que distinguen entre dos mecanismos diferentes de control. Uno de ellos, que los autores denominan *contention scheduling*, está constituido por un conjunto de esquemas generados a partir de la experiencia con situaciones cotidianas y/o repetitivas. Estos mecanismos de control son fruto del aprendizaje y del conjunto de asociaciones que los esquemas de control establecen con diferentes contextos. Estos esquemas de control mantienen entre sí relaciones de activación e inhibición, de forma que el esquema de control dominante en una situación es el que logra mayor grado de activación en esa situación. El segundo mecanismos de control es el *Sistema Atencional Supervisor* que es el responsable del control consciente y que entra en juego en situaciones en las que los esquemas de control no pueden hacerse cargo de la situación, bien porque no existen, como ocurre en situaciones nuevas, bien porque exista competición entre los esquemas, como ocurre en una tarea Stroop, bien porque haya que corregir errores, o porque las situaciones sean difíciles o peligrosas. Estos dos mecanismos no son una clasificación de procesos sino dos tipos diferentes de mecanismos de control que se comunican entre sí de forma flexible. En esta investigación hemos puesto de manifiesto la importancia de mecanismos que controlan el conflicto, tanto cognitivo como emocional y que son el resultado de procesos asociativos ligados al contexto o a procesos ligados a la secuencia de los ensayos. Ambos tipos de procesos hemos visto que pueden ocurrir en situaciones en que las personas no son conscientes de una parte de los factores que controlan la situación. No obstante debe tenerse muy en cuenta que en todos los experimentos hemos mantenido constante la atención a los estímulos presentados y hemos mantenido activa la expectativa de las relaciones entre el estímulo previo y el objetivo (Kiefer, M., Adams, S. C., & Zovko, M. (2012). Como conclusión final cabe subrayar que la asociación necesaria entre control y consciencia, que ha sido defendida por importantes investigadores (Botvinick, Braver, Barch, Carter, & Cohen, 2001) debe ser definitivamente abandonada.

REFERENCIAS

Alguacil, S., Tudela, P. and Ruz, M. (2013). Cognitive and affective control in a flanker word task: Common and dissociable brain mechanisms. *Neuropsychologia, 51*(9), 1663-1672.

Anderson, J., (1982). Acquisition of cognitive skill. *Psychological Review*, *89(4)*, 369-406

Ashton-Jones, G. & Cohen, J. D. (2005). An integrative theory of locus coeruleus-norepinephrine function: adaptive gain and optimal performance. *Annual Review of Neuroscience, 28*, 403-450.

Atalay, N. B. & Misirlisoy, M. (2012). Can contingency learning alone account for item-specific control? Evidence from within- and between-language ISPC effects. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38*, 1578-1590.

Barch, D. M., Braver, T. S., Sabb, F. W., & Noll, D. C. (2000). Anterior cingulate and the monitoring of response conflict: Evidence from an fMRI study of overt verb generation. *Journal of Cognitive Neuroscience, 12*, 298–309.

Becker, E., Rinck, M., Margraf, J. & Roth, W. (2001). The emotional Stroop effect in anxiety disorders. General emotionality or disorder specificity?. *Anxiety Disorders, 15*, 147-159.

Bench, C. J., Frith, C. D., Grasby, P. M., Friston, K. J., Pauleso, E, Frackowiak, R. S. J. & Dolan, R. j. (1993). Investigations of the functional anatomy of attention using the stroop test. Neuropsychologia, 31(9), 907-922.

Bishop, S., Duncan, J., Brett, M. & Laerence, A. (2004). prefrontal cortical function and anxiety: controlling attention to threat-related stimuli. *Nature Neuroscience, 7*, 184-188.

Blais, C., & Bunge, S. (2010). Behavioral and neural evidence for item-specific performance monitoring. *Journal of Cognitive Neuroscience*, *22*(12), 2758–67.

Blais, C., Harris, M. B., Guerrero, J. V, & Bunge, S. A. (2012). Rethinking the role of automaticity in cognitive control. *Quarterly Journal of Experimental Psychology (2006)*, *65*(2), 268–76.

Blais, C., Robidoux, S., Risko, E. F., & Besner, D. (2007). Item-specific adaptation and the conflict-monitoring hypothesis: A computational model. *Psychological Review, 114*(4), 1076-1086.

Blais, C., Tudela, P.,& Bunge, S. (2007) *Proportion congruency and the neural correlates of consciousness*. Paper presented at the Annual meeting of the Society for Neuroscience, San Diego, CA, USA.

Balkin, T. J., Braun, A. R., Wesensten, N. J., Jeffries, K., Varga, M., Baldwin, Belenky, G., & Herscovitch, P. (2002). The process of awakening: a PET study of regional brain activity patterns mediating the reestablishment of alertness and consciousness. *Brain, 125(10)*, 2308-2319.

Botvinick, M. M., Braver, T. S., Barch, D. M., Carter, C. S., & Cohen, J. D. (2001). Conflict monitoring and cognitive control. *Psychological Review*, *108*(3), 624–52.

Botvinick, M. M., Cohen, J. D., & Carter, C. S. (2004). Conflict monitoring and anterior cingulate cortex: an update. *Trends in Cognitive Sciences*, *8*(12), 539–546.

Braver, T.S., Gray, J.R., & Burgess, G.C. (2007). *Explaining the many varieties of working memory variation: Dual mechanisms of cognitive control*. In A.R.A. Conway, C. Jarrold, M.J. Kane, A. Miyake, & J. Towse (Eds.), Variation in working memory (pp. 76–106). New York: Oxford University Press.

Bugg, J. M. & Crump, M. J. C. (2012). In support of a distinction between voluntary and stimulus-driven control: A review of the literature on proportion congruent effects. *Frontiers in psychology, 3*, article 367.

Bugg, J. M. & Hutchison, K. A. (2013). Converging evidence for control of color-word Stroop interference at the item level. *Journal of Experimental Psychology: Human Perception and Performance, 39*(2), 433-449. doi: 10.1037/a0029145.

Bugg, J. M., Jacoby, L. L., & Chanani, S. (2011). Why it is too early to lose control in accounts of item-specific proportion congruency effects. Jour- nal of Experimental Psychology: Human Perception and Performance, 37, 844–859. doi:10.1037/a0019957

Bush, G., Luu, P., & Posner, M. I. (2000). Cognitive and emotional influences in anterior cingulate cortex. *Trends in Cognitive Sciences*, *4*(6), 215–222.

Carreti, L., Martin-Loeches, M., Hinojosa, JA., & Mercado, F. (2001). Emotion and attention interaction studied through event-related potentials. *Journal of Cognitive Neuroscience, 13*, 1109-1128.

Cañadas, E., Rodríguez-Bailón, R., Milliken, B., & Lupiáñez, J. (2012). Social categories as a context for the allocation of attentional control. *Journal of Experimental Psychology, 142*(3), 934-943.

Carter, C. S., Cohen, J. D., & Mintun, M. (1995). Functional anatomy of selective attention in normals and schizophrenia. *Biological Psychiatry,37*, *9*, 638-639

Casey, B. J., Castellanos, F. X., Giedd, J. N., Marsh, W. L., Hamburger, S. D., Anne, B., et al. (1997). Implication of right frontostriatal circuitry in response inhibition and attention-deficit/ hyperactivity disorder. *Journal of the American Academy of Child and Adolescent Psychiatry, 36*, 374–383.

Cheesman, J., & Merikle, P. M. (1986). Distinguishing conscious from unconscious perceptual processes. *Canadian Journal of Psychology, 40*, 343-367.

Clayson, P. & Larson, M. (2011). Effects of repetition priming on electrophysiological and behavioral indices of conflict adaptation and cognitive control. *Psychophysiology, 48*(12), 1621-1630.

Clayson, P. E., & Larson, M. J. (2011). Conflict adaptation and sequential trial effects: support for the conflict monitoring theory. *Neuropsychologia*, *49*(7), 1953–61. doi:10.1016/j.neuropsychologia.2011.03.023

Compton, R. (2003). The interface between emotion and attention: A review of evidence from Psychology and Neuroscience. *Behavioral and Cognitive Neuroscience Reviews, 6*(2), 115-129.

Corballis, P. M. and Gratton, G. (2003). Independent control of processing strategies for different locations in the visual field. *Biological Psychology, 64*, 191-209

Corbetta, M., Akbudak, E., Conturo, T. E., Snyder, A. Z., Ollinger, J. M., Drury, H. A., Linenweber, M. R., Petersen, S. E., Raichle, M. E., Van-Essen, D. C. & Shulman, G. L. (1998) A common network of functional areas for attention and eye movements. *Neuron 21*(4):761–73.

Cox, W., Hogan, L., Kristian, M. & Race, J. (2002). Alcohol attentional bias as predictor of alcohol abusers´treatment outcome. *Drug and Alcohol Dependence, 68*, 237-243.

Crump, M. J. C., Gong, Z., & Milliken, B. (2006). The context-specific proportion congruent Stroop effect: Location as a contextual cue. *Psychonomic Bulletin & Review*, 13, 316–321.

Crump, M. J. C., & Milliken, B. (2009). The flexibility of context-specific control: Evidence for context-driven generalization of item-specific control settings. *Quarterly Journal of Experimental Psychology, 62*, 1523-1532.

Crump, M. J. C., Vaquero, J. M. M., & Milliken, B. (2008). Context-specific learning and control: the roles of awareness, task relevance, and relative salience. *Consciousness and Cognition*, *17*(1), 22–36.

Daza, M. T., Ortells, J. J., & Fox, E. (2002). Perception without awareness: Further evidence from a Stroop priming task. *Perception & Psychophysics*, *64*(8), 1316–1324.

Dehaene, S., Artiges, E., Naccache, L., Martelli, C., Viard, A., Schurhoff, F., Recasens, C., Martinot, M. L., Leboyer, M., & Martinot, J. L. (2003a). Conscious and subliminal conflicts in normal subjects and patients with schizophrenia: The role of the anterior cingulate. *Proc. Natl. Acad. Sci. USA* 100, 13722–13727.

Dehaene, S. & Changeux, J. P. (2011). Experimental and Theoretical Approaches to Conscious Processing. *Neuron, 70*(2), 200-227.

Dehaen, S., Changeoux, J. P., Naccache, L., Sackur, J & Sergent, C. (2006). Conscious, preconscious, and subliminal processing: a testable taxonomy. *Trends in Cognitive Sciences, 10*, 204-211

Dehaene, S., Posner, M. I. & Tucker, D.M.. (1994). Localization of a neural system for error detection and compensation. *Psycholical. Science, 5*, 303–305.

Dehaene, S., Sergent, C., and Changeux, J. P. (2003b). A neuronal network model linking subjective reports and objective physiological data during conscious perception. *Proc. Natl. Acad. Sci. USA* 100, 8520–8525.

Desender, K., & Van den Bussche, E. (2012). Is consciousness necessary for conflict adaptation? A state of the art. *Frontiers in Human Neuroscience*, *6*, 3.

Desimone, R., & Duncan, J. (1995). Neural mechanisms of selective visual attention. *Annual Review of Neuroscience*, *18*, 193–222.

Donchin, E. & Coles, M. G. H. (1988). Is the P300 component a manifestation of context updating? *Behavioural and Brain Sciences, 11*, 357-374.

Driver, J. & Vuilleumier, P. (2001). Perceptual awareness and its loss in unilateral neglect and extinction. *Cognition, 79*(1-2), 39-88.

Egner, T. (2008). Multiple conflict-driven control mechanisms in the human brain. *Trends in Cognitive Sciences*, *12*(10), 374–80. doi:10.1016/j.tics.2008.07.001

Egner, T., Etkin, A., Gale, S., & Hirsch, J. (2008). Dissociable neural systems resolve conflict from emotional versus non-emotional distracters. *Cerebral Cortex*, *18*(6), 1475–84.

Egner, T., & Hirsch, J. (2005). Cognitive control mechanisms resolve conflict through cortical amplification of task-relevant information. *Nature Neuroscience*, *8*(12), 1784–90. doi:10.1038/nn1594

Ekman, P., & Friesen, W. V. (1976). Measuring facial movement. *Environmental Psychology and Nonverbal Behavior*, *1*(1), 56–75.

Eriksen, B. and Eriksen, C. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics, 16*(1), 143-149.

Etkin, A., Egner, T., Peraza, D., Kandel, E., & Hirsch, J. (2006). Resolving emotional conflict: a role for the rostral anterior cingulate cortex in modulating activity in the amygdala. *Neuron*, *51*(6), 871–82.

Falkenstein, M., Hoormann, J., & Hohnsbein, J. (1999). ERP components in Go/Nogo tasks and their relation to inhibition. *Acta Psychologica, 101*(2-3), 267-291

Fan, J., Cu, X., Guise, K., Liu, X., Fossella, J., Wang, H. & Posner, M. I. (2009). Testing the behavioral interaction and integration of attentional networks. Brain and Cognition, 70(2), 209-220.

Fan, J., & Posner, M. (2004). Human attentional networks. *Psychiatrische Praxis*, *31 Suppl 2*, S210–4. doi:10.1055/s-2004-828484

Fernandez-Duque, D., Posner, M.I., 1997. Relating the mechanisms of orienting and alerting. *Neuropsychologia, 35*, 477–486.

Folstein, J. R., & Van Petten, C. (2008). Influence of cognitive control and mismatch on the N2 component of the ERP: a review. *Psychophysiology*, *45*(1), 152–70.

Friston KJ, Frith CD, Liddle PF, Frackowiak RSJ (1991): Comparing functional (PET) images: The assessment of significant change. *Journal or Cerebral Blood Flow & Metabolism, 11*, 690-699.

Frünholz, S., Godde, B., Finke, M. & Herrmann, M. J. (2011). Spatio-temporal brain dynamics in a combined stimulus-stimulus and stimulus-response conflict task. *Neuroimage, 54*, 622-634

Funes, M. J., Lupiáñez, J., & Humphreys, G. (2010). Analyzing the generality of conflict adaptation effects. *Journal of Experimental psychology: Human Perception and Performance, 36*(1), 147-161.

Gehring, W. J., Coles, M. G. H., Meyer, D. E., & Donchin, E. (1990). The error-related negativity: An event-related brain potential accompanying errors [Abstract]. *Psychophysiology, 27*, S34.

Gratton, G., Coles, M. & Donchin E. (1992). *Journal of Experimental psychology: General, 121*(4), 480-506.

Greenwald, A. G., Klinger, M. R., & Liu, T. J. (1989). Unconscious processing of dichoptically masked words. *Memory & Cognition, 17*(1), 35–47.

Hampton, A. N. & O´Doherty, J. P. (2007) Decoding the neural substrates of reward-related decision making with functional MRI. Proceeding of the National Academy of Science of the United States of America, 104(4), 1377–1382.

Heil, M., Osman, A., Wiegelmann, J., Rolke, B., & Hennighausen, E. (n.d.). N200 in the Eriksen-task: Inhibitory executive process?

Heinemann, A., Kunde, W., & Kiesel, A. (2009). Context-specific prime-congruency effects: on the role of conscious stimulus representations for cognitive control. *Consciousness and Cognition*, *18*(4), 966–76.

Henik, A., Bibi, U. Yanai, M. & Tzelgov, J. (1997) The Stroop effect is largest during first trials. *Abstracts of the Psychonomic Society, 2*, 57.

Hillyard, S. a, Vogel, E. K., & Luck, S. J. (1998). Sensory gain control (amplification) as a mechanism of selective attention: electrophysiological and neuroimaging evidence. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *353*(1373), 1257–70.

Hohnsbein, J, Falkenstein, M, & Hoormann, J. (1995). *Effects of Attention and Time-Pressure on P300 Subcomponents and Implications for Mental Workload Research*. Biological Psychology, 40(1–2), 73–81. Special Issue: EEG in Basic and

Hommel, B., Proctor, R. & Vu, KPL. (2004). *A feature-integration account of sequential effects in the Simon task. Psychological Research, 68*(1), 1-17.

Jacoby, L.L., Lindsay, D. S., & Hessels, S. (2003). Item-specific control of automatic processes: Stroop process dissociations. *Psychonomic Bulletin & Review, 10*, 638-644.

Kahneman, D. (1973) *Attention and Effort*. Englewood Cliffs, N. J.: Prentice-Hall.

Kane, M. J., & Engle, R. W. (2003). Working-memory capacity and the control of attention: The contributions of goal neglect, response competition, and task set to Stroop interference. *Journal of Experimental Psychology: General, 132*, 47-70.

Kanske, P., & Kotz, S. (2010). Modulation of early conflict processing: N200 responses to emotional words in a flanker task. *Neuropsychologia*, *48*(12), 3661–3664.

Kanske, P. & Kotz, S. (2011). Attentional orienting towards emotion: P2 and N400 ERP effects. Neuropsychologia, 49, 3121-3129.

Kerns, J. G., Cohen, J. D., MacDonald, A. W., Cho, R. Y., Stenger, V. A., & Carter, C. S. (2004). Anterior cingulate conflict monitoring and adjustments in control. *Science*, *303*(5660), 1023–1026.

Kiehl, K. A., Liddle, P. F., & Hopfinger, J. B. (2000). Error processing and the rostral anterior cingulate: An event-related fMRI study. *Psychophysiology, 37*, 216–223.

Kiefer, M., Adams, S. C. & Zovko, M. (2012). Attentional sensitization of unconscious visual processing: Top-down influences on masked priming. *Advances in Cognitive Psychology, 8*(1), 50-61.

Klapp, S. T. (2007). Nonconscious control mimics a purposeful strategy: Strength of Stroop-like interference is automatically modulated by proportion of compatible trials. *Journal of Experimental Psychology: Human Perception and Performance, 33*(6), 1366-1376.

Kopp, B., Rist, F., & Mattler, U. (1996). N200 in the flanker task as a neurobehavioral tool for investigating executive control. *Psychophysiology*, *33*(3), 282–294.

Kornblum, S., Hasbroucq, T., & Osman, a. (1990). Dimensional overlap: cognitive basis for stimulus-response compatibility--a model and taxonomy. *Psychological Review*, *97*(2), 253–270.

Krug, M. K., & Carter, C. S. (2012). Proactive and reactive control during emotional interference and its relationship to trait anxiety. Brain Research, 1481, 13–36.

Kunde, W., Reuss, H., & Kiessel, A. (2012). Consciousness and cognitive control. *Advances in Cognitive Psychology, 8*(1), 9-18.

Laming DRJ. 1968. *Information Theory of Choice-Reaction Times*. London: Academic press.

Lehle, C., & Hübner, R. (2008). On-the-fly adaptation of selectivity in the flanker task. *Psychonomic Bulletin & Review, 15*(4), 814–818.

Lindsay, D. S., & Jacoby, L. L. (1994). Stroop process dissociations: The relationship between facilitation and interference. Journal of Experimental Psychology. *Human Perception and Performance, 20*, 219–234.

Logan, G. D. (1980). Attention and automaticity in Stroop and priming tasks: Theory and data. *Cognitive Psychology, 12*, 523-553.

Logan, G. (1988) Toward an instance theory of automatization. *Psychological Review 95*, 492–527

Logan, G. D., & Zbrodoff, N. J. (1979). When it helps to be misled: Facilitative effects of increasing the frequency of conflicting stimuli in a Stroop-like task. *Memory & Cognition, 7*, 166–174.

Logan, G. D., Zbrodoff, N. J., & Williamson, J. (1984). Strategies in the color-word Stroop task. *Bulletin of the Psychonomic Society*, *22*(2), 135–138.

Lowe, D.G. & Mitterer, J. O. (1982). Selective and divided attention in a Stroop task. *Canadian Journal of Psychology/Revue canadienne de psychologie, 36*(4), 684-700.

Luck, SJ. An introduction to the Event-Related Potential Technique. MIT Press; Cambridge, MA (2005).

MacLeod, C.M. (1991). Half a century of research on the Stroop effect: an integrative review. *Psychological Bulletin, 109*, 163–203.

Marrocco, R.T., Davidson, M.C., 1998. *Neurochemistry of attention*. In: Parasuraman, R. (Ed.), The Attentive Brain. MIT, Cambridge, MA, pp. 35 – 50.

Martens, U., Ansorge, U., & Kiefer, M. (2011). Controlling the unconscious: Attentional task sets modulate subliminal semantic and visuo-motor processes differentially. *Psychological Science, 22*, 282–291

McDonald, A. W. (2000). Dissociating the Role of the Dorsolateral Prefrontal and Anterior Cingulate Cortex in Cognitive Control. *Science*, *288*(5472), 1835–1838.

McDonald, A.W., Cohen, J.D., Strenger, V. A., & Carter, C. S. (2000). Dissociating the role of the dorsolateral prefrontal cortex and anterior cingulate cortex in cognitive control. *Science, 288*(9), 1835-1838.

Menon, V., Adleman, N. E., White, C. D., Glover, G. H., & Reiss, A. L. (2001). Error-related brain activation during a go/no-go response inhibition task. *Human Brain Mapping, 12*, 131–143

Merikle, P. M. & Joordens, S. (1997). Parallels between perception without attention and perception without awareness. *Consciousness and Cognition 6*(2-3), 219-236.

Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience*, *24*, 167–202.

Montalan, B., Caharel, S., Personnaz, B., Le Dantec, C., Germain, R., Bernard, C., Rebaï, M. (2008). Sensitivity of N170 and late positive components to social categorization and emotional valence. *Brain Research*, *1233*, 120–128.

Nieuwinhuis, S., Stins, J., Posthuma, D., Polderman, T., Boonsma, D. and de Geus, J. (2006). Accounting for sequential trial effects in the flanker task: Conflict adaptation or associative priming? *Memory & Cognition, 34*(6), 1260-1272.

Norman, D. A. & Shallice, T. (1986) Attention to Action. Willed and Automatic Control of Behavior. *Conciousness and Self-Regulation, 4*, 1-18.

Ortells, J. J., Marí-Beffa, P & Plaza-Ayllón, V. (2002). Unconscious congruency priming from unpracticed words is modulated by prime-target semantic relatedness. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 39*(2), 394-413.

Oschner, K., Hughes, B., Robertson, E., Cooper, J and Gabrielli, J. (2009). Neural Systems Suporting the Control or Affective and Cognitive Conflicts. *Journal of Cognitive Neuroscience, 21*(9), 1841-1854.

Panadero, A., Castellanos, M. C., and Tudela, P. (2015). Unconscious context-specific proportion congruency effect in a stroop-like task. *Consciousness and cognition*, *31*, 35-45.

Pardo, J. V., Pardo, P. J., Janer, K. W. & Raichle, M. E. (1990). The anterior cingulate cortex mediates processing selection in the Stroop attentional conflict paradigm. Neurobiology, 87, 257-259

Perrin, F., Pernier, J., Bertrand, O., & Echallier, J. F. (1989). Spherical splines for scalp potential and current density mapping. *Electroencephalography and Clinical Neurophysiology*, *72*(2), 184–187.

Petersen, S. E., Fox, P. T., Posner, M. I., Mintum, M. & Raichle, M. E. (1988). Positron emission tomographic studies of the cortical anatomy of single-words processing. *Nature, 331*, 585-589.

Petersen, S. M. & Posner, M. I. (2012) The Attention System of the Human Brain: 20 Years After. Annual review of neuroscience, 35, 73-89.

Polich, J. (2007). Updating P300: an integrative theory of P3a and P3b. *Clinical Neurophysiology : Official Journal of the International Federation of Clinical Neurophysiology*, *118*(10), 2128–48. doi:10.1016/j.clinph.2007.04.019

Posner, M.I. (1978). *Chonometric explanations of mind.* Hillsdale, NJ: Erlbaum.

Posner, M.I. (1980). Orienting of attention. *Quarterly Journal of Experimental Psychology, 32*, 3-25.

Posner, M. I., & Boies, S. J. Components of attention. Psychological Review, 1971 ,78, 391.

Posner, M. I., & Cohen, Y. (1984) Components of visual orienting. In Attention and Performance X, H. Bouma and D. Bowhuis, eds., pp. 531-556,

Posner, M.I. & Dehaene, S. (1994). Attentional networks. *Trends in Neuroscience, 17*, 75-79.

Posner, M. I., Inhoff, A. W., Friedrich, F. J. & Cohen, A. (1987) Isolating attentional system: A cognitive-anatomical analysis. *Psychology, 15*(2), 107-121.

Posner, M. I., Klein, R., Summers, J. &y Buggie, S. (1973). On the selction of signals. *Memory & Coognition, 1*, 2-12.

Posner, M.I. & Petersen, S. E. (1990). The attention system of the human brain. *Annual Reviews in Neuroscience, 13*, 25-42.

Posner, M. I. & Rothbart, M. K. (1991). Components of Visual Orienting in Early Infancy: Contingency Learning, Anticipatory Looking, and Disengaging. *Journal of Cognitive Neuroscience, 3*(4), 335-344.

Posner, M. I. & Snyder, C. R. R. (1975). Attention and cognitive control. In *Information Processing and Cognition* (pp. 55-85). Hillsdale, NJ: Erlbaum

Posner, M.I & Zinder, C.R.R Facilitation and inhibition in the processing of signals. In P. M. A. (Rabbit (Ed.) *Attention and Performace V*. London: Academia Press. 1975.

Rabbitt, P. M. A. (1966). Errors and error-correction in choice-response tasks. *Journal of Experimental Psychology, 71*, 264-272.

Ridderinkhof, K. R., Ullsperger, M., Crone, E. A., & Nieuwenhuis, S. (2004). The role of the medial frontal cortex in cognitive control. *Science (New York, N.Y.)*, *306*(5695), 443–7.

Rugg MD, & Coles MGH. (1995). *ERP studies of memory*. In: Electrophysiology of Mind: Event-related Brain Potentials and Cognition. New York: Oxford University Press, pp 132–170.

Ruz, M. & Lupiáñez, J. (2002). A review of Attentional Capture: On it´s automaticity to endogenous control. *Psicológica, 23*, 283-309.

Ruz, M., Madrid, E., Lupiáñez, J., & Tudela, P. (2003). High density ERP indices of conscious and unconscious semantic priming. *Cognitive Brain Research, 17, 3*, 719-731.

Schmidt, J.R. and Besner, D. (2008) The Stroop effect: why proportion congruent has nothing to do with congruency and everything to do with contingency. *Journal of Experimenta. Psycholpgy: Learning, Memory and Cognition, 34*, 514–523

Schmidt, J. R., Crump, M. J. C., Cheesman, J., & Besner, D. (2007). Contingency learning without awareness: Evidence for implicit control. *Consciousness and Cognition, 16*, 421- 435.

Schneider, W., & Shiffrin, R. M. (1977). Controlled and automatic human information processing: I. Detection, search, and attention. *Psychological Review, 84*, 1-66.

Scott, G. G., O'Donnell, P. J., Leuthold, H., & Sereno, S. C. (2009). Early emotion word processing: evidence from event-related potentials. *Biological Psychology*, *80*(1), 95–104.

Shallice, T, and Cooper, P. (2011) *The organization of mind*. Oxford: Oxford University Press.

Shiffrin R.M & Schneider, W. (1977) Controlled and Automatic Human Information Processing II. Perceptual Learning, Automatic Attending, and a General Theory. *Psychological Review, 84*(2), 127-191.

Shin, L., Whalen, P., Pitman, R., Bush, G., Macklin, M., lasko, N. et al. (2001). An fMRI study os anterior cingulate cortex function in postraumatic stress disorder. *Biological Psychiatry, 50*, 932-942.

Stroop, J.R.(1935). Studies of interference in serial verbal reactions. *Journal of Experimental psychology,18*, 643-662.

Sturn, W. & Willmes, K. (2001). On the functional neuroanatomy of intrinsic and phasic alertness. *Neuroimage, 14*, 78-84.

Taylor, S.F., Kornblum, s., Minoshima, S., Oliver, L. M. & Koeppe, L. A. (1994) Changes in medial cortical blood flow with a stimulus-response compatibility task. *Neuropsychologia 32*, 249–255.

Thomas, S., Jhonstone, S & Gonsalvez, C. (2007). Event-related potentials during an Emotional Stroop task. *International Journal of Psychophysiology, 63*(3), 221-231.

Thompson, K. G, Biscoe, K. L, Sato, T. R. (2005). Neuronal basis of covert spatial attention in the frontal eye field. Journal of Neuroscience,25,9479–9487

Van Veen, V., & Carter, C. (2002). The anterior cingulate as a conflict monitor: fMRI and ERP studies. *Physiology & Behavior*, *77*(4-5), 477–482.

Van Veen, V. & Carter, C. S. (2006). Conflict and Cognitive Control in the Brain. *Current Directions in Psychological Science, 15*, 237-240.

Wager, T. D., Davidson, M. L., Hughes, B. L., Lindquist, M. A., & Ochsner, K. N. (2008). Prefrontal-subcortical pathways mediating successful emotion regulation. *Neuron*, *59*(6), 1037–50. doi:10.1016/j.neuron.2008.09.006

Warburton, E., Wise, R., Price, C. J., Weiller, C., Hadar, U., Ramsay, S. & Frackowiak, R. S. J. (1996). Noun and verbal retrival by normal subject: Studies with PET. *Brain, 119*, 159-179.

Watts, F., McKenna, F. Sharrock, R. and Trezise, L. (1986) Colour naming of phobia-related words. *Brittish Journal of Psychology, 77*(1), 97-108.

Weiskrant, L. (2009). Blindsight: a case study spanning 35 years and new developments. 2nd edn. Oxford University Press, Oxford.

Wendt, M. & Luna-Rodríguez, A. (2009). Conflict-Frequency affects Flanker Interference: Role of Stimulus-Ensemble-Specific Practice and Flanker-Response Contingencies. *Experimental Psychology, 56*(3), 206-217.

West, R. & Baylis, G. C. (1998). Effects of increased response dominance and contextual disintegration on the Stroop interference effect in older adults. *Psychology and aging, 13*(2), 206-217.

Whalen, P., Bush, G., McNally, R., Wilhelm, S., McInerney, S., Jenike, M., & Rauch, S. (1998). The emotional counting Stroop paradigm: a functional magnetic resonance imaging probe of the anterior cingulate affective division. *Biological Psychiatry*, *44*(12), 1219–1228

Wise, R., Chollet, F., Hadar, U., Friston, K., Hoffner, E. & Frackowiak, R. S. J. (1991). Distribution of cortical neural networks involved in woed comprehension and word retrival. *Brain, 114*(4), 1803-1817.

Wong, P. S., Bernat, E., Snodgrass, M. & Shevrin, H. (2004). Event-related brain correlates of associative learning without awareness. *International Journal of Psychophysiology, 53*(3), 217-231.

Yetkin, F. Z, Hammeke, T. A., Swanson, S. J., . Morris, G. L., Mueller, W. M., . McAuliffe, T. L. & Haughton, V. M. (1995). A Comparison of Functional MR Activation Patterns during Silent and Audible Language Tasks. *Amwrican Journal of Neuroradiology, 16*, 1087-1092 Zhu, H. R.,

Zhang, H. J., Wu, T. T., Luo, W. B., & Luo, Y. J. (2010). Emotional conflict occurs at an early stage: Evidence from the emotional face-word Stroop task. *Neuroscience Letters, 478*, 1–4