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The role of social processes and decision making in the psychobiological response to social stress

Tesis Doctoral

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Presentar la tesis doctoral es el fin del viaje que he realizado durante más de 4 años de mi vida. Durante este viaje he aprendido una gran cantidad de cosas tanto a nivel laboral, académico como personal. Todos estos aprendizajes han venido siempre acompañados de personas que me han rodeado, y que, de una forma u otra, han aportado su granito de arena a que yo sea capaz de escribir esta tesis y llegar tan lejos. Es por eso que tengo un millón de agradecimientos para todas esas personas y es por eso que todos y cada uno de ellos se merecen un cachito de esta tesis.

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PREFACIO

Los humanos, a diario, se enfrentan a diversas interacciones sociales, que pueden ser interpretadas como retos o como amenazas en función del contexto y del individuo que las enfrenta. Es por ello, que el cuerpo humano acaba activando sus mecanismos fisiológicos y conductuales en función de cómo interpreta está situación. Durante toda esta interpretación los humanos deciden un patrón de conducta que les lleva a tomar un tipo de decisiones u otras para adaptarse a estas interacciones sociales. Es por ello que la toma de decisiones puede ser una variable de estudio importante a lo largo de toda una interacción social, tanto como decidimos en función de la interacción y la respuesta fisiológica, como si la toma de decisiones es un factor de vulnerabilidad/resiliencia a las consecuencias ocasionadas por estas interacciones.

Por ello, el interés de esta tesis se centra en como los humanos interpretan ciertas interacciones sociales más bien amenazantes y como la toma de decisiones interviene en esa interpretación. En primer lugar, se hará énfasis en el estudio de algunos factores sociales, como el enfrentamiento a otro grupo, y como estos factores afectan a la respuesta fisiológica y psicológica a un conflicto. En segundo lugar, focalizaremos la atención en la toma de decisiones como factor que podría predecir la conducta o la respuesta fisiológica ante una interacción social.

El primer capítulo expone una introducción de la literatura, compuesta por un apartado que repasa la respuesta fisiológica y psicológica a las interacciones sociales, y un segundo apartado que repasa el proceso de toma de decisiones, como las interacciones sociales y la respuesta fisiológica puede alterar estos procesos, y finalmente, si los procesos de toma de decisiones pueden ser un factor de afrontamiento a las interacciones sociales siendo un factor que ayude a tener una mejor salud general.

El segundo capítulo expone los objetivos e hipótesis generales de la tesis doctoral.

El tercer capítulo presenta el primer experimento dedicado a la respuesta fisiológica al conflicto intergrupal, y las diferencias de sexo asociadas.

El cuarto capítulo consiste en el segundo experimento que evalúa la toma de decisiones después de una interacción social competitiva en función de la respuesta endocrina después de dicha competición.

El quinto capítulo presenta el tercer experimento que muestra como la toma de decisiones puede ser un factor que promueve una respuesta cardiovascular adaptativa a una interacción social competitiva.

El sexto y séptimo capítulos muestran una validación del cuestionario *General Decision Making Styles* así como su relación con variables de personalidad, estilos de afrontamiento al estrés y variabilidad de la frecuencia cardiaca en condiciones de reposo.

El octavo y noveno capítulos contienen una discusión general de la tesis, limitaciones, direcciones futuras y un resumen general de los principales hallazgos de los estudios.

El décimo y onceavo capítulos son dos resúmenes generales de la tesis doctoral, uno en inglés y el otro en castellano. Finalmente, se presentan las referencias bibliográficas.

ABREVIATURAS / ABREVIATURES

A = Adrenaline / Adrenalina

ACTH = Adenocorticotropic hormone / Hormona adenocorticotropina

ANS / SNA = Autonomic nervous system / Sistema nervioso autónomo

BART = Balloon Analogue Risk Task

BMI / IMC = Body mass index / Índice de masa corporal

BPM / ppm = Beats per minute / Pulsaciones por minuto

C = Cortisol

CAN = Central autonomic network / Red autonómica central

CFA = Confirmatory factor analysis / Análisis factorial confirmatorio

CNS = Central nervous system / Sistema nervioso central

CRH = Corticotropin releasing hormone / Hormona liberadora de corticotropina

CV = Cardiovascular

ECG = Electrocardiogram / Electrocardiograma

EFA = Exploratory factor analysis / Análisis factorial exploratorio

FSH = Follicle-stimulating hormone / Hormona folículo estimulante

GDMS = General Decision Making Style

GnRH = Gonadotropin-releasing hormone / Hormona liberadora de gonadotropina

GR = Glucocorticoid receptors / Receptores glucocorticoides

HF = High frequencies / Altas frecuencias

HHA = Hypothalamic-hipofiso-adrenal / Hipotálamo-hipófiso-adrenal

HHG = Hypothalamic-hipofiso-gonadal / Hipotálamo-hipófiso-gonadal

HLA = Lateral hypothalamus / Hipotálamo lateral

HLM = Hierachichal linear modeling / Modelo linear jerárquico

HR / FC = Heart rate / Frecuencia cardiaca

HRV / VFC = Heart rate variability / Variabilidad de la frecuencia cardiaca

Hz = Hertz / Hercios

ICC = Intraclass correlation / Correlación intraclase

IG = Iowa index / Índice Iowa

IGT = Iowa Gambling Task

LF = Low frequencies / Bajas frecuencias

LH = Luteinizing hormone / Hormona luteinizante

LHA = Lateral hipotalamus / Hipotálamo lateral

MR = Mineralcorticoid receptors / Receptores mineralcorticoides

NA = Noradrenaline / Noradrenalina

O = Oxytocin / Oxitocina

OC = Cardiac output / Output cardiaco

PFC = Prefrontal cortex / Cortex prefrontal

PNS / SNP = Parasympathetic nervous system / Sistema nervioso parasimpático

PVN = Paraventricular nucleus / Núcleo paraventricular

RMSSD = Root Mean Square Successive Difference

RSA / ASR = Respiratory sinus arrhythmia / Arritmia sinusal respiratoria

SEM = Statistical error of mean / Error típico de la media

SES = Socioeconomic status / Estatus socioeconómico

SNS = Sympathetic nervous system / Sistema nervioso simpatico

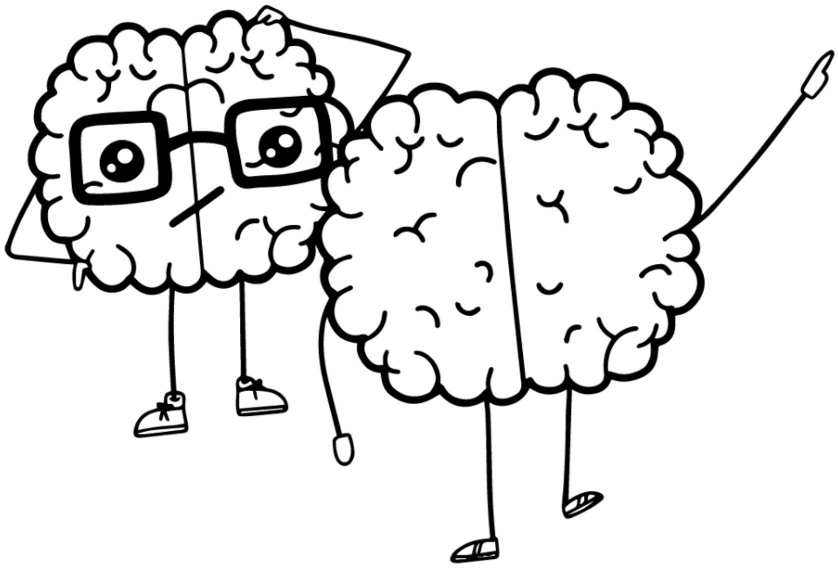
T = Testosterone / Testosterona

TPR / RTP = Total peripheral resistance / Resistencia total periférica

TSST = Trier social stress task

VC = Ventricular contractibility / Contractibilidad ventricular

VLF = Very low frequencies / Ultra bajas frecuencias



Capítulo 1:

Introducción

¿Cómo decidimos en entornos sociales?

Desde una perspectiva fisiológica, emocional y cognitiva

1. Interacciones sociales y correlatos psicobiológicos.

1.1 La importancia de las interacciones sociales en el ser humano

Una de las características más importantes del ser humano es su capacidad y, a la vez necesidad, de organizarse en grupos (Kurzban & Neuberg, 2015; Wilson & Wilson, 2007). Esto lleva a nuestra especie a relacionarse e interaccionar de diversas maneras, con consecuencias tanto positivas como negativas. En general el ser humano es una de las especies más propensa a cooperar y a formar grupos con otros miembros no genéticamente relacionados (Nowak, Tarnita, & Wilson, 2010), consiguiéndose beneficios, tales como favorecer el desarrollo cultural o el aumento de la seguridad y la supervivencia (Bowles, Choi, & Hopfensitz, 2003; Gintis, 2000; Henrich, 2004). De hecho, la cooperación en grupo como especie ha propiciado el desarrollo de múltiples aptitudes y herramientas que han favorecido el desarrollo del arte, la cultura y un lenguaje complejo (Zilhão, 2007); el aprendizaje en el intercambio y la negociación para obtener recursos, materiales e inmateriales (Horan, Bulte, & Shogren, 2005); el perfeccionamiento en la transmisión del conocimiento, la ética y los valores y el desarrollo de innovaciones sociales y tecnológicas (Flinn, Geary, & Ward, 2005; Wynn, Coolidge, & Bright, 2009) incrementando la adaptación al medio y disminuyendo la probabilidad de no extinguirnos como especie. Además, la organización grupal de la especie humana satisface necesidades psicológicas individuales (Correll & Park, 2005; Kurzban & Neuberg, 2015; D. S. Wilson & Wilson, 2007), como el sentido de pertenencia a un grupo (Brewer, 1991), la autoestima (Tajfel & Turner, 1979) o un descenso de la incertidumbre en el día a día (Hogg, 2000). Es por ello que, probablemente, la evolución ha favorecido el desarrollo y mantenimiento de genes que activan estructuras y mecanismos psicobiológicos que fomentan la formación de grupos, predisponiendo al individuo para las interacciones sociales (De Dreu & Kret, 2016).

Por todo ello la especie humana es considerada una especie social y, por lo general, las personas interaccionan con otros individuos o grupos diariamente. Asimismo, puede que estas interacciones interpersonales sean con miembros considerados del propio grupo (*in-group*) o con miembros de otro grupo o intergrupales (*out-group*). Un grupo se ha definido como "un colectivo de individuos que se perciben a ellos mismos como miembros de la misma categoría social, comparten algunas implicaciones emocionales en esta definición común sobre ellos mismos, y logran algún grado de consenso social acerca la evaluación de su grupo y la pertenencia a dicho grupo" (Tajfel & Turner, 1979, p. 40). Dicha definición pone de manifiesto la flexibilidad y subjetividad para incluir a un individuo o grupo dentro del propio grupo. De hecho, diferenciar si una interacción social es, o no, intergrupal puede ser una tarea complicada. No es necesario que varios individuos o miembros del propio grupo se hallen frente a uno o varios miembros de otro grupo, para considerar que una situación es intergrupal. En el mismo momento en el que nos encontremos con un miembro que consideremos del *out-group* la situación se vuelve intergrupal (Tajfel et al., 1971).

La importancia de diferenciar una situación como interpersonal o intergrupal radica en que la interpretación de dicha situación social será diferente. Por ejemplo, cualquier interacción social puede ser un estresor social para una persona (Brondolo et al., 2003). Desde este punto de vista, un individuo, o grupo, interpretarán una interacción social como amenazante, o no, en función del contexto en el que ocurre dicha interacción y los recursos de los que dispone el individuo (o grupo) para afrontarla. (Folkman, Lazarus, Dunkel-Schetter, DeLongis, & Gruen, 1986; Lazarus & Folkman, 1984). De este modo una interacción social percibida como importante, pero donde no se dispone de los recursos necesarios para afrontarla será evaluada como negativa o amenazante. Dicha valoración puede provocar una respuesta psicobiológica de estrés; mientras que una interacción social percibida como importante, donde se dispone de los recursos necesarios para afrontarla, será evaluada como positiva o reto, reduciéndose la respuesta de estrés (Taylor, 2006). Las personas, por norma general, confían menos en los grupos que en los individuos y esperan que las interacciones intergrupales sean mucho más hostiles que las interacciones interpersonales (Bornstein & Ben-Yossef, 1994; Pemberton, Insko,

& Schopler, 1996; Wildschut, Pinter, Vevea, Insko, & Schopler, 2003). Desde este punto de vista, una persona puede percibir una interacción social con uno o varios miembros de otro grupo como más amenazante y, por ello, podría exacerbar su respuesta de estrés, en contraste con una interacción con uno o varios miembros del propio grupo, la cual podría interpretarse como menos amenazante.

Asimismo, los objetivos que tiene un individuo ante una interacción social, en función de los agentes de dicha interacción y las expectativas de los miembros implicados, son otra variable relevante. En este sentido, la interpretación de la situación será muy distinta si el objetivo de la interacción es cooperativo o competitivo dando lugar también a respuestas psicobiológicas distintas. Los objetivos de una interacción social pueden ser muy diversos como, por ejemplo, atraer a la persona con la que se está interactuando para establecer un vínculo afectivo con posibilidades de reproducción. En este caso estamos ante una interacción de cortejo favoreciendo conductas dirigidas a informan a la otra persona de la propia disponibilidad y la madurez sexual. Otros objetivos podrían ser recibir apoyo social o instrumental, dar o recibir afecto o satisfacer sentimientos de pertenencia al grupo, objetivos cooperativos, frecuentes en las interacciones con seres queridos como familiares y amigos. Otra posibilidad es que dos o más individuos tengan el mismo objetivo (eg. finalizar un trabajo, obtener unos recursos o compartir información) , y que dicho objetivo sea alcanzable para todos, por lo que pueden cooperar para maximizar la posibilidad de alcanzar dicho objetivo (Zeigler-Hill, Welling, & Shackelford, 2015). No obstante, las interacciones sociales también pueden ser conflictivas, por ejemplo, en situaciones donde los recursos naturales son limitados, cuando los objetivos o las motivaciones son dispares, e incluso, en situaciones donde las expectativas o las ideologías son contrapuestas (Koban, Pichon, & Vuilleumier, 2014). En este sentido, es posible que un individuo o grupo se enfrenten con otros individuos o grupos por recursos naturales limitados, estatus, para atraer a una persona para una relación amorosa o, simplemente, por demostrar tener la razón, dando lugar a interacciones competitivas o conflictivas (Zeigler-Hill et al., 2015).

Estas interacciones conflictivas se traducen en luchas, confrontaciones, competiciones y/o negociaciones para dirimir qué individuo, o individuos, lograran el objetivo, obtendrán o controlarán los recursos limitados y/o status o poder (Koban et al., 2014; Mazur, 1985; van Anders & Watson, 2007; Wingfield, Hegner, Dufty, & Ball, 1990). De hecho, la competición por recursos, estatus o por cortejo no existe únicamente en nuestra especie, es un fenómeno que se ha descrito en otras especies como, por ejemplo, ratones, ratas u homínidos no humanos, lo cual indica que es una conducta muy arraigada a nivel evolutivo (Sherrow, 2012). En cuanto a las interacciones con miembros del propio grupo o de otros grupos, hay sesgos cognitivos que suelen llevar a que el individuo se comporte de manera más competitiva/conflictiva con el *out-group* y más cooperativa con el *in-group* (Pemberton et al., 1996), lo cual es uno de los efectos del denominado altruismo localizado (*parochial altruism*) o la tendencia a favorecer a los miembros del *in-group* en detrimento del *out-group* (Brewer, 1979; Messick & Mackie, 1989).

La evolución ha favorecido que los seres humanos desarrollen mecanismos biológicos flexibles para categorizar a otras personas dentro su propio grupo o como parte de otro grupo según diversos criterios. Hay múltiples reglas de categorización y criterios para clasificar a una persona como miembro de nuestro propio grupo o miembro de un grupo distinto (Hensley & Duval, 1976; Tajfel, 1969, 1970). Algunos ejemplos podrían ser lazos genéticos, habilidades y/o aficiones en común, el tener una ideología diferente o pertenecer a una clase social distinta en comparación con la persona con la que se interacciona. Por tanto, podemos llegar a clasificar a una persona basándonos en información relevante o trivial, estable o inestable (Tajfel, Billig, Bundy, & Flament, 1971) y por ello la categorización grupal es muy fluida y dependiente del contexto (Turner, Oakes, Haslam, & McGarty, 1994). Basándose en esos criterios, el ser humano se categoriza a sí mismo como parte de un colectivo, mediante un proceso de identificación social (Tajfel & Turner, 1979) y por un proceso de categorización social (Turner, Hogg, Oakes, Reicher, & Wetherell, 1987) que orienta la interpretación de uno mismo en relación con el resto. Una vez conocido el grupo o grupos a los cuales pertenece un individuo categoriza a los demás como miembros del *in-group* o miembros del *out-group* (Macrae & Bodenhausen, 2000; Rabbie & Horwitz, 1969). Por tanto, la condición de pertenencia al grupo, o no, se caracteriza por criterios meramente subjetivos los cuales pueden actualizarse dependiendo de la situación social, siendo por ello un proceso flexible. Esta categorización, da lugar a distintos sesgos y diferentes comportamientos, en función tanto del propio grupo de pertenencia, como del grupo de no pertenencia (ver Cikara & Van Bavel, 2014 para una revisión).

Desde la neurociencia se han identificado algunas de las áreas cerebrales relacionadas con estos sesgos cognitivos. Se ha descrito una relación entre el lóbulo parietal inferior y la capacidad de valorar mejor las acciones del grupo propio, con respecto a las del otro grupo; la corteza prefrontal, la ínsula el córtex cingulado anterior y la corteza temporoparietal se relacionan con mayor empatía hacia los miembros del propio grupo; o la activación del giro fusiforme y la amígdala percibiendo las caras de los miembros de un *out-group* como más amenazantes (ver Molenberghs, 2013 para una revisión). Lamentablemente, estos sesgos cognitivos pueden favorecer conductas agresivas entre miembros de la especie humana (Anderson & Bushman, 2002). Complementariamente, la valoración del individuo va más allá de la pertenencia, o no, al grupo, de modo que, cuando se categoriza a otra persona, aparte de si pertenece a nuestro grupo, se diferencian otras cualidades, tales como si puede llegar a ser amigo o enemigo (para el individuo o el grupo del individuo), las posibles intenciones de dicha persona, o si tiene acceso a recursos que nos puedan interesar (Cuddy, Fiske, & Glick, 2007; Fiske, Cuddy, & Glick, 2007; Fiske, Cuddy, Glick, & Xu, 2002). Por tanto, no se evalúan a todas las personas de forma equivalente.

Los investigadores han aprovechado que los grupos se forman de forma subjetiva, flexible y rápida, así como los sesgos cognitivos de pertenencia a grupos, para la investigación del conflicto intergrupal y sus consecuencias. Para ello han utilizado métodos como el contacto intergrupal entre miembros de distintos grupos naturales (separados por su etnia, su partido político…) (ver Cikara & Van Bavel, 2014, para una revisión) o como el paradigma del grupo mínimo, en el cual se divide a los participantes en grupos de forma arbitraria (aleatorizada) (Tajfel, 1970; Tajfel et al., 1971). Un claro ejemplo de conflicto intergrupal generado por el paradigma del grupo mínimo es el famoso "*Robbers Cave experiment*", en el cual juntaron a alumnos universitarios en un campamento de verano. En dicho experimento establecieron dos grupos de forma aleatoria "Rattlers" y "Eagles", los cuales desconocían la existencia del otro grupo. Posteriormente involucraron los grupos en juegos competitivos donde podían ganar premios. Como resultado, algunos miembros de los grupos llegaron a presentar violencia física al encontrarse con miembros del *out-group* (Sherif, Harvey, White, Hood, & Sherif, 1961). El problema se presenta cuando estas situaciones de agresión se descontrolan, pudiendo llegar a situaciones de guerra o terrorismo (Fujii, 2010; Staub, 2004), produciendo gran cantidad de muertes. Por ello se ha descrito al conflicto intergrupal como uno de los problemas más importantes a los que se enfrenta el mundo actual (Cohen & Insko, 2008). Además, las interacciones sociales conflictivas son un proceso común en el día a día de una persona.

Por todo lo expuesto con anterioridad, surge el interés por investigar las interacciones sociales conflictivas y competitivas en esta tesis doctoral. Más concretamente, nos interesa conocer si la forma de decidir de una persona puede facilitar la adaptación a dichas interacciones sociales conflictivas y competitivas, y qué impacto pueden tener aquellas en la respuesta psicobiológica de una persona, así como sus efectos en sus decisiones y conductas futuras. Dada la importancia de diferenciar si una situación es intergrupal o no, se debe definir claramente. La revisión de la literatura previa no ha clarificado cómo diferenciar una interacción interpersonal de una interacción intergrupal, pero dadas sus características, cualquier relación entre dos o más personas podría considerarse interpersonal, formen o no parte del mismo grupo. A efectos prácticos, en esta tesis, basándonos en la definición de Tajfel & Turner (1979) definiremos una situación como intergrupal cuando en un protocolo experimental con interacción social haya claridad en la definición de las características de los diferentes grupos y los participantes sepan que pertenecen a uno de esos grupos (en algunos contextos de grupos naturales los participantes lo sabrán de forma implícita ej. raza, sexo, status…), en caso contrario la interacción será considerada como interpersonal.

1.2 La respuesta de estrés ante interacciones sociales

Como hemos introducido en el apartado anterior las interacciones sociales conflictivas pueden llegar a considerarse un estresor social en función de la interpretación de la situación. Las situaciones donde el rendimiento es importante para conseguir un objetivo (tangible o intangible) son situaciones donde hay compromiso con dicha situación o implicación en la tarea (*task engagement*) favoreciendo que la situación sea estresante, activándose la respuesta fisiológica de estrés. En este sentido el simple deseo de causar una buena impresión en otro puede ser un objetivo durante una interacción social (Baumeister & Leary, 1995) y podría inducir esta implicación. El modelo biopsicosocial de Blascovich & Tomaka (1996) propone que cuando hay implicación en una situación social, el organismo responderá activando los sistemas neuroendocrinos necesarios para afrontar la situación, los cuales guiaran la conducta. Por tanto, se pueden considerar las interacciones sociales conflictivas como estresores sociales capaces de activar la respuesta psicobiológica de estrés en el organismo.

El término estrés proviene de la física y lo utilizo Selye (1936) por primera vez en neurociencia para describir un fenómeno general de adaptación en ratas expuestas a agentes nocivos denominado: Síndrome general de adaptación. La respuesta de estrés del organismo provoca la movilización, por parte del individuo, de una serie de mecanismos biológicos para recuperar el estado interno de un individuo en el que se mantienen las constantes vitales o homeostasis (Cannon, 1932). Por tanto, cualquier estímulo que amenace la homeostasis es capaz de inducir una respuesta de estrés como, por ejemplo la posibilidad de ser atacado por un depredador. Pero el estrés social tiene una connotación diferente a las teorías clásicas del estrés, ya que no amenazan directamente a la homeostasis fisiológica. Por ello se debe tener en consideración las características de nuestra especie, intrínsecamente social. Desde una perspectiva evolutiva, la evolución ha favorecido que los humanos desarrollen mecanismos biológicos y comportamientos (Troisi & McGuire, 2002) que propician la consecución de objetivos a corto plazo, tales como, adquirir recursos, reducir el efecto de las emociones negativas, establecer relaciones íntimas u obtener status (Troisi, 2001, 2018); basados en la consecución de objetivos a largo plazo como la supervivencia y la transmisión de los genes. Desde este punto de vista, cualquier situación social que interfiera con el logro de estos objetivos puede considerarse un estresor social (Troisi & McGuire, 1992) capaz de producir una respuesta de estrés. Según la hipótesis de Troisi (2001) los estresores que amenazan el cumplimiento de los objetivos vitales activan al sistema emocional provocando estado de ánimo negativo, el cual induce la respuesta psicobiológica y conductual de estrés.

Ahora bien, la respuesta de estrés en algunos casos está asociada a un acontecimiento que causa una respuesta desagradable o de distrés. No obstante, en otros casos el estrés conduce a un sentimiento de activación necesario para la adaptación al medio, basado en una interpretación positiva de la situación (eustrés) (McEwen & Wingfield, 2003) dando lugar a distintas respuestas fisiológicas, siendo importante la interpretación de la situación social a la que se enfrenta el individuo (Lazarus & Folkman, 1984). Hay que considerar que esta interpretación depende de las características de la persona que se enfrenta a la situación y de la propia situación social. En este sentido, según el modelo biopsicosocial (Blascovich & Tomaka, 1996) en contextos donde el individuo tiene alta implicación (p.e. situaciones difíciles pero alcanzables), se puede evaluar la situación como amenazante o como un reto. Ante una situación concreta, el individuo realizar una evaluación las demandas de la situación y de los recursos propios para afrontar dichas demandas, dando lugar a una interpretación de reto cuando los recursos superan a las demandas y de amenaza cuando sucede lo contrario. Este proceso de evaluación de recursos-demandas puede suceder de forma automática e inconsciente y se va actualizando continuamente durante todo el proceso (Quigley, Barrett, & Weinstein, 2002).

El modelo de Afrontamiento a la Competición de Salvador & Costa (2009) basado en investigaciones en contextos competitivos, expone cómo puede ser dicho proceso de evaluación.

Según el modelo, hay dos grupos de variables que pueden afectar a la interpretación de un estresor social: las variables distales y las variables proximales. Las variables distales serían variables rasgo (estables en el tiempo) características de la persona en base a su condición biológica o experiencia previa (p.e. sexo, personalidad o habilidades cognitivas). Las variables proximales serían las más cercanas a la situación social, dependientes del contexto, y se trata de la evaluación que el sujeto realiza tanto de la tarea y/o su ejecución antes y durante la tarea (p.e. Autoeficacia situacional, dificultad de la tarea o motivación). Basándose en dichas variables, los individuos interpretan la situación como un reto o una amenaza. Si el individuo percibe que la situación es importante, que tiene cierto control sobre la misma y tiene las estrategias suficientes para hacerle frente, es más probable que la perciba como un reto y utilice estrategias de afrontamiento activo. En cambio, si la persona considera que no puede controlar la situación y/o que no dispone de suficientes recursos para hacerle frente, es más probable que evalúe la situación como amenazante, relacionándose con un afrontamiento pasivo.

Dicho proceso de evaluación comienza en el Sistema nervioso central (SNC) que integra la información procedente del exterior y coordina los mecanismos neuroendocrinos y conductuales para dar una respuesta ante estas situaciones amenazantes, novedosas o potencialmente dañinas. Clásicamente, se considera que la respuesta de estrés tiene dos componentes (Russell & Shipston, 2015) que se activan de forma complementaria para afrontar el estresor la activación del Sistema nervioso simpático (SNS) y del eje hipotálamo-hipófiso-adrenal (HPA). Sin embargo, se ha demostrado que es una respuesta integrada del organismo que envuelve todo tipo de sistemas, incluidos la activación/inhibición de otros ejes hormonales o del sistema inmunitario induciendo la liberación de beta-endorfinas, prolactina, vasopresina, glucagón y oxitocina o inhibiendo la liberación de los esteroides gonadales, la insulina y la hormona del crecimiento (Carter, 2003; Sapolsky, 1992, 2002). Por tanto, la respuesta de estrés es muy compleja y difícil de abarcar. En esta tesis se describirán con detalle solamente los sistemas que se han trabajado empíricamente. Concretamente, la activación del Sistema nervioso autónomo (SNA) y del eje HHA por su importancia en la respuesta de estrés y su implicación en la toma de decisiones, así como la liberación de la testosterona (T) debida a la activación del eje hipotálamo-hipófiso-gonadal (HHG) por su importancia en la conducta social y en la toma de decisiones sociales.

1.2.1 Sistema nervioso autónomo y sistema cardiorrespiratorio:

El primer componente de la respuesta de estrés es una rápida activación del SNA, el cual tiene como objetivo principal mantener la homeostasis ajustando el funcionamiento del cuerpo en función del entorno externo o interno mediante la activación o desactivación de diversos órganos y vísceras corporales (Jänig, 1989). Se considera clásicamente que ante un estresor la rama simpática del SNA se activa y la rama parasimpática, el sistema nervioso parasimpático (SNP), se desactiva. En consecuencia, este patrón aumenta las pulsaciones por minuto (ppm) del corazón, la presión sanguínea y la frecuencia respiratoria con el fin de aumentar la velocidad de la circulación de la sangre, obtener más cantidad de oxígeno, y distribuir más rápidamente oxígeno y nutrientes y, en consecuencia, energía a los músculos esqueléticos. Finalmente estos efectos se ven exacerbados por la liberación de catecolaminas, adrenalina (A) y noradrenalina (NA), al corriente sanguíneo, por la activación del SNS (Guimarães & Moura, 2001; Levy, 1984).

Las interacciones sociales con implicación en la tarea son capaces de activar el SNS aumentando la frecuencia cardiaca (FC) y la fuerza contractibilidad ventricular del corazón (VC) inferida a través de menores niveles del periodo de pre-eyección cardiovascular (Seery, 2013). En este sentido, cuando hay mayor incertidumbre acerca de los posibles resultados que se pueden obtener tras una situación social y cuanto más relevante sea la situación para nosotros, habrá mayor activación de la FC y mayor VC (Seery, Weisbuch, & Blascovich, 2009). Como hemos expuesto previamente, generalmente se ha considerado que la existencia de un balance autonómico (activación del SNS y retirada del PNS) durante una tarea estresante, seguido de una recuperación rápida al estado basal previo es la forma más adaptativa de responder ante un estresor (Thayer & Lane, 2009; Williams, Suchy, & Rau, 2009). Pero el SNS y SNP no son completamente antagónicos y, por tanto, la activación del SNS no implica necesariamente la retirada del SNP, está claramente demostrado que las dos ramas del SNA pueden activarse de forma simultanea (Berntson & Cacioppo, 1999). En ocasiones, la respuesta del balance autonómico no es la más adecuada, esto sucede cuando la tarea requiere de mayor control ejecutivo, en las cuales una retirada del SNP puede ser desadaptativa (Sylvain Laborde, Lautenbach, & Allen, 2015; Sylvain Laborde, Raab, & Kinrade, 2014; Park, Vasey, Van Bavel, & Thayer, 2014).

La FC se ha utilizado clásicamente para inducir interpretaciones de activación/inhibición del SNS y del SNP, mayor FC implica mayor actividad simpática y menor parasimpática. Pero además de la cantidad de ppm, se puede evaluar la ritmicidad cíclica de los latidos del corazón, variable que puede aportar información más precisa de la activación del SNP (Chapleau & Sabharwal, 2011) y de otros sistemas psicofisiológicos. Estos ritmos cíclicos tienen unas frecuencias que coinciden con las frecuencias de otros sistemas fisiológicos, como el respiratorio. Basándose en el periodo cardiaco, o la diferencia de tiempo que hay entre un pico R y el siguiente pico R (intervalo R – R), se pueden recoger dichos periodos cíclicos del corazón a distintas frecuencias de respuesta, y a este grupo de medidas se les denomina variabilidad de la frecuencia cardiaca (VFC) (Berntson et al., 1997; Task Force, 1996).

Algunos ejemplos de estas variables (Tabla 1) y sus relaciones serían: las ultra bajas frecuencias (VLF) relacionadas con los sistemas endocrinos (Claydon & Krassioukov, 2008), las bajas frecuencias (LF) relacionadas con el reflejo barorreceptor (de Lartigue, 2014) y las altas frecuencias relacionadas (HF) con la arritmia sinodal respiratoria (RSA) (Eckberg & Eckberg, 1982). El indicador vagal más claro son las HF, se ha demostrado que al aplicar un bloqueo vagal completo las oscilaciones de la banda HF desaparecen (Pomeranz et al., 1985). Por otro lado, las LF se han considerado clásicamente un indicador mixto de SNS y PNS. Sin embargo, investigaciones previas han demostrado que el efecto del SNS en estas oscilaciones es muy bajo (ver Goldstein, Bentho, Park, & Sharabi, 2011; Reyes del Paso et al., 2013 para revisiones sistemáticas del tema). A su vez gran cantidad de estudios han probado las relaciones entre las variables de la HRV y la autorregulación cognitiva (Geisler & Kubiak, 2009; Reynard, Gevirtz, Berlow, Brown, & Boutelle, 2011), afectiva (Appelhans & Luecken, 2006; Geisler, Vennewald, Kubiak, & Weber, 2010) e incluso social (Geisler, Kubiak, Siewert, & Weber, 2013; Smith et al., 2011).

Tabla 1: Variables de la variabilidad de la frecuencia cardiaca y sus relaciones fisiológicas

Variable (*English*)	**Descripción**	**Relaciones fisiológicas**
Raw data		
HR	Media de la frecuencia cardiaca, pulsaciones por minuto (ppm)	Índice mixto de actividad de SNS y PNS
R-R	Media de los intervalos R-R	Índice mixto de actividad de SNS y PNS
Time domain		
SDRR	Desviación estándar de los intervalos R-R	Componentes cíclicos de la HRV
RMSSD	Valor cuadrático medio de las diferencias sucesivas	Tono vagal
pNN50	Porcentaje de intervalos sucesivos normales de RR sinusal con más de 50 ms	Tono vagal
Peak-valley	Filtro de dominio de tiempo centrado dinámicamente en la frecuencia respiratoria continua exacta	Tono vagal
Frequency domain		
HRV_{TOT}	Total variability frequencies, 0 – 0.40 hz.	Marcador genérico de salud
ULF	Ultra low frequencies, < 0.0033 Hz.	Ritmos circadianos, regulación del metabolismo, la temperatura y el sistema renina-angiotensina
VLF	Very low frequencies, 0.0033 – 0.04 Hz.	Termorregulación y mecanismos hormonales
LF	Low frequencies, 0.04 – 0.15 Hz.	Índice mixto de actividad de SNS y PNS[1], Actividad del reflejo barorreceptor
HF	High frequencies, 0.15 – 0.40 Hz.	Tono vagal, RSA
Non-linear		
SD1	Desviación típica del gráfico poincaré Crosswise	Incierto, relacionado con los cambios en las altas frecuencias
SD2	Desviación típica del gráfico poincaré Lengthwise	Incierto, relacionado con los cambios en las bajas frecuencias

1.2.2 El eje hipotálamo hipófiso adrenal:

El segundo componente de la respuesta de estrés aparece tras unos minutos del inicio es la activación del eje HHA dando lugar a la liberación del cortisol (C) (Russell & Shipston, 2015). La activación del eje HHA comienza cuando en el núcleo paraventricular (PVN) del hipotálamo segrega la hormona liberadora de corticotropina (CRH). La CRH estimula a la hipófisis para segregar y liberar la hormona adenocorticotropina (ACTH), en la sangre. Por último, la ACTH llega a la glándula adrenal donde favorece la síntesis y liberación de la hormona esteroidea C (Ehrlenspiel & Strahler, 2012).

El C ha sido clásicamente llamada la hormona del estrés (Selye, 1936), dado que es la hormona que organiza el organismo para favorecer el mantenimiento de la respuesta de "lucha o huida" (Cannon, 1932). Las funciones del C son catabólicas, poniendo a disposición del organismo la mayor cantidad de energía posible para afrontar un estresor. El C facilita la lipolisis y la glucogénesis para la obtención de glucosa, asimismo refuerza la acción del SNS para que el riego sanguíneo pueda transportar con la mayor brevedad posible la glucosa a los músculos esqueléticos (Ehrlenspiel & Strahler, 2012). Los niveles de C tras el inicio del estresor, empiezan a aumentar, con incrementos en saliva a los 10 minutos, llegando a un pico máximo aproximadamente entre los 10 – 30 minutos desde el inicio del estresor (Foley & Kirschbaum, 2010).

1.2.3 El eje hipotálamo hipófiso gonadal:

En este contexto de las interacciones sociales es relevante el papel de la T, una hormona que modula gran cantidad de conductas sociales (Eisenegger et al., 2011; Salvador, 2012). La T es una hormona esteroidea relacionada con conductas agresivas y competitivas, y conductas de aproximación como la lucha (Anestis, 2010). Es una hormona que se segrega como resultado de la activación del eje Hipotalámico-hipofiso-gonadal (HHG). El eje se inicia en el hipotálamo el cual libera de forma pulsátil la hormona liberadora de gonadotropinas (GnRH). La GnRH circula a través de la vena porta hipofisaria hasta la hipófisis donde favorece la secreción de la hormona luteinizante (LH) y la hormona folículo estimulante (FSH). Ambas hormonas llegan a los órganos diana (testículos, ovarios y glándulas suprarrenales), los cuales segregan T (la LH influye en mayor medida en la secreción de T) (Ehrlenspiel & Strahler, 2012).

Al igual que el C, la T tiene un ritmo circadiano con un incremento de la T sobre las 7 de la mañana, el cual se mantiene hasta las 10 y un descenso regular a lo largo del resto del día.

Además, la T tiene un ritmo estacionario habiendo una mayor liberación de T en los meses de verano (Zitzmann & Nieschlag, 2001). En cuanto a la respuesta frente a un estresor, la T se libera más rápidamente que el C, unos 5 minutos pasados el estresor (Sokoloff, Misra, & Ackerman, 2016). Además, hay diferencias de sexo en la cantidad de T en sangre, siendo de entre 300 – 1200 ng/dl en hombres y entre 30 – 60 ng/dl en mujeres (Swerdloff, Wang, & Sinha Hikim, 2010). Esta es una de las razones por las cuales el sexo cobra gran importancia en el análisis de las respuestas psicobiológicas y conductuales a las interacciones sociales.

1.2.4 El sistema nervioso central y la integración de las respuestas:

La respuesta de estrés está controlada, en última instancia, por las conexiones de la corteza prefrontal (PFC), concretamente la corteza prefrontal medial y la corteza orbitofrontal, con algunas estructuras del sistema límbico: la corteza cingulada, la ínsula y la amígdala central. Dichas estructuras mantienen una comunicación bidireccional y acaban enviando aferencias a los núcleos encargados de controlar la respuesta de estrés: el núcleo paraventricular (PVN) y lateral (LHA) del hipotálamo, el núcleo pontino y de la substancia gris periacueductal. A raíz de la información recibida, los núcleos PVN y LHA del hipotálamo activan los ejes hormonales necesarios para dar respuesta al estresor. Asimismo, envían señales excitatorias o inhibitorias al núcleo del tracto solitario el cual a su vez inerva al nervio vago, el núcleo ambiguo y a la médula rostral ventrolateral con el objetivo de controlar las ramas simpáticas y parasimpáticas las cuales inervan los distintos órganos del cuerpo: corazón, arterias y pulmones, entre otras(Thayer & Lane, 2009). Basándose en varios estudios de neuroimagen, junto con medidas electrofisiológicas, Thayer & Lane (2000) propusieron el modelo de la integración neurovisceral, el cual describe la red de estructuras cerebrales mencionada anteriormente y la denominan la "C*entral autonomic network*" (CAN: Figura 1). La teoría afirma que la CAN controla la regulación cognitiva, afectiva y fisiológica en los seres humanos.

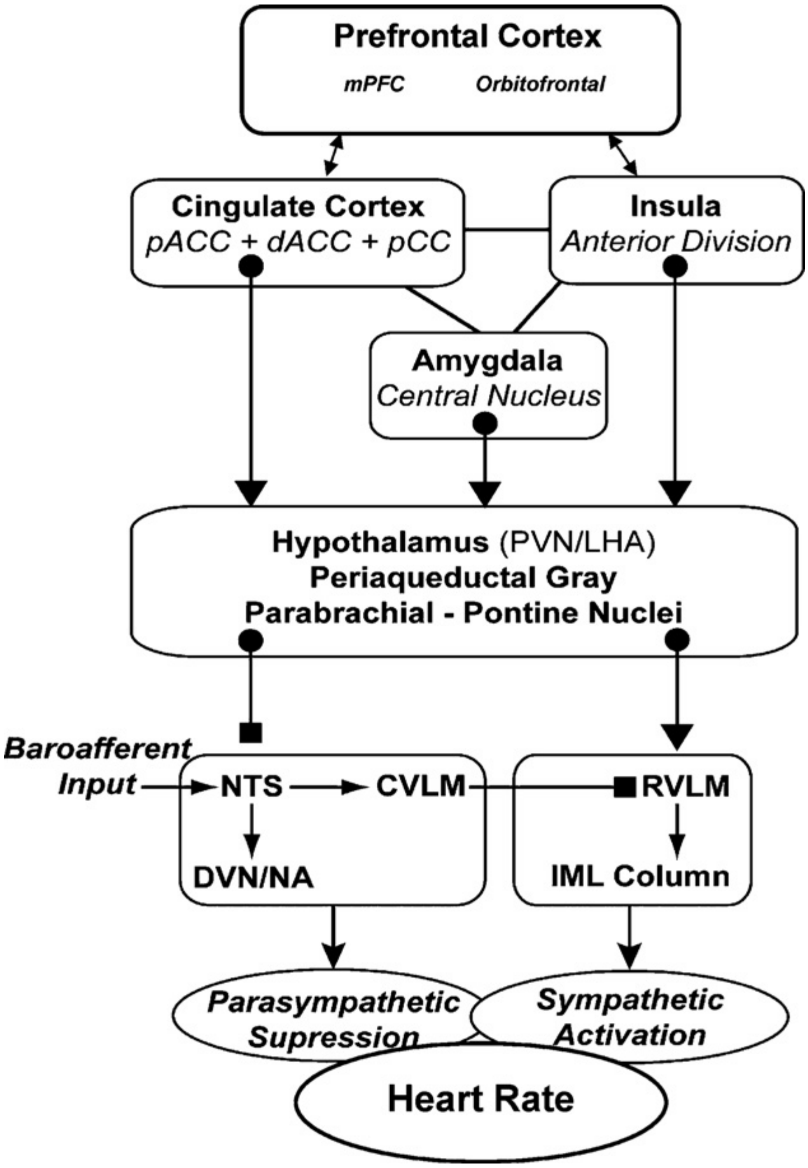


Figura 1: Esquema del *Central autonomic network* (CAN), extraída de Thayer & Lane (2009) Claude Bernard and the heart-brain connection: Further elaboration of a model of neurovisceral integration. *Neuroscience & Biobehavioral reviews, 33,* 81-88. doi:10.1016/j.neubiorev.2008.08.004. Con permiso de la editorial.
Nota: CeA = Amígdala central; NTS = Núcleo del tracto solitario; CVLM = Medula caudal ventrolateral; RVLM = Medula rostral ventrolateral; NA = Núcleo ambiguo; DVN = Núcleo vagal motor dorsal. Flechas = Vías inhibitorias; Cuadrados = vías inhibitorias.

El lóbulo frontal tiene conexiones con el resto de estructuras del cerebro, desde otros centros implicados en la percepción sensorial, la memoria y el lenguaje hasta los centros del cerebro más “primitivos”, como el sistema límbico o el tronco cerebral encargados del procesamiento emocional y la respuesta conductual a las emociones (Suchy, 2009). Por tanto, la percepción del estrés social depende de la activación o inhibición de estos circuitos cerebrales que favorecerán, en última instancia, que los seres humanos interpreten la situación como amenaza o reto (Thayer, Ahs, Fredrikson, Sollers, & Wager, 2012) y de esta forma coordinarán la respuesta biológica y conductual ante un estresor social como pueden ser las interacciones sociales competitivas o conflictivas.

En función de esta interpretación, la respuesta fisiológica es diferente: ante la interpretación de reto se activa el SNS y ante la situación de amenaza se activa tanto el SNS como el HHA (Blascovich & Tomaka, 1996; Seery, 2013). De este modo la respuesta cardiovascular (CV) también será distinta. Por un lado, ante situaciones de reto la respuesta será mediada por el SNA y las catecolaminas, lo cual llevará a un aumento de la sangre que bombea el corazón por minuto (output cardiaco (OC)) y dando lugar a vasodilatación, es decir, una resistencia periférica total (RPT) menor a la sangre. En este sentido la respuesta CV de reto es más parecida a los patrones de respuesta ante ejercicio físico aeróbico, facilitando el metabolismo y dando lugar a conductas de acercamiento hacia un objetivo, lo cual parece un afrontamiento activo a la situación. De hecho en contextos competitivos el afrontamiento activo se ha relacionado precisamente con el aumento de la activación del SNS, un estado de ánimo positivo y un aumento de la T hormona que propicia estas conductas de acercamiento, y se hipotetiza este patrón de respuesta aumenta las posibilidades de obtener buenos resultados (Salvador and Costa, 2009).

Por otro lado, la respuesta de amenaza está influenciada por el C y como resultado hay menor CO y mayor TPR. Este patrón de respuesta CV es más parecida a una vigilancia activa donde el sujeto está preparado para activar su metabolismo y conducta, pero a la vez está preparado para inhibir dichos comportamientos, lo cual es más similar a un comportamiento de huida o incluso de "*freezing*" (Seery, 2013). En este sentido la respuesta de amenaza da lugar a comportamientos donde se maximiza evitar posibles pérdidas, es decir, induce una mayor aversión a las pérdidas frente a la respuesta de reto donde se maximiza el acercamiento a las recompensas (Chalabaev, Major, Cury, & Sarrazin, 2009; Seery et al., 2009). En contextos competitivos la interpretación de amenaza se ha asociado a un afrontamiento pasivo acompañado por un aumento de la respuesta de C y una disminución o activación insuficiente de la T y el SNS así como un estado de ánimo más negativo lo cual propicia conductas que disminuye las posibilidades de obtener buenos resultados (Salvador and Costa, 2009).

Sin embargo, los patrones de respuesta y conductuales que se han mencionado previamente se han basado en estudios con hombres/machos principalmente y sobregeneralizan los resultados en mujeres/hembras. Desde esta perspectiva, a nivel teórico, se ha propuesto otro patrón de respuesta ante interacciones sociales estresantes, denominado "*Tend-and-Befriend*" (Taylor et al., 2000; Taylor, 2006), caracterizado por el cuidado de la descendencia y formación de grupos. En estos casos se considera que la regulación de la conducta social cobra gran importancia y, por tanto, es necesario un mayor control ejecutivo de la conducta social. Basándose en dicho modelo, Porges (2007) propuso su teoría polyvagal; donde defiende que los humanos responden de tres formas a un estresor: (i) mediante las fibras mielinizadas del nervio vago, lo cual da lugar a conductas asociadas con el "*Tend-and-Befriend*", (ii) mediante el sistema simpático-adrenérgico induciendo conductas de "*Fight or Flight*" y (iii) mediante las fibras amielínicas del vago, lo cual induce conductas asociadas al "*Freezing*". Por ello, afirma que los patrones de respuesta más relacionados con las conductas "*Tend-and-Befriend*" están mediados por el PNS y por tanto por un aumento de la HF, mientras que los patrones "*Fight or Flight*" responden al clásico patrón de respuesta del balance autónomo.

1.2.5 La situación social y la importancia del grupo

Como se ha indicado en apartados previos, las variables situacionales son centrales en la respuesta de las personas ante una interacción social. Este hecho puede afectar directamente a la respuesta fisiológica y emocional puesto que la evaluación de la situación de una forma u otra puede influir en dicha respuesta y, en consecuencia, en la conducta para adaptarse al contexto. Es por ello que la diferencia entre una interacción social interpersonal y una intergrupal, puede dar lugar a respuestas diferenciadas en función de la percepción de amenaza.

En concreto, las interacciones interpersonales donde se tiene un mayor estatus social suele relacionarse con respuestas CV de reto (mayor CO y menor TPR) (Scheepers, de Wit, Ellemers, & Sassenberg, 2012). A pesar de esto, una pérdida de estatus da lugar a respuesta CV de amenaza mientras que aumentar de estatus implica respuestas de reto, durante una tarea cooperativa (Scheepers, Röell, & Ellemers, 2015). Asimismo, estudios de conflicto interpersonal entre parejas han demostrado que ambos sexos muestran mayor respuesta de C durante un conflicto (Kiecolt-Glaser et al., 1997; Laurent et al., 2013), siendo menor esta respuesta en mujeres (Fehm-Wolfsdorf, Groth, Kaiser, & Hahlweg, 1999). En cambio, en la investigación de conflictos interpersonales entre extraños ambos sexos mostraban una respuesta de C, pero las mujeres que tenían mayor amplitud de respuestas conductuales durante el conflicto, se beneficiaban de menores niveles de C con respecto a los hombres o a las mujeres con menor amplitud de respuestas (Roubinov et al., 2012). Sin embargo, un estudio reciente ha mostrado que ambos, hombres y mujeres, respondían con incrementos del C y la FC ante un conflicto romántico, sin diferencias sexuales en dichas respuestas (Coutinho et al., 2017).

Por otro lado, las situaciones intergrupales han demostrado, al igual que las interpersonales, aumentar la respuesta CV de los participantes. Ante tareas de *role-playing* donde se sometía a los participantes a conflictos intergrupales había un aumento de la FC (Martínez-Tur et al., 2014; Ricarte, Salvador, Costa, Torres, & Subirats, 2001). Sin embargo, en situaciones intergrupales cobra gran importancia la interpretación que un participante tenga de sí mismo, de los miembros de su grupo y de los miembros del otro grupo. En este sentido, cuando una persona pertenece a una minoría (étnica, social, religiosa…) suele mostrar respuestas CV de amenaza y aumentos de C y ansiedad ante una interacción social con un miembro de una mayoría, en contraste el miembro de la mayoría suele mostrar una respuesta de reto (Gray, Mendes, & Denny-Brown, 2008; Mendes, Blascovich, Lickel, & Hunter, 2002; Page-Gould, Mendes, & Major, 2010; Sampasivam, Collins, Bielajew, & Clément, 2016; Sawyer, Major, Casad, Townsend, & Mendes, 2012). Respecto al patrón conductual, la percepción de amenaza en una muestra de hombres, después de un estresor social intergrupal, seguido de un aumento del C y ansiedad, es capaz de inducir patrones conductuales de "*Fight or Flight*" (Steinbeis, Engert, Linz, & Singer, 2015). De forma que parece ser que la percepción de estatus o dominancia durante la interacción social es una variable clave, para considerarla como más amenazante, independientemente del sexo o el tipo de interacción.

En este sentido, la T, hormona relacionada con el status social, también pueda estar respondiendo de forma distinta. Los estudios realizados con T han sido generalmente en contextos competitivos. Generalmente, se ha hipotetizado que la T será mayor en ganadores que en perdedores (Mazur, 1985), mostrando el denominado efecto del ganador el cual está asociado a un mayor estatus y dominancia (Mehta, Jones, & Josephs, 2008; Mehta & Josephs, 2006). Aunque se ha mostrado un efecto del ganador en deportes competitivos mayor que en estudios de laboratorio, así como un efecto de la competición en mujeres a través de un meta-análisis (Geniole, Bird, Ruddick, & Carré, 2017) las revisiones teóricas más recientes ponen de manifiesto resultados controvertidos en cuanto a este efecto del ganador (Carré & Olmstead, 2015; L. D. Hamilton, Carré, Mehta, Olmstead, & Whitaker, 2015). Hay estudios que ponen de manifiesto que los hombres que atribuyen que aportan a la victoria de su equipo frente a otro equipo, parecen tener mayores respuestas de T (Gonzalez-Bono, Salvador, Serrano, & Ricarte, 1999; Oxford, Ponzi, & Geary, 2010); sin embargo cuando compiten con los miembros de su propio equipo tener un mayor ranking disminuye su T (Oxford et al., 2010). En cuanto al sexo, se han encontrado diferencias entre hombres y mujeres en una competición grupal de remo, mostrando un descenso de T en mujeres durante la competición en comparación con los hombres (Kivlighan, Granger, & Booth, 2005), este efecto fue interpretado por la tendencia de las mujeres a formar equipo entre ellas previamente a la competición.

Por tanto, más que un efecto del ganador, la T parece estar influenciada por la situación social a la que van a enfrentarse los participantes regulando su conducta social. La T ha demostrado tener un efecto muy relevante en el altruismo localizado (*parochial altruism*); es decir, altos niveles de cooperación y altruismo con los miembros del *in-group* frente a altos niveles de competición y agresión frente al *out-group*. Algunos estudios han observado que los hombres con altos niveles de T muestran mayor favoritismo por el *in-group* y mayor hostilidad frente al *out-group* en tareas competitivas (Diekhof et al., 2014; Reimers and Diekhof, 2015). Estos datos muestran que los efectos de la T son consistentes con lo expuesto anteriormente, sobre los descensos de T cuando se interactúa con miembros del *in-group,* por ello quizá el descenso de T facilite las conductas de "*tend-and-befriend*". Según la *triple-imbalance hypothesis* (Terburg, Morgan, & van Honk, 2009) los descensos de T y aumentos de C impiden una agresión social directa y viceversa. Sin embargo, los aumentos en T propicien una respuesta de lucha, y los aumentos de C una respuesta de huida o *freezing*. En este sentido, se ha visto que hombres con mayores niveles basales de T y menores de C toman decisiones más dañinas en contra de un competidor (Mehta, Lawless DesJardins, van Vugt, & Josephs, 2017). Estos estudios van en consonancia con los resultados obtenidos en monos de cola roja, los cuales ante encuentros intergrupales tienen un aumento en su respuesta de C y una disminución en su respuesta de T (Jaeggi, Trumble, & Brown, 2018) independientemente del sexo.

Por tanto, menores niveles de T pueden propiciar conductas más afiliativas y asimismo más conservadoras. En relación a ello, la respuesta CV también se ha relacionado con las conductas afiliativas parece ser que altos niveles de HF se relacionan con altos niveles de cooperación (Beffara, Bret, Vermeulen, & Mermillod, 2016). Asimismo se ha demostrado que la sincronización de la HR en un grupo está implicada en procesos de creación confianza (Mitkidis, McGraw, Roepstorff, & Wallot, 2015); de hecho, la sincronización de la HF se ha relacionado con el favoritismo hacía los miembros de nuestro aunque sea un grupo creado por el paradigma del grupo mínimo (Sahdra, Ciarrochi, & Parker, 2015). El aumento de la HF además de la sincronización de la respuesta CV puede estar indicando un mayor control ejecutivo durante la interacción social con el fin de tomar decisiones que aumenten las conductas en pro del *in-group*.

En resumen, durante una interacción social un humano se puede preguntar a sí mismo, de forma consciente o no consciente cuestiones como ¿soy capaz de afrontar la situación?, ¿esta persona es amigo o enemigo?, ¿la situación es perjudicial para mí?, ¿cómo debo comportarme con ella?, ¿qué puede aportarme o qué puede quitarme?, ¿debo ser amable o debo ser asertivo? Estas cuestiones favorecen unos patrones de respuesta biológicos y emocionales que pueden guiar nuestras decisiones tanto durante como tras la interacción social (Figura 2). Las decisiones que se toman conllevan que los individuos sean más proclives a luchar, huir, crear lazos o paralizarse, y también dan lugar a una mayor sensibilidad o aversión a las recompensas/pérdidas. Finalmente, el resultado que se obtenga después de la interacción social dará información a la persona sobre la interacción social, su conducta y las decisiones que ha tomado, aumentando su experiencia para futuras ocasiones.

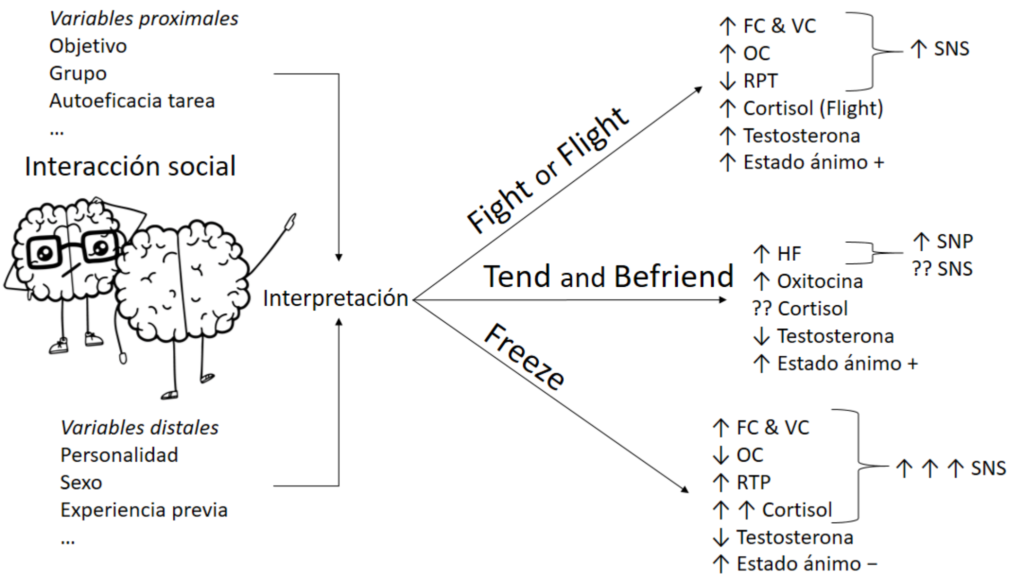


Figura 2: Esquema resumen de las respuestas fisiológicas, emocionales y conductuales durante las interacciones sociales, basado en los modelos y los resultados más recientes de la literatura previa.

2. La toma de decisiones:

Las conductas que se realizan durante una interacción social pueden dar lugar a distintos resultados que pueden afectar nuestra vida a corto y largo plazo. Como se ha explicado en apartados anteriores, las interacciones sociales pueden actuar como un estresor agudo con efectos en el comportamiento, tanto durante como después de dicha interacción social. Decidir entre un comportamiento u otro cobra gran importancia, ya que facilitará o dificultará la adaptación a la situación. La elección del comportamiento adecuado se realizará de forma consciente o inconsciente a través de un proceso de toma de decisiones.

La toma de decisiones es una función cognitiva compleja considerada como parte de las funciones ejecutivas, en la cual interaccionan procesos de aprendizaje, experiencia previa y sensibilidad a la retroalimentación (Bechara, 2004). Las funciones ejecutivas son funciones cognitivas superiores necesarias para mantener un objetivo mental especifico y llevar a cabo dicho objetivo evitando distractores (Funahashi, 2001). En este sentido las funciones ejecutivas son un término "paraguas" y de límites difusos que engloba diversos procesos como por ejemplo: la inhibición de respuestas, planificación, previsión, la alternancia de tareas o el mantenimiento y actualización de la memoria (Schmeichel & Tang, 2015) y que, dependiendo de la definición, incluye a la toma de decisiones. Concretamente, la toma de decisiones es una variable clave en los procesos de planificación y adaptación al medio. De hecho, una mayor capacidad de adaptación a la retroalimentación contextual se relaciona directamente con un mejor rendimiento en pruebas de toma de decisiones (Brand, Labudda, & Markowitsch, 2006).

Además, los procesos de toma de decisiones están afectados por el estado fisiológico y emocional del individuo, por lo que se ha investigado, por ejemplo, los efectos de los cambios emocionales y fisiológicos inducidos por estresores sociales agudos en la posterior toma de decisiones (Porcelli & Delgado, 2017; Starcke & Brand, 2012, 2016), como se detallará en apartados posteriores. Por tanto, para tomar una decisión se recaba información externa, del entorno social, e interna, del estado del organismo, las emociones y el procesamiento cognitivo de la situación, con la finalidad de dar una respuesta apropiada y adaptativa. Pero para entender cómo la toma de decisiones es un proceso que nos permite adaptarnos a entornos cambiantes y estresantes primero debemos conocer las variables implicadas en el proceso de toma de decisiones, que se detallarán en el próximo apartado.

2.1 Los procesos de toma de decisiones

Las variables más relevantes estudiadas para explicar el proceso de toma de decisiones se agrupan en varios continuos que permiten explicar cómo se toma la decisión: desde la incertidumbre a la certidumbre (en este continuo se ha diferenciado entre la ambigüedad y el riesgo) y desde una decisión intuitiva a una racional. A continuación, se explicarán dichos procesos y sus bases biológicas.

Generalmente, las decisiones se toman con cierto nivel de incertidumbre, es decir, elegir una opción no necesariamente asegura el resultado esperado. Por tanto, es importante tener en cuenta cómo es el contexto de dicha toma de decisiones: ¿hay dos o más opciones para elegir?, ¿se conocen las posibilidades de obtener un resultado concreto en función de lo que se escoja?, ¿tengo realmente claras las opciones que puedo elegir?... El contexto en el cual se toma una decisión lo definen, en primer lugar, la información explícita del entorno que actúa como input para el tomador de decisión y, en segundo lugar, el grado de incertidumbre en el que se toman dichas decisiones.

El grado de incertidumbre del contexto decisional puede situarse en un continuo el cual va desde la completa ignorancia hasta la total certeza, dependiendo del conocimiento sobre las opciones posibles y las probabilidades de obtener un resultado u otro en función de la elección, es decir, del conocimiento de las "reglas de juego". En medio de este continuo se encuentran los contextos decisionales más comunes en las interacciones sociales diarias: la incertidumbre de ambigüedad y la incertidumbre de riesgo (Volz & Gigerenzer, 2012). Por un lado, en la incertidumbre de ambigüedad se conocen algunas opciones, pero no las posibles consecuencias de escoger una opción, o las posibilidades de obtener una consecuencia u otra en función de la elección. Por otro lado, la incertidumbre de riesgo se encuentra más cercana a la certeza, ya que el individuo conoce las posibles opciones y, además, las consecuencias, por lo que puede estimar las probabilidades de lograr un resultado u otro en función de la elección (Brand et al., 2006; Weber & Johnson, 2009). Debido a las diferencias en el contexto, los procesos de toma de decisiones serán distintos en función de si el contexto es de ambigüedad o de riesgo; ante la ambigüedad se suele utilizar la retroalimentación obtenida por experiencia previa o se suele decidir mediante heurísticos (Bechara & Damasio, 2005; Volz & Gigerenzer, 2012), mientras que ante el riesgo se aplica un procesamiento más estadístico basado en el cálculo de probabilidades (Keeney & Raiffa, 1976).

Las características del contexto decisional serán analizadas e integradas de forma paralela, por dos procesos distintos, los procesos intuitivos y los procesos reflexivos o racionales (Schiebener & Brand, 2015). Los procesos intuitivos se caracterizan por guiarse por las emociones y las "corazonadas" o "intuiciones", se guían por la sensación de riesgo, la sensibilidad a las recompensas o la aversión al castigo, entre otras. El procesamiento intuitivo, se basa en la teoría del marcador somático (Damasio, Everitt, & Bishop, 1996), la cual afirma que la retroalimentación, en forma de recompensa o castigo tras una decisión, provoca una respuesta emocional y fisiológica convirtiéndose en un marcador somático. Así, cuando se reexperimentan situaciones parecidas se activa el marcador somático guiando nuestras decisiones. Sin embargo, el procesamiento reflexivo es guiado por las funciones ejecutivas, la memoria de trabajo y el razonamiento. En este caso se procesa la información de forma racional y se elaboran estrategias decisionales en función del conocimiento que tiene el individuo sobre la decisión (probabilidades, información…), en este caso se utiliza un razonamiento bayesiano, como si se tratara de un razonamiento basado en cálculos probabilísticos(Schiebener et al., 2014).

En la base de ambos procesos encontramos estructuras cerebrales diferentes. Por un lado, los procesos intuitivos están mediados por la amígdala, el estriado ventral y la corteza orbitofrontal, mientras que los procesos reflexivos están mediados por la corteza prefrontal dorsolateral, el cingulado anterior y el lóbulo parietal posterior (Schiebener & Brand, 2015). El hecho que dichos procesos estén regulados por estructuras distintas cobra gran importancia, puesto que los productos biológicos endógenos liberados, como el C o la T, en función de las circunstancias del entorno, o de los estados internos del individuo, afectarán solamente a aquellas estructuras con receptores para ellos.

Aunque ambos procesos actúen de forma paralela, generalmente uno de los dos procesos lidera el procesamiento de la información por encima del otro (Schiebener & Brand, 2015). Asimismo, la toma de decisiones bajo condiciones de ambigüedad o riesgo interactúan durante el desarrollo de toma de decisiones y la vía de procesamiento (intuitivo *vs.* reflexivo) puede intercambiarse en función de las circunstancias. Al final se habrán valorado las opciones del contexto decisional activando ambos procesos (uno como principal) y se tomará una decisión, la cual conllevará unas consecuencias. Dichas consecuencias, por mecanismos de retroalimentación serán posteriormente analizadas para continuar con el proceso de toma de decisiones y/o para afrontar futuras decisiones. Si el proceso de toma de decisiones continua, la retroalimentación podrá indicar cuál de los dos procesos de evaluación de la información es el más adecuado en ese momento. En este sentido, un refuerzo después de una decisión arriesgada aumenta el procesamiento por la vía intuitiva, mientras que el castigo aumenta el procesamiento por la vía reflexiva (Figner, Mackinlay, Wilkening, & Weber, 2009). Finalmente, cuando se toman decisiones similares durante un tiempo, basándose en la retroalimentación de decisiones previas y en las características de la persona, se desarrollan estrategias decisionales a largo plazo (West & Stanovich, 2003).

En definitiva, la literatura ha dedicado mucha investigación en el proceso de toma de decisiones, ya que pueden tener efectos beneficiosos o perjudiciales para el individuo, a corto y a largo plazo. A continuación, se explicará una de las tareas más ampliamente utilizadas en la medida neuropsicológica de los procesos de toma de decisiones, el Iowa Gabling Task (IGT: Bechara, Damasio, Damasio, & Anderson, 1994)

Tabla 2: Resumen de las tareas más utilizadas para evaluar toma de decisiones de riesgo y toma de decisiones sociales:

Tarea	Incertidumbre	Reglas de la tarea	Ensayos	Elección
Tareas Neuropsicológicas Individuales de Toma de Decisiones				
Columbia Card Task (CCT) Finger et al. (2009)	Riesgo	Se presentan 32 cartas de las cuales 1, 2 o 3 serán grandes pérdidas (250, 500 o 750 €) frente al resto que son pequeñas ganancias (10, 20 o 30 €). Los participantes deben levantar las cartas 1 a 1 y pueden parar en cualquier momento y recoger el dinero acumulado, pero si sacan una carta de pérdidas se le sustrae ese dinero y no puede continuar. Hay dos versiones: Hot, los jugadores reciben feedback cada vez que levantan una carta. Cold, los jugadores deciden el número de cartas que quieren levantar sin recibir feedback inmediato	54	1. Levantar o parar y recoger el dinero 2. Carta que se levanta
Cambridge gambling task (CGT) Rogers et al. (1998a, b)	Riesgo	Se presentan 10 cajas con dos colores rojo o azul, con una ratio variada de cajas azules y rojas (5:5, 4:6, 3:7, 2:8 o 1:9). Al azar 1 caja ocultará una ficha. El participante debe elegir el color donde cree que estará la ficha. Después debe elegir cuánto dinero apuesta.	–	1. Cajas rojas *vs* Cajas azules 2. Cantidad de dinero apostada
Game of Dice Task (GDT) Brand et al. (2005)	Riesgo	El participante debe adivinar qué número saldrá en un dado de 6 caras, si acierta le cierta cantidad de dinero y si falla se lo quitan dinero. Deberá elegir entre 14 opciones por cuantos números quiere y a que números quiere apostar, 1 número (1000 €), 2 números (500 €), 3 números (200 €), 4 números (100 €).	18	14 opciones de números: 1 número (1, 2, 3, 4, 5 o 6) 2 números (1:2, 3:4 o 5:6) 3 números (1:2:3 o 4:5:6) 4 números (1:2:3:4, 2:3:4:5 o 3:4:5:6)
Cups Task Levin & Hart (2003)	Riesgo	El participante elige entre dos conjuntos de 2,3 o 5 cubiletes de los cuales uno se abrirá al azar. Un set de cubiletes otorga o quita siempre 25 céntimos mientras que en el otro set solo uno de los cubiletes otorga 2, 3 o 5 veces más dinero. La mitad de los ensayos otorgan dinero y la mitad quitan.	54	Set de cubilete seguro *vs* Set de cubilete arriesgado
Probability-Associated Gambling Task Sinz et al. (2008); Delazer et al. (2007)	Riesgo	Los participantes deben escoger entre una suma de dinero fija (20 €) o una lotería para ganar 100 €. Después se meten 24 cubos rojos o azules en una urna con una de estas 4 ratios (3:21, 9:15, 15:9 o 21:3), si se saca un cubo rojo el participante gana 100 € si se saca azul el participante pierde 100 €	40	Suma fija *vs* Lotería
Balloon Analogue Risk Task (BART) Lejuez et al. (2002)	Ambigüedad	La tarea consiste en inflar un globo que explotará al azar en algún momento. Cada vez que se le bombea aire se ganan 5 céntimos. Se puede parar en cualquier momento y acumular lo ganado. Si el globo explota no se gana nada. Hay 3 tipos de globo, azul, amarillo y naranja, que normalmente exploraran antes o después, según el color.	90	Seguir inflando *vs* Parar de inflar
Iowa Gambling Task (IGT) Bechara et al. (1994)	Ambigüedad y riesgo	La tarea consiste en elegir entre 4 barajas de cartas. Todas las barajas otorgan ganancias, 2 barajas grandes ganancias (A y B) y dos barajas pequeñas ganancias (C y D). Pero cada cierto número de ensayos las barajas dan perdidas, en el cómputo total las barajas A y B dan más pérdidas siendo barajas de pérdidas a largo plazo, mientras que el cómputo de las barajas C y D es de ganancias a largo plazo.	100	Elegir entre 1 de las 4 barajas

Tarea	Reglas de la tarea	Variable objetivo
Tareas sociales de toma de decisiones		
Trust Game (TG) Berg et al. (1995)	Un jugador es el inversor y el otro es el administrador. El inversor debe decidir cuánto dinero le da al administrador de un fondo. Ese dinero se multiplica por un factor azaroso y le llega al administrador que debe decidir cuánto dinero le devuelve al inversor.	Confianza y reciprocidad
Prisoner´s Dilemma (PD) Rapoport & Chammah (1965)	Este juego es similar al TG, sin embargo en el PD los jugadores deben tomar sus decisiones sin conocer las decisiones del otro jugador.	Cooperación
Ultimatum Game (UG) Güth et al. (1982)	En el UG hay dos jugadores el proponente y el respondiente. El proponente debe dividir una suma de dinero entre los dos. El respondiente debe aceptar o rechazar la suma de dinero. Si la rechaza ningún jugador obtiene dinero.	Justicia / Equidad *vs* Egoísmo
Dictator Game (DG) Kahneman et al. (1986)	Es una versión del UG donde solo actúa el proponente y el respondiente no puede decidir, es pasivo. Por tanto cada uno ganará lo que decida el proponente.	Altruismo
Hawk-Dove Game Maynard-Smith (1982)	Los jugadores deben elegir entre una opción A (Dove) y una opción B (Hawk) que tendrán consecuencias monetarias para ambos. Si ambos escogen A se llevan la misma cantidad de dinero, si ambos escogen B ambos se llevan 0. Si uno escoge A y el otro B, el que escoge B se lleva 4 veces más dinero que el que escoge A.	Status y dominancia

2.1.1 El Iowa Gambling Task (IGT):

Debido a la importancia de discernir entre los dos tipos de incertidumbre en los procesos de toma de decisiones, se han desarrollado diversas tareas que evalúan la toma de decisiones en sus distintos niveles de incertidumbre (Tabla 2). Concretamente una de estas tareas, el *Iowa Gambling Task* (IGT: Bechara, Damasio, Damasio, & Anderson, 1994), ha sido ampliamente utilizada en investigación básica y clínica (Chiu, Huang, Duann, & Lin, 2018). El IGT es un test neuropsicológico que consiste en la presentación de 4 mazos de cartas boca abajo, dándole la instrucción al participante que debe ir cogiendo cartas durante 100 ensayos con el objetivo de conseguir el máximo dinero posible. El juego se inicia con un saldo de 2000 euros. Cada mazo contiene 40 cartas y, proporciona distintas ganancias o pérdidas, dando retroalimentación al participante después de cada elección (modificándose cantidad de dinero ganado o perdido). Los mazos A y B son mazos que proporcionan grandes ganancias a corto plazo pero mayores pérdidas, dando lugar a pérdidas a largo plazo (siendo desfavorables), mientras que los mazos C y D proporcionan pequeñas ganancias y menores perdidas a largo plazo, proporcionando ganancias a largo plazo, siendo mazos favorables (Tabla 3 para un resumen de los mazos). Asimismo, cada 10 elecciones, en los mazos A y C 5 cartas contienen pérdidas mientras que en los mazos B y D es solo 1. La tarea se puntúa mediante el índice *gambling* (IG) que equivale a la formula (A + B) – (C + D); valores positivos indican que se tomaron decisiones conservadoras y los valores negativos que se han asumido muchos riesgos y, por tanto, se ha perdido dinero.

Tabla 3: Resumen de los mazos del *Iowa Gambling Task*

	A		B		C		D	
Trial	Gain	Loss	Gain	Loss	Gain	Loss	Gain	Loss
1	100	0	100	0	50	0	50	0
2	100	0	100	0	50	0	50	0
3	100	−150	100	0	50	−50	50	0
4	100	0	100	0	50	0	50	0
5	100	−300	100	0	50	−50	50	0
6	100	0	100	0	50	0	50	0
7	100	−200	100	0	50	−50	50	0
8	100	0	100	0	50	0	50	0
9	100	−250	100	−1250	50	−50	50	−250
10	100	−350	100	0	50	−50	50	0
Dinero total	−250		−250		+ 250		+ 250	
% Pérdidas	50 %		10 %		50 %		10 %	

Cuando se aplica esta tarea los participantes no tienen ninguna pista de los resultados al elegir entre una u otra baraja, por ello se ha considerado que el contexto decisional es de ambigüedad (Bechara et al., 1994). Sin embargo, la retroalimentación que proporciona la tarea durante los 100 ensayos promueve que los participantes puedan aprender, en los primeros ensayos, cuáles son los mejores mazos (Maia & McClelland, 2004). Así, la incertidumbre de la tarea pasa a ser de riesgo a partir del ensayo 41, dado que se ha podido aprender la probabilidad de futuras ganancias o pérdidas con la retroalimentación de los primeros 40 ensayos (Bechara, Damasio, Tranel, & Damasio, 2005; Buelow, Okdie, & Blaine, 2013). Esta característica del IGT es muy interesante, puesto que, permite mostrar qué sucede en los dos niveles de incertidumbre, y por tanto se puede observar cómo el participante se adapta a la retroalimentación que recibe como podría suceder en situaciones de la vida real. Aunque otras tareas con incertidumbre de ambigüedad, como el *Balloon Analogue Risk Task* (BART: Lejuez et al., 2002) proporcionen retroalimentación a lo largo del desarrollo de la tarea, su simplicidad (solo dos opciones: hinchar el globo o recoger el dinero) y aleatoriedad no permiten un aprendizaje correcto de las reglas de la tarea. Por ello, el IGT es una de las tareas más utilizadas para evaluar la toma de decisiones, puesto que recoge ambos niveles de incertidumbre (ambigüedad y riesgo), ambos procesamientos de información (intuitivo y racional) y los procesos de aprendizaje y adaptación al ambiente similares a situaciones de la vida diaria.

2.2 Efecto de las interacciones sociales en la toma de decisiones

Todo el proceso de toma de decisiones, explicado en el apartado anterior, puede verse alterado por el estado en el que se encuentre el individuo, el contexto en el cual se están tomando las decisiones y los factores individuales de una persona como por ejemplo la predisposición del individuo por uno de los procesamientos (Schiebener & Brand, 2015). En este sentido, los estresores agudos, incluidos los sociales, han demostrado tener una gran influencia en la toma de decisiones, alterando el procesamiento de retroalimentación, el aprendizaje o la evaluación de riesgos (Mather & Lighthall, 2012; Porcelli & Delgado, 2017; Starcke & Brand, 2012).

Es posible que la influencia del estrés sobre la toma de decisiones sea debida al cambio que induce en el estado de ánimo. La hipótesis del marcador somático (Damasio et al., 1996) pone de manifiesto la importancia del procesamiento emocional en la toma de decisiones (Lerner, Li, Valdesolo, & Kassam, 2015). Estudios previos han demostrado que cambiar el estado emocional de una persona afecta a su toma de decisiones posterior (Buelow, Okdie, & Blaine, 2013; Matthews, Panganiban, & Hudlicka, 2011; de Vries, Holland, Corneille, Rondeel, & Witteman, 2012). Las decisiones más arriesgadas se toman cuando el individuo siente emociones asociadas a baja incertidumbre como la felicidad o el enfado, mientras que las emociones asociadas a alta incertidumbre, como el miedo, inducen decisiones más conservadoras (Bagneux, Bollon, & Dantzer, 2012; Lerner & Keltner, 2001). Además, el estado de ánimo positivo se ha relacionado con una preferencia de opciones más arriesgadas y el negativo con más conservadoras (de Vries, Holland, & Witteman, 2008a; Heilman, Crișan, Houser, Miclea, & Miu, 2010; de Vries, Holland, & Witteman, 2008b).

La influencia del estrés en las emociones y el procesamiento cognitivo de las diversas opciones durante la toma de decisiones se debe, en parte, al efecto de las substancias neuroendocrinas liberadas durante la respuesta de estrés, que pueden afectar a los principales centros de control de la toma de decisiones, la corteza prefrontal y el sistema límbico (Porcelli et al., 2008; Pruessner et al., 2008; Starcke & Brand, 2012). De hecho, la respuesta de C después de un estresor ha demostrado aumentar las conductas arriesgadas (Starcke, Wolf, Markowitsch, & Brand, 2008) así como la administración exógena de C (Kluen, Agorastos, Wiedemann, & Schwabe, 2017; Putman, Antypa, Crysovergi, & Van Der Does, 2010). Sin embargo, un reciente meta-análisis (Starcke & Brand, 2016) muestra que el estrés también puede ejercer efectos en la toma de decisiones independientemente del C. Aunque el C suele estar relacionado con el miedo y la inhibición de la conducta (Roelofs et al., 2009); por tanto hay una inconsistencia en lo referente al C, puesto que, como se ha explicado con anterioridad, los aumentos de C después de un estresor favorecen las conductas arriesgadas.

Ahora bien, la respuesta de estrés, sobre todo ante interacciones sociales, es una respuesta integrada que implica otros sistemas endocrinos, neuronales y psicológicos los cuales pueden influir en la toma de decisiones. Concretamente, la T es otra hormona con capacidad para influir en la toma de decisiones posteriores a un estresor social, ya que es una hormona que muy arraigada a conductas de dominancia, status y agresividad (Eisenegger et al., 2011; Salvador, 2012). En este sentido la T está relacionada con conductas de aproximación a los objetivos (Op De MacKs et al., 2011). Es por ello que los incrementos de T suelen favorecer decisiones arriesgadas, (para una revisión, ver Apicella, Carré, & Dreber, 2015), no obstante, existen algunas inconsistencias en la literatura, que podrían explicarse por la acción conjunta de la T y el C.

Por ejemplo, un estudio reciente ha mostrado que cuando se analizan por separado los cambios en T y C provocados por un estresor social, no predicen las conductas arriesgadas tras el mismo (Smith & Apicella, 2016). Sin embargo, otro estudio mostró que la administración exógena de T y C predecía decisiones financieras arriesgadas (Cueva et al., 2015). Es posible que se puedan aclarar dichas inconsistencias analizando las dos hormonas conjuntamente, como se ha propuesto desde la *dual-hormone hypothesis* (Mehta & Josephs, 2010). Según esta hipótesis, la T basal es una hormona implicada en conductas de acercamiento y dominancia, induciendo decisiones más arriesgadas, mientras que el C basal está implicado en conductas de evitación y en la inducción de miedo, induciendo decisiones más conservadoras. Por ello, altos niveles de T basal predicen un aumento en las conductas de riesgo, pero sólo cuando además hay a bajos niveles de C basal (Barel, Shahrabani, & Tzischinsky, 2017; Mehta, Welker, Zilioli, & Carre, 2015). Este patrón de respuesta hormonal es capaz de predecir mayor agresividad, un aumento del status social, una disminución de la empatía, mayores niveles de dominancia y la tendencia a competir de nuevo después de una derrota (ver, Mehta & Prasad, 2015, para una revisión). Todas estas relaciones muestran un papel importante de ambas hormonas en lo que se refiere a la toma de decisiones sociales y la conducta asociada a estas decisiones.

Sin embargo, esta hipótesis analiza los niveles basales, sin tener en cuenta los cambios endocrinos debidos a un estresor social. Posteriormente, el mismo grupo de investigación, estudió si los cambios en T y C tras una negociación competitiva influían en decisiones de tipo económico. Encontraron que los participantes con mayores cambios en T y menor C después de la negociación predecían ganancias más elevadas, maximizando la recompensa económica, mientras que los participantes con altos cambios tanto en T como en C predecían conductas de negociación con alta preocupación sobre las consecuencias sociales, y menores ganancias (Mehta, Mor, Yap, & Prasad, 2015).

Como se ha indicado anteriormente, hay variables que pueden modular la interpretación de la situación social, dando lugar a diferentes respuestas emocionales y biológicas y, por tanto, induciendo patrones conductuales distintos. Las decisiones que tomamos durante las interacciones sociales también pueden verse afectadas por estas variables, como pueden ser el sexo, la personalidad, la impulsividad o el auto-control (Schiebener & Brand, 2015). De ellas, una de las más importantes es el sexo, habiéndose descrito diferencias entre hombres y mujeres, por ejemplo, en los resultados del IGT (ver, van den Bos, Homberg, & de Visser, 2013 para una revisión).

2.2.1 Diferencias de sexo en la toma de decisiones

Hombres y mujeres adquieren información del entorno de forma distinta; los hombres adquieren información más global mientras que las mujeres adquieren información más detallada (Graham, Myers, & Stendardi, 2010). Estas diferencias en la adquisición de información se manifiestan en los patrones de respuesta en el IGT, donde los hombres tienden a elegir las barajas más ventajosas en los últimos 60 ensayos, en comparación con las mujeres (R. van den Bos et al., 2013). Parece ser que las mujeres son más sensibles a las pérdidas, lo que les hace cambiar de baraja más fácilmente, frente a los hombres que son más resistentes a dichas perdidas y mantienen la estrategia a largo plazo para maximizar las ganancias. Por lo visto, estas diferencias se reflejan también en diferencias de activación cerebral a nivel de corteza prefrontal y orbitofrontal, durante la aplicación del IGT. Es posible que sea debido a diferencias estructurales en la corteza cerebral, producto de los efectos organizacionales de las hormonas sexuales durante los primeros años de vida (Clark & Goldman-Rakic, 1989; Wilson, Westberry, & Trout, 2011). Asimismo, los efectos organizadores y activadores de las hormonas sexuales favorecen el desarrollo de otras estructuras, dando lugar a las diferencias sexuales en los ejes y en los niveles hormonales basales de ciertas hormonas (Williams & Meck, 1991), en las respuestas hormonales ante estresores sociales y en la sensibilidad de las regiones cerebrales a dichas hormonas (R. van den Bos et al., 2013).

Además de la corteza prefrontal, Mather & Lighthall (2012) hipotetizan que el estrés, incluido el estrés social, amplifica las diferencias de sexo en la toma de decisiones, debido a que altera la activación de la ínsula y el putamen de forma distinta en hombres y mujeres (Balleine, Delgado, & Hikosaka, 2007; Clark et al., 2008; O'Doherty et al., 2003; Weller, Levin, Shiv, & Bechara, 2009), estructuras importantes en la predicción, la integración y la valoración de la retroalimentación, así como en el inicio de conductas habituales. Todas estas diferencias de activación dan lugar a distintas formas de decidir ante una interacción social.

En este sentido, la relación positiva entre C y conductas de riesgo, explicada en el apartado anterior, aparece consistentemente en hombres; sin embargo, es más inconsistente en las mujeres (Lighthall et al., 2012; Lighthall, Mather, & Gorlick, 2009; R. van den Bos, Harteveld, & Stoop, 2009). Para complicar más el panorama un meta-análisis reciente afirma que el sexo no tiene importancia en esta relación (Starcke & Brand, 2016). Asimismo, otra hormona involucrada en las decisiones arriesgadas, la T, tiene niveles más elevados en hombres que en mujeres (Barel et al., 2017), de forma que es posible que las diferencias en la toma de decisiones arriesgadas entre hombres y mujeres ante circunstancias estresantes, sean debidos a los niveles diferenciales de base en la T y en su respuesta. Y a su vez, cabe la posibilidad que hombres y mujeres tengan distintos patrones de respuestas biológicas y conductuales ante una interacción social determinada (Taylor, 2006).

Desde una perspectiva evolutiva, hombres y mujeres invierten su tiempo en objetivos vitales distintos y por tanto la evolución habrá favorecido el desarrollo de estrategias conductuales distintas (Troisi, 2001, 2018). Los hombres suelen tener metas relacionadas con una mayor logro de status frente a las mujeres, que invierten más tiempo en el desarrollo de redes sociales (Ellis, 2011). A raíz de esto, ambos podrían haber desarrollado características que les ayuden a la consecución de sus objetivos como pueden ser características más egocéntricas en los hombres (se caracterizan por ser más dominantes, asertivos y competitivos en comparación con las mujeres) y características más sociables en las mujeres (se caracterizan por ser más amigables, cálidas y amables en comparación con los hombres) (Wood & Eagly, 2012). Concretamente, las mujeres tienen una mayor tendencia a realizar estas conductas de "protección y apego" que los hombres, lo cual sería congruente con desarrollar conductas más conservadoras (Tamres, Janicki, & Helgeson, 2002). Asimismo, desde esta perspectiva, ambos podrían percibir mayor nivel de amenaza en cuanto una situación pueda afectar a sus objetivos vitales más relacionados con su rol sexual (Troisi, 2018), de ahí la importancia del contexto social para conocer las respuestas biológicas y conductuales diferentes que pueden dar hombres y mujeres.

2.3 La toma de decisiones como un factor de afrontamiento ante las interacciones sociales

En el punto anterior se ha descrito cómo las respuestas biológicas ante las interacciones sociales están moduladas por la percepción de la situación, y cómo pueden afectar a la toma de decisiones. En este sentido, desde la neurociencia se ha descrito que los procesos cognitivos superiores (atención, memoria, aprendizaje, entre otros) modulan la percepción que tenemos del entorno. Es bien conocido, desde los estudios de Damasio et al. (1994), el papel del lóbulo frontal en la evaluación e interpretación emocional de la situaciones. Los procesos cognitivos superiores recogen e integran la información que proviene del ambiente para dar una respuesta lo más adaptativa posible a dichas situaciones sociales estresantes (Schmeichel & Tang, 2015). Por todo esto, estos sistemas autorregulan el nivel de activación fisiológica adecuado al contexto y esto en parte depende de la experiencia pasada de una persona y sus diferencias individuales en funciones ejecutivas y, en concreto, de la toma de decisiones (Thayer, Hansen, Saus-Rose, & Johnsen, 2009).

El modelo de la integración neurovisceral propone que la respuesta de los sistemas fisiológicos controlados por el nervio vago están relacionadas con las estructuras cerebrales superiores del CAN, explicadas en el apartado 1.2.4, donde el lóbulo frontal tiene un papel fundamental en la autorregulación ante los estresores (Thayer et al., 2012). De hecho, mayor actividad en la banda HF de la HRV se relaciona directamente con una activación neuronal óptima para realizar conductas más flexibles ante entornos cambiantes (Sylvain Laborde et al., 2014). Es por ello que los procesos cognitivos controlado, en última instancia, por el CAN están implicados también en la interpretación y adaptación de una interacción social, y ejercen una función de autorregulación emocional y fisiológica que se relacionan directamente con un aumento de la HRV (Lane et al., 2009; Thayer et al., 2009). En este sentido, un mejor funcionamiento de los procesos cognitivos superiores, supone también una respuesta fisiológica más adaptativa y flexible que ayuda a afrontar mejor las interacciones sociales (ver, Williams et al., 2009 para una revisión).

De entre los procesos cognitivos superiores, la toma de decisiones podría jugar un papel esencial en la autorregulación emocional y fisiológica en entornos cambiantes. Un estudio relacionó un mejor rendimiento en toma de decisiones medido con el IGT, con una respuesta fisiológica más saludable ante un estresor social ampliamente utilizado, el *Trier Social Stress Task* (TSST: Kirschbaum, Pirke, & Hellhammer, 1993). Los autores dividieron a los participantes en buenos o malos tomadores de decisiones y demostraron que los buenos tomadores de decisiones tenían una respuesta de C menor al exponerse al TSST, demostrando que unas competencias adecuadas en la toma de decisiones puede ayudar en el afrontamiento de un estresor social. Al ser un constructo cognitivo muy relacionado con la adaptación al medio cambiante, la mejor capacidad en toma de decisiones pueda favorecer las respuestas conductuales y fisiológicas más adaptativas en entornos cambiantes. En relación a ello, se ha demostrado que una mayor capacidad de adaptación a la retroalimentación contextual se relaciona directamente con un mejor rendimiento en pruebas de toma de decisiones (Brand et al., 2006).

Tanto los procesos cognitivos superiores como los niveles basales de HRV son variables endofenotípicas (Thayer & Lane, 2009). Un endofenotipo es una característica heredable, independiente de la situación y asociada con enfermedades, además los miembros de una familia tienen mayor probabilidad de tener, las mismas características endofenotípicas, con sus enfermedades asociadas, que la población general (Gottesman & Gould, 2003; Gould & Gottesman, 2006). Es decir, las diferencias individuales heredables, tanto en funciones ejecutivas como en HRV pueden influir en el patrón de afrontamiento. En este sentido, se ha descrito que disfunciones en funciones ejecutivas estaban relacionadas con menor incremento de HR durante un estresor y una recuperación más lenta a los niveles basales (Lin, Heffner, Mapstone, Chen, & Porsteisson, 2014; Roiland, Lin, Phelan, & Chapman, 2015). Aunque, no debemos olvidar que, pese a ser características heredables, tanto los procesos cognitivos superiores como la HRV en condición de reposo pueden verse afectados por los hábitos de vida: como fumar o beber alcohol (Luhar, Sawyer, Gravitz, Ruiz, & Oscar-Berman, 2013; Shahrestani, Stewart, Quintana, Hickie, & Guastella, 2015; Sjoberg & Saint, 2011), hacer ejercicio físico (Barha, Davis, Falck, Nagamatsu, & Liu-Ambrose, 2017; Stanley, Peake, & Buchheit, 2013) o la dieta y el peso (Veronese et al., 2017; Yi, Lee, Shin, Kim, & Kim, 2013).

Tanto la toma de decisiones como la HRV basal son variables relativamente estables que pueden favorecer la regulación comportamental para lograr un afrontamiento más adaptativo a situaciones de estrés social, como las interacciones sociales. Aparte de los instrumentos neuropsicológicos como el IGT o el BART, se están desarrollando otros instrumentos para evaluar aspectos relacionados con los hábitos en la toma de decisiones. En este sentido, para medir las competencias en toma de decisiones, definidas como la capacidad de tomar buenas decisiones desde un punto de vista racional, se ha creado la *Adult - Decision Making Competence* scale (A-DMC: De Bruin, Parker, & Fischhoff, 2007); para evaluar la capacidad de obtener resultados satisfactorios después de la toma de decisiones, se ha diseñado la *Decision Outcome Inventory* (DOI: De Bruin et al., 2007). Para evaluar la aproximación a la toma de decisiones, se ha desarrollado el *Flinders Decision Making Questionnaire* (Mann, Burnett, Radford, & Ford, 1997). Finalmente, para evaluar los estilos de toma de decisiones o, de otro modo, las respuestas habituales ante situaciones de toma de decisiones se han creado el *Decision Styles Scale* (DSS: K. Hamilton, Shih, & Mohammed, 2016) o el *General decision making style* (GDMS: Scott & Bruce, 1995).

Los estilos de toma de decisiones están relacionados con la autorregulación y el autocontrol (Baiocco, Laghi, & D'Alessio, 2009; Scott & Bruce, 1995), con los estilos de afrontamiento en la gestión de conflictos (Loo, 2000) y con la gestión del estrés y variables generales de salud mental (Bavolar & Orosova, 2015). Además, los estilos de toma de decisiones han demostrado ser factores moduladores de la respuesta de C ante un estresor, mostrando ser factores de vulnerabilidad/resiliencia ante los estresores (Thunholm, 2008). Los estilos decisionales están estrechamente relacionados con las competencias en toma de decisiones (Bavolar & Orosova, 2015) y, junto a variables de personalidad, parecen predecir dichas competencias (Dewberry, Juanchich, & Narendran, 2013). Estos hechos muestran la estrecha relación entre las variables de personalidad, la forma en la que tomamos las decisiones, la competencia en la toma de decisiones y los sistemas de autorregulación cognitivos, emocionales y fisiológicos como factores que se interrelacionan para dar las respuestas fisiológicas y conductuales necesarias para afrontar las interacciones sociales.

En definitiva, el estilo y la competencia de una persona a la hora de tomar decisiones tendrán consecuencias directas en su vida. Los estilos en toma de decisiones pueden predecir decisiones importantes que tendrán consecuencias a largo plazo en su futuro, como por ejemplo la elección de un colegio mayor (Galotti et al., 2006) o una futura carrera profesional (Gati, Landman, Davidovitch, Asulin-Peretz, & Gadassi, 2010; Singh & Greenhaus, 2004). A su vez, las personas propensas a tomar decisiones arriesgadas pueden realizar conductas potencialmente dañinas para ellos mismos (Steinberg, 2008) e.g. consumo de drogas (Castellanos-Ryan, Parent, Vitaro, Tremblay, & Seguin, 2013; Gowin, Sloan, Ramchandani, Paulus, & Lane, 2018), toma de riesgos financieras (J. Coates & Gurnell, 2017) o la falta de adherencias a tratamientos médicos (Bender, 2006). Además, se ha demostrado que algunos trastornos mentales cursan con un déficit en la toma de decisiones como el trastorno bipolar (Yechiam, Hayden, Bodkins, O'Donnell, & Hetrick, 2008), el abuso de drogas (Stout, Busemeyer, Lin, Grant, & Bonson, 2004) o los trastornos alimentarios (Chan et al., 2013). De hecho, estos déficits en toma de decisiones también están implicados en la conducta suicida (Jollant et al., 2007; Jollant, Lawrence, Olié, Guillaume, & Courtet, 2011; Richard-Devantoy, Berlim, & Jollant, 2014; Richard-Devantoy et al., 2013), pudiendo llegar a predecir esta decisión de vida o muerte.

Chapter 2:

General Aims and Hypothesis

General Aims and Hypothesis:

As it has been revised in the previous section, humans are usually involved in complex social interactions that provide both positive and negative consequences, depending on the context. These interactions have different implications depending on the type of interaction (group or individual) with different psychobiological implications. In this sense, the way people appraise these interactions modulate the psychological and physiological response. Furthermore, this appraisal is modulated, at the same time, by experience and trait (or more stable) variables, such as decision-making style. In this regard, decision-making processes in social interactions can guide behavior. In a specific context, physiological and emotional responses can influence subsequent decision-making in order to behave a priori, adaptively, though not necessarily. For that reason, it is worth noting consider situational variables (i.e. the interaction objective, whether it is an interpersonal or intergroup interaction) involving social interactions.

Taking into account all these topics, this doctoral thesis is focused on two aspects of social interactions. First, considering the scarce literature about psychobiology of group conflict, the first main aim is to study the psychobiological response to a group conflict to understand the complexity of group processes in the biology during a conflict. Second, we are interested in decision-making as a variable that influences social interactions. Our general aim was to analyze how decision-making modulates the psychobiological response to social interactions and its relation to better task outcomes. In the latter case, taking into account that decision-making is an individual process, we have chosen to study decision-making in face-to-face competition, a context similar to conflict, but that allows higher control during the interaction (just two people) and to study decision-making individually, without group influence. Both objectives will be studied considering differences between sexes.

These two main aims have been divided into five specific aims; these aims were accomplished in five different studies that compose the following chapters. Each chapter provided a more complete version of aims and hypothesis based on the relevant literature. Here an excerpt of these aims and hypothesis are summarized:

Objective 1: Intergroup conflict is common in our society; however there is few studies investigation intergroup conflict. The first aim is to analyze the emotional and physiological response to intergroup conflict between groups using the minimal group paradigm. Furthermore, we aimed to study sex differences in these responses. We expected to find sex differences in the responses to intergroup conflict in order to adapt their behavior to this kind of social interaction.

Objective 2: After research on intergroup conflict our project provided two principal results, sex-differences in the biological response and an influence of conflict in the following decision-making (Martínez-Tur et al., 2014). Taking into account these results, we focused our interest on decision-making after another social interaction considering sex differences. Thus, the second objective of this thesis was to test how the physiological and emotional changes after a competition would affect risk-taking behavior in men and women. We expected that higher in T changes and lower in C changes would induce a greater risk taking behavior in a decision-making task.

Objective 3: One important variable that would help to adapt to social interactions is the decision-making skills. Having better decision-making skills would help to have a better physiological adaptation to conflictive social interactions, such as competition. In this sense, CV responses have been related to an adaptive physiological response pattern that would help people to cope with social stress. Considering this pattern, our third aim was to analyze whether decision-making skills influence the way to cope with social interaction, specifically a competition. In this sense we hypothesize higher response of HF HRV that is a marker of executive control, but also, lower LF HRV that would indicate more mental load in order to confront the competition.

Objective 4: Decision-making styles can be considered as a personality trait that can predict the long-term decision-making strategies. There is a questionnaire named "*General*

Decision-making Scale" (GDMS) that has been proved to be useful to measure proneness to decision-making styles. However, there is not a Spanish validation of this scale. For that reason we aimed to adapt the GDMS to Spanish population and provide psychometric characteristics of this adaptation to validate this questionnaire. Also, we aimed to expand the research in decision-making styles analyzing sex differences in decision-making styles, but firstly performing sex invariance analyses.

Objective 5: Related to the validation of the decision-making styles as a personality factor, recently it has been indicated that personality traits could be related to an endophenotypic physiological marker of executive control as HRV. Thus, the last objective is to explore the relationships between the decision-making styles, measured with the validated version of GDMS, and HRV indexes, in order to give support of physiological correlates of decision-making style.

Chapter 3: THREAT

Sex differential physiological response to intergroup conflict

The influence of group on the physiological and emotional response

Main results of the present chapter have been submitted in Adrián Alacreu-Crespo, Vicente Peñarroja, Vanesa Hidalgo, Vicente Martínez-Tur, Alicia Salvador & Miguel Ángel Serrano. Sex differences in the psychophysiological patterns of response to an intergroup conflict, Biological Psychology

1. Introduction

People need to interact with others, even though many of these interactions are conflictive (Anderson & Bushman, 2002) and some can even lead to terrorism or war in a large scale scenario (Fujii, 2010; Staub, 2004). These dangerous situations directly threaten people's lives and health, but other common life conflicts, such as romantic or job conflicts, can also lead to dire consequences. In addition to several social consequences, conflicts are able to alter the psychophysiological state of the people involved in them, increasing the activity of systems such as the sympathetic nervous system (SNS) and the hypothalamus-pituitary-adrenal (HPA) axis (Baumeister & Leary, 1995; Salvador, 2012), similarly to what occurs in stressful situations. In fact, the interaction with the outgroup usually represents a threat to in-group members (Trawalter, Adam, Chase-Lansdale, & Richeson, 2012). Thus, people involved in conflicts are more vulnerable to developing health problems derived from dysregulation of these stress systems (Blascovich & Tomaka, 1996). Therefore, the importance of studying conflict from a psychophysiological perspective is clear (Cikara & Van Bavel, 2014).

As mentioned above, conflictive situations are able to induce a stress response mainly involving the activation of the autonomic nervous system (ANS) and the HPA-axis, in addition to the hypothalamus-pituitary-gonadal (HPG) axis (Henry & Stephen, 1977; Koolhaas & Bohus, 1989). There is evidence that interpersonal conflicts induce cardiovascular (CV) reactivity, including increases in Heart Rate (HR) and arterial blood pressure (Luong & Charles, 2014; Suchday & Larkin, 2001; Waldstein, Neumann, Burns, & Maier, 1998), as well as HPA-axis reactivity, with higher levels of Cortisol (C) (Coutinho et al., 2017; Laurent et al., 2013b; Powers et al., 2016; Roubinov et al., 2012). By contrast, to our knowledge, there are no studies on HPG responses in laboratory interpersonal conflicts in humans, apart from studies in competitive situations. In fact, the final product of HPG axis activation, Testosterone (T), has been widely investigated in competition (Salvador, 2012). Overall, competition induces an increase in T levels (Casto & Edwards, 2016; Steiner, Barchard, Meana, Hadi, & Gray, 2010; van der Meij, Buunk, Almela, & Salvador, 2010) that depends largely on participants' interpretation of the situation (for a review, see Salvador and Costa, 2009).

However, despite the numerous studies focused on interpersonal conflicts, less is known about the physiological response to intergroup conflict. Generally, contact with a member of an outgroup induces SNS and HPA axis responses that are more exacerbated when the in-group pertains to the minority (Mendes et al., 2002; Page-Gould et al., 2010; Sampasivam et al., 2016; Sawyer et al., 2012; Townsend, Major, Gangi, & Mendes, 2011). Moreover, these changes can be accompanied by different behaviors. Thus, studies carried out with male soccer fans show that higher levels of T promote in-group (same soccer team) favoritism and outgroup (the other soccer team) hostility behaviors (Diekhof et al., 2014; Reimers et al., 2017; Reimers and Diekhof, 2015). However, these studies analyzed natural groups, and, therefore, some variables such as prejudice could mask the direct effects. To the best of our knowledge, only Ricarte et al. (2001) examined the psychophysiological response to intergroup conflict between newly created groups, using the minimal group paradigm (H Tajfel & Turner, 1979) and employing a role-play to induce a conflict in the laboratory. They found HR increases during the conflict in men and women, with the latter showing higher increases. However, to date, no previous studies have measured C and T responses to laboratory intergroup conflicts, except in competitive situations. Thus, Oxford et al. (2010) reported a high C and low T response in high ranking men in a videogame competition between groups, whereas Kivlighan et al. (2005) found a T decrease in women and increase in men during a group rowing ergometer competition.

In addition to the physiological response, conflict scenarios also elicit higher arousal and more negative emotions (Blascovich & Tomaka, 1996). Some studies have demonstrated that, after conflict, people show verbal and non-verbal behaviors associated with anger, contempt and disgust (Matsumoto, Hwang, & Frank, 2012, 2014) or fear (Halperin & Gross, 2011), with all these emotions being related to negative affect (Watson, Clark, & Tellegen, 1988). Specifically, one study simulating intergroup conflict between two teams showed that when participants were provoked by a member of the outgroup, they obtained higher scores on negative mood (Newheiser & Dovidio, 2015). Furthermore, sex differences have been reported in the emotional response to conflict (W. Wood & Eagly, 2012), with women showing more negative mood than men. These sex differences were explained by Role Congruity Theory (Eagly & Karau, 2002), which suggests that women's role during a social interaction is usually more social than men's role, which is more agentic. This theory supports the idea that the congruence between the social interaction and the sex role will influence the emotional, biological, and behavioral responses to the situation, with incongruent interactions being more threatening. Accordingly, when conflict situations are more incongruent with their role, women experience higher aversion and try to avoid them (Bear, 2011). Moreover, women show more distress (Kudielka et al., 2004), irritability, and fear and less happiness than men in these types of situations (Kelly, Tyrka, Anderson, Price, & Carpenter, 2008).

As mentioned above, only a few studies have been carried out on the psychophysiological response to intergroup conflicts, and so the effects of group on this social behavior have not been addressed. There is evidence that intergroup interactions can be much more competitive than interpersonal interactions (Pemberton et al., 1996; Wildschut et al., 2003). Moreover, it is worth taking into account that in intergroup interactions there are social processes, such as group identification, group creation, or intergroup bias (Hewstone, Rubin, & Willis, 2002), which may influence the way participants interpret the situation and, consequently, their response to conflict. Furthermore, the study by Levenson and Ruef (1992) demonstrated the linkage of the participants' psychophysiological responses during cooperative tasks. This "synchronization" between the members of the same group could be a factor that influences the psychophysiological response to intergroup conflict.

With all this in mind, our main purpose was to study the emotional, CV, and endocrine responses to conflict between two newly created groups, focusing on the group level. To accomplish our aim, we employed a protocol with small groups (composed of 3 people) that participated in either a role-play conflict or a control condition. Moreover, we also aimed to analyze the potential sex differences in the psychophysiological responses. Based on previous studies, we hypothesized that intergroup conflict would induce a social stress response characterized by higher negative mood, SNS, HPA-axis, and HPG-axis response, compared to a control condition. Based on Role Congruity Theory (Eagly & Karau, 2002), we hypothesized that women would have more negative affect and less positive affect than men, along with higher HR and C (Kelly et al., 2008; Kivlighan et al., 2005; Kudielka et al., 2004; Ricarte et al., 2001; Stroud et al., 2002). Finally, based on the potential importance of the group characteristics, we looked at whether the group affects the results of the analyses.

2. Methods and materials

2.1. Participants

An initial sample of 150 healthy Caucasian undergraduate students from the University of Valencia (Spain) participated in this study. The sample was recruited through informative talks, and then a screening questionnaire was used to check whether they met the study prerequisites. The exclusion criteria were: presence of cardiovascular, endocrine, neurological, or psychiatric disease, presence of a stressful life event during the past year, smoking ten or more cigarettes per day, alcohol or other drug abuse, and doing more than 10 hours of physical activity *per* week. For each session, we contacted six participants of the same sex by telephone, in order to form two teams of three participants each. Thus, we recruited 50 teams with three participants of the same sex in each. These teams were randomly submitted to one of the different conditions: 32 teams in the conflict condition

(CC; 12 teams of men and 20 teams of women) and 18 teams in the no-conflict condition (NCC; 8 teams of men and 10 of women).

Before each session, participants were asked to maintain their general habits, sleep as long as usual, refrain from heavy physical activity the day before the session, and not consume alcohol since the night before the session. Additionally, they were instructed to drink only water and refrain from eating, brushing their teeth, smoking, or taking any stimulants, such as coffee, cola, caffeine, tea or chocolate, two hours prior to the session. Six participants were excluded because they did not follow these recommendations, and two other participants were excluded because they were considered outliers on the body mass index (BMI; [BMI] + 3 Standard Deviations [SD]) (2 women from the CC, and 3 women and 3 men from the NCC).

Therefore, the final sample was composed of 142 participants (60 men and 82 women). Participants' mean age was 21.16 (± 0.19 [SE]), and their mean BMI was 22.56 Kg/m^2 (± 0.27 SE). Ninety-four subjects participated in the CC (36 men and 58 women; 21.29 ± 0.25 years of age, and a BMI of 22.58 ± 0.31 Kg/m2), whereas 48 subjects (21 men and 27 women; 20.96 ± 0.34 years of age and a BMI of 23.11 ± 0.43 Kg/m2) participated in the NCC (see Table 1).

Participants were asked to attend a 3h session that took place in a laboratory at the Faculty of Psychology at the University of Valencia. All the sessions were held between 15:30 and 18:30h in order to control the circadian rhythms of the hormones. Once all the sessions were over, participants were informed about the rationale for the study, and they received €9 (about 12 USD) for their participation.

2.2. Procedure

Each session was conducted by two male experimenters. When the participants arrived at the laboratory, they were informed about the general study procedure, and they signed the informed consent approved by the Ethics Research Committee of the

University of Valencia. The study was conducted according to the Declaration of Helsinki. Moreover, participants were asked whether they had followed the recommendations given previously, and about demographic variables such as weight, height, and perceived socioeconomic status (SES). Later, participants were distributed into six individual rooms. In addition, an HR monitor was placed on each participant in order to start HR acquisition at the same time for all participants.

Conflict condition. To provoke intergroup conflict, participants performed the task known as "Viking Investments" (Greenhalgh, 1993). This task consisted of a conflict role-play between two teams, where one team represents a real estate investment company and the other represents a carpentry business. Following the Howard et al. (2007) procedure, each team received a different description of the conflict. This information was intended to make each team think that the other team was responsible for the problems caused. It is important to note that participants did not have to be experts to understand and defend their position in the conflict, and the complexity and multifaceted nature of the conflict did not make it possible to determine a clear winner or loser in the established period of 10 min. This duration was previously found to be ideal for generating conflict, and it was not long enough to allow the two teams to arrive at a position accepted by both teams.

The session started with a *habituation* phase of 15 min in order to ensure the participants' adaptation to the laboratory setting. During this phase, participants completed a mood scale (pre-task) and collected the first saliva sample (baseline) in an individual room. To avoid disturbing participants' CV baseline, they did not receive any specific instruction to keep their eyes open or closed or breathe differently from usual. Next, the task, which was composed of three phases, took place (Figure 1). For 35 min, in the *individual preparation* phase, participants had to individually read the description of the conflict according to his/her team. After this, each participant on each team was moved from an individual room to a team room. Each team was instructed to prepare a discussion meeting that would take place later with the other group (20 min) (*pre-interaction* phase). At the end of this phase, participants provided the second saliva sample (pre-interaction sample). Then, the interaction between the two teams took place (*interaction* phase). To achieve a dispute with a conflictive nature, teams were seated face-to-face in the interaction room. Moreover, participants only had 10 min to interact with the other group. This short time only allowed participants to become aware of the intergroup conflict and the different perspectives of the two groups. One experimenter stayed in the interaction room and instructed participants to start the meeting, stating that it was important to become immersed in the role. During this phase, participants could freely intervene with their arguments. The experimenter did not mediate in the interaction, and participants were free to do or say anything, but without moving from their positions. Once the conflict had ended, participants returned to the individual rooms and again completed the mood scale (post-task) and the conflict perception scale, and they provided the third, fourth, and fifth saliva samples at 0 (Post-0) and 30 (Post-30) and 45 (Post-45) minutes after the interaction, respectively. Finally, the experimenter thanked the participants and informed them that the experimental session was over.

Non-conflict condition. The NCC condition was similar to the CC condition, except that the interaction between the two teams was not a conflict situation. For this purpose, participants received the same cases to read, but with different instructions from those for the CC condition in the *pre-interaction* and *interaction* phases. They were instructed to prepare a summary of their case, according to their team, in order to explain it to the other team during the meeting in the interaction phase. It is important to note that, as in the CC, teams were seated face to face in the interaction room, but they only had to explain their cases. The scales completed, the timing of the saliva samples, and the phase durations were the same for the two conditions. A summary of the entire procedure is shown in Figure 1.

Figure 1:

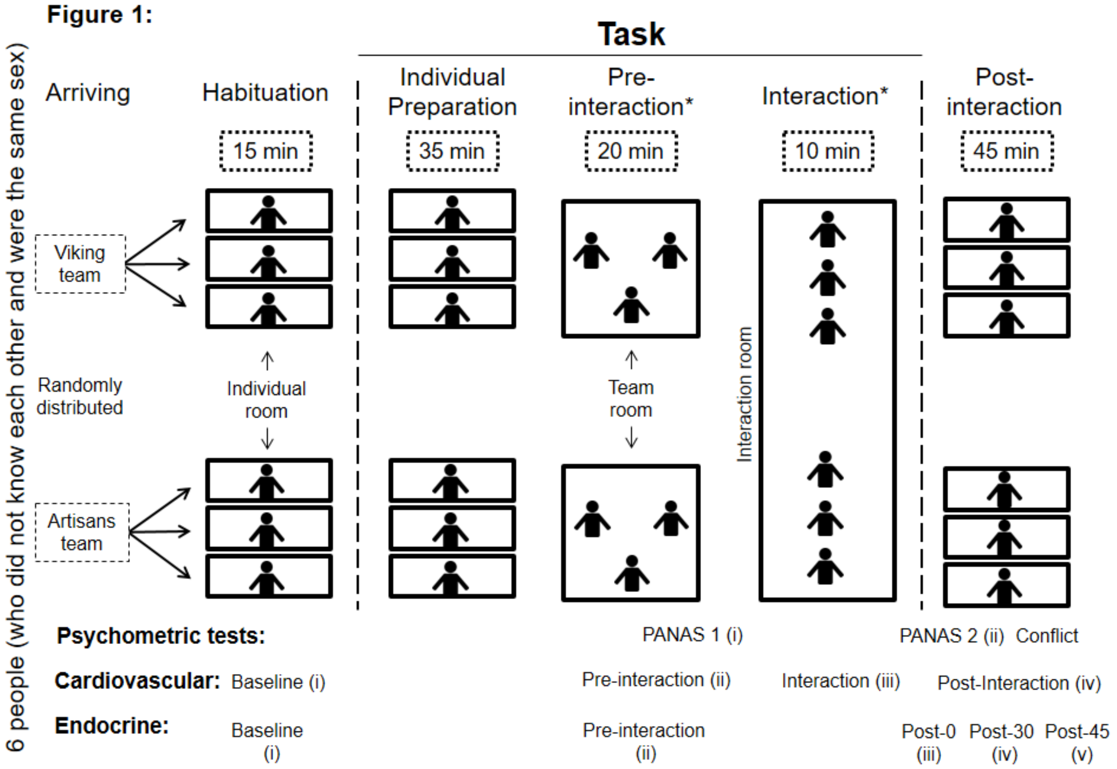


Figure 1: Summary of the study protocol. * Periods where the CC and NCC groups were different: In Pre-interaction, groups received different instructions (CC: Prepare strategy to enter into conflict with the other team / NCC: Prepare a summary to explain the case to the other team), In interaction, the CC group entered into conflict, and NCC summarized the cases.

2.4. Questionnaires and scales

Mood. The Spanish version (Sandín et al., 1999) of the Positive and Negative Affect Scale (PANAS; Watson et al., 1988) was used. This questionnaire provides scores in two dimensions: positive and negative affect. The two-dimensionality of the Spanish version of the PANAS has been confirmed with $\alpha = 0.89$ for positive mood and $\alpha = 0.91$ for negative mood.

Conflict perception. All the participants answered two sub-scales of the Conflict Type Perception Test (Jehn, Greer, & Levine, 2008): (i) Task Conflict (disagreements between groups concerning ideas and opinions about the task) and (ii) Relation Conflict (disagreements between group members about personal ideas that are not task-related), composed of six and four items, respectively. This version has previously been used

(Martínez-Tur et al., 2014). Participants must assess the level of conflict experienced between their group and the other group, based on statements rated on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). A high degree of internal consistency was found in our sample, with $\alpha = 0.90$ for Task Conflict and $\alpha = 0.86$ for Relation Conflict.

2.3. Cardiovascular measures

Heart rate was measured using a Polar©RS800cx watch (Polar CIC, USA), which consists of a chest belt for the detection and transmission of the heartbeats and a Polar watch for data storage; this device is very useful in research (Perandini et. al., 2009). The Polar watch records R-R intervals with a sampling frequency of 1000 Hz. We used this instrument because it allowed participants to move to different rooms according to the procedure. Data were analyzed using the Heart Rate Variability (HRV) software Kubios Analysis (Biomedical Signal Analysis Group, University of Kuopio, Finland, Tarvainen et al., 2014). Following the recommendations of the Task Force (1996), we analyzed the HR in periods of 5 minutes, exactly in the middle of the following periods: (i) Baseline, (iii) Pre-interaction, (iv) Interaction, and (v) Post-interaction periods. We eliminated the time spent moving to another room from the data, as well as the time when the subjects were completing questionnaires. Automatic Kubios artifacts were fixed with the appropriate degree of correction.

For this study, we chose the HR mean in order to estimate whether SNS was activated and the parasympathetic nervous system (PNS) was deactivated during the conflict (Bernston et al., 2007). Furthermore, the Root Mean Square Successive Difference (RMSSD) was chosen, which is considered an index related to Respiratory Sinus Arrhythmia and, thus, with the parasympathetic branch (Bernston et al., 2007). Finally, some HRV variables could be affected by respiration. Thus, to control the respiration, we calculated the hertz (hz.) where the High Frequency band was collected (HFhz; between 0.15 to 0.40

hz.), which is an index of respiratory rate (a lower HFhz implies a higher respiration rate). However, we used this variable as another source of information, and we did not control it in the computation of HRV variables such as RMSSD, based on previous suggestions (Denver, Reed, & Porges, 2007).

2.4. Saliva sampling and biochemical analyses

Five saliva samples were collected for each participant: (i) Baseline, (ii) Pre-interaction, (iii) Post-0, (iv) Post-30, and (v) Post-45, in order to obtain the hormonal response. Saliva was directly collected from mouth to vial by depositing 5 ml. Participants took no more than 5 min. to fill each vial. Samples were centrifuged (5000 rpm, 15+2°C) and frozen at -20°C until determination.

Salivary C levels were determined in duplicate with the Spectria Cortisol RIA kit from Orion Diagnostica (Espoo, Finland). Assay sensitivity was 0.8 nmol/l. For each subject, all the samples were analyzed in the same trial. The within- and inter-assay variation coefficients were all below 8%.

Salivary T concentrations were determined in duplicate with the salivary testosterone enzyme-immunoassay kit from Salimetrics (Suffolk, UK). Assay sensitivity was < 1.0 pg/ml. For each subject, all the samples were analyzed in the same trial. The within- and inter-assay variation coefficients were all below 10%.

2.5. Data reduction and statistical analyses

Kolmogorov-Smirnoff was used to check the normality of the variables measured. Task conflict, HFhz, C, and T values did not have a normal distribution and were normalized with the Log10 method. After that, we calculated the Area Under the Curve with respect to ground (AUCg) for HR, RMMSD, HFhz, C, and T, using all the periods for each variable (Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003). Moreover, we calculated the reactivity index for the interaction (Interaction – Baseline) for mood, CV, C and T. To check the homogeneity of independent factors (i.e. condition and sex), first, chi-square analyses were performed between Condition (CC/NCC) and Sex (men/women), and second, ANOVAs were conducted, with Condition and Sex as independent factors, and Age, BMI, SES, and Baseline of mood, HR, HFhz, RMSSD, C, and T as dependent variables. When age, BMI, or SES were significant, we used them as covariates in the later analyses with the endocrine and cardiovascular variables.

To test our principal hypotheses, we examined whether Hierarchical Linear Modeling (HML), using Team as the cluster variable, was needed in our analyses. HML takes into account the hierarchical structure of the data (e.g., individuals who are nested within teams) and allows the simultaneous examination of the relationships between variables at different levels of analysis (e.g., individual and group levels), as well as possible cross-level interactions (Raudenbush and Bryk, 2002; Snijders and Bosker, 1999). To do so, we examined the differences in the – 2loglikelihood between the null model and the model, using team as cluster for all the variables analyzed in this study (see Table 2). Significant differences in the – 2loglikelihood between the null model and the model with team as cluster indicate the need for HML. Table 2 also shows the Intra-Class Correlation (ICC) index for each dependent variable. ICC represents the proportion of variation in the outcome variables due to team membership.

When HLM was required, the following steps were taken in the analysis to build a two-level model with predictors at the individual and group levels. First, we conducted a null model for the dependent variables, which is a requirement for cross-level analysis (Heck and Thomas, 2000; Raudenbush and Bryk, 2002). Second, we tested the random intercept model using Team as the cluster variable. Third, we introduced the covariates at the individual level, if necessary. Fourth, we introduced the fixed effects of Sex at the individual level. Fifth, we tested the random slopes of Sex, which were allowed to vary across teams. Sixth, we introduced the fixed effects of Condition at the group level. Finally, we introduced the cross-level interaction between Condition and Sex. We used a model comparison procedure to check whether the effect of adding the fixed and random effects to each model was statistically significant. In the results section, we only describe the results from the model with the better fit. Table 3 shows the results of the final model for all the variables where HLM was used. When the model showed significant cross-level interactions, *post-hoc* simple slope analyses with Bonferroni correction of the degrees of freedom were conducted.

When HLM was not necessary, two-way ANOVAs or ANCOVAs were carried out, with Condition and Sex as between-subjects factors, and covariates when necessary. *Post-hoc* tests were performed with Bonferroni correction. The decision about whether to use HLM or not is explained in the results section for each variable.

The alpha significance level was fixed at 0.05, and the CI 95% were reported for HLM. Partial eta squared was reported for ANOVAs and ANCOVAs as a measure of the effect size. *β-1* was reported as a measure of power. All the statistical analyses were performed with R 3.4.2.

3. Results

3.1. Preliminary Analyses

Chi-square did not show significant differences between the number of men and women in the two conditions (X^2= 0.07, p < .79). ANOVAs only showed a significant effect of Condition at Baseline on C ($F_{1,\,134}$ = 23.98, p < .001, η^2_p = .152, *power* = .99), with CC participants showing higher levels than NCC participants.

Sex differences were found in BMI ($F_{1,\,136}$ = 27.04, p < .001, η^2_p = .166, *power* = .99), Baseline HR ($F_{1,\,87}$ = 4.02, p < .05, η^2_p = .044, *power* = .51), Baseline C ($F_{1,\,134}$ = 8.27, p < .01, η^2_p = .058, *power* = .81) and Baseline T ($F_{1,\,132}$ = 88.68, p < .001, η^2_p = .402, *power* = 1.00). Thus, men had higher scores on BMI (Mean ± SE; men = 24.27 ± .41, women = 21.46 ± .36), Baseline C (Mean ± SE; men = 1.02 ± .02, women = .96 ± .02) and Baseline T (Mean ± SE; men = 1.97 ± .03, women = 1.62 ± .03) than women.

By contrast, men had lower scores on HR (Mean ± SE; Men = 76.26 ± 1.88, women = 81.09 ± 1.39) than women. Therefore, in the next sections, BMI was used as covariate for cardiovascular and endocrine variables. Age and SES did not show significant differences ($p > .05$). Mean ± SE for sociodemographic and baseline values are presented in Table 1.

Table 1: Mean ± SE of sociodemographic variables, conflict, mood, cardiovascular, and hormonal variables in both conditions in men and women.

	Men	Women	Men	Women
Sociodemographic				
Age	21.59 ± .39	21.00 ± .32	20.67 ± .57	21.26 ± .35
BMI	23.68 ± .42	21.48 ± .37	24.77 ± .83	21.44 ± .59
SES	6.05 ± .201	6.11 ± .149	6.48 ± .235	6.22 ± .187
Conflict				
Task Conflict	.71 ± .026	.76 ± .022	.51 ± .035	.48 ± .031
Relation Conflict*	3.82 ± .30	5.31 ± .23	3.06 ± .39	2.86 ± .35
PANAS				
Positive mood baseline	28.47 ± .82	28.00 ± .68	29.71 ± 1.10	27.31 ± .99
Conflict reactivity positive mood♯	- 2.16 ± .78	- 1.91 ± .64	- 4.05 ± 1.03	- 4.69 ± .93
Negative mood baseline	22.53 ± .79	21.93 ± .66	23.86 ± 1.07	21.12 ± .96
Conflict reactivity positive mood♯	- .27 ± .74	- .66 ± .60	- 2.43 ± .98	- 2.19 ± .88
Cardiovascular				
Heart rate baseline[c]	78.57 ± 2.35	82.25 ± 1.87	73.95 ± 2.84	79.93 ± 2.04
Heart rate AUCg [c ♯]	6277.96 ± 181.94	6563.05 ± 144.97	5773.18 ± 219.63	6211.38 ± 160.67
Heart rate Conflict reactivity [c ♯]	2.56 ± 2.49	5.78 ± 1.98	- 1.08 ± 3.01	- 1.74 ± 2.16
HFhz baseline[c]	.22 ± .02	.24 ± .01	.23 ± .02	.24 ± .01
AUCg HFhz[c]	16.06 ± .82	17.86 ± .65	17.50 ± .99	17.99 ± .71
Conflict reactivity HFhz[c]	- .031 ± .017	- .036 ± .014	- .015 ± .021	.002 ± .015
RMSSD baseline[c]	40.78 ± 4.19	38.69 ± 3.34	45.04 ± 5.07	36.44 ± 3.64
RMSSD AUCg [c]	3296.43 ± 336.97	3877.17 ± 417.04	3290.43 ± 237.95	3241.29 ± 267.63
RMSSD Conflict reactivity [c ♯]	1.80 ± 4.20	.43 ± 2.13	7.37 ± 5.31	6.06 ± 2.39
Hormones				
Cortisol baseline[c]	1.08 ± .026	1.04 ± .021	.97 ± .034	.88 ± .031
Cortisol AUCg [c ♯]	27.11 ± .93	23.89 ± .77	25.52 ± 1.25	22.12 ± 1.12
Cortisol Conflict reactivity [c]	- .14 ± .029	- .19 ± .024	- .21 ± .038	- .15 ± .034
Testosterone baseline[c]	1.96 ± .034	1.62 ± .028	1.98 ± .045	1.63 ± .040
Testosterone AUCg [c]	221.12 ± 3.69	180.74 ± 3.15	219.36 ± 4.94	185.75 ± 4.34
Testosterone Conflict reactivity [c *]	- .053 ± .020	- .120 ± .017	- .083 ± .027	- .034 ± .024

[c] Covariated with BMI (22.66) Mean. * $p < 0.05$ for Conflict × Sex ♯ $p < 0.05$ for Conflict

3.2. *Intraclass correlation for dependent variables*

The ICC represents the total variance explained by Team membership on lower-level variables (Bliese, 2000). Thus, higher ICCs indicate a higher influence of group on the dependent variables. The variables with a large ICC were the perception of conflict: Task conflict (ICC = .55) and Relation conflict (ICC = .51); some cardiovascular measures: Reactivity of HR (ICC = .55) and RMSSD (ICC = .47); and, finally, the AUCg of T (ICC = .41). Moreover, some variables had an ICC superior to .20 as the AUCg of C (ICC = .24). Table 2 showed the ICCs for all the variables.

Table 2: Intraclass correlation with team as a cluster variable for all the variables analyzed using hierarchical linear models (HLM) and the differences in - 2loglikelihood between the null model (model I) and the model with Team as cluster (model II).

	ICC	X^2	*p*
Task conflict	*r* = .55	40.62	.001
Relation conflict	*r* = .51	33.41	.001
Positive mood conflict reactivity	*r* = .08	0.51	.471
Negative mood conflict reactivity	*r* = .14	2.59	.107
Heart rate AUCg	*r* = .17	8.78	.003
Heart rate conflict reactivity	*r* = .55	17.09	.001
RMSSD AUCg	*r* = .11	0.57	.452
RMSSD conflict reactivity	*r* = .47	13.41	.001
HFhz AUCg	*r* = .01	0.002	.961
HFhz Conflict reactivity	*r* = .16	0.79	.373
Cortisol AUCg	*r* = .24	14.54	.001
Cortisol conflict reactivity	*r* = .08	0.24	.623
Testosterone AUCg	*r* = .41	48.70	.001
Testosterone conflict reactivity	*r* = .02	0.001	.978

Note: ICC = Intraclass correlation, AUCg = Area under the curve with respect to ground, RMSSD = Root mean square successive difference, HFhz = High frequency hertz

3.3. *Conflict scales*

For the conflict scales (task conflict and relation conflict), the random intercepts for Team are nested ($p < 0.05$), and then HLM was computed for both variables.

Task conflict showed significant variance in the intercepts across Teams (SD = 0.14, [CI 95% = .11, .19], X^2 (1) = 40.62, p < 0.001). When we added the fixed effects of Sex and the random slopes of Sex, the model fit did not significantly improve ($p > 0.05$). The fit only improved significantly when we add the fixed effects of Condition to the model (X^2 (1) = 32.09, p < 0.001). Finally, the Sex × Condition interaction does not significantly improve the model ($p > 0.05$). We found a significant effect of Condition on task conflict ($b = -0.24$, SE = .04, [CI 95% = − .30, − .07], $t(47) = -6.91$, $p < 0.001$); participants in CC had higher task conflict than participants in NCC (Mean ± SEM; CC = .74 ± .02, NCC = .49 ± .02).

In the case of relation conflict, significant variance was found in the intercepts across Teams (SD = 1.28, [CI 95% = .98, 1.67], X^2 (1) = 33.41, p < 0.001). Moreover, when we added the fixed effects of Sex, the model fit improved significantly (X^2 (1) = 5.54, $p <$ 0.019). Adding the random slopes of Sex did not improve the model ($p > 0.05$). However, the fixed effects of Condition (X^2 (1) = 17.23, p < 0.001) and the cross-level Sex × Condition interaction significantly improved the model fit (X^2 (1) = 6.43, p < 0.011). We found a significant effect of Sex on relation conflict ($b = 1.48$, SE = .38, [CI 95% = .72, 2.25], $t(46) = 3.86$, $p < 0.001$); women had higher relation conflict than men (Mean ± SEM; Women = 4.08 ± 0.21, Men = 3.44 ± .24). In addition, the Condition × Sex interaction showed significant effects for relation conflict ($b = -1.68$, SE = .65, [CI 95% = − 2.98, − .39], $t(46) = -2.59$, $p < 0.013$). *Post-hoc* analyses showed higher relation conflict in women in CC than women in NCC ($b = 2.45$, SE = .43, $t(46) = 5.75$, $p < 0.001$) and men in both CC ($b = -1.48$, SE = .38, $t(46) = -3.86$, $p < 0.002$) and NCC ($b = -2.24$, SE = .46, $t(46) = -4.86$, $p < 0.001$ (Table 1).

3.3. Emotional response to conflict

For mood, none of the mood scales showed significant differences in the – 2loglikelihood comparison models for the null model and the second model (Table 2), and so we performed ANOVAs.

For positive mood reactivity, a main effect of Condition ($F_{1,\,133} = 8.22$, $p < .005$, $\eta^2_p = .059$, *power* = .81) was found. Positive mood decreased less from the basal levels after the conflict task than after the no-conflict task (Mean ± SEM; CC = − 2.02 ± 0.51, NCC = − 4.39 ± .70). However, Sex and the Sex × Condition interaction were not significant ($p > .05$).

For negative mood reactivity, a significant effect of Condition ($F_{1, 132} = 6.07$, $p < .015$, $\eta^2_p = .044$, *power* = .69) was found. Negative mood reactivity was higher in CC participants than in NCC participants (Mean ± SEM; CC = − .47 ± 0.50, NCC = − 2.32 ± .69). Similarly to positive mood, Sex and the Sex × Condition interaction did not show significant effects ($p > .05$).

3.4. Cardiovascular response to conflict

We found significant differences between the null model and the model using team as cluster for all the cardiovascular variables of HR AUCg, HR reactivity, and RMSSD reactivity (See Table 2). Thus, we used HLM in the first case, whereas ANCOVA was used for the other variables. In both cases, BMI was introduced as covariate.

3.4.1. Heart rate

The HR AUCg showed significant variance in the intercepts across teams (SD = 542.78, [CI 95% = 371.21, 793.63], X^2 (1) = 8.78, p < 0.003). Including Condition (X^2 (1) = 4.46, p < 0.034) significantly improved the model. However, BMI, Sex fixed effects, Sex random slopes, and the Sex × Condition interaction did not significantly improve the model fit ($p > 0.05$). We found significant effects of Condition on HR AUCg ($b = -417.93$, SE = 197.47, [CI 95% = -805.96, -29.91], $t(49) = -2.12$, $p < 0.039$), with participants in the CC showing higher HR AUCg than in the NCC (Mean ± SEM; CC = 6449.30 ± 127.89, NCC = 6031.37 ± 156.27). However, the significant effects of Condition disappeared when we included the cross-level interaction term (Table 3).

HR reactivity to conflict showed significant variance in the intercepts across teams (SD = 8.29, [CI 95% = 6.17, 11.13], X^2 (1) = 17.09, p < 0.001). For this variable, the model fit improved marginally when we included Condition in the model (X^2 (1) = 3.77, p < 0.051), but not when we included the rest of the variables ($p > 0.05$). We found a trend of Condition in the HR reactivity to conflict (b = -5.48, SE = 2.81, [CI 95% = -10.99, .03], $t(49) = -1.95$, $p < 0.06$), with higher HR reactivity in CC participants than in NCC participants (Mean ± SEM; CC = 3.95 ± 1.77, NCC = -1.52 ± 2.19). However, if we included the interaction term, the marginal effects of Condition disappeared (Table 3).

3.4.2. Respiration

No significant effects were found in the ANCOVA for HFhz AUCg or HFhz reactivity ($p > .05$).

3.4.3. RMSSD

The ANCOVA did not show significant effects for RMSSD AUCg ($p > .05$).

RMSSD reactivity to conflict showed significant variance in the intercepts across Teams (SD = 9.12, [CI 95% = 6.49, 12.81], X^2 (1) = 13.41, $p < 0.001$). Only the addition of Condition significantly improved the fit of the model (X^2 (1) = 3.94, $p < 0.047$). Adding BMI, Sex, the slopes of Sex, or the Sex × Condition interaction did not improve the model ($p > 0.05$). We found a significant effect of Condition on the RMSSD reactivity to conflict (b = 5.62, SE = 2.85, [CI 95% = 0.01, 11.23], $t(49) = 1.97$, $p < 0.05$), with lower RMSSD reactivity in CC participants than in NCC participants (Mean ± SEM; CC = 1.11 ± 2.14, NCC = 6.73 ± 2.48). However, the significant effects of Condition disappeared when we included the interaction term Sex × Condition (Table 3).

3.5. Endocrine response to conflict

The – 2loglikelihood between the null model and the second model for both C and T AUCg was significant ($p < 0.001$). In this case, we performed HLM. However, we carried out ANCOVAs for conflict reactivity because the variance in the intercepts across teams was not significant for C and T. BMI was used as covariate in all the analyses.

3.5.1. *Cortisol*

In the case of C AUCg, significant variance in the intercepts across teams was found (SD = 9.30, [CI 95% = 6.61, 13.07], X^2 (1) = 14.54, p < 0.001). Moreover, adding BMI (X^2 (1) = 5.59, p < 0.018), fixed effects of Sex (X^2 (1) = 5.07, p < 0.024), and Condition (X^2 (1) = 23.33, p < 0.001) significantly improved the model. Random slopes for Sex and the Sex × Condition interaction did not improve the model ($p > 0.05$). We found a significant effect of Sex ($b = -8.61$, SE = 2.87, [CI 95% = -14.31, -2.93], $t(47) = -3.00$, $p < 0.004$); men had a more pronounced curve than women (Mean ± SEM; Men = 26.32 ± .78, Women = 23.00 ± .68). Furthermore, significant effects of Condition were also found ($b = -15.25$, SE = 2.83, [CI 95% = -20.86, -9.65], $t(47) = -5.39$, $p < 0.001$); CC participants had a higher C curve than NCC participants (Mean ± SEM; CC = 25.49 ± .61, NCC = 23.82 ± .84).

However, no significant effects were found for C reactivity ($p > .05$).

3.5.2. *Testosterone*

The T AUCg showed significant variance in the intercepts across teams (SD = 23.86, [CI 95% = 18.70, 30.45], X^2 (1) = 48.70, $p < 0.001$). Adding BMI (X^2 (1) = 12.05, $p < 0.001$) and the fixed effects of Sex (X^2 (1) = 39.49, $p < 0.001$) significantly improved the fit of the model; however, the next three models with random slopes of Sex, Condition, and the Sex × Condition interaction did not improve the fit of the model ($p > 0.05$). Only Sex showed significant effects on T AUCg ($b = -37.85$, SE = 4.95, [CI 95% = -47.70, -28.00], $t(48) = -7.64$, $p < 0.001$); with a higher curve for men than for women (Mean ± SEM; Men = 220.34 ± 3.66, Women = 182.49 ± 3.15).

Finally, ANCOVA showed a significant Condition × Sex interaction for T reactivity ($F_{1,\,127} = 7.19$, $p < .01$, $\eta^2_p = .054$, *power* = .76). *Post-hoc* analyses showed that CC women had lower T reactivity than CC men ($F_{1, 127} = 6.17$, $p < .01$, $\eta^2_p = .045$, *power* = .69) and NCC women ($F_{1, 127} = 8.99$, $p < .01$, $\eta^2_p = .064$, *power* = .84).

Table 3: Results of multilevel analyses of the main effects, cross level interactions, and random effects in the model with the best fit for each variable:

	Task conflict^{lg}	Relation conflict	HR AUCg	HR CR	RMSSD CR
Intercept (γ_{00})	0.73 (0.03)***	3.82 (0.30)***	6547.57 (640.67)***	− 3.59 (8.07)	5.03 (10.18)
Main predictors					
Ind-level: BMI (γ_{10})^{c}	–	–	− 11.54 (25.63)	0.28 (0.32)	− 0.14 (0.39)
Ind-level: Sex (γ_{20})^{a}	0.02 (0.04)	1.48 (0.38)***	326.81 (210.36)	2.49 (2.85)	− 1.34 (3.75)
Gr-Level: Condition (γ_{03})^{b}	− 0.24 (0.04)***	− 0.76 (0.49)	− 417.93 (197.48)*	− 5.48 (2.81)^{t}	5.62 (2.85)*
Cross-level interactions					
Sex × Condition (γ_{23})	–	− 1.69 (0.65)**	–	–	–
Random effects					
Team (σ_{00})	0.10	0.76	509.07	6.50	11.77
Sex Slope (τ_{10})	0.12	1.00	637.94	10.08	12.49
Intercept-slope cov. (τ_{01})	− .78	− .69	− .71	− .53	− .95
Residual	0.13	1.27	618.79	7.27	10.18
	Cortisol AUCg^{lg}	Testosterone AUCg^{lg}			
Intercept (γ_{00})	134.80 (9.27)***	190.31 (14.84)***			
Main predictors					
Ind-level: BMI (γ_{10})^{c}	− 1.03 (0.38)**	1.32 (0.59)*			
Ind-level: Sex (γ_{20})^{a}	− 8.61 (2.87)**	− 37.83 (4.95)***			
Gr-Level: Condition (γ_{03})^{b}	− 15.25 (2.83)***	–			
Cross-level interactions					
Sex × Condition (γ_{23})	–	–			
Random effects					
Team (σ_{00})	4.48	11.95			
Sex Slope (τ_{10})	8.38	–			
Intercept-slope cov. (τ_{01})	− .51	–			
Residual	11.79	–			

Notes: *** $p < .001$, ** $p < 0.01$,* $p < 0.05$, ^{t} $p < 0.07$, ^{lg} log-transformed dependent variables; ^{c} Covariate, ^{a} Women = 0, ^{b} Control = 0; GR = Group Reactivity, AUCg = Area under the curve with respect to the ground, HR = Heart rate, CR = Conflict Reactivity, RMSSD = Root mean squared successive difference, BMI = Body mass index, cov. = Covariance

4. Discussion

The current study investigated the psychophysiological response to an intergroup conflict and the existence of sex differences in this response. First, as predicted, intergroup conflict was able to induce a psychophysiological pattern characteristic of a social stress response because it elicited a response at different levels, that is, psychological (i.e. more perception of task conflict and increases in positive and negative mood), cardiovascular (i.e. HR increases and RMSSD decreases), and endocrine (i.e. C increases). Second, regarding sex differences, we found that women felt more relation conflict than men, and C was higher in men than in women, independently of the condition. In the conflict situation, women showed T decreases, whereas men and the control group did not show significant changes. Finally, as the ICC showed, belonging to a team influenced conflict perception, HR, RMSSD, and T.

First of all, the task designed induced a conflict perception because participants in the intergroup CC showed higher scores than participants in the NCC on both conflict scales: task conflict (disagreements about task ideas) and relation conflict (disagreements about personal ideas). Thus, we confirmed that our manipulation stimulated a conflict that was able to induce psychological and physiological changes.

In fact, one of these changes involved increases in negative mood, which is consistent with previous research where participants felt more negative emotions after the conflict situation (Matsumoto et al., 2012, 2014; Newheiser & Dovidio, 2015). However, there were also increases in positive mood, which contradicts previous research. A possible explanation for this result would be the fact that the interaction ended prior to the resolution of the conflict, while the participants were still defending their positions. Salvador and Costa (2009) suggested that an active pattern of coping may increase positive mood, and we probably measured mood while the participants were active. In addition, because no objective outcome was given, participants never reached defeat, and they may have felt their own performance was positive.

According to Blascovich and Tomaka (1996), a social interaction with emotional changes, as in conflict, also includes a CV response. In this regard, this intergroup conflict seems to induce SNS activation, as shown by HR increases, perhaps with PNS withdrawal, as the RMSSD decrease indicates. This CV response pattern suggests CC participants' task engagement (Seery, 2013; Seery et al., 2009), compared to NCC, who did not show CV activation. Therefore, because intergroup conflict seems to be self-relevant to participants, the body prepares for motivated performance, inducing SNS activation and PNS withdrawal in order to mobilize energy reserves to cope with conflict (Obrist, 1981; Seery, 2013). Furthermore, due to the lack of differences in the respiratory index, our CV data do not seem to be affected by the breathing or other demands of participating in a conflictive/negotiation conversation (Brondolo et al., 2003; Denver, Reed, & Porges, 2007). These results show that intergroup conflict would produce at least a similar CV activation pattern to that of interpersonal conflict (Luong & Charles, 2014; Suchday & Larkin, 2001; Waldstein et al., 1998). Furthermore, previous studies with members of natural groups (e.g., different ethnic groups) showed a similar CV response (Mendes et al., 2002; Page-Gould, Mendoza-Denton, & Tropp, 2008). Because our study avoided potential race or sex prejudices, it could be revealing a direct effect of conflict on the CV response.

Complementary to the CV response, there is a C response that leads to extending the energy mobilization (Dienstbier, 1989; Seery, 2013). In fact, the AUC of C was statistically significant, but not the reactivity, probably because the peak of C appears approximately 30 minutes after the conflict (Ehrlenspiel & Strahler, 2012). Previous research on conflict in couples showed a similar HPA axis activation (Coutinho et al., 2017; Laurent et al., 2013). Social evaluation and uncontrollability in the CC probably contributed to the perception of this situation as threatening, thus favoring SNA and HPA axis activation, also common in social stress contexts (Dickerson and Kemeny, 2004). Consistent with this idea that intergroup conflict is a threatening situation, T increments could be expected in order to promote hostile behavior toward the outgroup (Diekhof et al., 2014; Reimers et al., 2017; Reimers and Diekhof, 2015). However, the results contradicted this expectation because there were no increases in T after the conflict. It is worth noting that decreases in the HPG axis response and no response have been considered when facing a threat or defeat in a competition (For reviews see, Casto and Edwards, 2016; Salvador, 2012; Salvador and Costa, 2009). Interestingly, increases in C and decreases in T after conflicts with the outgroup have been observed in red-tail monkeys (Jaeggi et al., 2018), perhaps because it is the most adaptive or common endocrine response in confronting intergroup conflict.

Additionally, we found sex differences in the endocrine response to the social interaction. Specifically, the curve of C was higher in men than in women in both conditions. This result is surprising because, from an evolutionary point of view, men are more prone to interacting with members of another group and usually get more positive outcomes from these encounters than women (McDonald, Navarrete, & Van Vugt, 2012). For men, interactions with an outgroup could be interpreted as a role-congruent situation and, therefore, less threatening and followed by less HPA axis activation (W. Wood & Eagly, 2012). However, men usually show greater reactivity than women when facing some standardized social stressors (Kudielka et al., 2004), which would be an alternative explanation for this higher C response. We expected the intergroup conflict to be more threatening for women, provoking more negative mood and higher SNS and HPA axis activation because it is a role-incongruent situation for them (W. Wood & Eagly, 2012). However, in our study, the intergroup conflict seems to be threatening for both men and women. However, sex differences were found in the T response, a hormone very related to the behavior in social contexts (Salvador, 2012). Women in the CC showed a significant T decrease just after the intergroup conflict, compared to men and women in the NCC.

Previously, Kivlighan et al. (2005) also reported sex-differences during an intergroup competition, with T decreases in women. They interpreted this result as being an effect of the social interaction among the participants during group creation because in their study, before starting the competition, participants warmed-up with their teammates. Similarly, our participants had to prepare a strategy with their teammates. Based on this idea, we could interpret the T decreases in women as an effect of social interaction with the in-group. Thus, if we consider that women express "*tend-and-befriend*" coping strategies (unlike "*fight or flight*" strategies in men) to face stress situations more than men (Shelley E. Taylor et al., 2000), women's T response might tend to decrease in order to increase trust behavior and avoid aggression and conflict. This "*tend-and-befriend*" behavior in women would be related to a psychophysiological pattern of C and T responses during a stressful event mediated by higher levels of oxytocin and estrogen (Shelley E. Taylor et al., 2000).

Thus, according to our results, intergroup conflict can induce mood changes and SNS and HPA axis activation, regardless of the sex of the participants. Agreeing with previous studies, our results show that intergroup conflict induces a psychophysiological response similar to a stress response, and also similar to responses involving interpersonal conflict, competition, or a fake intergroup conflict. Moreover, our results show potential sex-differences in the T response to intergroup conflict. According to the biosocial construction model proposed by Wood and Eagly (2012), during social situations such as negotiation or conflict, the social construction of gender roles influences hormonal and social regulation to the context, inducing sex differentiated affect, cognition, and behaviors. Taking this into account, men and women probably had these different T responses due to the group nature of the conflictive situation. In this regard, women may perceive the situation as threatening, developing a "*tend-and-befriend*" strategy in the inner-group *vs.* a possible "*fight or flight*" response from men (Shelley E. Taylor et al., 2000).

Human and animal research suggests that two or more individuals can mimic the behavior, affect, and actions of each other (Cheng & Chartrand, 2003). This suggestion agrees with theories about affect contagion (Hatfield, Cacioppo, & Rapson, 1994), and physiological synchronization is based on this research. Recently, HRV synchronization between individuals that would improve the coherence, communication, kindness, and cooperation among in-group individuals has been discussed (McCraty, 2017). In this context, our results indicate that belonging to a group influences the psychophysiological response to conflict. Specifically, conflict perception and the CV measures were the most influenced by group, as shown by the higher ICC. We consider it important to highlight this result because it is a very interesting topic for further research.

Several limitations of this study must be mentioned. First, the role-play selected (a conflict between two companies) exposes participants to an uncommon conflictive situation in young people that limits generalization to other types of conflicts; however, our design adds some elements that help to understand conflict situations because it provides a context where people can develop social in-group and outgroup identification patterns during the procedure (Macrae & Bodenhausen, 2000). In this regard, we did not have any direct measure of group cohesion, which limits the interpretation of a situation as intergroup. Despite this, the current procedure has previously been utilized to achieve the basis for group formation (Martínez-Tur et al., 2014). Second, because the participants were healthy young university students, our results may not be representative of other populations. Thus, further research about this topic with other population groups is needed. Third, we did not control the participants' previous experience with conflict resolution. It is possible that these previous experiences would help them to cope with the situation and, consequently, their psychophysiological response. Therefore, we suggest that this variable be controlled in future studies. In contrast to these weak points, the current study also has some strengths that give value to the results obtained. For example, this type of design is novel in social neuroscience because it uses a real intergroup conflict and rigorous control of both the design and participant selection.

In conclusion, intergroup conflict elicits mood, CV, and endocrine changes, with some differences between men and women. Thus, intergroup conflict is able to induce a stress response in both sexes, influenced by belonging to a group. Taking into account that conflict is present in nearly all the contexts of daily life, our study contributes to delving into the human psychophysiological response to a frequent type of social interaction. In this regard, knowing the most adaptive way of coping with intergroup conflict would help us to prevent the dire consequences of this common social stressor, such as CV, metabolic, or mental illnesses.

Chapter 4:

Risk taking decisions after competition, the effects of testosterone and cortisol changes

Main results of the present chapter have been submitted in Adrián Alacreu-Crespo, Raquel Costa, Diana Abad-Tortosa, Alicia Salvador, Vanesa Hidalgo & Miguel Ángel Serrano Hormonal changes after competition predicts sex-different decision-making. *Journal of behavioral decision making*

1. Introduction

On a daily basis, people make decisions that involve some level of uncertainty with short-term and long-term consequences. These decisions can become maladaptive, thus eliciting harmful risk-taking behaviors (Steinberg, 2008). One of the widely decision-making task used is the *Iowa Gambling Task* (IGT: Bechara, Damasio, Damasio, & Anderson, 1994). In this task individual had to gain as much money as possible by means of choosing among four decks with feedback with a total of 100 trials. It was proposed that IGT has two levels of uncertainty: ambiguous or unable to estimate outcome (first 40 trials) and risky or able to estimate an outcome (from 41 to 100 trials) (Brand, Recknor, Grabenhorst, & Bechara, 2007; Buelow et al., 2013). In the task half of the decks give participants short-term high earnings and long-term loses meanwhile the other two give participants short-term low earnings but long-term gains; then, IGT rewards a conservative decision-making (Bechara et al., 1994).

Thus, IGT assesses decision-making, and it is included in the so-called executive functions, that is, superior cognitive process that implement and guide our behavior (Suchy, 2009). One core area in the control of executive functions and, specifically, of the decision-making under uncertainty, is the prefrontal cortex (H. Damasio et al., 1994; Schiebener & Brand, 2015; Starcke & Brand, 2012). The former is richly connected with other brain structures, being involved in the emotional regulation, feedback sensitivity or long-term memory, contributing to adapt our behavior to external circumstances (Schiebener & Brand, 2015). Furthermore, prefrontal cortex is highly sensitive to endocrine response with high-density receptors for the final products of the hypothalamic-pituitary-adrenal (HPA) axis, cortisol (C), and the hypothalamic-pituitary-gonadal (HPG) axis, testosterone (T) (Ludwig, Roy, & Dwivedi, 2018; Porcelli et al., 2008; Pruessner et al., 2008). Therefore, the circulating levels of these hormones could influence decision-making (see, Apicella, Carré, & Dreber, 2015 for a review in T; Starcke & Brand, 2012 for a review in C).

In this regard, C is usually associated with behavioral inhibition (Dickerson and Kemeny, 2004; Roelofs et al., 2009), whereas T is more related to approach behavior and appetitive motivation (Op De MacKs et al., 2011). The opposing effects of both hormones in behavior, suggest a cross talk between HPA and HPG axes; that is, C can suppresses the activity of HPG axis (Viau, 2002), also suppressing the action of T on target issues and downregulating androgen receptors (Burnstein, Maiorino, Dai, & Cameron, 1995; S. Y. Chen, Wang, Yu, Liu, & Pearce, 1997). These results point to C is able to antagonize the effects of T in behavior. In fact, it has been stated that the interaction between C and T is involved in some relevant social behaviors, such as aggressiveness, competitiveness and risk-taking (Terburg, Morgan, & van Honk, 2009). The study on Mehta et al. (2015) pointed out that basal T was positively related to risk-taking, but only when basal C was low, in agreement with the dual-hormone hypothesis (Mehta & Josephs, 2010). This results were replicated in a recent study in men, showing women the opposite pattern (Barel et al., 2017). Authors explained these results from an evolutionary view, emphasizing men predisposition to engage in high risk behaviors during social interactions such as competitions, compared to women which engage in low risk taking behaviors as an indirect form of cope with these situations (Barel et al., 2017; Shelley E. Taylor, 2006).

In fact, during social interactions, as competition, there are endocrine changes (Salvador & Costa, 2009; Costa, Salvador & Serrano, 2016) that could affect on decision-making processes (Lerner et al., 2015; Schiebener & Brand, 2015; Starcke & Brand, 2012). In this sense, C and T changes may influence subsequent decision making. Specifically, previous literature employing social stressors showed a relationship between C responses and riskier decision-making (Starcke et al., 2008). Furthermore, C administration also increases risk taking (Kluen et al., 2017; Putman et al., 2010). However, this effect of C on risk-taking did not show a unanimous panorama between sexes. In men, most studies showed riskier decisions after stress. But, in women, some studies found that C is not related to decision-making (Daughters, Gorka, Matusiewicz, & Anderson, 2013; Lighthall et al., 2012; Lighthall, Mather, & Gorlick, 2009; van den Bos, Harteveld, & Stoop, 2009), others showed the inverse, that is, C response is related to decreased risk-taking (Ligthall et al., 2009), or even a U-shaped relationship between the C response and risk decisions (van den Bos et al., 2009). Moreover, Smith & Apicella (K. M. Smith & Apicella, 2016) found that neither T changes nor C changes predicted risk-taking behavior after a competitive stressor. Subsequently, it has been demonstrated that C and T changes after a face-to-face negotiation influence economic decision-making; specifically higher T and higher C predicted low earnings and a sensation of conflict (Mehta, Mor, et al., 2015).

Those inconsistencies can be explained as a consequence of the differential procedures carried out to induce stress and to assess risk-taking behavior. For example, competition paradigm, is a relevant context which, from an evolutionary perspective, has been shaped in order to reach status and/or resources, eliciting hormonal changes (Salvador, 2005; Salvador and Costa, 2009). Moreover, decision-making under ambiguous or risky uncertainty are governed by different cognitive mechanism, and the endocrine levels affect differently these processes (Schiebener & Brand, 2015; Starcke & Brand, 2012). Taking into account the relationship between of hormonal responses to stress and subsequent decision-making, our main purpose was to analyze how T changes after competition are explaining the performance in the IGT, in men and women, moderated by C changes, depending on the different degrees of decision-making uncertainty (Ambiguous/Risky). We expected a positive relationship between T changes and risk-taking when C changes were low, following previous literature (Mehta, et al., 2015).

2. Methods and materials

2.1. Participants

The sample was composed of 48 male and 46 female students from different faculties at the University of Valencia (Spain). The participants were preselected from a larger sample (N = 220). The exclusion criteria were: presence of cardiovascular, endocrine, neurological, or psychiatric disease, presence of a stressful life event during the past month, smoking 5 or more cigarettes per day, alcohol or other drug abuse, and practicing physical activity for more than 10 hours *per* week. Moreover, women taking oral contraceptives or did not have a regular menstrual cycle (cycles of 25-35 days) were excluded because their cortisol response to stress is blunted (Rohleder, Wolf, Piel, & Kirschbaum, 2003).

The participants were randomly divided into a Competition group (32 men, 28 women) or a Control group (16 men, 18 women). Six participants were eliminated because it was later detected that they did not meet the inclusion criteria. Thus, 3 men and 3 women were eliminated (two from the Competition group and one from the Control group, in both cases). Thus, the final male sample was composed of: Competition group (N= 30) and Control group (N= 15). The final female sample was composed of: Competition group (N= 26) and Control group (N= 17).

2.2. Study protocol

Participants were selected from different classes to create dyads of the same sex and afterwards were contacted by telephone. It was verified that they did not meet each other before the protocol. Participants were asked to maintain their normal food intake and sleep patterns, avoid doing strenuous physical exercise, and avoid drinking alcohol the day before the experiment. Moreover, they were asked not to take any stimulants, drink alcohol, or smoke two hours prior to the experimental session. When the participants arrived at the laboratory, they were asked whether they had followed the recommendations, they were informed about the general study procedure, and they signed the informed consent approved by the Ethics Research Committee of the University of Valencia. The study was conducted in accordance with the Declaration of Helsinki. Participants were distributed in different rooms, provided a first saliva sample (Pre-task), and completed the standard computerized IGT to assess decision-making (IGT-1).

Later, participants were led to the competition room and seated at the same table face-to-face. Then, participants were exposed to the Competition or the Control task, which lasted 20 minutes. 15 minutes after the end of the task, participants provided another saliva sample (Post-15). Finally, participants moved to individual rooms and completed the inverse computerized IGT (IGT-2); after that, we took the anthropometric measures. One experimenter of the same-sex as the participants conducted the experimental procedure.

2.3. Task

The Competition was based on previous studies (Abad-Tortosa, Alacreu-Crespo, Costa, Salvador, & Serrano, 2017; R. Costa & Salvador, 2012) and consisted of a paper-and-pencil cognitive task characterized by high attention and perception levels, 'the letters squares' (Cordero, Seisdedos, González & De la Cruz, 1990). The participants had to find one repeated letter in a line or column of a matrix as fast as possible and repeat the process on next matrix (see Costa and Salvador, 2012 for more detail). The Competition Group received competitive instructions, performance feedback during the task and an economic reward for the winner. The Control Group was instructed to complete the same task without competitive instructions, performance feedback, neither reward.

2.4. Iowa Gambling Task

A computerized original version of the Iowa Gambling Task (IGT: Bechara, Damasio, Damasio, & Anderson, 1994; Bechara, 2008) was used twice, before and after the competition. The second IGT was the inverse version, in order to minimize the learning effect. This task evaluates decision-making skills under conditions of ambiguity and risk uncertainty. The subjects received the instruction to gain as much money as possible, starting with 2000 €. They had to choose between 4 decks: two disadvantageous decks (Decks A and B) that provided immediate high gains but large future losses (long-term loss), and two advantageous decks (Decks C and D) that provided immediate lower gains but a smaller future loss (long-term gain). Participants completed 100 trials, and the program provided feedback after each trial. The primary dependent variable was the difference between the number of trials if the advantageous decks were chosen minus the number of trials if the disadvantageous decks were chosen (CD – AB), called the IG index, in 5 blocks of 20 trials. The level of uncertainty of decision-making in the first 40 trials is referred to as an ambiguity decision (IG Ambiguous), and the 60 final trials correspond to a risky decision (IG Risky) (Brand et al., 2007; Buelow et al., 2013). Therefore, this IGT correction includes two dimensions: IG Ambiguous, IG Risky.

2.5. Saliva sampling and biochemical analyses

Two saliva samples were collected by means of passive drooling. Participants deposited 5ml of saliva in approximately 5 minutes. The samples were stored at –80 °C until the analyses were performed in the Laboratory of Social Cognitive Neuroscience, Faculty of Psychology (University of Valencia). Then, they were centrifuged at 3000 rpm for 15 min, resulting in a clear supernatant with low viscosity that was analyzed.

Salivary cortisol concentrations were determined in duplicate with the salivary cortisol enzyme-immunoassay kit from Salimetrics (Newmarket, UK). Assay sensitivity was < .007 ug/dL. For each subject, all the samples were analyzed in the same trial. The mean inter- and intra-assay coefficients of variations were all below 10%. Cortisol levels were expressed in nmol/L.

Salivary testosterone concentrations were determined in duplicate using enzyme-immunoassays with the expanded range salivary testosterone enzyme-immunoassay kit from Salimetrics (Suffolk, UK). Assay sensitivity was < 1.0 pg/ml, and the mean inter- and intra-assay coefficients of variation were all below 10%. Testosterone levels were expressed in pg/ml.

2.6. Data reduction and statistical analyses

We calculated outliers, studying whether the subjects were more than 3 standard deviations from the mean using Z scores for Body mass index (BMI), age, and socioeconomic status (SES). Moreover, we measured Mahalanobis distances using the $p <$ .001 criterion with the salivary T and C samples, and IGT, given that repeated measures were calculated for each variable. No outliers were found, but two men (one from the Control group and one from the Competition group) could not provide a large enough saliva sample for the T analyses. Therefore, each variable has a different degree of freedom. Kolmogorov-Smirnoff was used to check the normality of the variables measured. C values did not have a normal distribution and were normalized with the Log10 method. Also, in order to compare T changes in men and women we calculated Z-scores separated by each sex following the recommendations of previous studies (Mehta & Josephs, 2010). Although we used the normalized variables to carry out the analyses, descriptive statistics presented in this paper are raw data. Delta changes (Post15 – Basal) were computed for hormones: ΔT and ΔC

First, previously to moderate regression analyses we performed preliminary analyses on Pearson correlations with the variables used in the following regression analyses. Correlations are presented in Table 1. Second, moderated regression analyses were conducted using mean-centered predictors to calculate the interaction term. Significant and trend interactions were decomposed using simple slopes analyses (Aiken & West, 1991). Moderated regression analyses were used to assess whether ΔT, ΔC and Sex interacted to predict risk-taking after competition in the two levels of IGT ambiguity: IG ambiguous (1 to 40 trials) and IG risky (41 to 100 trials). In step 1, we put pre-competition IG scores (ambiguous or risky depending on the regression) as covariate to control the learning effect. In step 2 we introduced ΔT, ΔC and Sex as a dummy (0 = women, 1 = men). In step 3, we introduced two way interactions ΔT × ΔC, ΔT × Sex, ΔC × Sex. In step 4, we introduced the three-way interaction ΔT × ΔC × Sex. *Post-hoc* were calculated using simple slopes analyses. We performed the same analyses segmenting the sample between Condition (Competition/Control).

The alpha significance level was fixed at 0.05 and the trend level at 0.07. Partial eta squared for the ANOVAs was reported as a measure of effect size. *β-1* was reported as a measure of power. All statistical analyses were performed with the SPSS 20.0.

3. Results

3.1. Preliminary analysis:

Correlation analyses showed that Post-task IG Ambiguous correlated moderately and positively with Pre-task IG Ambiguous ($r = .44$, $p < .001$), Pre-task IG Risky ($r = .53$, $p < .001$), Post-task IG Risky ($r = .21$, $p < .05$) and Age ($r = .26$, $p < .05$). Moreover, Post-task IG Risky correlated negatively with Pre-Task IG Risky ($r = -.27$, $p < .01$). In addition, ΔT correlated positively with ΔC ($r = .48$, $p < .001$).

Table 1: Pearson correlations of variables for regression analyses

	1	2	3	4	5	6	7	8	9
1. IGTAmb pre	–								
2. IGTAmb post	.44***	–							
3. IGTRisk pre	.36***	.53***	–						
4. IGTRisk post	.13	.21*	.38***	–					
5. T changes	.05	-.07	-.27**	-.16	–				
6. C changes	.14	.07	-.13	.01	.48***	–			
7. Age	.19	.26*	.19	.01	.02	.33***	–		
8. BMI	.15	.06	.06	.12	.09	.08	.27**	–	
9. SES	.07	.05	.08	-.08	.08	.07	.12	.10	–

Note: IGTAmb = first 40 trials Iowa gambling score from pre-competition Iowa gambling task, IGTRisk= last 60 trials Iowa gambling score from first Iowa gambling task, Pre = Pre-competition, Post = Post-competition, T = testosterone, C = cortisol, BMI = Body mass index, SES = Socioeconomic status
*** p < .05., ** p < .01., *** p < .001**

3.2. Hormone changes and risk taking:

Moderator regression analyses were performed for IG Ambiguous and IG Risky. ΔT was introduced as dependent variable and ΔC and sex as moderators. No significant results were found for the IG Ambiguous ($p > .05$). There was a significant effect of the ΔT × ΔC × Sex interaction for IG Risky ($\beta = -.80$, CI_{95}: [− 306.50, − 57.15], $r_{partial} = -.31$, $p < .005$; Fig. 1). Simple slopes analyses (Aiken & West, 1991) revealed different associations between sexes. For Men, when ΔC was low (− 1 SD), ΔT was not associated with risky decision-making ($b = 11.98$, $se = 15.39$, $t(79) = .78$, $p < .439$). However, when ΔC was high (+ 1 SD), IG Risky was negatively explained by ΔT ($b = -30.64$, $se = 10.92$, $t(79) = -2.81$, $p < .006$). For Women when ΔC was low (− 1 SD), the relationship between IG Risky and ΔT was not significant ($b = -16.21$, $se = 12.07$, $t(79) = -1.34$, $p < .183$), also, when ΔC was high (+ 1 SD), the ΔT was not related with IG Risk ($b = 30.51$, $se = 18.46$, $t(79) = 1.65$, $p < .102$). These results indicate that, in men, IG risky was negatively related to ΔT, that is, higher ΔT are explaining higher risk-taking during decision-making under risky uncertainty, but only when ΔC was high, whereas no relationship were found between IGT and ΔT in women.

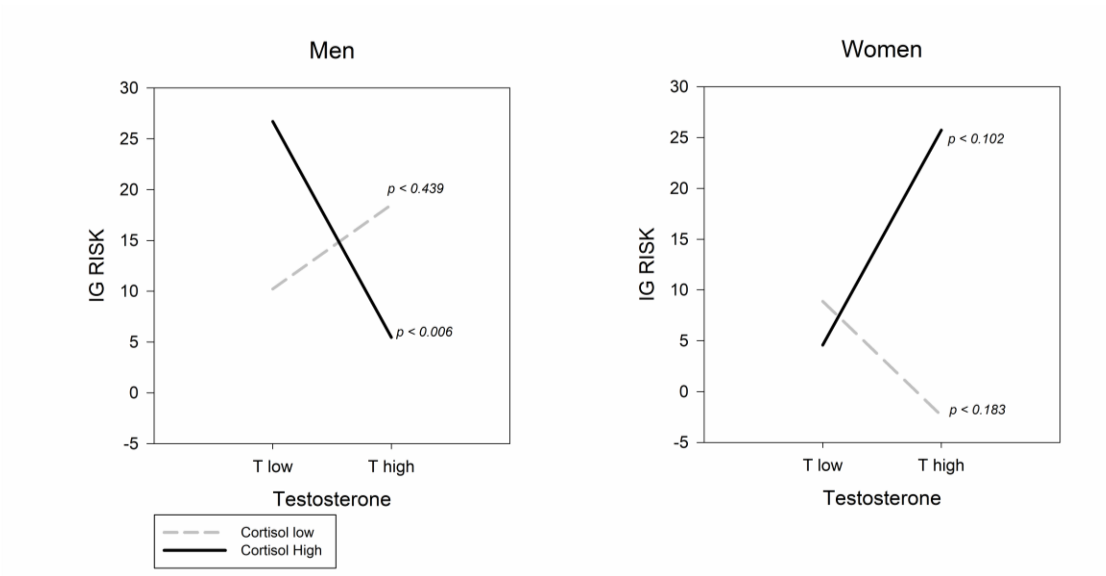


Figure 1: Iowa Gambling Task IG Risky scores as a function of testosterone and cortisol after task, form men and women. Note: Plotted points represent conditional low and high values (± 1 SD) of testosterone and cortisol scores.

3.3. Effect of competition in the hormone changes and risk taking:

In order to analyze the effect of competition on the relationship between IGT and ΔT, we carried out moderator regression analyses with the total sample segmented by condition (Competition/Control).

For Competition group no significant effects were found for the IG Ambiguous. Respect to IG Risky, a significant interaction between ΔT × ΔC × Sex appeared in the Competition group ($\beta = -.89$, CI_{95}: [− 343.70, − 62.24], $r_{partial} = -.39$, $p < .006$; Fig. 2). Simple slopes revealed that, for Men, when ΔC was low (− 1 SD), ΔT was not significantly associated with IG Risky ($b = 13.29$, $se = 15.65$, $t(47) = .85$, $p < .400$). Nevertheless, when ΔC was high (+ 1 SD), a negative relationship between ΔT and IG Risky appeared as a trend ($b = -23.65$, $se = 13.55$, $t(47) = -1.75$, $p < .087$). In the case of Women when ΔC was low (− 1 SD), the relationship between ΔT and IG Risky was not significant ($b = -5.74$, $se = 10.89$, $t(47) = -.53$, $p < .601$). But, when ΔC was high (+ 1 SD), the ΔT was positively related to IG Risk ($b = 55.87$, $se = 24.29$, $t(47) = 2.29$, $p < .026$). These results indicate that, in the competition group, men with high ΔT showed higher risk-taking decision-making during risky uncertainty, only when ΔC was high; whereas in women appeared the contrary relationship, with higher ΔT lower risk-taking decision-making under risky uncertainty, when ΔC was high.

Regressions for Control group showed no significant effects ($p > .05$). Interaction of IG Risky from Control group was plotted in figure 2.

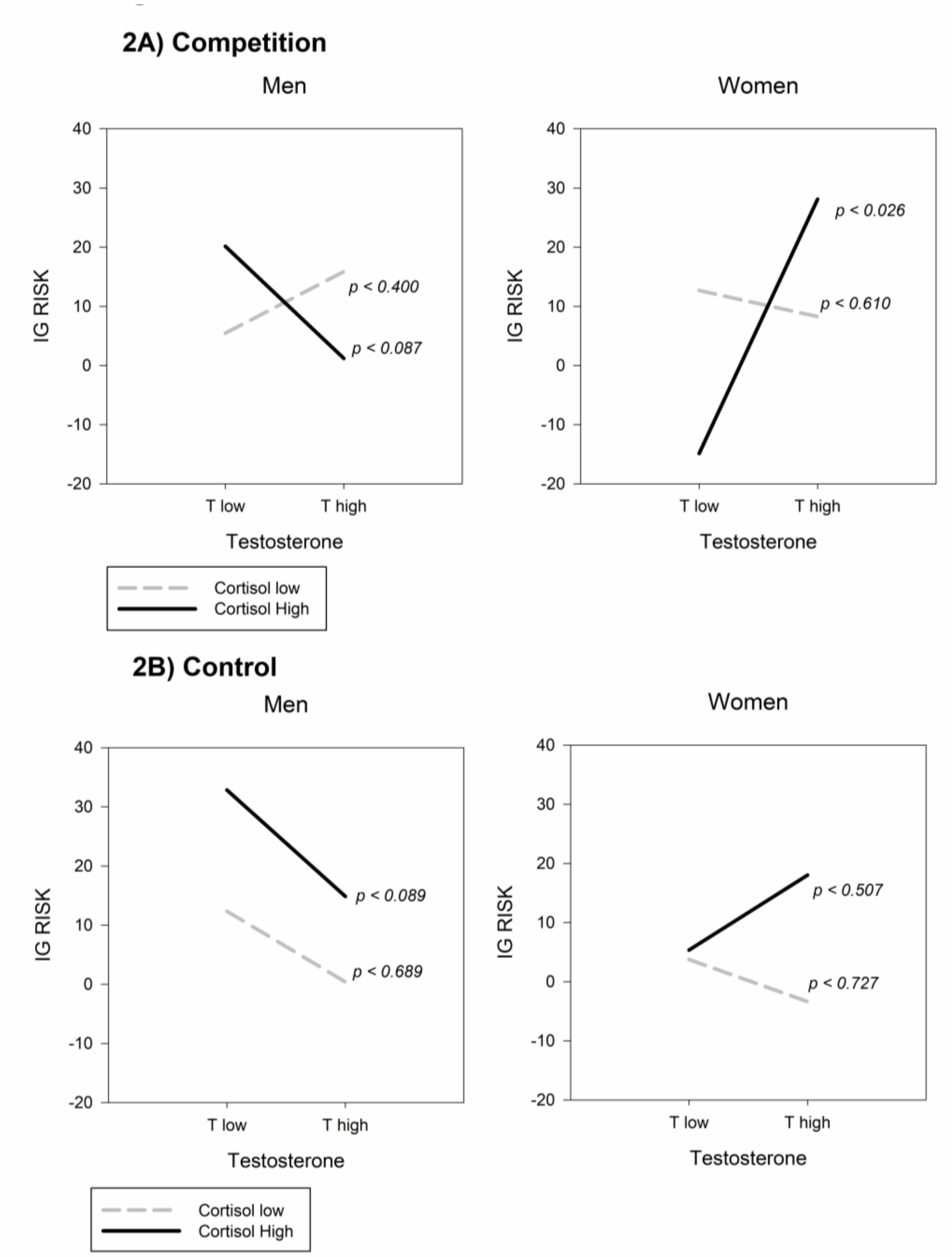


Figure 2: Iowa Gambling Task IG Risky scores as a function of testosterone and cortisol after task, form men and women, segmented by (2A) competition and (2B) control conditions. Note: Plotted points represent conditional low and high values (± 1 SD) of testosterone and cortisol scores.

Table 3: Multiple regression model of Testosterone × Cortisol or Anxiety interaction predicting post-competition IG ambiguous in men, total sample and segmented by condition (Competition/Control)

Total Sample	*B*	*β*	*t* (79)	*p*	$r_{partial}$	95% CI		*B*	*β*	*t* (79)	*p*	$r_{partial}$	95% CI
IG Ambiguous R^2 = .24							***IG Risky R^2 = .28***						
IGT-1 (Ambiguous)	.69	.43	4.27	.001	.43	(.37, 1.01)	IGT-1 (Risky)	.46	.36	3.57	.001	.37	(.19, .72)
Testosterone	-8.75	-.06	-1.63	.108	-.04	(-19.45, 1.95)	Testosterone	-1.28	.13	.79	.431	.09	(-14.85, 12.29)
Cortisol[a]	3.19	.09	.41	.684	.05	(-12.34, 18.72)	Cortisol[a]	13.61	.31	1.52	.134	.17	(-5.73, 32.94)
Sex (Men =1)	-1.25	-.08	-.34	.734	-.04	(-8.53, 6.03)	Sex (Men =1)	6.02	.31	1.31	.194	.15	(-3.12, 15.16)
T × C[b]	-19.02	-.28	-.76	.449	-.13	(-68.74, 30.70)	T × C[b]	2.11	.42	1.84	.070	.20	(-60.46, 64.67)
T × Sex[b]	-11.72	-.27	-1.09	.277	-.12	(-33.07, 9.63)	T × Sex[b]	-16.48	-.29	-1.24	.221	-.14	(-43.05, 10.08)
C × Sex[b]	16.67	.27	1.06	.294	.12	(-14.71, 4.06)	C × Sex[b]	-20.74	-.27	-1.06	.292	-.12	(-59.63, 18.14)
T × C × Sex[b]	60.18	.34	1.19	.236	.13	(-40.05, 160.39)	**T × C × Sex[b]**	-181.83	-.80	-2.90	.005	-.31	(-306.50, - 57.15)
Competition	*B*	*β*	*t* (47)	*p*	$r_{partial}$	95% CI		*B*	*β*	*t* (47)	*p*	$r_{partial}$	95% CI
IG Ambiguous R^2 = .30							***IG Risky R^2 = .41***						
IGT-1 (Ambiguous)	.65	.40	3.63	.007	.47	(.29, 1.01)	IGT-1 (Risky)	.66	.52	4.31	.001	.53	(.35, .97)
Testosterone	-7.91	-.04	-1.17	.248	-.03	(-21.49, 5.68)	Testosterone	8.86	.32	1.06	.295	.24	(-7.96, 25.69)
Cortisol[a]	-9.61	-.39	-.80	.426	-.15	(-33.64, 14.43)	Cortisol[a]	-3.38	-.17	-.24	.811	-.07	(-31.69, 24.92)
Sex (Men =1)	3.33	.13	.70	.486	.06	(-6.21, 12.87)	Sex (Men =1)	2.36	.14	.42	.679	.07	(-9.04, 13.76)
T × C[b]	-12.09	-.30	-.42	.677	-.16	(-70.29, 46.10)	T × C[b]	18.15	.56	.51	.609	.30	(-52.88, 89.18)
T × Sex[b]	-6.04	-.24	-.45	.658	-.12	(-33.31, 21.24)	T × Sex[b]	-30.25	-.33	-1.88	.066	-.17	(-62.57, 2.07)
C × Sex[b]	30.63	.45	1.22	.228	.16	(-19.79, 81.06)	C × Sex[b]	8.58	.22	.29	.772	.09	(-50.71, 67.87)
T × C × Sex[b]	77.13	.44	1.30	.199	.19	(-42.19, 196.46)	**T × C × Sex[b]**	-202.97	-.89	-2.90	.006	-.39	(-343.70, -62.24)

B indicates unstandardized regression coefficients. *β* indicates standardized regression coefficients.

[a] Log-transformed because of non normality

[b] Interaction term computed from mean-centered predictors

4. Discussion

The present study provided new evidence about decision-making after social competitive stress. As predicted, C changes after task were a moderator variable in the relationship between T changes and decision-making. This relationship was different in men and women. On one hand, in men joining both conditions, the higher T changes the riskier decision-making, only in the high C changes group. However, when moderator analyses were carried out separately for competition and control groups, only competition group showed an almost significant relationship. On the other hand, women in competition group, the higher T changes after the competition, the more conservative decision-making, but only the group with higher C changes. It is worth noting that these results appear in the 60 final trials of IGT, were uncertainty was risky but not in the 40 first trials, were uncertainty was ambiguous.

Literature on risk taking behavior has found that there is a relationship between basal T and higher risk in decision-making, but only when basal C is low (Mehta, Welker, et al., 2015). This approach is based on the dual-hormone and triple imbalance hypotheses (Mehta & Josephs, 2010; Terburg et al., 2009). In this regard, T boosts reward sensitivity (Mehta, Snyder, Knight, & Lassetter, 2015) and approach behavior and appetitive motivation (Op De MacKs et al., 2011), whereas C is associated with behavioral inhibition (Dickerson and Kemeny, 2004; Roelofs et al., 2009). Thus, it has been suggested that higher basal T levels may induce reward-seeking and more risk-taking behaviors when C is not inhibiting these behaviors (Mehta, Welker, et al., 2015). Besides, we have studied the hormonal changes to competition or control task, as Metha, Mor et al. (2005) recommended, because it has been hypothesized that situational hormonal modification would be related to short-term decisions and that hormones can shape daily choices and decisions that significantly impact long-term outcomes (Stanton, 2017). Surprisingly, our data suggest the opposite relationship with C changes; showing a relationship between T and decision-making only in participants with higher C changes after competition. These paradoxical results could be explained by the moment hormones were measured (before or after stressor) and the condition. Past research using the dual-hormone hypothesis usually investigates basal C and T levels to predict risk taking (Barel et al., 2017; Mehta, Welker, et al., 2015). By contra, based on Metha, Mor et al. (2015) our aim was to test whether C and T, after competition, could influence the posterior decision-making.

In this regard, literature has shown contradictory results about the relationship between risk-taking behavior and C response to stress. For example, a linear relationship has been described (Cano-López, Cano-López, Hidalgo, & González-Bono, 2017), a reverse U-shaped relationship (van den Bos et al., 2009), and even no relationship between risk attitudes and C (Sokol-Hessner, Raio, Gottesman, Lackovic, & Phelps, 2016; Starcke & Brand, 2016). Then, although contradictory results, this previous research showed that, paradoxically, C responses could have a behavioral facilitation effect, regardless the inhibition effect.

Our results showed that men with higher C changes after competition could have a facilitator effect on risk-taking behavior when ΔT was higher too. It is worth noting that the IGT task instructions were to “win as much money as possible”, therefore the optimal strategy in the IGT is to pick the decks that give low economic reward but long-term smaller losers in order to win much money. Our results indicate that men with high T changes pick from the disadvantageous decks, that is, those that primary give higher economic reward but greater long-term loses, in the second part of the task, when a previous learning should drive them to pick the other decks. Besides, this relationship appears only in men with higher C changes. In the same line that our results, high T has been previously related to a decreased aversion to risk (Carney & Mason, 2010). Also, administration of both C and T increases the risk-taking behavior in financial decision-making (Cueva et al., 2015). However, although other investigations have demonstrated that there is a positive relationship between T and maximization of monetary rewards (Apicella et al., 2008; Coates & Herbert, 2008), it is possible that men with higher C and T had less risk aversion and reward maximization inducing an economic risk-taking behavior.

On the other hand, women showed a different panorama. Only after competition, women with higher T changes showed a more conservative decision-making, when C changes were also high. This result agrees with previous literature that described more risk aversion in women than in men (Byrnes, Miller, & Schafer, 1999) or a linear negative relation between basal T levels and risk-aversion (Sapienza, Zingales, & Maestripieri, 2009). Thus, increases in both T and C, enhanced the propensity to earn less money in an economical negotiation in order to maintain an harmonious relation (Mehta, Mor, et al., 2015) and also increased the concern over the negative consequences of the negotiation. Thus, our result showed, in women, more conservative financial choices (less-earnings at short term decks) in the IGT after a competition, Moreover, another explanation to these results are that IGT is a complex task where feedback and learning are crucial (a Bechara et al., 1994). Thus, T favored implicit learning and memory (Bos, Panksepp, Bluthé, & Honk, 2012), and these effects would be associated with short-term neuroplasticity induced by T (Losecaat, Riečanský, & Eisenegger, 2016). In this sense, our results pointed out that T and C changes after competition induced an adaptive flexibility to feedback, at least in women.

Sex-differences found in our study could be due to the social nature from the task. On one hand, the results of men (higher risk-taking due to the increments in both T and C) appeared in both conditions (competition and control). On the other hand, the conservative behavior of women, due to the same changes in hormones, appeared only in the competition condition. Probably, for men, both tasks were considered as a threat for their status. In this sense, Taylor suggested that men are more prone to enter in a "*fight or flight*" behavior during a threatening situation while women would prefer use a "*trend-and-*

befriend" behavior (Shelley E. Taylor, 2006; Shelley E. Taylor et al., 2000). For that, higher T changes in men are more likely to induce a riskier behavior, as for example compete again although their loss in a previous competition (Mehta & Josephs, 2010). Also, the potential effects of C changes in the economical risk-taking would increase this risk behavior on the IGT. However, it is possible that women would interpret only the competitive situation as threatening. Also, women's interpretation of a competitive stressor and their psychobiological responses are slightly different, leading to different cognitive performance after competition (Costa, Salvador & Serrano, 2016). Then, in women, higher in T and C changes after competition would induce a more conservative behavior to maintain a positive social context.

Finally, it is important to note that our results were found in the 60 final IGT trials, when the degree of uncertainty is considered risky. In that degree of uncertainty in decision-making participants had learned the rules of the IGT then are more capable to predict the probabilities to obtain a positive or a negative outcome in their decision (Brand et al., 2007; Buelow et al., 2013). Under this degree of uncertainty, decisions are easier made using an analytical-mathematical approach that requires higher resources from the executive functions as working memory, planning or categorization process (Brand et al., 2006; Schiebener & Brand, 2015). But sometimes, these processes switch to a more intuitive and biased processes in the decision-making (Todd & Gigerenzer, 2000). Then, it is possible that in our study men were more vulnerable to this bias induced by the endocrine responses that lead them not to learn properly in our decision context.

Future research with larger samples is needed on this topic to corroborate our results. We recommend taking into account sex when analyzing the endocrine effects on decision-making because of the differential results found by sex. Moreover, it is important to consider the type of task used to induce stress before the decision-making tasks. Another type of stressor, such as the Trier Social Stress Task or a mental arithmetic task, could induce other effects on IGT (Starcke & Brand, 2012, Singer et al., 2017). The decision behavior after a competitive paradigm could be different from these other stress tasks because, in competition, variables such as dominance, social interaction, or the outcome of the competition are involved (Salvador and Costa, 2009).

In conclusion, our investigation points out that men and women have differently decision-making behavior depending on the endocrine changes. Men are more prone to risk-taking behavior when C and T are higher, while women are more prone to conservative decision-making after competition. This study increases the knowledge in the social neuroendocrinology field, showing that the social nature of the competitive task and the financial nature of the decision-making are influenced by hormones differently in men and women.

Chapter 5:

The decision making as a factor to copes with competitive social interactions

Main results of the present chapter have been published in Adrián Alacreu-Crespo, Raquel Costa, Diana Abad-Tortosa, Alicia Salvador & Miguel Ángel Serrano (2018) Good decision-making is associated with an adaptive cardiovascular response to social competitive stress, Stress, DOI: 10.1080/10253890.2018.1483329

1. Introduction

Researchers have investigated the effects of stress on subsequent decision-making, finding deleterious or beneficial effects depending on the characteristics of the task and the situation (Starcke & Brand, 2012). However, little is known about how decision-making skills affect stress responses. Good performance on executive function (EF) tasks, such as decision-making, could be a resilience factor in coping with stress (Thayer & Lane, 2009; Williams, Suchy, & Rau, 2009). Decision-making is a complex cognitive function that involves learning processes, previous experience, and sensitivity to feedback (Bechara, 2004). The Iowa Gambling Task (IGT) is one of the most widely used computerized tasks to assess decision-making (Bechara, Damasio, Damasio, & Anderson, 1994; Bechara, 2004). People have to choose among four decks that give a virtual monetary reward or punishment. Two decks have disadvantageous consequences (short-term high gains, but greater long-term punishment), whereas the other two have favorable consequences (with low gains, but smaller long-term losses), thus rewarding conservative decision-making. To our knowledge, only one study (Santos-Ruiz et al., 2012) investigated the effect of decision-making on coping with a social stress situation. These authors divided participants into good or poor decision makers depending on their performance on the IGT. They found that good IGT performers displayed lower cortisol increases in response to social stress than poor performers; that is, the better the decision-making skills, the more adaptive the physiological stress response (Santos-Ruiz et al., 2012).

Therefore, stress and decision-making would have a reciprocal relationship. In this regard, competition is a real-life social stressor that elicits psychobiological responses (Salvador and Costa, 2009). In their Coping Competition Model, Salvador and Costa (2009) pointed out that psychobiological responses to competition can be best explained as part of a coping response. Thus, a core factor of competition is appraisal, which begins before competition and is influenced by distant factors such as previous experience or generic abilities (eg. cognitive, psychomotor, or social skills). In this context, decision-making can be considered a distal variable, and good performance on the IGT has been found to depend on the capacity to use contextual feedback and act in consequence, adapting the choices (Brand et al., 2006). Therefore, good decision-making is a personal resource that would help people to cope adaptively with stress situations (Bechara, Damasio, & Damasio, 2000; Santos-Ruiz et al., 2012).

A balanced autonomic reactivity (high Sympathetic nervous system -SNS- activity and low Parasympathetic nervous system -PNS- tone) and quick recovery to previous levels have been considered an adaptive physiological response to stress (Thayer & Lane, 2009; Williams et al., 2009). It is worth noting that impaired EF, including decision-making, are related to smaller increases in heart rate (HR) under stress and slower recovery after stress (Lin et al., 2014; Roiland et al., 2015). In fact, HR is partially controlled by the same brain region as decision-making, the pre-frontal cortex (Starcke & Brand, 2012). According to the neurovisceral integration model, heart rate variability (HRV) could be a good measure of cognitive regulation under stress (Thayer, Ahs, Fredrikson, Sollers, & Wager, 2012). Particularly, High frequency (HF) HRV (an index of respiratory sinus arrhythmia) is considered a marker of good self-control (Duschek, Wörsching, & Reyes del Paso, 2013; Thayer & Lane, 2009; Zahn et al., 2016), whereas reduced levels of Low frequency (LF, an index of barorreflex function) would be a marker of mental load (Mukherjee, Yadav, Yung, Zajdel, & Oken, 2011). Finally, higher levels of the sum of the three HRV band frequencies (HRV_{tot}) are related to greater autonomous nervous system (ANS) flexibility in modulating cardiac activity during changing situations (Thayer, Hansen, Saus-Rose, & Johnsen, 2009). Therefore, good decision-making skills would imply a better cardiovascular balance during stress and quick recovery after the stressful situation (Williams et al., 2009). In laboratory competitive situations, using 'the letters squares' task or social group negotiations, these cardiovascular patterns for competition were found in both sexes; winners showed increases in heart rate (HR) and Systolic Blood Pressure (SBP) from basal levels during the task and faster recovery, whereas losers had decreases or smaller increases in HR and SBP (R. Costa & Salvador, 2012; Ricarte et al., 2001). More specifically, similar patterns were found, with a predominance of SNS (increases in electrodermal activity) and PNS withdrawal (HF reduction) during a laboratory competition, and a quicker recovery in winners than in losers and control groups (Abad-Tortosa et al., 2017).

Our main objective was to analyze how decision-making skills (assessed with IGT) influence the subjective and cardiovascular response to a laboratory competition; 'the letters squares' task. We hypothesized that: (a) decision-making skills would modulate the subjective assessment of competition; and (b) good decision-makers would show higher HRV_{tot} during the competition (Santos-Ruiz et al., 2012; Williams et al., 2009), with a higher SNS response during competition and faster recovery with PNS dominance after competition.

2. Material and methods

2.1 Participants

The total sample was composed of 116 university students (Women: N = 44) from different departments at the University of Valencia and University Miguel Hernandez (Spain). These participants were screened from a larger (n=220) sample of volunteers, using a questionnaire that included the following exclusion criteria: having cardiovascular, endocrine, neurological or psychiatric disease; smoking 5 or more cigarettes per day; consuming drugs; doing more than 10 hours of physical exercise per week; or experiencing a stressful life event in the past month. Selected participants were asked to maintain their normal food intake and sleep patterns and avoid strenuous physical exercise and drinking alcohol 24 hours before the experiment. Moreover, they were instructed to avoid stimulant beverages or smoking two hours before the experimental session.

The 116 participants were randomly distributed into two groups: Competition group (N = 86; 43 couples) and Control group (N = 30; 15 couples). Additionally, the Competition group was divided into winners and losers, depending on the outcome obtained on the task: Winners (N = 43; 29 men, 14 women; age, Mean ± Standard Error of the Mean (SEM) = 21.92 ± 0.48 years), Losers (N = 43; 29 men, 14 women; age, Mean ± SEM = 21.61 ± 0.46 years), and Controls (N = 30; 14 men, 16 women; age, Mean ± SEM = 21.45 ± 0.56 years). From this sample, four men (one from the Control group and three from Winners) were eliminated due to ECG irregularities. Thus, the final sample was composed of 112 participants. Previously, all the participants had performed the IGT, whose outcome was used as a criterion to additionally differentiate between Good and Poor Deciders, as explained below.

The study was approved by the Ethics Research Committee of the University of Valencia in accordance with the ethical standards of the 1964 Declaration of Helsinki.

2.2 Procedure

All sessions were carried out between 15:30 pm and 20:00 pm, and procedures (Figure 1) lasted 1 hour and 30 minutes. Participants arrived at the laboratory in same-sex dyads and were placed in different rooms where the experimenter explained the general procedure (without referring to competition) before the participants signed the informed consent. Weight and height were measured, and participants were instructed to put on an HR monitor. Next, participants rested for 10 minutes in order to become habituated to the situation (Baseline). Then, they performed the standard computerized IGT (Bechara et al., 1994; Bechara, 2008) to assess whether they were good or poor decision-makers.

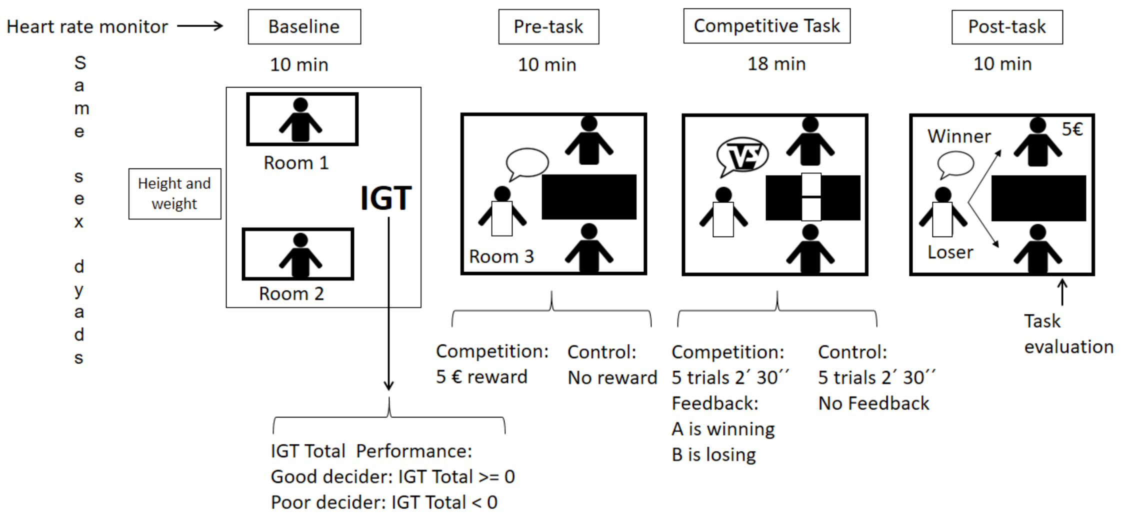


Figure 1: Summary of the study protocol.

After performing the IGT, participants moved to the interaction room, where the competitive/control task took place, and a same-sex experimenter invited them to sit face-to-face at a table. Then, the experimenter read the competitive/control task instructions. For the competition group, the instructions emphasized that they were going to compete for an economic reward. In the case of the control group, the task was merely explained, without mentioning competition or rewards. Instructions were read in order to maintain the same experimental condition. This period lasted approximately 10 minutes.

Next, participants performed the paper-and-pencil task for approximately 18 minutes (Task). Finally, participants waited 10 minutes (Post-task). During this period, they all answered questions about the competitive/control task, and the women answered some questions about the characteristics of their menstrual cycles.

2.3 Decision-making skills

To measure decision-making skills, we used the standard version of the Iowa Gambling Task (IGT: Bechara et al., 1994; Bechara 2008). This computerized task simulates the usual components of daily decision-making under conditions of uncertainty and risk. The participants received the instruction to win as much money as possible starting from 2000 € of virtual money. They had to choose between four decks. Decks A and B are disadvantageous because they provide immediate high gains but great future losses (long-term loss). The other two decks (Decks C and D) are advantageous because they provide immediate smaller gains, but smaller future losses (long-term gain). Participants had to choose 100 times, and after each pick, the computer showed feedback, that is, the amount of money earned or lost. The result of the IGT was the IG index, assessed using the number of advantageous decks selected minus the number of disadvantageous decks selected (CD – AB), in blocks of 20 trials. Total IG values (100 trials) greater than zero imply a predominance of advantageous decisions (good decider), whereas negative values are related to disadvantageous decisions (poor decider). Thus, the IG values were computed, and participants were assigned to Good decider or Poor decider groups based on their performance on the IGT. If they had a total IG value equal to or greater than 0, they were assigned to the Good deciders group, and if they had a total IG below 0, they were assigned to the Poor deciders group (Santos-Ruiz et al., 2012). Participants were not aware of this distribution.

2.4 Competitive/control task

The competitive task was 'the letters squares' task (Cordero, Seisdedos, González & De la Cruz, 1990), a paper-and-pencil cognitive task that measures perception and attention. Each participant received 90 matrixes of 16 letters (4 x 4) and another page of 50 matrixes if necessary. Participants had to find the repeated letter in a line or column.

The original task was modified by dividing it into five trials lasting 2.5 minutes each (R. Costa & Salvador, 2012). In order to increase competitiveness, the competition group was informed that they were going to compete for a prize consisting of 5 € of real money for the winner (the higher accumulated matrix score). After each competition trial, the experimenter who corrected the schedules gave feedback about who was winning and who was losing. The feedback sentences were standardized for all participants ('A is winning, go on; B is losing, try harder, you can win). At the end, the experimenter informed them about their total scores and gave the economic reward to the winner. Therefore, in each dyad, the winner performed better than the loser.

The control group (also participating in dyads) was instructed to complete the task with the same instructions as the competition group, but without referring to competition (the word competition was changed to task). Participants were not informed about an economic reward and did not receive any feedback after each trial; moreover, they had no knowledge about the performance of the other person.

The assignment to the Competitive or Control group was random.

2.5 Competitive/control task evaluation

After the interaction, participants completed a 5-item scale to characterize the competitive task. They rated perceived effort, frustration, performance, stress, and difficulty on a Likert scale (0 – 100), based on previous studies (Carrillo et al., 2001; R. Costa & Salvador, 2012). In the control group, the word “competition” was replaced by “task”.

2.6 Cardiovascular measures

Cardiovascular levels were recorded with the Polar©RS800cx watch (Polar CIC, USA), which consists of a chest belt for the detection and transmission of heartbeats and a Polar watch for data storage (sampling frequency of R-R intervals of 1000 Hz), previously validated (Williams et al., 2016). Data were analyzed using the HRV software Kubios Analysis (Biomedical Signal Analysis Group, University of Kuopio, Finland; Tarvainen, Niskanen, Lipponen, Ranta-Aho, & Karjalainen, 2014). Means were analyzed every 5 minutes from Baseline, Task, and Post-Task, following the recommendations of the Task Force (1996), from the middle of the recorded periods. Automatic Kubios artefacts were fixed with the appropriate degree of correction. Scores from missing values were computed with the method of row and column means when the participant had only one missing period (20% of the total).

We computed the R–R interval (ms) time series. Power spectral analyses of HRV were calculated by means of Fast Fourier Transformation (FFT) using Kubios to extract frequency domain measures. Spectral power density was expressed in absolute units (ms^2/hz). We computed the High frequency (HF) band (between 0.15 to 0.40 Hz), which reflects respiratory sinus arrhythmia (RSA) and can be used as an index of parasympathetic control; the Low frequency (LF) band (between 0.04 to 0.15 Hz.), which is an index of the baroreflex function and can be interpreted as both sympathetic and parasympathetic control (Berntson et al., 2007); and the Very low frequency (VLF) band (between 0.003 to 0.04 Hz.). The total HRV power (HRV_{tot}) was assessed with the sum of the frequency bands (Liao, Carnethon, Evans, Cascio, & Heiss, 2002; Svensson et al., 2016). In order to highlight the effects of HF, we calculated the normalized units on this band. Previous studies criticize the use of normalized units because, in the estimation of these indexes, only LF and HF are used in the denominator (Reyes del Paso et al. 2013), and they recommend including VLF in the estimation of these indexes (HF/HRV). Finally, we calculated the hertz where HF were collected (HF_{hz}), which is an index of the respiratory rate. However, following some authors' suggestions (Denver et al., 2007), the respiratory rate was not controlled in the computation of the HRV variables.

2.7 Data reduction and statistical analyses

We calculated outliers using the 3 standard deviations method for variables measured one time and the Mahalanobis distances method $p < 0.001$ criterion for variables measured two or more times. No outliers were found. Kolmogorov-Smirnoff was used to check normality. HRV_{tot}, VLF, LF, HF, HF_{hz}, perceived effort, frustration, performance, stress, and difficulty did not have normal distributions and were normalized with the Log10 method (Field, 2009).

Participants randomly performed the competition or control task. The Competition group was divided into Winners or Losers depending on their performance on the competitive task. Additionally, using the total IGT scores, participants were distributed into Good decision-makers (0 or positive total IG) and Poor decision-makers (negative total IG) during the data analysis process, based on Santos-Ruiz et al. (2012). Preliminary analyses were performed to check the homogeneity of the groups. We performed three-way ANOVAs with `Outcome´, `Decision´, and `Sex´ as independent variables, and BMI and Baseline HRV as dependent variables. Chi-square analyses of `Outcome´ (Winners/Losers/Control) and `Sex´ (Men/Women) and `Decision´ (Good/Poor) were performed. Moreover, ANOVAs were performed with the 'menstrual cycle phase' classification (Yildirir, Kabakci, Akgul, Tokgozoglu, & Oto, 2002).

To identify the psychological evaluation of the task depending on the decision-making skills, we carried out one-way ANOVAs, with `Decision´ as the independent variable and the task evaluation variables as dependent variables. In order to study whether decision-making skills were related to the outcome, chi-square analyses were conducted with `Outcome´ and `Decision´. Moreover, Pearson correlations were carried out with total IG and the performance on the 'letters squares' test.

Next, we calculated the Reactivity (Task – Baseline) and Recovery (Post-task – Task) indexes for the HRV variables. A two-way ANCOVA was performed, with `Outcome´ and `Decision´ as independent factors, using BMI as covariate and these indexes (Reactivity and Recovery) as dependent variables. *Post hoc* tests were performed with simple contrasts using the Bonferroni correction. We only present the results when the `Decision´ factor or the `Decision × Outcome´ interaction was significant.

The alpha significance level was fixed at 0.05. Partial eta squared for ANCOVAs was reported as a measure of effect size. *β-1* was reported as a measure of power. All statistical analyses were performed with the SPSS 20.0.

3. Results

3.1 Preliminary analyses

Participants were distributed into groups depending on their IGT performance (good or poor deciders) and the outcome of the competition (winners, losers, and control). The number of participants in each condition was the following: Good decision-makers (N = 61; Winners = 22, Losers = 21 and Control = 18) and Poor decision-makers (N = 51; Winners = 18, Losers = 22 and Control = 11).

No significant differences were found in the number of men and women based on the `Outcome´ ($X^2 = 4.19$, $p < 0.12$) and `Decision´ ($X^2 = 0.00$, $p < 0.99$) factors. Furthermore, the menstrual cycle phase was not significant (*p´s* >.05), and age did not correlate significantly with the HRV variables (*p´s* > .05).

The three-way ANOVA with `Outcome´, `Decision´, and `Sex´ as independent factors did not show significant effects of the `Decision´ and `Outcome´ factors (*p´s* > 0.05). Only the `Sex´ factor showed significant effects for BMI ($F_{1, 99} = 9.47$, $p < 0.01$, $\eta^2_p = .071$, *power* = .86), Baseline R-R ($F_{1, 99} = 7.91$, $p < 0.01$, $\eta^2_p = .074$, *power* = .79), Baseline LF ($F_{1, 99} = 5.06$, $p < 0.03$, $\eta^2_p = .049$, *power* = .61), and Baseline HF/HRV ($F_{1, 99} = 4.49$, $p < 0.04$, $\eta^2_p = .044$, *power* = .56). Men had higher BMIs (Mean ± SEM: Men = 24.38 ± 0.42 kg/m^2 *vs* Women = 22.32 ± 0.52 kg/m^2), Baseline R-R (Mean ± SEM: Men = 861.41 ± 15.69 *vs* Women = 790.83 ± 19.58), and Baseline LF (Mean ± SEM: Men = 2153.99 ± 153.93 *vs* Women = 1493.06 ± 192.04), but lower Baseline HF/HRV, than women (Mean ± SEM: Men = .300 ± .019 *vs* Women = .364 ± .024).

We included BMI as covariate in the subsequent analyses.

Table 1: Mean ± SEM of Total IG, Number of participants (N=), BMI, basal HRV indexes, IGT, Total `Square letters´ scores and Task perception of participants by Decision (Good/Poor) and Outcome (Winners/Losers/Control).

Variable	Good Deciders				Poor Deciders			
Outcome	**Winners**	**Losers**	**Control**	**Total**	**Winners**	**Losers**	**Control**	**Total**
Participants	N = 22	N = 21	N = 18	N = 61	N = 18	N = 22	N = 11	N = 51
Preliminary								
BMI (Kg/m)	23.7 ± .67	24.5 ± .74	23.2 ± .79	23.8 ± .42	23.5 ± .77	23.0 ± .68	23.7 ± 1.1	23.4 ± .49
R-R interval basal	820.9 ± 26.6	847.1 ± 27.2	814.7 ± 29.4	827.5 ± 16.0	865.3 ± 29.4	876.2 ± 27.2	803.6 ± 37.6	848.4 ± 18.3
HRV_{tot} basal	3054.8 ± 449.9	3619.5 ± 449.9	2750.8 ± 485.9	3141.7 ± 266.9	3837.6 ± 485.9	3536.9 ± 449.9	3017.2 ± 621.6	3463.9 ± 302.7
VLF basal	181.4 ± 77.4	399.7 ± 77.4	243.4 ± 83.6	274.8 ± 45.9	307.9 ± 83.6	296.8 ± 77.4	219.1 ± 106.9	274.6 ± 52.1
LF basal	1824.6 ± 258.9	2111.9 ± 265.1	1326.8 ± 286.3	1754.4 ± 156.1	2253.0 ± 286.3	1912.7 ± 265.1	1842.5 ± 366.3	2002.7 ± 178.4
HF basal	985.5 ± 206.0	1107.9 ± 210.8	1180.7 ± 227.7	1091.3 ± 124.2	1276.7 ± 227.7	1327.4 ± 210.8	955.6 ± 291.3	1186.6 ± 141.9
HF/HRV_{tot} basal	.339 ± .033	.303 ± .033	.389 ± .036	.344 ± .020	.338 ± .036	.348 ± .033	.301 ± .046	.329 ± .022
HF_{hz} basal	.221 ± .015	.206 ± .015	.253 ± .016	.227 ± .009	.208 ± .016	.237 ± .015	.237 ± .021	.227 ± .010
Execution								
Total IG *	17.3 ± 2.7	18.1 ± 2.8	13.3 ± 3.0	**16.4 ± 1.8**	- 15.8 ± 3.0	- 16.1 ± 2.7	- 10.9 ± 3.9	**- 14.9 ± 1.5**
`Square letters test´	82.4 ± 2.9	60.1 ± 3.0	73.6 ± 3.3	72.1 ± 2.2	85.9 ± 3.3	69.4 ± 2.9	67.6 ± 4.2	74.8 ± 2.1
Task perception								
Perceived Effort *	73.6 ± 3.5	70.5 ± 3.5	64.6 ± 4.5	**70.4 ± 2.1**	62.2 ± 3.8	60.0 ± 3.5	60.0 ± 6.1	**60.9 ± 2.5**
Perceived Frustration	36.9 ± 5.4	56.2 ± 5.5	37.7 ± 6.9	44.3 ± 3.5	38.5 ± 5.9	49.6 ± 5.4	35.7 ± 9.5	43.3 ± 3.8
Perceived Performance	77.7 ± 3.4	51.4 ± 3.5	69.2 ± 4.5	65.9 ± 2.6	82.2 ± 3.8	55.5 ± 3.4	64.3 ± 6.1	67.2 ± 2.9
Perceived Stress	62.7 ± 4.9	55.2 ± 5.0	42.3 ± 6.4	55.2 ± 3.2	58.4 ± 5.4	56.9 ± 4.9	60.0 ± 8.7	57.9 ± 3.3
Perceived Difficulty	52.7 ± 4.2	51.0 ± 4.3	52.3 ± 5.5	51.9 ± 2.8	53.9 ± 4.7	52.7 ± 4.2	54.3 ± 7.5	53.4 ± 2.6

Note: * $p < 0.05$ for Decision factor (Between Good and Poor Deciders, regardless of outcome)

3.2 Decision-making skills and task evaluation

Regarding the evaluation of the task, Good and Poor decision-makers only showed significant differences in Perceived effort ($F_{1, 101} = 6.54$, $p < 0.01$, $\eta^2_p = 0.062$, *power* = 0.72). Good decision-makers perceived higher effort than Poor decision-makers. Mean ± SEM for the psychological variables are presented in Table 1.

Regarding the proportion of Good or Poor decision-makers in the `Outcome´ factor, the result was not significant ($X^2 = 4.19$, $p = 0.12$). Moreover, no significant correlations were found between Total IG and the performance on the 'square letters' test (p´s > .05).

3.3 Decision-making skills and HRV responses

3.3.1 R–R interval:

For the R–R interval Reactivity and Recovery indexes, neither `Decision´ nor 'Decision × Outcome' showed significant differences or interactions (p´s > 0.05; Fig. 2A).

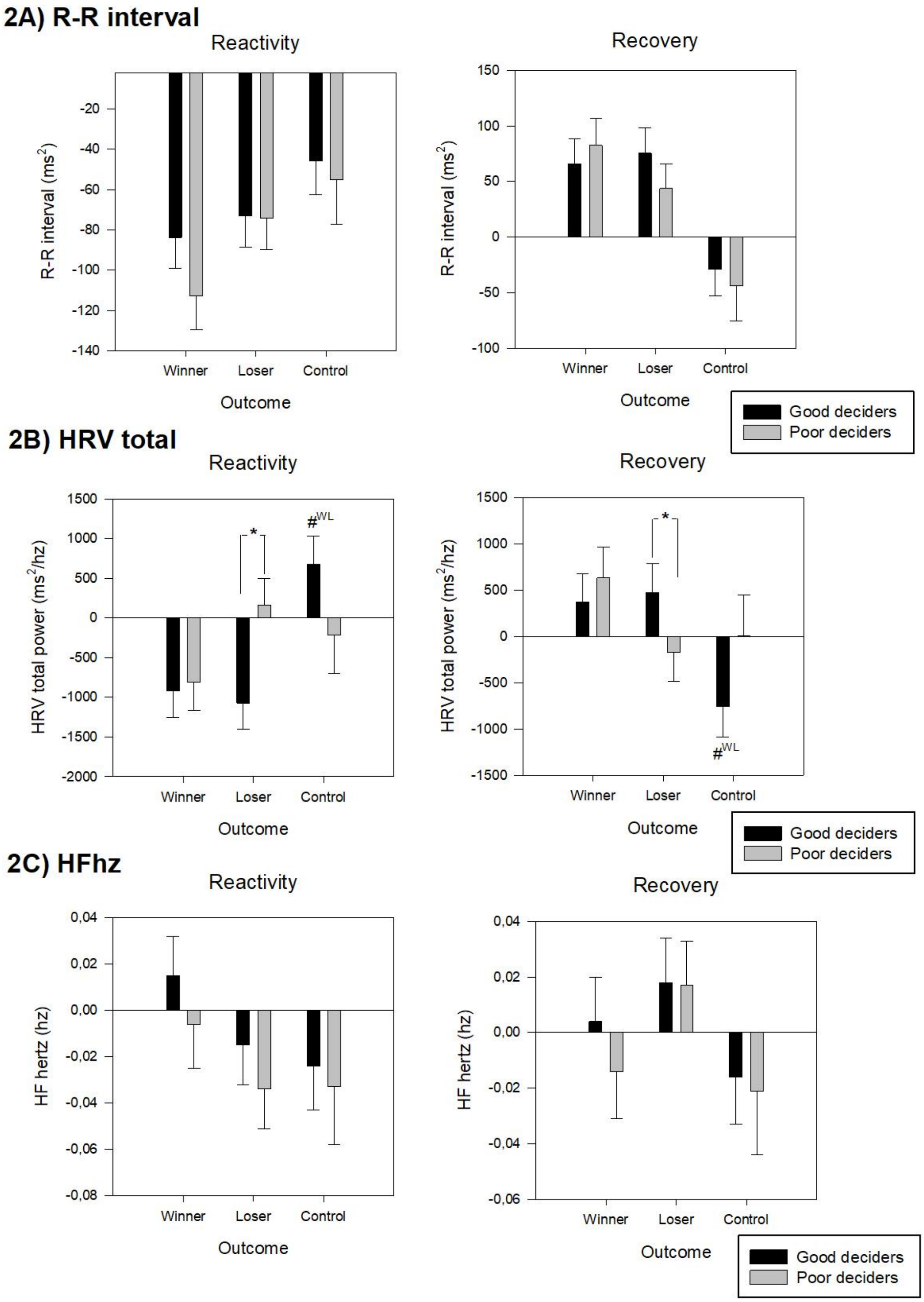


Figure 2: 2A) Means ± SEM of R−R interval reactivity (Task - Baseline) and recovery (Recovery - Task) indexes of Good decision-makers and Poor decision-makers separated by Outcome (Winners/Losers/Control), covariate of BMI (23.40). 2B) Means ± SEM of the total power of heart rate variability reactivity (Task - Baseline) and recovery (Recovery - Task) indexes of Good decision-makers and Poor decision-makers separated by Outcome (Winners/Losers/Control), covariate of BMI (23.40). 2C) Means ± SEM of high frequency band hertz reactivity (Task - Baseline) and recovery (Recovery - Task) indexes of Good decision-makers and Poor decision-makers separated by Outcome (Winners/Losers/Control), covariate of BMI (23.40). * (p <0.05) showed *Post-hoc* significant effects of the Decision × Outcome interaction, between good or poor-deciders in the indicated Outcome group. ♯ (p <0.05) showed *Post-hoc* significant effects of the Decision × Outcome interaction, between the indicated Outcome group (W = Winners, L = Losers) and Controls for the indicated Decision group.

3.3.2 Total Heart Rate Variability Spectrum:

For the HRV_{tot} Reactivity index, we found a significant `Decision × Outcome´ interaction ($F_{2, 102} = 3.28$, $p < 0.04$, $\eta^2_p = 0.060$, *power* = 0.61; Fig. 2B). *Post-hoc* comparisons showed differences between losers; good-deciders who lost the competition had lower HRV_{tot} Reactivity than poor-deciders who lost ($F_{2, 102} = 5.55$, $p < 0.02$, η^2_p = 0.052, *power* = 0.65). Moreover, good-deciders who competed (Winners and Losers) had lower HRV_{tot} Reactivity than Control group good-deciders ($F_{2, 102} = 5.84$, $p < 0.01$, η^2_p = 0.103, *power* = 0.86).

For the HRV_{tot} Recovery index, we found the same `Decision × Outcome´ interaction ($F_{2, 101} = 3.64$, $p < 0.03$, $\eta^2_p = 0.067$, *power* = 0.66; Fig. 2B), with Loser good-deciders showing higher HRV_{tot} Recovery than Loser poor-deciders ($F_{2, 101} = 4.25$, $p < 0.04$, η^2_p = 0.040, *power* = 0.53). Furthermore, good deciders in the Competition group (Winners and Losers) had higher HRV_{tot} Recovery than good-deciders in the Control group ($F_{2, 101} = 6.24$, $p < 0.01$, $\eta^2_p = 0.110$, *power* = 0.89).

3.3.3 Very Low Frequency:

For VLF power, no significant effects were found (*p´s* > 0.05; Fig. 3A).

3.3.4 Low Frequency:

In the case of LF Reactivity, a significant `Decision × Outcome´ interaction was found ($F_{2, 102} = 3.68$, $p < 0.03$, $\eta^2_p = 0.067$, *power* = 0.67; Fig. 3B). In Losers, good-deciders had lower LF Reactivity than poor-deciders ($F_{2, 102} = 4.51$, $p < 0.04$, $\eta^2_p = 0.042$, *power* = 0.56). Furthermore, good-deciders (both Winners and Losers) had lower LF Reactivity than good-deciders in the Control group ($F_{2, 102} = 8.62$, $p < 0.001$, $\eta^2_p = 0.145$, *power* = 0.96).

For the LF Recovery index, the same `Decision × Outcome´ interaction was significant ($F_{2, 101} = 3.68$, $p < 0.03$, $\eta^2_p = 0.068$, *power* = 0.67; Fig. 3B). In the group of Losers, good-deciders had higher LF Recovery than poor-deciders ($F_{2, 101} = 3.83$, $p < 0.05$, $\eta^2_p = 0.037$, *power* = 0.49). Good-deciders (both Winners and Losers) had higher LF Recovery than good-deciders in the Control group ($F_{2, 101} = 7.47$, $p < 0.001$, $\eta^2_p = 0.129$, *power* = 0.94).

3.3.5 High Frequency:

Regarding the HF Reactivity index, no significant effects were found (*p´s* > 0.05; Fig. 3C). However, for HF Recovery, there was a significant `Decision × Outcome´ interaction ($F_{2, 101} = 3.35$, $p < 0.04$, $\eta^2_p = 0.062$, *power* = 0.62; Fig. 3C). *Post-hoc* comparisons showed that good-deciders who lost had higher HF Recovery than good-deciders in the Control group ($F_{2, 101} = 3.36$, $p < 0.03$, $\eta^2_p = 0.067$, *power* = 0.66).

For the HF_{hz} respiratory index, no significant effects were found (*p´s* > 0.05; Fig. 2C).

Finally, for the HF/HRV Reactivity index, a significant `Decision × Outcome´ interaction was found ($F_{2, 102} = 3.32$, $p < 0.04$, $\eta^2_p = 0.061$, *power* = 0.62; Fig. 3D). Good-deciders who won the competition had higher Reactivity than poor-deciders ($F_{2, 102} = 8.10$, $p < 0.01$, $\eta^2_p = 0.074$, *power* = 0.81). Moreover, among the Losers, good-deciders had higher HF/HRV Reactivity than poor-deciders ($F_{2, 102} = 3.81$, $p < 0.05$, $\eta^2_p = 0.036$, *power* = 0.49). Furthermore, the group of good-deciders who competed (Winners and Losers) had higher HF/HRV Reactivity than the Control group ($F_{2, 102} = 5.80$, $p < 0.01$, $\eta^2_p = 0.102$, *power* = 0.86).

Analyzing the index of HF/HRV Recovery, a `Decision × Outcome´ interaction was found ($F_{2, 101} = 3.71$, $p < 0.03$, $\eta^2_p = 0.068$, *power* = 0.67; Fig. 3D). *Post-hoc* comparisons showed, for Winners, lower HF/HRV Recovery in good-deciders than in poor-deciders ($F_{2, 101} = 7.54$, $p < 0.01$, $\eta^2_p = 0.069$, *power* = 0.78). In good-deciders, lower HF/HRV Recovery was found for Winners than for the Control group ($F_{2, 101} = 3.19$, $p < 0.05$, $\eta^2_p = 0.059$, *power* = 0.60).

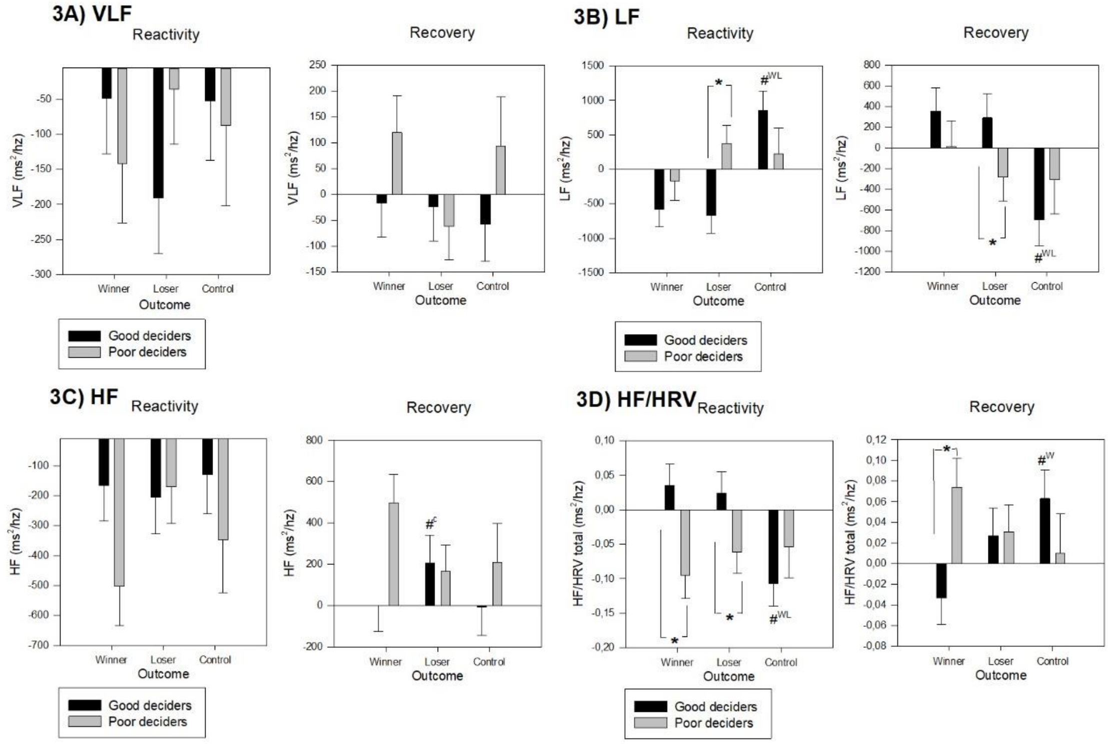


Figure 3: 3A) Means ± SEM of very low frequency total power (Task - Baseline) and recovery (Recovery - Task) indexes of Good decision-makers and Poor decision-makers separated by Outcome (Winners/Losers/Control), covariate of BMI (23.40). 3B) Means ± SEM of low frequency total power reactivity (Task - Baseline) and recovery (Recovery - Task) indexes of Good decision-makers and Poor decision-makers separated by Outcome (Winners/Losers/Control), covariate of BMI (23.40). 3C) Means ± SEM of high frequency total power reactivity (Task - Baseline) and recovery (Recovery - Task) indexes of Good decision-makers and Poor decision-makers separated by Outcome (Winners/Losers/Control), covariate of BMI (23.40). 3D) Means ± SEM of high frequency divided by total power of heart rate variability (Task - Baseline) and recovery (Recovery - Task) indexes of Good decision-makers and Poor decision-makers separated by Outcome (Winners/Losers/Control), covariate of BMI (23.40). (*p* <0.05) showed *Post-hoc* significant effects of the Decision × Outcome interaction, between good or poor-deciders in the indicated Outcome group. ♯ (*p* <0.05) showed *Post-hoc* significant effects of the Decision × Outcome interaction, between the indicated Outcome group (W = Winners, L = Losers) and Controls for the indicated Decision group.

4. Discussion

The present study reveals that the performance on a decision-making task (IGT) influences the situational appraisal and cardiovascular response to competition. Results show that good-deciders perceived greater effort than poor-deciders. Moreover, good-deciders had a withdrawal from their vagal influences during the Competition (lower HF/HRV and HRV reactivity), and subsequently recovered quickly, compared to the Control group. Our investigation points out that the HRV response is affected by the interactions among decision-making, the task characteristics (competitive vs non-competitive), and the outcome.

From an evolutionary point of view, the most adaptive way of coping with stress is to increase SNS activation and experience PNS deactivation, in order to achieve an autonomic balance that allows the best "fight or flight" response (Harrison et al., 2001; Manuck, 1994; Orbist, 1981). In a competition, this autonomic balance could lead to an increase in the probability of winning (Salvador and Costa, 2009), although it would depend on the type of task involved. In terms of autonomic balance, good-deciders who competed had this autonomic balance, showing lower HRV_{tot} and LF reactivity and higher recovery than the control group; in other words, the better the IGT performance, the lower the LF reactivity and the faster the recovery. We hypothesized that good-deciders would show higher HRV_{tot}, that is, an adaptive response to stress, but our data did not actually support this. Thus, to interpret this result, it should be kept in mind that LF reductions in good-deciders during the task affected the HRV_{tot} scores (Fig. 2B and 3B). This decrease in good-deciders can represent higher levels of mental effort during the task (Mukherjee et al., 2011), coinciding with the higher levels of psychological perceived effort. These results suggest that good-deciders could have better LF band adaptability than poor-deciders. Thus, these influences of LF do not necessary imply that lower levels of HRV_{tot} during a task are related to lower adaptability, but that people increase their mental effort during the task in order more adaptively perform the task. Therefore, LF reductions could reduce HRVtot, reflecting the person's effort to increase control. This cardiovascular response in good-deciders agrees with Obrist's (1981) postulations that the most demanding tasks induce greater beta-adrenergic stimulation with a higher sympathetic response (Richter, Friedrich, & Gendolla, 2008). Therefore, the pattern of CV reactivity in good decision-makers seems more adaptive in a competitive situation.

With regard to the CV response of poor-deciders, our data show that their response is similar to that of the Control participants. A recent investigation shows that people with higher levels of mental stress have high levels of LF and low levels of HF (von Rosenberg et al., 2017). Our data show that poor-deciders and the Control group had a mental stress response during and after the task that is consistent with the von Rosenberg et al. (2017) study (Fig. 3B and 3C). Therefore, poor-deciders probably interpreted the situation as threatening, regardless of whether it was competitive or not. In fact, our data show an approximation to this pattern in good-deciders during the task (Fig. 3B and 3C), which is consistent with an appraisal on a social stress task.

An important contribution of our study is that it shows the interaction between decision-making and the outcome of competition. The group of winning Good-deciders had better vagal control during (higher HF/HRV reactivity) and after competition (lower HF/HRV recovery) than Poor-deciders. The association between higher HRV_{tot} and higher adaptability comes from HF band associations with PNS activation and pre-frontal activity (Lane, Reiman, Ahern, & Thayer, 2001; Lane et al., 2009) and better EF performance (Hansen, Johnsen, & Thayer, 2003). The parasympathetic branch is known to induce the speediest changes in the heart, and this branch is controlled by inhibitory input from prefrontal areas to the central amygdala (Thayer et al., 2012). In fact, neurobiological correlates of decision-making (like the IGT) also lie in pre-frontal areas (Starcke & Brand, 2012). Our results indicate that having good decision-making abilities may help to improve the inhibitory connection, which would be reflected in higher PNS activation during a stressor and higher HF indexes as a result. In our data, when we control the HF component, considering all the HRV_{tot} components (HF/HRV), good-deciders who win have more HF than poor-deciders who win. Therefore, the higher vagal control in good-deciders could probably facilitate winning the competition.

Losers showed a different CV response. Loser poor-deciders had higher HRV_{tot} and LF reactivity, but lower HF/HRV reactivity. Loser poor-deciders probably show SNS over-activation on PNS, which would be related to less emotional control (HF/HRV diminution) and less effort when facing the stressful situation (higher LF). This kind of CV response in poor-deciders could lead to a greater likelihood of losing the competition (Salvador and Costa, 2009).

Regarding CV recovery after competition, regardless of the outcome, our results showed that good-deciders had higher HF/HRV reactivity and slower recovery (in winners), which means higher PNS activation, unlike the control group. In this regard, after competition, good decision-makers may show more PNS activation and more SNS withdrawal than poor decision-makers. Faster recovery to basal levels is considered an adaptive stress response (Chida & Steptoe, 2010). This recovery pattern is healthier than permanent activation of the SNS (Brosschot, Gerin, & Thayer, 2006; Chida & Steptoe, 2010; Schwartz et al., 2003; Williams et al., 2009). Previous literature showed that better EF could predict this healthier cardiovascular recovery in elderly people (Lin et al., 2014; Roiland et al., 2015). Our results are similar for young people and include decision-making skills as another predictor. Moreover, the cardiovascular response in good-deciders is usually associated with better cortisol recovery (Johnsen, Hansen, Murison, Eid, & Thayer, 2012), as reported in Santos-Ruiz et al. (2012), and thus with a healthier stress response.

Given these findings, it is worth noting that the IGT is a decision-making task that rewards conservative decisions (Bechara et al., 1994). Therefore, in our study, good-deciders avoided disadvantageous decisions. However, other decision tasks reward risky behavior. Thus, depending on the situation, it is better to make more conservative decisions rather than risky decisions, or *vice versa*.

This pattern of cardiovascular response could be mediated by the more conservative behavior of our participants, although, for example, in adolescents, high risk behaviors are cardiovascular protective (Liang et al., 1995). Moreover, higher HF levels were related to less conservative behaviors in adults (Ramírez, Ortega, & Reyes del Paso, 2015). Depending on the rules of the competition, sometimes it is better to behave more conservatively and sometimes in a riskier way. During our competition, participants were able to adapt their behavior depending on the feedback given. Therefore, our results indicate that good decision-making is related to the CV pattern, due to the capacity for adaptation in uncertain situations. Good decision-makers have the capacity to experience less uncertainty under social stress (a situation with an uncertain result), which implies less cortisol increase (J. M. Coates & Herbert, 2008; Santos-Ruiz et al., 2012). In this regard, higher HF activity is related to optimal activation of the neural pathways, leading to more flexible behaviors in changing environments (Sylvain Laborde et al., 2014).

This study has some limitations, such as the moderate effect sizes in some analyses, and it would be interesting to increase the sample size. Moreover, the exclusion criteria and our sample population also limit the generalization of the results to other health samples or to a clinical situation. It would be interesting to study decision-making skills in clinical populations such as chronic patients or patients with CV or metabolic illness in future studies. Finally, there are some limitations in the interpretation of the HRV frequency domain as SNS or PNS activation indexes (Goldstein, Bentho, Park, & Sharabi, 2011; Reyes del Paso et al., 2013). Future studies would benefit from the inclusion of other psychological variables, such as coping styles (Folkman, Lazarus, Gruen, & DeLongis, 1986) or mood response, in order to have more information about how decision-making could be a factor in coping with competition.

Chapter 5

4.1 Conclusion

In conclusion, this study shows that participants with better performance on the IGT have a cardiovascular reactivity pattern that could be adaptive in coping with competition. By contrast, poor-deciders could have a worse cardiovascular response when coping with the competitive stressor. Moreover, participants who win the competition with better decision-making skills seem to have better vagal control and quicker recovery. In the case of losers, being a poor-decider involves higher cardiovascular reactivity, which could imply worse emotional control in the competitive situation. Therefore, this study contributes to understanding how decision-making helps people to cope with a social stressor such as competition, and it opens up new lines of investigation into the stress coping paradigm.

Chapter 6:

Spanish validation of General Decision-Making Style questionnaire: Sex invariance and differences

And the relations of decision-making styles with coping styles and personality

1. Introduction

Previous research in decision-making highlighted the importance of the individual differences in the way of how people decide (Driver, 1990; Scott & Bruce, 1995). Scott and Bruce (1995) defined decision-making styles as ''*the learned habitual response pattern exhibited by an individual when confronted with a decision situation. It is not a personality trait, but a habit-based propensity to react in a certain way in a specific decision context (p. 820)*." Researchers proved the utility of decision-making styles in the prediction of some important decisions in the daily life of people as for example in chose a career with a future good person-job fit (Gati et al., 2010; Singh & Greenhaus, 2004), chose a major college (Galotti et al., 2006) or the satisfaction with a job choice (Crossley & Highhouse, 2005). Moreover, some coping styles for conflict management showed to be related to decision-making styles (Loo, 2000). Also, decision-making styles are considered as factors of resilience/vulnerability to stress (Thunholm, 2008). Therefore, having good instruments for measuring decision-making styles is necessary due to its relation to some daily-life behaviors.

Scott and Bruce (1995) developed an instrument of 25 items to measure decision-making styles: *General Decision Making Style* questionnaire (GDMS) that was composed of five scales: *rational style,* characterized by logical approach to decisions by searching some information and alternatives and a carefully thought out; *intuitive style,* as a style when persons make decisions depending on their hunches or feelings and the flow of the information; *dependent style,* in which people search advice and guidance from other people in their decision-making processes; *avoidant style,* characterized by procrastinate the decision-making and avoid as much as possible the decision-making process; and *spontaneous style,* a style characterized by the need to take decisions as quickly as possible. The first four scales (rational, intuitive, dependent and avoidant) were theorized by Scott and Bruce (1995), but, during the evaluation of the instrument the fifth factor structure including the spontaneous style emerged. GDMS has been validated using Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) probing the five factor structure with good psychometric characteristics (Baiocco, Laghi, & D'Alessio, 2009; Curşeu & Schruijer, 2012; Gambetti, Fabbri, Bensi, & Tonetti, 2008; Loo, 2000; Spicer & Sandler-Smith, 2005; Thunholm, 2004). Furthermore, there are different adaptations to different languages: Swedish (Thunholm, 2004), Italian (Baiocco et al., 2009; Gambetti et al., 2008), Dutch (Curşeu & Schruijer, 2012), Slovak (Bavol'ar & Orosova, 2015), French (Girard, Reeve, & Bonaccio, 2016) and an English adaptation for patients clinical decision making (Fischer, Soyez, & Gurtner, 2015). In the case of Spanish, a Spanish translation have been found (del Campo, Pauser, Steiner, & Vetschera, 2016), however, the psychometric properties from this Spanish GDMS has not been completely probed.

Thus, our purpose was to translate and create a Spanish adaptation of the GDMS and use this adaptation to correlate the decision-making styles, considering sex differences, personality and coping patterns to stress. Two studies are presented to achieve this objective. In the Study 1 a) we have translated and adapted the GDMS using EFA and search for the psychometric properties of the scale, and b) we have compared the resultant decision-making styles with some personality factors and coping styles to stressful situations. In the Study 2 c) we aimed to confirm the psychometric properties from the adapted GDMS using CFA and d) to explore sex invariances analyses and search for sex differences.

2. Study 1: Spanish adaptation of General Decision-Making Style Questionnaire

2.1. Introduction

Previous research has proved, using EFA with varimax rotation and oblimin rotation, CFA and measurement invariance (MI) that GDMS has valid psychometric properties (see

Table 1 for a summary of the adaptations/translations). In fact, the scale shows similar construct validity with both types of rotation varimax and oblimin. But, due to the scale presents inter-correlation between scales in all the previous research, the use the oblimin rotation is preferable, because this rotation do not assume totally independence between scales. . However, most of these studies, even the most recent, recommend keep investigating the psychometric properties of the scale, because some problematic items appear (showing cross-load between scales and low inter-item correlation). Moreover, it is not clear if decision-making style would be defined as a trait characteristic. Decision-making styles is defined as learned habits or propensity to respond to a decision-making situation (Scott & Bruce, 1995). Only Spicer & Sandler-Smith (2005) performed four weeks test-retest reliability for test the temporal stability of the scale. Although the five scales showed acceptable temporal stability, authors recognized that four weeks is a short period for test-retest and that they had a low sample on retest (82 respondents); therefore, further test-retest analyses are needed to probe the temporal stability.

Table 1: Summary of the validation and adaptations for the General Decision Making Style questionnaire

Article	Language	Sample	Factorial analysis	Problematic items	Conv/Disc validation
Scott & Bruce (1995)	English	1. 1441 male military 2. 84 students (44 % women) 3. 229 students (39 % women) 4. 189 engineers (8 % women)	EFA Principal components Varimax rotation	S5	*Locus of control and Innovativeness* R ↑ Internal locus of control ↓ Innovativeness I ↑ Innovativeness D ↑ External locus of control ↓ Innovativeness A ↑ External locus of control S ↓ Internal locus of control
Loo (2000)	English	223 students (42 % women)	EFA Principal components Varimax rotation CFA Maximum likelihood Correlated and uncorrelated	I2 D4 S5	*Conflictive-management style and Social desirability* D ↑ Social interactions/Relations A ↑ Avoidant conflict-management S ↓ Accommodating conflict-management
Thunholm (2004)	Swedish	233 military (2 % women)	CFA Maximum likelihood Correlated	–	*Self-esteem, Self-regulation, Educative ability and Social desirability* R ↑ Self-esteem and Social desirability D and A ↓ Self-esteem and Self-regulation
Spicer & Sandler-Smith (2005)	English	1. 200 students (44 % women) 2. 200 students (54 % women)	EFA Principal components Varimax rotation CFA Maximum likelihood Correlated	R4 S5	–
Baiocco et al. (2007)	Italian	500 adolescents (57% women)	EFA Principal components Oblimin rotation CFA Maximum likelihood Correlated	I2 A4 D5 S5	*Regulatory Self-efficacy and Locus of Control* R ↓ External locus of control ↑ Self-efficacy D ↑ External locus of control ↓ Self-efficacy A ↑ External locus of control ↓ Self-efficacy S ↑ External locus of control ↓ Self-efficacy
Gambetti et al. (2008)	Italian	422 students (66 % women)	EFA Principal components Varimax rotation CFA Maximum likelihood Correlated	A4 S4 and S5	*Hemisphere thinking preference* R and D ↑ Left hemisphere ↓ Right hemisphere I and S ↓ Left hemisphere ↑ Right hemisphere

Article	Language	Sample	Factorial analysis	Problematic items	Conv/Disc validation
Baiocco et al. (2009)	Italian	700 adolescents (53 % women)	EFA Principal components Oblimin rotation CFA Maximum likelihood Correlated	Not	*Sensation seeking and Locus of control* R ↑ Internal locus of control ↓ Sensation seeking I ↑ Sensation seeking D ↑ External locus of control ↑ Sensation seeking A ↑ External locus of control S ↑ External locus of control ↑ Sensation seeking
Curşeu & Schruijer (2012)	Dutch	102 students (100% women)	EFA Principal components Varimax rotation CFA Maximum likelihood Correlated	D2 and D4 S3 and S5	*Rationality and Indecisiveness in decision-making* R ↑ Rationality ↓ Indecisiveness A ↑ Indecisiveness
Fischer et al. (2015)*	German	1. 212 patients 2. 176 patients	CFA Maximum likelihood Correlated	R2, R3 and R4 I3 and I4 D5 A3 S all	*Sociodemographic, Decision regret and Treatment success* I ↓ Decision regret D ↑ Young (age)
Bavol'ár & Orosová (2015)	Slovak	1. 427 students (47 % women) 2. 212 students (83 % women)	EFA Principal components Oblimin rotation CFA Maximum likelihood Correlated	S5	*Decision making competences and Mental health* I ↑ Mental health A ↓ DM competences ↓ Mental health S ↓ DM competences
Girard et al. (2016)	French English	1. 325 students (84 % women) 2. 345 students (77 % women)	EFA Maximum likelihood Oblimin rotation CFA and Invariance Maximum likelihood Correlated	I4 S5	—
del Campo et al. (2016)	Spanish German	1. 142 Spanish students staff (51 % women) 2. 179 Austrian students staff (63 % women)	EFA Principal components Oblimin rotation	I4 D5 S5	—

Note: If some information were not in the cited articles we asked the authors in order to obtain the information; Problematic items = Items who cross-load in some scales or had low inter-items correlations

Chapter 6

Decision-making styles are conceptualized as "surface" individual differences according to the theory of Curry (1983). In that theory, individual differences are represented as the layers of an onion, being the more stable characteristics the layers closest to the center of the onion (e.g. Personality traits or cognitive styles). The "surface" characteristics, although have some stability, are more malleable and adaptive to situations as for example the coping styles or the cognitive strategies (Curry, 1983). In this sense, using a decision-making style or a different one depends on the situation, but also, on the "central" individual differences of people (Thunholm, 2004).

Each decision-making style has been related to some personality and cognitive variables. In this sense, people who scores highly in the *rational* scale have high internal locus of control (Baiocco et al., 2009; Scott & Bruce, 1995), self-esteem and self-regulation (Baiocco et al., 2009; Thunholm, 2004) and low indecisiveness (Curşeu & Schruijer, 2012). Moreover, high scores in the rational scale are related to less innovative (Scott & Bruce, 1995) and low sensation seeking (Baiocco et al., 2009). Therefore, people who scores highly in this scale seem to be people with a great control of the situation and themselves but less open or emotional.

Conversely, people with high scores in the *dependent, avoidant* or the *spontaneous* scales have showed high external attribution (Baiocco et al., 2009; Scott & Bruce, 1995), by different reasons. First, the *dependent* scale shows positive relations to conflict management coping styles associated with social interactions (Loo, 2000); moreover, scores on dependent style are negatively related to innovation and self-esteem/self-regulation (Baiocco et al., 2009; Scott & Bruce, 1995; Thunholm, 2004). Besides, people with high scores are focused on the relations to other people. Second, *avoidant* scale was positively related to conflict avoidance (Loo, 2000) and indecisiveness (Curşeu & Schruijer, 2012); and negatively associated with self-esteem and self-regulation (Baiocco et al., 2009; Scott & Bruce, 1995). This scale has been related to having worse decision making competences and also worse mental health and higher stress perception (Bavol'ar & Orosova, 2015). Furthermore, participants who scores highly in the *avoidant* style showed higher levels of cortisol (the stress hormone) under a stressful task (Thunholm, 2008). Third, *spontaneous* scale has been negatively related to settle to conflict (Loo, 2000) and positively with sensation seeking (Baiocco et al., 2009). It is also a scale associated with worse decision-making competences (Bavol'ar & Orosova, 2015); that is, people with high scores on this scale makes decision fast but with the sensation of uncontrollability that is related to lower scores in internal locus of control.

Finally, higher scores in the *intuitive* style are associated with higher innovativeness (Scott & Bruce, 1995) and sensation seeking (Baiocco et al., 2009). Also, similarly to *spontaneous* scale the *intuitive* scale is associated with lower decision-making competence (Bavol'ar & Orosova, 2015). However, differently to *spontaneous* style, the higher *intuitive* scores the lower regrets of their decisions (Fischer et al., 2015) and the better mental health (Bavol'ar & Orosova, 2015), showing that intuitive style is related to health and adaptation.

Thus, for the first study, we made a Spanish adaptation of the *General Decision Making Styles* inventory using a sample of Spanish university students. Our aim was to adapt the scale to the structure that explains better internal consistency using EFA. Also, we tested the relationships of decision-making with the Big-Five personality factors and coping styles. Based on previous research we hypothesize that *rational* style would negatively correlate with openness and *intuitive* style and positively with openness. Also, *dependent* style would positively correlate with extraversion, agreeableness and the coping styles related to search support in others. Finally, we hypothesize that *avoidant* and *spontaneous* styles will be related to less emotional stability; moreover, *avoidant* style would correlate with coping styles related to avoid the stressful situations.

2.2. Methods

2.2.1. Participants

The sample was composed of 361 (125 men) Spanish students from different faculties of the University of Valencia and the University Miguel Hernandez. Mean age of sample was 20.94 (SD = 3.84; range = 18 – 53 years of age). Participants were recruited during their academic course and complete the battery of instruments during around 15 minutes. Participation was voluntary and informant consent was obtained before participation.

In other to take the test-retest reliability we passed the same battery of test after exactly two months from the first evaluation. From the original sample a total of 137 students (37.9 %) fulfilled the retest.

2.2.2. Instruments

General decision making style: We adapt the GDMS (Scott and Bruce, 1995) and translate the instrument to Spanish from English; subsequently a native English, translate the scale back into English. No special problems were detected in the back-translated version. Past research showed that one item from the *spontaneous* style as a "problematic" item in some of the validations (see Table 1), showing cross-load with the *intuitive* scale consistently. The item is "When making decisions, I do what seems natural at the moment". Although, other items showed cross-load problems too, only this item was consistently problematic, and for that we decided to eliminate that item from our adaptation. Then, at the first step, our adaptation of GDMS had 24 items, one item less than the original version (Scott & Bruce, 1995). Four of the scales had 5 items and only the spontaneous had 4 items rated on a 5-point Likert-type scale ranged from "strongly disagree" to "strongly agree". The questionnaire heading was: "Listed below are statements describing how individuals go about making important decisions".

Ten Item Personality Inventory: We used the Spanish version of the Ten Item Personality Inventory (TIPI: Romero, Villar, Gómez-Fraguela, & López-Romero, 2012) that assess personality traits based on the five factor theory of personality, being a shorter measure than the typical personality scales like NEO-FFI (P. T. Costa & McCrae, 1992). The scale had a total of 10 items consisting of a pair of descriptors and scored from 1 (strongly disagree) to 7 (strongly agree). Each Big-Five dimension was represented by two items (E = Extraversion (α = .54), A = Agreeableness (α = .38), ES = Emotional Stability (α = .59), O = Openness (α = .48), C = Conscientiousness (α = .54)). This version shows reasonable psychometric properties in terms of test-retest reliability and convergence with the biggest five factor scales.

Brief COPE: A Spanish translation (Morán, Landero, & González, 2010) of the brief COPE (Carver, 1997) was used to assess the habitual coping strategies. The scale had 28 items with four alternatives of response from 1 (I usually don't do this at all) to 4 (I usually do this a lot) and it is divided in first order 14 sub-scales (Active coping (α = .58), Planning (α = .60), Emotional support (α = .78), Instrumental support (α = .64), Religion (α = .80), Positive reframing (α = .59), Acceptance (α = .30), Denial (α = .64), Humor (α = .79), Self-distraction (α = .59), Self-blame (α = .58), Behavioral disengagement (α = .63), Venting (α = .58) and Substance use (α = .93)).

2.2.3. Data Analysis

An exploratory factor analysis was performed using the maximum likelihood method for factoring, followed by oblimin rotation. The internal consistency from the subscales was measured using Cronbach's alpha coefficient. Also, test-retest reliability was measured using Intraclass correlations (ICC) using the two-way mixed effects model with absolute agreement (Koo & Li, 2016). Finally, Pearson correlations were performed between the scales of GDMS with the scales of TIPI and briefCOPE. All the analyses were performed using SPSS 20.0.

2.3. Results

2.3.1. Exploratory factor analyses

The scree plot of EFA suggested that five factors should be extracted (Kline, 1994). The five-factor structure were confirmed after factor analyses and accounted for 51.11 % of the post-rotated variance. All items loaded in their hypothesize scale with a loading superior to .49 (Table 2), except two items from the intuitive scale the I3 "I generally make decisions that feel right to me" and the I4 "When I make a decision, it is more important for me to feel the decision is right than to have a rational reason for it"; who no loaded in any factor (loading < .30). Then, factor 1 (eigenvalue = 4.82, 18.08 % variance) was loaded by the five items of the *avoidant* scale, factor 2 (eigenvalue = 3.60, 13.39 % variance) was loaded by the four items of the *spontaneous* scale, factor 3 (eigenvalue = 2.71, 7.82 % variance) was loaded by 3 items of the *intuitive* scale, factor 4 (eigenvalue = 2.02, 7.45 % variance) was loaded by the 5 items of the *dependent* scale and factor 5 (eigenvalue = 1.26, 4.36 % variance) was loaded by the 5 items of the *rational* scale. Not cross-loading problems appear in any of the items.

Table 2: Exploratory factor analysis oblimin rotation of the GDMS

	Factor 1 Avoidant	Factor 2 Spontaneous	Factor 3 Intuitive	Factor 4 Dependent	Factor 5 Rational
R1					.60
R2					.55
R3					.51
R4					.66
R5					.49
I1			.86		
I2			.89		
I3			—		
I4			—		
I5			.56		
D1				.78	
D2				.49	
D3				.69	
D4				.77	
D5				.65	
A1	.75				
A2	.88				
A3	.92				
A4	.76				
A5	.79				
S1		.73			
S2		.89			
S3		.76			
S4		.87			

Note: Only loadings superior .30 appears in the table

2.3.2. Internal consistency, test-retest reliability and inter-scale correlations:

After the results obtained in the EFA we decided to eliminate the two items from the *intuitive* scale who not loaded in any scale. The scales were calculated, and descriptive statistics from both the test and the retest were calculated too; Table 3 shows descriptive, test-retest reliabilities, Cronbach's alpha and the inter-scale correlations. Test-retest reliability using ICC showed a great significant temporal stability for all the scales (range ICC = .77 to .86, p < .001). Also, all the scales showed an acceptable internal consistency (Cronbach α > .70; see Guilford, 1954). Finally, correlations between the scales shows *avoidant* negatively correlated with *rational* and *intuitive* styles, and positively correlated with *dependent* and *spontaneous* styles; also shows *spontaneous* style negatively correlated with *rational* style and positively related with the *intuitive* style.

Table 3: Descriptive statistics, test-retest reliability, internal consistency and inter-scales correlations

	Mean (SD)		Test-retest ICC	Cronbach's alpha	Inter-scales correlations			
	Test	Retest			R	I	D	A
Rational	3.99 (.55)	3.96 (.59)	.77*** [CI: .68, .84]	α = .70	–			
Intuitive	3.67 (.78)	3.68 (.78)	.81*** [CI: .74, .87]	α = .80	– .03	–		
Dependent	3.57 (.80)	3.61 (.80)	.83*** [CI: .76, .88]	α = .79	.04	.03	–	
Avoidant	2.52 (1.01)	2.58 (1.05)	.86*** [CI: .80, .90]	α = .91	**– .11***	**– .11***	**.23*****	–
Spontaneous	2.59 (.93)	2.51 (.91)	.81*** [CI: .74, .87]	α = .89	**– .38*****	**.36*****	.01	**.21*****

Note: SD = standard deviation; ICC = Intraclass correlation; CI = Confident interval 95 %;
R = Rational; I = Intuitive; D = Dependent; A = Avoidant
***** *p* < .001; ** *p* < .01; * *p* < .05**

2.3.3. Relationships of GDMS with personality factors

Pearson correlations for study the relations of decision-making styles with five factor personality and coping styles to stress were described in Table 4.

The *rational* scale was positive moderately related to affability and conscientiousness and positively weakly associated to emotional stability. The *intuitive* scale was positive moderately related to extraversion and positively weakly related to openness. The *dependent* style was negative and weakly related to emotional stability. The *avoidant* style was negatively associated with all the five factors. Finally, the *spontaneous* style was positively related to extraversion and negatively to emotional stability, affability and conscientiousness.

Table 4: Pearson correlations between GDMS scales with TIPI and BriefCOPE scales

	Rational	Intuitive	Dependent	Avoidant	Spontaneous
TIPI					
Extraversion	− .01	**.20*****	− .02	**− .18*****	**.14****
Emotional stability	**.15****	− .09	**− .11***	**− .22*****	**− .21*****
Affability	**.22*****	− .05	.06	**− .14****	**− .22*****
Conscientiousness	**.30*****	.07	− .03	**− .37*****	**− .16****
Openness	.06	**.15****	− .10	**− .11***	.02
Brief COPE					
Active coping	**.32*****	**.19*****	.01	**− .36*****	− .07
Planning	**.36*****	− .002	− .01	**− .17*****	**− .24*****
Emotional support	− .06	− .01	**.45*****	.02	− .02
Instrumental support	− .02	− .01	**.64*****	.07	− .04
Religion	.03	.02	− .04	**.11***	.03
Positive reframing	.04	**.11***	− .01	**− .12***	.01
Acceptance	**.11***	− .02	− .04	− .09	− .03
Denial	− .04	− .02	.01	**.23*****	**.23*****
Humor	**− .13****	− .02	**− .13****	.02	**.11***
Self-distraction	− .02	.09	.10	**.12***	**.16****
Self-blame	− .07	**− .12***	.04	**.22*****	**.15****
Behavioral disengagement	**− .17*****	**− .16****	.03	**.43*****	**.21*****
Venting	**− .11***	− .05	**.12***	.08	.07
Substance use	**− .21*****	− .02	− .05	**.19*****	**.24*****

Note: *** $p < .001$; ** $p < .01$; * $p < .05$

2.3.4. Relationships of GDMS with coping styles

Respect to coping styles, *rational* style from GDMS correlates positively with the coping active scale and the planning coping scale, also was positively but weakly related to the acceptance coping scale and was negatively related to humor, behavioral disengagement, venting and substance use coping styles. *Intuitive* scale was positively correlated to active coping and positive reframing and negatively related to self-blame and behavioral disengagement. *Dependent* style strongly positively correlated to emotional support and instrumental support, also weakly positively correlated to venting and negatively correlated to humor. *Avoidant* scale strongly positively correlated to behavioral disengagement, and positively correlated to denial, self-blame, substance use, self-distraction and religion; furthermore, *avoidant* GDMS style negatively correlated to active coping, planning and positive reframing. Finally, *spontaneous* style positively correlated to substance use, denial, behavioral disengagement, self-distraction, self-blame and humor, and negatively correlated to planning.

2.4. Discussion

The main aim from the study 1 was to develop a Spanish adaptation of the GDMS. Exploratory analyses using oblimin rotation showed the same five factor structure as the original scale (Scott & Bruce, 1995), and subsequent adaptations to other languages (Baiocco et al., 2009; Bavolar & Orosova, 2015; Curşeu & Schruijer, 2012; Gambetti et al., 2008; Girard et al., 2016; Loo, 2000; Thunholm, 2004).

However, this adaptation has 22 items instead of 25 items from the original scale. As we explained in methods section, one of the items from *spontaneous* scale, the item S5, was removed from the adaptation prior to the analyses. The decision of removing item S5 was made because previous research in the GDMS psychometric characteristics showed the item is generally problematic, showing cross-load systematically with the *intuitive* scale (Baiocco, Laghi, D´alesio, Gurrieri, & Di Chiacchio, 2007; Bavolar & Orosova, 2015; Curşeu & Schruijer, 2012; del Campo et al., 2016; Gambetti et al., 2008; Girard et al., 2016; Loo, 2000; Scott & Bruce, 1995; Spicer & Sadler-Smith, 2005), that is reasonable because the highly similarity between both, *spontaneous* and *intuitive* scales. Previous research also showed that it had been other problematic items but, only S5 appear in almost all the previous research as problematic, then, it had enough evidence to the inadequacy of the item. Moreover, once the EFA was performed two more items were removed from the *intuitive* scale because they did not showed loading in any scale: the I4 and the I5. The meaning of both items seems to be slightly different to the other three items of the *intuitive* scale. In this sense, items I3 and I4 are asking what the feeling is after the decision making while items I1, I2 and I5 are focused on the information (hunches) that influenced decision-making.

Despite these modifications, results showed acceptable internal consistency in all the scales. Moreover, the scale showed high test-retest reliability for all the scales. In this regard, this adaptation seems to be able to measure the decision-making styles in Spanish population. Moreover, we provided evidence about temporal stability with a sample of 137 participants in the retest (two months after the first measure), one month more than

Spicer & Sandler-Smith (2005) study. For that it is possible that decision making styles from GDMS could be considered as a trait. However, we should not forgive that decision-making styles were conceived as a more malleable "surface" characteristic and people would engaged in one style or another one depending on the situation (Curry, 1983; Thunholm, 2004).

Decision making styles correlated with some personality traits from the five-factor personality theory. As we hypothesize *intuitive* style correlated positively with openness and (although not hypothesized) with extraversion, that is in the same line that previous research that showed associations with innovativeness and sensation seeking (Baiocco et al., 2009; Scott & Bruce, 1995). But, contrary to our hypothesis about *rational* scale based in negative relations with innovativeness, the scale did not correlate with openness. However, rational style scale correlated positively with agreeableness, emotional stability and conscientiousness. Those relations are similar to the relations found previously (N. L. Wood & Highhouse, 2014) in which 50 items NEO-PI-R (Goldberg et al., 2006) were used. Therefore, almost all the other relations are similar to Wood & Highouse (2014) research.

Regarding to the relationship between decision-making styles and coping styles, *dependent* style is highly related to the support based on others (social support), showing a great level of convergent validity. Moreover, *rational* scale is positively associated with planning strategies and active coping. On the other hand, *intuitive style* shows also relationships to active coping and positive reframing. Previous research showed that people with *intuitive* style have better mental health (Bavolar & Orosova, 2015) and with *rational* styles showed lower levels of stress (Allwood & Salo, 2012; Salo & Allwood, 2011). For that reason, it is possible that both are positively related to some of the healthier coping styles to confront stress situations. Finally, *avoidant* and *spontaneous* style were positively related to impulsiveness or flight from the reality, as for example, self-blame, denial or also behavioral disengagement. Furthermore, it was negatively associated with planning. For that, these scales along with *dependent* scale presented negative relations with emotional stability. Previous research also demonstrated relationships between *dependent* and *avoidant* styles with less mental health and higher levels of stress (Allwood & Salo, 2012; Bavolar & Orosova, 2015; Salo & Allwood, 2011). Altogether, results provided convergent/divergent validity, with personality and coping styles, but we can use more proximate constructs to evaluate this kind of validity. That is one of the aims of the subsequent study.

3. Study 2: Confirming the structure of GDMS; invariance across sex and sex differences

3.1. Introduction

The purpose off the second study was to confirm the structure from the Spanish adaptation of GDMS and provide more convergent-divergent evidence. Furthermore, another purpose from this study is to provide evidence of sex invariance to GDMS in order to know if sex differences of decision making styles are due to the psychometric properties of instrument.

As we show in the study 1, the decision-making styles had been related to coping styles ("surface" variables in the onion model) and personality ("central" variables). However, another "central" variable more closely associated with decision-making styles would be tested, that is, thinking styles. According to the cognitive-experiential self-theory (Epstein, 1994), thinking styles are the two qualitatively systems of information processing: a rational system and a experiential system. On one hand, the rational system is more analytic, free of emotions, abstract and conscious and requires more effort and cognitive resources. On the other hand, the experiential system is more automatic, based on emotions or guts, imaginative, unconscious and requires less effort (Epstein, 2010). These definitions of rational-experiential thinking styles are similar to the definition of two of the decision-making style the *rational* and the *intuitive*. In fact, during the item development Scott and Bruce (1995) based on the concept cognitive style, defined as the way of how people take the external data and make decisions based on it; that shows two styles: the analytical and the intuitive (Hunt, Krzystofiak, Meindl, & Yousry, 1989). Then, the constructs thinking styles and decision-making styles can be considered closely related.

Gambetti et al. (2008) evaluated the relation of thinking styles and decision-making styles using the Style of Learning and Thinking test (SOLAT: Albaili, 1993). This test evaluates differences in individual preferences of thinking associated with the right or left hemisphere. Their results showed the *rational* and *dependent* as styles positive related to the left hemisphere thinking style (more analytical and sequential) while *intuitive* and *spontaneous* positive related to the right hemisphere thinking style (more holistic and intuitive) (Gambetti et al., 2008). Although these results, more investigation on the relation of thinking styles and decision-making styles is needed using another type of scales more directly linked to thinking styles as the rational-experiential inventory (REI: Pacini & Epstein, 1999).

Concerning sex-differences in decision-making styles, mixed results have been found previously. Some studies did not find sex-differences in decision-making styles (Baiocco et al., 2009; Loo, 2000). However, in other study, using cluster analyses for creating different decision style profiles, women showed lower predisposition to an affective/experiential profile than men whereas women had higher predisposition to a dependent style (Delaney, Strough, Parker, & Bruine de Bruin, 2015). Another study using police investigators showed more evidence for the predisposition of women to *dependent* style compared to men; in addition, this study found that men use more the *rational* styles than women (Salo & Allwood, 2011). However, at the best of our knowledge, any study provided sex invariance evidence for GDMS. Thus, it is possible that sex-differences from previous studies appeared due to the absence of equivalence in the psychometric properties of GDMS between men and women.

Considering the literature revised, we expect to confirm the 5-factor structure from GDMS. Moreover, we expect to find positive relations between the rational thinking style and the *rational* decision-making style and the contrary with the experiential thinking style. Also, we expect to find the reverse relationships between the *intuitive* and *spontaneous* with thinking styles. In relation to sex, previous research shows evidence of sex-differences in decision making styles, so we will explore sex invariance to prove that sex-differences in decision styles are not due to the psychometric properties of scale. Finally, we expect to find sex-differences in *dependent* scale having women higher scores than men, while men would probably score more in *spontaneous, intuitive* or *rational* decision-making styles.

3.2. Methods

3.2.1. Participants

The sample was composed of 300 (158 women) Spanish students from different faculties of the University of Valencia. Mean age of sample was 21.84 (SD = 2.45; range = 18 – 34 years of age). Participants were recruited using informative posters and were cited to the laboratory by telephone. Participation was voluntary and informant consent was obtained before participation.

3.2.2. Instruments

General decision making style: Following the results of the Study 1 we readapt the scale discarding the two items from *intuitive scale* I3 "I generally make decisions that feel right to me" and I4 "When I make a decision, it is more important for me to feel the decision is right than to have a rational reason for it". Then, the finally Spanish adaptation of the GDMS was composed by 22 items. The scales composition was: Rational (5 items), Intuitive (3 items), Dependent (5 items), Avoidant (5 items) and Spontaneous (4 items).

Rational-Experiential Inventory: we used the 40 items Rational-Experiential Inventory (REI: Pacini & Epstein, 1999) in its Spanish version (Peñarroja et al., 2017) of 40 items. This scale measure rational or experiential thinking style and subdivide each scale in ability or engagement. On one hand, ability sub-scale reflects the person belief of his/her abilities in using the rational or the experiential thinking. On the other hand, the engagement reflects the person preference to engage in the rational or the experiential style. Spanish version probed, using CFA and EFA, adequate psychometric properties (Rational engagement (α = .84), rational ability (α = .87), experiential engagement (α = .80) and experiential ability (α = .89)).

3.2.3. Data analyses

Confirmatory factor analyses (CFA) were performed using minimum likehood estimation with robust corrections (MLR) due to the ordinal nature of the data (Finney and Di Stefanno 2006). Two models were tested in this order: a correlated 5 factor model (M_C) and a correlated 5 factor model with 2 error of covariance freely estimated ($M_{C\_r\#}$). We performed the final model due to the high degree of overlap in the item content from the items A2 and A3 in the avoidant scale and the items S1 and S4 in the spontaneous scale (Byrne, 2006). To evaluate model fit we considered the Satorra-Bentler scaled chi-square (SB-χ2) (Satorra & Bentler, 2001), however, the evaluative strategy involving SB-χ2 represents a traditional approach (Jöreskog, 1971) and is too sensitive to sample size being an impractical and unrealistic criterion on which to base evidence of invariance (Cheung & Rensvold, 2002; Marsh, Hey, Roche, & Perry, 1997). In spite of this, we also calculated more robust and practical indexes as: the non-normed fit index (NNFI); the comparative fit index (CFI), where values > .95 implies good fit and values > .90 implies acceptable fit (Marsh & Hau, 1996); and the root mean square error of approximation (RMSEA)(Hu & Bentler, 1999) with an confidence interval of 90 %, where <.05 values implies good fit, values between .05 and .08 implies acceptable fit and values >.08 implies marginal or poor fit (Browne & Cudeck, 1992).

When the structure of CFA was settled a model testing approach was employed using multi-sample CFA to examine the invariance from GDMS across sex (Men / Women).

First, the five-factor structure were separately tested on each group separately (Models M0a and M0b). After the determination of good fit for each group, a configural model was tested simultaneously for both groups and was stablished as the baseline model (M1). This model tested the configural invariance (same factor structure holding for both groups). Later, increasingly constrained models were applied to examine the equality of measurement in that order: Factor loading invariance (M2), Factor variances-covariances invariance (M3), Error variances-covariances invariance (M4) and Intercepts invariance (M5). It is only mandatory testing factor loadings invariance and intercepts invariance for proving invariance between group and be able to interpret the latent mean differences (Meredith, 1993), but adding the factor variances-covariances and the error variances-covariances restrictions improve the hypothesis of equivalence across sex. To test invariance hypothesis a model comparison procedure was used using as indexes the changes in the SB-$\chi 2$ (ΔSB-$\chi 2$), but we must remember that problems with the SB-$\chi 2$ are transferred to the ΔSB-$\chi 2$ (Cheung & Rensvold, 2002), thus, we also calculated the changes in NNFI (ΔNNFI), the changes in CFI (ΔCFI) and the changes in RMSEA (ΔRMSEA). The hypothesis of invariance is accepted whit measures of $< .01$ in the ΔNNFI and ΔCFI (Cheung & Rensvold, 2002). Moreover, when ΔRMSEA not increase more than .015 provides support to the most parsimonious model (F. F. Chen, 2007).

We also performed Pearson correlations between GDMS scale and REI scales in order to provide more convergent and divergent validity. Also, we performed Cronbach´s alpha and descriptive analyses. Finally, we performed *t* test to check sex-differences in the GDMS scales.

All the analyses were performed using SPSS 20.0 and EQS 6.1.

3.3 Results

3.3.1 Confirmatory factor analyses

CFA confirms that the correlated 5-factor with 2 errors of covariance freely estimated ($M_{C\_r\#}$) is the model with better fit (SB-χ2 = 305.86, NNFI = .949, CFI = .956, RMSEA = .043: Table 5) confirming the validity of the 5-factor model.

3.3.2 Sex invariance

Previous to multi-group analyses, the one factor model was separately tested for women (M0a) and men (M0b). Both models parts with acceptable fit: women (SB-χ2 = 290.31, NNFI = .929, CFI = .940, RMSEA = .055) and men (SB-χ2 = 249.39, NNFI = .940, CFI = .949, RMSEA = .044). Regarding the multi-sample baseline model for invariance (M1) results showed acceptable fit (SB-χ2 = 539.84, NNFI = .933, CFI = .943, RMSEA = .050). Model comparisons procedure showed that the subsequent levels of constrain for invariance are accepted (Table 5); statistical and practical approaches to model comparisons agree that there were not statistically differences between baseline model (M1) and Factor loadings invariance model (M2), factor variances-covariances model (M3) and error variances-covariances model (M4). When intercepts invariances were tested by gender the chi-square differences was statistically significant (ΔSB-χ2 = 116.18, $p < .001$). By contra, differences in practical fit criteria were minimum (ΔNNFI = .004, ΔCFI = .006, ΔRMSEA = .004). Therefore, we can conclude that GDMS accomplish the criterion of sex metric and structural invariance and is equivalent by sex.

Table 5: Confirmatory factor analyses and sex invariance models of GDMS

Model	Model description	SB-χ^2	df	ΔSB-χ^2	Δdf	NNFI	CFI	RMSEA [IC 90%]	ΔNNFI	ΔCFI	ΔRMSEA
Confirmatory factor analyses											
M_O	5 Orthogonal Factors	449.746	209			.889	.899	.064 [.055 – .071]			
M_C	5 Correlated Factors	346.436	199			.928	.938	.051 [.042 – .060]			
$M_{C\_r\#}$	5 Correlated factors + 2 Error Covariances	305.856	197			.949	.956	.043 [.033 – .052]			
Invariance analyses											
M0a	Baseline Model Men	290.314	197			.929	.940	.055 [.041 – .068]			
M0b	Baseline Model Women	249.392	197			.940	.949	.044 [.024 – .059]			
M1	Baseline Model Structural Invariance	539.836	394			.933	.943	.050 [.039 – .060]			
M2	FL Invariance	569.228	418	28.760	24	.935	.941	.049 [.039 – .059]	.002	.002	.001
M3	FL + FVC Invariance	578.529	428	9.270	34	.937	.941	.049 [.038 – .058]	.004	.002	.001
M4	FL + FVC + EVC Invariance	605.499	450	27.706	56	.936	.941	.048 [.038 – .058]	.003	.002	.002
M5	FL + FVC + EVC + INT Invariance	678.709	472	116.179***	78	.929	.937	.054 [.045 – .063]	.004	.006	.004

Note: FL = Factor loadings, FVC = Factor variances-covariances, EVC = Error variances-covariances, INT = Intercepts

3.3.3 Relations of GDMS with thinking styles:

In this section we describe the relations with the total rational and experiential thinking styles, for more information about engagement and ability sub-scales see Table 6.

The *rational* decision making style was positive and moderately related to rational thinking style (r = .24) and negatively weakly associated with experiential thinking style. The *intuitive* decision making style was positively associated to experiential thinking style. The *dependent* style was only negative weakly related to rational style. The *avoidant* style was negatively related to rational style too. And, finally, the *spontaneous* style was positively associated with experiential style.

Table 6: Pearson correlations between GDMS scales and REI thinking styles

	Rational	Intuitive	Dependent	Avoidant	Spontaneous
REI					
Rational	**.24*****	− .004	**− .16****	**− .19*****	− .08
Rational ability	**.28*****	− .02	**− .13****	**− .17****	− .11
Rational engagement	**.19*****	− .002	**− .21*****	**− .29*****	**− .14***
Experiential	**− .14****	**.64*****	− .09	.03	**.33*****
Experiential ability	− .09	**.55*****	− .10	− .03	**.25*****
Experiential engagement	**− .17****	**.61*****	− .06	.08	**.36*****

Note: *** $p < .001$; ** $p < .01$; * $p < .05$; REI = Rational-Experiential Inventory

3.3.4 Internal consistency, inter-items correlations and sex differences:

All the scales showed acceptable internal consistency (Table 7). Moreover, similar to results in study 1, correlations between the scales showed that *avoidant* correlated negatively with *rational* and positively with *dependent* and *spontaneous* styles; also, *spontaneous* style correlated negatively with *rational* style and positively with the *intuitive* style; finally, *dependent* style correlated positively with *rational* style (Table 7).

Only the *dependent* style shows significant sex-differences ($t_{292.8}$ = 2.58, p < .01), showing women higher scores in the *dependent* style in comparison to men.

Table 7: Descriptive statistics, internal consistency and inter-scales correlations

	Mean (SD)			Cronbach's alpha	Inter-scales correlations			
	Men	Women	Total		R	I	D	A
Rational	4.01 (.61)	4.07 (.58)	4.04 (.59)	$\alpha = .74$	–			
Emotional	3.63 (.85)	3.54 (.82)	3.58 (.84)	$\alpha = .79$	− .07	–		
Dependent	3.59 (.91)	3.34 (.72)	3.47 (.83)	$\alpha = .81$	**.16***	− .12	–	
Avoidant	2.43 (1.14)	2.52 (1.00)	2.47 (1.07)	$\alpha = .92$	**− .19****	− .01	**.22*****	–
Spontaneous	2.48 (.95)	2.58 (.89)	2.53 (.91)	$\alpha = .85$	**− .43*****	**.37*****	− .07	**.34*****

Note: SD = Standard deviation; R = Rational; I = Intuitive; D = Dependent; A = Avoidant;
*** $p < .001$; ** $p < .01$; * $p < .05$

3.4 Discussion:

In this second study, we confirmed the 5-factor structure from the Spanish adaptation of GDMS. Results showed that the model with better fit is the correlated model, which agrees with the previous research (Loo, 2000). Moreover, our results showed that the best fit model is the model with two errors of covariance freely estimated. In this regard, liberate the covariances errors is methodologically valid because forcing large error terms to be uncorrelated is rarely appropriate with real data (Bentler & Chou, 1987).

Regarding invariance, at the best of our knowledge this is the first time that GDMS showed invariance for sex. One previous study showed invariance between two different languages English and French that is an interesting way to perform an adaptation to another language (Girard et al., 2016). But our results on invariance provided both metric and scalar invariance evidence for sex. Indeed, scale surpass factor loadings invariance and intercepts invariance, that is the constrains necessaries to check sex-differences knowing that scale is equivalent by sex, and the latent means differences are due to the variable sex and not to scale inequivalence. Moreover, we also provided more invariance evidence to the scale, in concrete the scale surpass the factor variance-covariance invariance and the error variances-covariances invariance. Indeed error variances-covariances is a really improbable and heavy restriction (Meredith & Horn, 2001). Therefore, GDMS showed equivalence across sex surpassing all, the basic and the more robust restrictions. These results implies that the previous sex-differences found in previous studies did not have error coming from the structure of the scale. Previous research on sex-differences showed *dependent* style as more used by women than men, and *rational* style or a combination of *spontaneous* and *intuitive* style as more used by men than women (Delaney et al., 2015; Salo & Allwood, 2011). However, sex-differences provided only more evidence for the *dependent* style in women. Probably sample characteristics from the studies affects to these sex-differences showing these controversial results between studies.

Finally, similarly to the results from Gambetti et al. (2008) with SOLAT scale, our results showed, on the one hand, that *rational* decision making style correlates positively with rational thinking style and negatively with the experiential thinking style. On the other hand, *intuitive* decision-making style showed the reverse direction in its relationships with thinking styles. Moreover, our results showed the more scores in *dependent* and *avoidant* styles the less scores in rational thinking style. Furthermore, having more *spontaneous* style implies having more experiential thinking style that is also logic, for the strong relationship between *intuitive* and *spontaneous* decision-making style and because *spontaneous* style is based on rapid decisions based sometimes in hunches.

4. General discussion:

The principal aim of this research was to create a Spanish adaptation of GDMS and provide psychometric properties from this adaptation. For that, we performed a two-step research: in the first step we aimed to adapt the GDMS using EFA, as a result of this first study we obtained a GDMS with 22 items. In the second step we aimed to confirm the 5 factor structure and provided invariance by sex evidence. We consider that this adaptation has considerable good construct validity for the correlated five factor structure. Furthermore, the structure of the test is also invariant across sex, confirming the hypothesis of equivalence by sex. Moreover, both studies showed acceptable internal consistency in all the scales of GDMS and test-retest reliability supporting that decision making styles can be considered as a trait.

The correlations between GDMS factors with personality five factor model, coping styles and thinking styles, are consistent with the hypothesis and with previous research. Finally, women scored more in *dependent* style than men that is reasonable for the women tendency to use social support as a coping strategy (Shelley E. Taylor, 2006; Thoits, 1991).

Having a good measure of how people usually decide, as decision making styles, is helpful for research and for psychological practice. Previous research showed decision making styles as really good predictors of real life decision-making with long term consequences which could influence peoples' lifes (Galotti et al., 2006; Gati, Gadassi, & Mashiah-Cohen, 2012; Gati et al., 2010; Singh & Greenhaus, 2004). Moreover, decision making styles demonstrates its influence in how people perceived and cope with situations (Allwood & Salo, 2012; Salo & Allwood, 2011; Thunholm, 2008) being good predictors of general mental health (Bavolar & Orosova, 2015). In this sense, previous research has been supported by our results pointing out that the *rational* and *intuitive* styles as the healthier styles. In fact, both styles showed positive relationships with emotional stability, and active and healthier coping styles (e.g. active coping, positive reframing, or planning). This confirms the results from previous research, showing *rational style* relationships with high self-efficacy and self-esteem (Baiocco et al., 2007; Thunholm, 2004) and low stress in public officials (Allwood & Salo, 2012); and showing *intuitive style* as a style associated with less regret after a medical decision and better mental health (Bavolar & Orosova, 2015). By contra, *dependent, avoidant* and *spontaneous* styles were related to less emotional stability. In this sense, *dependent* and *avoidant* style were related in the past to lesser self-esteem and self-efficacy (Baiocco et al., 2007; Thunholm, 2004) and higher levels of perceived stress and sleep disturbance (Allwood & Salo, 2012; Salo & Allwood, 2011). It is probable that having those decision-making styles would be worse for mental health. Concretely, *avoidant* and *spontaneous* styles showed associations with passive coping styles or maladjusted behaviors (drug use, denial, or self-blame).

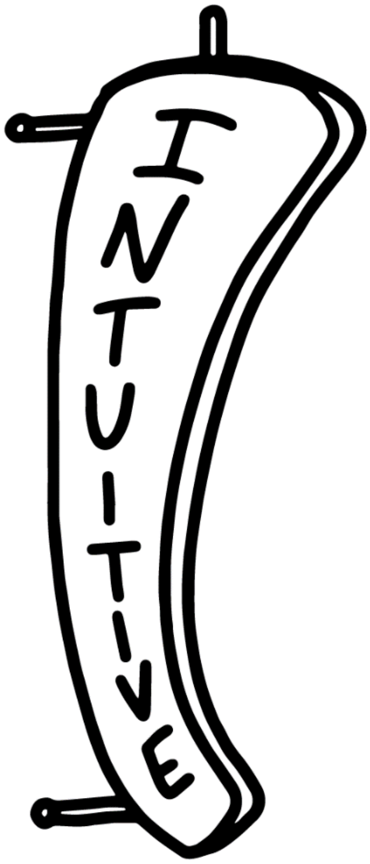
As a confirmation of this hypothesis, *avoidant* style was related in previous research to worse mental health (Bavolar & Orosova, 2015) and higher levels of cortisol after a real-life stressful decision environment (Thunholm, 2008).

Regarding *dependent* decision style, it is important to highlight sex differences. Taking into account that women engage more with this decision style it is possible that relationships to other constructs would be biased. The relationship between *dependent* style with emotional instability could be due to the prevalence in women to have higher scores in neuroticism (Weisberg, De Young, & Hirsh, 2011). Also, the use of a *dependent* style would be based on an evolutionary characteristic from women to perform more "tending-and-befriend" behaviors under stressful situations (Shelley E. Taylor, 2006).

As a limitation of this research, participants from both studies were composed only by university students, so this difficult the generalization of the results to other samples. That is a generalized problem from the validation of GDMS, because almost all the previous validations were based on these type of samples (see Table 1), except for two samples of militaries, one of engineers and two of adolescents (Baiocco et al., 2009, 2007; Scott & Bruce, 1995; Thunholm, 2004). That issue is important to be considered because differences between samples with different age has been found in decision styles (Delaney et al., 2015). We suggest in future research to obtain more variety of samples in age and context and to perform age invariance.

In conclusion, the Spanish adaptation of General decision-making styles questionnaire shows acceptable psychometric characteristics and is a good adaptation from the Scott & Bruce (1995) original. Our research supplies a reliable and validate instrument to analyze decision making styles in Spanish speaking populations. Moreover, invariance by sex was provided for the measure leading more validity to the future sex-differences research using the GDMS.

Finally, personality and coping styles relationships with GDMS provides more clues to the adequacy of each decision style in relation to the way of people' cope with.



Chapter 7:

Intuitive decision and cardiovascular health, avoid decisions and cardiovascular risk

Decision making styles related with heart rate variability

Main results of the present chapter have been submitted in Adrián Alacreu-Crespo, Raquel Costa, Francisco Molins, Diana Abad-Tortosa, & Miguel Ángel Serrano (2018) Intuitive vs. Avoidance decision making styles and its relation to basal heart rate variability. Health Psychology

1. Introduction:

Our life as humans being is plenty of decisions, from trivial to the important ones. Experience allows us to develop decision-making patterns, also called the decision-making styles (Scott & Bruce, 1995). According to the *General Decision-Making Styles* questionnaire there are five decision styles: the *rational style,* characterized by a probabilistic thinking approach to decisions; the *intuitive style,* which is based on feelings; the *dependent style,* where people search advice from other people; the *avoidant style* characterized by the avoidance of decision-making; and the *spontaneous style,* characterized to make quickly decisions. These decision-making styles have been related to daily life decisions and its subsequent consequences (Crossley & Highhouse, 2005; Gati et al., 2012), to coping style in conflict management (Loo, 2000) and to competence and mental health (Bavolar & Orosova, 2015). People with *intuitive* style showed good mental health, meanwhile people with *avoidant* style showed a reduced mental health and decision-making competences. In addition, *rational* style have been related to lower perceived stress. However, having high *dependent* and *avoidant* styles scores are related to higher sleep problems and perceived stress (Allwood & Salo, 2012; Salo & Allwood, 2011). In fact, one study in a military sample using a stressful decision-making task showed that participants with *avoidant* decision style had higher levels of cortisol (Thunholm, 2008). In sum, these results pointed out that individual differences in the proneness to decision-making stile are related to differential adaptation to changing situations. Thus, high scores in *rational* and *intuitive* styles leads to mental health and, on the contrary, high scores in *dependent* and *avoidant* styles implies maladaptive physiological responses and impairment of mental health.

It is described a physiological marker related to flexible responses and behaviors in changing situations; that is, heart rate variability (HRV) (Sylvain Laborde et al., 2014). According to the neurovisceral integration model (Thayer, Hansen, Saus-Rose, & Johnsen, 2009), HRV is a marker of executive and emotional control, that depends on the prefrontal cortex (Thayer, Ahs, Fredrikson, Sollers, & Wager, 2012). Specifically, HRV is a cardiovascular index that reflects rhythmicity of heart period, and the different rhythms are related to physiological processes: high frequency (HF) rhythm is associated with respiratory sinus arrhythmia and vagal tone (Eckberg & Eckberg, 1982) and low frequency (LF) rhythm with baroreflex function (de Lartigue, 2014). Basal HRV has been considered an endophenotype (Thayer & Lane, 2009) showing people with low HRV higher vulnerability to mental and cardiovascular illness (Thayer et al., 2012). In addition, daily life habits are able to modify HRV, for instance smoking (Sjoberg & Saint, 2011), alcohol consumption (Quintana, McGregor, Guastella, Malhi, & Kemp, 2013) or physical exercise (Rosenwinkel, Bloomfield, Arwady, & Goldsmith, 2001), which could reflect people's cognitive styles, elicit HRV changes. In the current study we have focused our interest in decision-making styles, as a stable variable, in order to investigate their influence on HRV, in the same way as previous investigation have related to daily life habits. Therefore, the aim of this short communication is to test whether decision making styles predicted resting HRV. We hypothesized that higher *rational* and *intuitive* styles will be related to high HRV; by contra, people with predominance of *dependent* or *avoidant* style will show low HRV.

2. Methods

2.1. *Participants*

The sample was composed of 199 (119 women) Spanish university students, with an age range from 18 to 30 (Mean ± Standard error of mean (SEM) = 21.60 ± .17). Participants were recruited using informative posters and were selected from a larger (n=286) sample using a questionnaire that included the following exclusion criteria, based on Laborde et al. (2017) recommendations to perform HRV research: having cardiovascular, respiratory, neurological or psychiatric disease; consuming drugs; alcohol dependence; intake of cardioactive medication.

2.2. *Procedure*

When the participants arrived at the laboratory, they were informed about the general study procedure, and they signed the informed consent approved by the Ethics Research Committee of the University of Valencia. The study was conducted in accordance with the Declaration of Helsinki. Experimental sessions were carried out from 9:00 am to 20:00 pm an lasted around 30 minutes. Before the beginning of the procedure, experimenter asked if participant needed to use bathroom (Heathers, 2014). Measures of weight, height, and waist-to-hip were taken, and electrodes of electrocardiogram (ECG) were placed. Then participants were instructed to wait 10 minutes without any specific instruction of breathing or maintain their eyes open or closed. After that we retire the ECG electrodes and participants filled in the General Decision Making Style questionnaire and sociodemographic data.

2.3 *Instruments*

General decision making style: We use the Spanish adaptation of the GDMS composed by 22 items (Chapter 6), based on the Scott & Bruce (1995) original scale. This questionnaire is composed of five sub-scales that measure five decision-making styles: *rational, intuitive, dependent, spontaneous* and *avoidant*. The Cronbach´s alphas for each scale in the present study was: *rational* (α = .78), *intuitive* (α = .82), *dependent* (α = .83), *spontaneous* (α = .86) and *avoidant* (α = .91).

Sociodemographic data: Ad-hoc questionnaire was used in order to measure age an socioeconomical variables and to control the subsequent variables: sleeping hours the night before experiment, intense physical exercise or consumed alcohol 24 hours before experiment, smoking and the number of cigarettes per day and eating or taking stimulant beverage 2 hour before experiment.

2.4. Cardiovascular measures

The ECG was recorded using three adhesive foam electrodes with conductive hydrogel. Signal were acquired and digitalized at 1000 Hz using a PowerLab/16SP hardware (ADInstruments) and the LabChart software version 5.2. Data were filtered using a 1 Hz low-pass digital filter, after that ECG was visually inspected, and abnormal data were edited. ECG was analyzed using the software Kubios Analysis (Biomedical Signal Analysis Group, University of Kuopio, Finland; Tarvanien 2014). Following the recommendations of Task Force (1996) for Heart Rate Variability (HRV) analyses we analyzed the last 5 minutes of the record. The first 5 minutes were used as a habituation period and were discarded.

Power spectral analyses of HRV were calculated by means of the Fast Fourier Transformation (FFT) using Kubios to extract frequency domain measures. Spectral power density was expressed in absolute units (ms2/hz). We computed the Very low frequency (VLF) band (between 0.003 to 0.04 Hz.); the Low frequency (LF) band (between 0.04 to 0.15 Hz.) which is an index of the baroreflex function and could be interpreted by both sympathetic and parasympathetic control (Berntson et al., 2007); and the High frequency (HF) band (between 0.15 to 0.40 Hz.) which reflects the respiratory sinus arrhythmia (RSA) and can be taken as an index of parasympathetic control. The total HRV power (HRVtot) was assessed with the summary of the frequency bands. Finally, we calculated the hertz were HF were collected (HFhz) which is an index of respiratory rate.

2.5. Statistical analyses

We calculated outliers using the 3 standard deviations method and one outlier were found for HRV variables, this participant was discarded. Kolmogorov-Smirnoff was used to check the normality. Age, number of cigarettes, hours of sleep, rational style, intuitive style, spontaneous style, avoidant style, VLF, LF, HF, HRVtot and HFhz did not have normal distribution and were normalized with the Log10 method.

First, preliminary analyses were performed in order to check the potential influence of some confounding variables on our target variables (HRV), following Laborde et al. (2017) recommendations. Due to the influence of sex on HRV (Koenig & Thayer, 2016), we checked for sex-differences using *t*-test. Moreover, we used *t*-test to check if there were differences on HRV between participants who answer Yes or No to the following confounding variables: drinking stimulant beverages two hours before experiment, eating two hours before experiment, drinking alcohol 24 hours before experiment or doing strenuous physical exercise 24 hours before experiment. Also, we performed Pearson correlations with HRV variables, decision making styles, age, the body mass index (BMI), the waist-to-hip ratio, the number of cigarettes per day and the hours of sleep from the night before experiment. In the following analyses we covariate sex only on HRV variables when *t*-test showed significant for a HRV variable and we controlled for the other confusing variables if correlated with a HRV variable.

Second, to test our hypothesis, two-steps multiple linear regression analyses were performed to assess whether each decision-making style predicted the HRV. For each HRV variable (VLF, LF, HF and HRV_{TOT}) we performed five regressions using the decision-making styles (rational, intuitive, dependent, spontaneous and avoidant) separately. In the first step we introduced covariates (i.e. sex, stimulant beverage, ate 2 hours before, alcohol 24 hours before, strenuous exercise, age, BMI, waist-to-hip, number of cigarettes or hours of sleep) only when these variables showed significant *t*-test or correlated with the HRV tested variable in the preliminary analyses. In the second step, we introduced the decision-making style.

The alpha significance level was fixed at 0.05. All statistical analyses were performed with the SPSS 20.0.

3. Results

3.1. Preliminary analyses

Means from the demographic characteristics, decision-making styles and HRV variables are shown in Table 1 by men and women. When comparing men and women there were significant differences in body mass index (BMI) ($t_{195} = -2.99$, $p < .01$), waist-to-hip ratio ($t_{191} = -9.52$, $p < .001$), VLF ($t_{196} = -3.24$, $p < .01$), LF ($t_{196} = -4.51$, $p < .01$) and HRV_{TOT} ($t_{196} = -2.49$, $p < .01$); having women had less BMI, wait-to-wrist ratio, VLF, LF and HRV_{TOT} than men (Table 1). The rest of confounding variables checked by *t*-test did not show significant differences for HRV (*p´s* > 0.05).

Table 1: Means ± Statistical error of mean from demographic variables, decision-making styles and HRV by men and women

Variable	Men	Women	Total
Age	21.82 ± .25	21.45 ± .22	21.59 ± .17
BMI	24.05 ± .35	22.59 ± .32	23.17 ± .24
Waist-to-hip	.81 ± .01	.73 ± .01	.76 ± .004
Number of cigarettes	.85 ± .26	1.44 ± .29	1.21 ± .20
Hours' sleep	7.13 ± .19	6.76 ± .16	6.91 ± .12
Rational	4.10 ± .07	4.02 ± .06	4.06 ± .04
Intuitive	3.51 ± .09	3.62 ± .08	3.58 ± .06
Dependent	3.36 ± .08	3.57 ± .09	3.48 ± .06
Spontaneous	2.39 ± .09	2.45 ± .09	2.43 ± .07
Avoidant	2.46 ± .11	2.35 ± .10	2.39 ± .07
VLF	148 ± 16	101 ± 8	120 ± 8
LF	1776 ± 148	1055 ± 77	1343 ± 79
HF	893 ± 104	852 ± 93	868 ± 69
HRV	2816 ± 228	2008 ± 148	2330 ± 130
HFhz	.22 ± .01	.24 ± .01	.23 ± .01

All the correlations are presented in Table 2. From the confounding variables, HFhz correlated negatively with LF ($r = -.23$, $p < .001$); waist-to-hip correlated positively with VLF ($r = .16$, $p < .02$); the number of cigarettes correlated negatively with VLF ($r = -.14$, $p < .05$) and LF ($r = -.14$, $p < .05$); and the hours of sleep before experiment correlates positively with HF ($r = .17$, $p < 0.02$)

Table 2: Pearson correlations of variables for regression analyses

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. VLF	–														
2. LF	.53***	–													
3. HF	.36***	.62***	–												
4. HRV_{TOT}	.55***	.92***	.86***	–											
5. HFhz	-.08	-.23*	.10	-.10	–										
6. Rational	.10	.08	.001	.06	-.06	–									
7. Intuitive	.03	.04	.19**	.13	.02	-.02	–								
8. Dependent	-.06	-.11	.02	-.06	.12	.19**	.01	–							
9. Spontaneous	.05	.02	.09	.07	.06	-.33***	.37***	-.11	–						
10. Avoidant	-.08	-.11	-.06	-.11	.07	-.12	-.03	.19**	.26***	–					
11. Age	-.02	-.04	-.13	-.08	.03	.04	-.07	-.02	-.15*	-.17*	–				
12. BMI	.12	.01	.02	.02	-.04	-.02	-.03	-.10	.01	.001	.01	–			
13. Waist-to-hip	.16*	.12	-.03	.08	-.05	.01	-.09	-.14*	.001	.10	.15*	.26***	–		
14. Number cigarettes	-.14*	-.14*	-.09	-.13	.09	-.12	.04	.16*	.09	-.001	-.12	.04	-.09	–	
15. Hours' sleep	.13	.09	.17*	.14	.05	.06	.01	.05	-.02	-.001	-.05	-.11	-.03	-.11	–

*** $p < .05$.**
**** $p < .01$.**
***** $p < .001$**
Note: VLF = Very Low Frequency, LF = Low Frequency, HF = High frequency, HRV_{TOT} = Total heart rate variability, HFhz = Hertz of high frequency, BMI = Body mass index

3.2. Decision making styles predicts HRV:

After controlling the confounding variables for each HRV variable, results indicated, on the one hand, that *intuitive* decision-making style was positively associated with HF ($\beta = .18$, CI_{95}: [.11, 1.17], $r_{partial} = .18$, $t(174) = 2.39$, $p < .018$, $R^2 = .06$, $\Delta R^2 = .03$) and HRV_{TOT} ($\beta = .14$, CI_{95}: [.01, .83], $r_{partial} = .14$, $t(195) = 1.99$, $p < .048$, $R^2 = .07$, $\Delta R^2 = .02$).

On the other hand, *avoidant* decision-making style was negatively associated with LF ($\beta = -.13$, CI_{95}: [$-.49$, $-.004$], $r_{partial} = -.14$, $t(190) = -2.00$, $p < .047$, $R^2 = .16$, $\Delta R^2 = .02$) and as a trend with HRV_{TOT} ($\beta = -.13$, CI_{95}: [$-.47$, .02], $r_{partial} = -.13$, $t(190) = -1.83$, $p < .069$, $R^2 = .06$, $\Delta R^2 = .02$).

Rational, dependent and spontaneous styles did not predict any HRV measure (*p´s* < 0.1).

4. Discussion:

The present study reveals that decision-making styles are related to one of the most widely used physiological marker of emotional control and physiological and mental health, resting HRV. Specifically, participants who engage more on *intuitive* style have higher levels of resting HF and total HRV. On the other hand, participants who scored more on *avoidant* style have lower levels of resting LF and, as a trend, total HRV.

The better decision-making competences the better executive control (Del Missier, Mäntylä, & de Bruin, 2012) and probably the higher HRV. For this reason, it is possible that the habit-based decisions would suppose a more adaptive behavioral and physiological response to changing situations. In fact, a precedent study showed how a better performance in a decision-making task implied an adaptive HRV response to a competition (Alacreu-Crespo et al., 2018). In this regard, our results showed the *intuitive* style was positively related to HF band in resting conditions; a marker of respiratory sinus arrhythmia (Eckberg & Eckberg, 1982) and the total HRV. In this sense, high HF is associated with better self-control, emotional regulation and cognitive regulation (Duschek, Muckenthaler, Werner, & Reyes del Paso, 2009; Julian F. Thayer & Lane, 2009; Zahn et al., 2016). By contra, our results support the idea that *avoidant* styles are less adaptive to stressful situations (Thunholm, 2008). For that reason, avoidant style could be associated with long term alterations and diseases as, for example, sleep disturbance (Allwood & Salo, 2012; Salo & Allwood, 2011), high levels of stress, anxiety or depression (Bavolar & Orosova, 2015). In this regard, as we hypothesized, *avoidant* seems to be related to lower HRV, concretely with the LF band in resting conditions. This band of HRV is a marker of barorreflex function (de Lartigue, 2014) which exert an inhibitory control in the heart rate and the heart contractibility (Shaffer, McCraty, & Zerr, 2014). The inhibitory control of barorreflex function is cardioprotective, thus, the lower LF band the higher vulnerability to cardiovascular illness (J F Thayer et al., 2012). Altogether, it is possible that *avoidant* style makes people more vulnerable to consequences of acute and chronic stress leading people to have more cardiovascular vulnerability.

The rest of decision-making styles *rational, dependent* and *spontaneous*, did not showed any relationship with HRV. Previous research showed *rational* style associated with lower stress perception and *dependent* style with higher stress perception and sleep disturbances (Allwood & Salo, 2012; Salo & Allwood, 2011), although Bavolar & Orosova (2015) did not find relationships between those styles and mental health (Bavolar & Orosova, 2015). From our point of view, it is not surprising that dependent and spontaneous styles did not have any relationship with HRV, due to these styles imply depending on the others or being really fast in decisions, both with less internal cognitive processing than the other styles However, in spite of rational style seems to drive to a more consistent behavior and we expected a positive relationship with the resting HRV, results did not show any relationship. If we consider that rational styles are characterized by the necessity of understanding rationally the world around, it is possible that people with this style could be stressed in the interactions taking into account that these situations not are always "rational". In this sense, rational style is more related to conscientiousness than the rest of styles (N. L. Wood & Highhouse, 2014), and people who engage more on this style could be more perfectionist and less flexible. Therefore, on the basis of our results, we interpret that in a changing and unpredictable environment it could be better to make decisions based on feelings and to have an adaptive behavior (Starcke & Brand, 2012), which is more related to *intuitive* style.

This research has some limitations. We performed five linear regressions for each HRV parameter which would led us to incur in a potential type 2 error. Moreover, we cannot generalize to other samples because the characteristics of sample (young and healthy participants). However, we have a considerable sample that provided more statistical power and we tried to control the potential confounding factors that could affect HRV.

In conclusion, intuitive and avoidant styles predicted HRV, a physiological marker of mental and physiological health. In this regard, *intuitive* style seem to be more cardioprotective variables while *avoidant* style would be related to a less HRV, which has been related to health vulnerability. However, dependent, spontaneous and dependent styles were no associated with HRV. Thus, results provide new data about the relationship between cognitive variables (as decision making styles) and HRV, showing that certain decision-making styles predict HRV. Therefore, from our point of view, these results increase the knowledge about HRV and its potential influences in order to find biomarkers of cognitive styles.

Capítulo 8:

Discusión General, limitaciones y direcciones futuras

1. Discusión general:

Los estudios que componen esta tesis doctoral han explorado el efecto de algunos factores sociales (el conflicto, la competición, el enfrentamiento a un *out-group* y la pertenencia a un grupo) y la toma de decisiones en la respuesta fisiológica y conductual antes, durante y después de una interacción social, teniendo en cuenta las diferencias de sexo. En el primer estudio se investigó cual es la respuesta emocional, CV y endocrina ante una situación de conflicto intergrupal. En el segundo estudio se evaluó cómo la respuesta endocrina tras una interacción social puede afectar a la toma de decisiones. En el tercer estudio se analizó la influencia de las habilidades en toma de decisiones en la respuesta CV ante una interacción social competitiva. Finalmente, en el cuarto y quinto estudios se tradujo al español y se validó el cuestionario GDMS que evalúa los hábitos en la toma de decisiones, los estilos de toma de decisiones, y se relacionaron dichos estilos con factores de personalidad y con los niveles de HRV en condiciones de reposo.

Los principales resultados de cada estudio se discuten de forma independiente en el capítulo correspondiente. No obstante, en este capítulo final de la tesis integraremos los principales resultados de los estudios para discutirlos en conjunto, exponer las limitaciones generales y proponer direcciones futuras de estudio en el tema que concierne a esta tesis doctoral.

1.1 Diferencias de sexo en la respuesta fisiológica y la toma de decisiones tras una interacción social

Habitualmente, las personas se encuentran en situaciones en la que deben tomar decisiones acerca de su propio comportamiento, pero para las que no tienen suficiente información, ni una guía o clave clara que pueda ayudar a dirigir dicho comportamiento. No obstante, continuamente se toman decisiones tras un análisis racional consciente (valorando pros y contras) o de manera más bien intuitiva (más automática) y con distinto nivel de incertidumbre. En concreto, las interacciones sociales con otros individuos son circunstancias con un alto nivel de incertidumbre (Rilling & Sanfey, 2011) puesto que las consecuencias de las decisiones de una persona dependen también del resto de personas envueltas en la interacción (Sanfey, 2007). Para adaptarse a estas situaciones de alta incertidumbre los humanos deben interpretar la situación social en la que se encuentran, teniendo en consideración tanto el contexto como las características individuales (Schiebener & Brand, 2015). Desde un punto de vista evolutivo, ante interacciones sociales amenazantes, se considera que los humanos pueden mostrar distintas respuestas fisiológicas y distintos patrones de respuesta conductual ("*Fight or Flight*", "*Freeze*" y "*Tend-and-Befriend*") (Porges, 2007) los cuales tendrán consecuencias directas tanto en el individuo como en la interacción social.

La literatura ha relacionado los distintos patrones comportamentales ante situaciones novedosas, amenazantes, potencialmente dañinas, e incluso de reto con respuestas fisiológicas y de estado de ánimo complementarias. Aunque, a priori, se ha estudiado principalmente en el contexto de estrés, en dichas situaciones hay, frecuentemente, un componente social. Una respuesta fisiológica caracterizada por el "*Fight or Flight*" incluiría un aumento del SNS junto con una retirada del SNP durante la interacción social (Porges, 2007), junto con un aumento de la T para propiciar conductas de lucha y dominancia (Terburg et al., 2009) y un aumento del estado de ánimo positivo asociado al reto (Salvador and Costa, 2009). Respecto al C, un aumento podría significar aumentar la sensación de miedo o ansiedad llevando al sujeto a la respuesta de huida, frente a una disminución de C que podría propiciar la respuesta de lucha (Terburg et al., 2009). Por otro lado, una respuesta relacionada con el "*Tend-and-Befriend*" implicaría una predominancia parasimpática que aumentaría el control ejecutivo (Porges, 2007) y, quizás, un descenso de la T propiciando conductas de afiliación. Finalmente, la respuesta de "*Freeze*" aparecería en situaciones interpretadas como amenazantes dando lugar a una sobreactivación del SNS y del eje HPA, además de un aumento del estado de ánimo negativo (Seery, 2013).

En relación con lo anterior, en el ***estudio 1*** se sometió a hombres y mujeres a un conflicto intergrupal con el fin de analizar el efecto de este tipo de interacciones sociales en su respuesta fisiológica. Los resultados mostraron que ambos sexos tenían un aumento del estado de ánimo positivo y negativo, una activación del SNS, una disminución del SNP y un aumento del C. Sin embargo, las mujeres, a diferencia de los hombres, mostraron una disminución en sus niveles de T. Estos cambios psicobiológicos en el conflicto intergrupal parecen indicar que los hombres mostraron un patrón de respuesta compatible con "*fight or flight*" mientras que las mujeres mostraron un patrón de respuesta más relacionado con la descripción de "*tend-and-befriend*". Este último patrón es coherente con el planteamiento de que las mujeres serían más propensas a llevar a cabo conductas de protección y apego ante estresores sociales (Taylor, 2006), mientras que en los hombres predominaría la "*fihgt or flight*". De hecho, el ***estudio 4*** confirma que habitualmente las mujeres tienden a consultar más sus decisiones con otras personas que los hombres.

Los patrones conductuales de "*fight or flight*" en hombres, y "*tend-and-befriend*" en mujeres, ante un estresor social; se han confirmado en estudios recientes en investigaciones con tareas que evalúan la toma de decisiones sociales, como el *prisoner´s dilema,* el *ultimatum game,* el *trust game* o el *dictator game* (Nickels, Kubicki, & Maestripieri, 2017; Steinbeis et al., 2015; Youssef, Bachew, Bissessar, Crockett, & Faber, 2018) los cuales mostraban conductas más egoístas y competitivas en hombres, frente a conductas más altruistas y cooperativas en mujeres. Además, el hecho de que la T disminuya tras una situación donde hay miembros del *in-group* tanto en nuestro estudio como en otros estudios previos (Jaeggi et al., 2018; Kivlighan et al., 2005; Oxford et al., 2010) podría estar indicando un efecto del grupo en esta respuesta endocrina que favorezca la afiliación y la cooperación. Sin embargo, estos efectos siguen siendo paradójicos, puesto que aumentos de la T aumentan el *parochial altruism* favoreciendo a los miembros de nuestro grupo, al menos en hombres (Diekhof et al., 2014; Reimers et al., 2017; Reimers and Diekhof, 2015). Por lo que es posible que los efectos organizadores y activadores de la T en hombres modulen de manera diferencial sus efectos sobre el comportamiento, en comparación con las mujeres. Evidentemente, a falta del uso de tareas de toma de decisiones sociales en el ***estudio 1*** no podemos confirmar que haya cambios conductuales a raíz de los cambios en T y C, y, por tanto, sería necesaria más investigación en el tema.

Complementariamente, el objetivo del ***estudio 2*** consistía en analizar si los hombres y las mujeres tomaban decisiones más arriesgadas o conservadoras en función de los cambios hormonales tras una competición. Los resultados del ***estudio 2*** mostraron que los hombres con más T y C después de una interacción tanto competitiva como no competitiva tomaban decisiones más arriesgadas, mientras que las mujeres con más T y C tras una situación competitiva tomaban decisiones más conservadoras. Estas diferencias de sexo aparecían bajo una incertidumbre de riesgo en vez de ambigüedad, lo cual concuerda con estudios previos donde se muestran diferencias de sexo en los últimos ensayos del IGT (R. van den Bos et al., 2013).

Según los resultados de la literatura, los hombres muestran de forma consistente una relación entre una mayor T y un aumento de las tomas de decisiones arriesgadas; como, por ejemplo, en decisiones económicas arriesgadas (Apicella et al., 2008, 2015; Apicella, Dreber, & Mollerstrom, 2014; J. M. Coates & Herbert, 2008; Nofsinger, Patterson, & Shank, 2018) y decisiones más dominantes como la intención de competir de nuevo (Mehta & Josephs, 2010, 2006; K. M. Smith & Apicella, 2016). Con respecto a los cambios de T tras una situación estresante también se han visto resultados similares con la toma de riesgos (Barel, Shahrabani, & Tzischinsky, 2017; Mehta, Welker, Zilioli, & Carre, 2015). Además, los cambios en C tras un estresor social también predicen las conductas arriesgadas (Lighthall et al., 2012, 2009; van den Bos et al., 2009). Es posible que estos cambios hormonales promuevan un incremento de conductas arriesgadas en hombres, con respuestas de lucha o huida frente a un competidor directo.

Sin embargo, los resultados en las mujeres son más inconsistentes. Los estudios previos no han encontrado una relación clara entre respuesta de T o C después de un estresor social y decisiones arriesgadas en mujeres (Lighthall et al., 2012, 2009; van den Bos et al., 2009). En nuestro caso, el ***estudio 2*** muestra decisiones más conservadoras cuanto mayor es la T y el C después de una competición. A partir delos resultados del ***estudio 1*** hipotetizamos que menor T y mayor C tras el estresor social promovería tomar decisiones más conservadoras, las cuales estarían más relacionadas con conductas de "*tend-and-befriend*" (Tamres et al., 2002). Sin embargo, parece ser que en situaciones de negociación económica, mayor T y C propician, por un lado, más preocupación acerca de las consecuencias sociales de la negociación y, por otro, que se prime mantener una relación harmoniosa sobre el dinero que se gane (Mehta, Mor, et al., 2015). Debido al carácter económico del IGT, puede que este efecto se haya visto propiciado en las mujeres del ***estudio 2***, que posiblemente se sentían bajo la presión social de la competición. Por tanto, existen diferencias de sexo en la toma de decisiones que podrían ser debidas a sus diferencias en los sistemas dopaminérgicos influenciados por el estrés social, como se ha demostrado recientemente en un estudio en ratas de laboratorio (Georgiou et al., 2018). Asimismo, las diferencias en las hormonas sexuales también podrían explicar los resultados dispares (Barel et al., 2017). Sin embargo, para poder afirmar a qué se deben las diferencias de sexo sería conveniente realizar más investigación en el tema.

1.2 La toma de decisiones como un factor clave en el afrontamiento de las interacciones sociales

Como hemos explicado anteriormente, una gran parte de las interacciones sociales son situaciones de alta ambigüedad (Rilling & Sanfey, 2011), sobre todo aquellas en las que interaccionamos con desconocidos. Por ello, un alto nivel de flexibilidad cognitiva puede ayudar al individuo a adaptarse a las interacciones sociales (Porges, 2007). Bajo estas circunstancias es importante tener un buen funcionamiento de los sistemas de toma de decisiones para analizar la situación y adaptarse a ella (Brand et al., 2006). En este sentido, las funciones ejecutivas son una variable central en las decisiones que tomamos (Brand et al., 2006), ya que ayudan a interpretar la retroalimentación del exterior y a dirigir la conducta y las decisiones a la meta concreta que se haya propuesto el individuo. En este sentido una mayor VFC está estrechamente relacionada con un alto rendimiento en funciones ejecutivas (Thayer, Hansen, Saus-Rose, & Johnsen, 2009), así como con la interpretación emocional y de las variables sociales, dando lugar a decisiones generalmente más adaptadas al ambiente (Appelhans & Luecken, 2006; Geisler & Kubiak, 2009; Geisler et al., 2013; Reynard et al., 2011). En consecuencia, una mejor toma de decisiones puede conllevar respuestas CV más saludables y adaptativas ante estresores sociales (Lin et al., 2014; Roiland et al., 2015). Por ello, incrementos en las competencias de toma de decisiones se ha relacionado con una respuesta de C atenuada ante un estresor social (Santos-Ruiz et al., 2012), mientras que ciertos hábitos decisionales, como procrastinar, se relacionan con peor salud mental (Bavolar & Orosova, 2015), sensación de estrés (Allwood & Salo, 2012; Salo & Allwood, 2011) o mayor C ante un estresor (Thunholm, 2008).

En relación con lo anterior, el ***estudio 3*** tenía como objetivo comprobar si las habilidades en la toma de decisiones podían predecir la respuesta de los participantes ante una interacción social competitiva. Los resultados mostraron que los participantes con mayores habilidades en la toma de decisiones tenían una respuesta del sistema CV más adaptativa al entorno competitivo en el que se encontraban. Concretamente, encontramos que los buenos decisores ejercían un mayor esfuerzo mental durante la tarea, inferido por bajos niveles de LF, seguido de un mantenimiento de la activación del SNP y el control ejecutivo inferido por mayores niveles de HF, dando lugar a una pronta recuperación de la tarea.

Por otro lado, los ***estudios 4 y 5*** tenían un doble objetivo, por un lado, traducir al español y validar la escala GDMS de estilos de toma de decisiones para, por otro lado, investigar si los hábitos en la toma de decisiones están relacionados con factores de personalidad y estrategias afrontamiento, así como con la VFC. En este sentido, el ***estudio 4*** mostró que la versión española del GDMS tenía unas propiedades psicométricas adecuadas y, además, que tener un estilo racional o intuitivo se relacionaba con mejores patrones de afrontamiento ante estresores y mayor estabilidad emocional. Mientras que los estilos de personalidad evitativo y espontáneo se relacionaban con patrones de afrontamiento ante el estrés más pasivos o dañinos (como el uso de drogas, la autoinculpación o la negación) y, además, una menor estabilidad emocional. El ***estudio 5*** confirmó algunos de estos resultados que relacionaban los estilos decisionales con la VFC. El estilo intuitivo se relacionó con una mayor VFC en condiciones de reposo, mientras que el estilo evitativo se vinculó con menor VFC. Según la literatura, menor VFC en reposo está relacionado con el desarrollo de trastornos mentales y con el incremento del riesgo de sufrir una enfermedad cardiovascular o metabólica (Beauchaine & Thayer, 2015; Thayer, Ahs, Fredrikson, Sollers , & Wager, 2012). Por tanto, los estilos decisionales que impliquen menor VFC podrían ser un factor de vulnerabilidad a la enfermedad mental y los trastornos cardiovasculares.

Nuestros resultados, en conjunto con la investigación previa, muestran que la toma de decisiones puede ayudar o perjudicar a afrontar las interacciones sociales. En este sentido quizá tener mejor rendimiento en tareas de toma de decisiones, como el IGT, esté relacionado con una mayor flexibilidad a la retroalimentación cambiante durante una interacción social (Alacreu-Crespo, Costa, Abad-Tortosa, Salvador, & Serrano, 2018; Sylvain Laborde et al., 2014). Asimismo, los hábitos de toma de decisiones están relacionados con la HRV en condiciones de reposo. Además, algunos estilos decisionales, como el evitativo o el espontaneo, están relacionados con estilos de afrontamiento al estrés menos adaptativos y más peligrosos para uno mismo (***estudio 4***), favoreciéndose, por ejemplo, decisiones de la vida diaria que puedan afectar a largo plazo a la HRV, como fumar o tomar alcohol (Quintana et al., 2013; Sjoberg & Saint, 2011). Complementariamente, un estudio reciente en animales ha mostrado que el estrés crónico afecta directamente a las vías neuronales del procesamiento de la retroalimentación (Friedman et al., 2017) implicadas también en los sistemas de regulación fisiológicos del CAN (Thayer & Lane, 2009). Por ello, consideramos que los hábitos en la toma de decisiones podrían conllevar diferencias individuales en vulnerabilidad o resistencia a la enfermedad a largo plazo. Como hemos visto en el ***estudio 5*** es posible que el estilo intuitivo sea el más relacionado con una respuesta flexible a la retroalimentación cambiante y sería considerado el más relacionado con una alta HRV, así como con factores de salud, mientras que procrastinar y/o evitar las decisiones podría tener efectos negativos, a largo plazo, en nuestra salud.

En definitiva, los resultados de esta tesis doctoral ponen de manifiesto que, tanto las características del entorno como la capacidad de un sujeto a adaptarse a dichas características, afectan de forma directa a su toma de decisiones y a su conducta. En concreto, la pertenencia de grupo puede tener influencia en la respuesta fisiológica de las personas. Asimismo, el conflicto intergrupal ha demostrado ser un estresor que da lugar a respuestas fisiológicas diferenciales en hombres y mujeres (***estudio 1***). Además, la respuesta fisiológica puede alterar la forma diferencial la toma de decisiones de hombres y mujeres después de una interacción social (***estudio 2***). Por otra parte, la toma de decisiones también está implicada en como interpretamos una interacción social, y un buen rendimiento en una tarea de toma de decisiones puede predecir una respuesta cardiovascular más adaptativa ante una interacción social (***estudio 3***). Por último, se ha mostrado que se pueden evaluar los estilos decisionales en español (***estudio 4***). Algunos de estos hábitos a la hora de tomar decisiones han mostrado diferencias de sexo (estudio 4), así como relaciones con algunos indicadores de VFC en reposo (estudio 5) pudiendo ser también variables rasgo que afecten a la interpretación de las interacciones sociales.

3. Limitaciones generales

Las limitaciones de cada estudio están especificadas al final de cada capítulo, sin embargo, en este apartado presentamos las limitaciones generales de la tesis en general.

En primer lugar, en todos los estudios hay una falta de control directo de las hormonas gonadales de las mujeres. El ciclo menstrual ha demostrado estar envuelto tanto en la toma de decisiones (van den Bos et al., 2013) como en las variables endocrinas (Dabbs, 1990; Kajantie & Phillips, 2006) y cardiovasculares (Vallejo, Márquez, Borja-Aburto, Cárdenas, & Hermosillo, 2005; Yildirir et al., 2002) medidas en la mayoría de estudios. Por ello consideramos que un control directo de los estrógenos y progestágenos, mediante muestras de saliva para los análisis endocrinos, podrían haber ayudado a comprender mejor algunos resultados concernientes a estas respuestas en mujeres, así como matizar las diferencias sexuales encontradas. Además sería recomendable medir también los niveles de oxitocina, hormona relacionada con el patrón de respuesta de "tend-and-befriend".

En segundo lugar, todos los estudios han sido realizados con muestras de jóvenes universitarios sanos, dando lugar a un error probabilístico. El estudio de las variables fisiológicas como el C, la T y la VFC necesita de un control de variables de error muy exhaustivo. Sin embargo, esto da lugar a muestras con un perfil salutogénico inusual que limita la generalización de los resultados a la población general y por supuesto a muestras clínicas. Asimismo, el hecho de que la muestra sea de sujetos jóvenes impide también la generalización de resultados a muestras con mayor edad.

Finalmente, todos los estudios fueron transversales. Un estudio longitudinal podría haber aportado mucha más información y confirmar de forma más fehaciente las hipótesis que formulamos. Este hecho se aplica especialmente a los últimos 3 estudios, donde se evaluaban variables más relacionadas con la personalidad y las habilidades generales de la persona. Utilizar un estudio longitudinal donde se evalúan repetidamente las mismas variables fisiológicas podría confirmar que efectivamente nuestras hipótesis se confirman en el tiempo y no vienen influenciadas por un momento determinado de medida.

4. Direcciones futuras:

Tras los hallazgos obtenidos en los diferentes estudios de esta tesis doctoral, se presentan una serie de preguntas nuevas en este campo de estudio. Tanto los estudios de esta tesis doctoral como gran parte de la bibliografía previa, deja en evidencia que hombres y mujeres responden de forma diferencial a las interacciones sociales. En primer lugar, su respuesta fisiológica suele ser diferente y en segundo lugar sus sistemas cerebrales de toma de decisiones están influenciados de forma diferencial por las hormonas (Lighthall et al., 2012; van den Bos et al., 2013) dando lugar a conductas sociales distintas. Sin embargo, todavía hay muchas inconsistencias en la forma en que las respuestas endocrinas afectan a dichas decisiones y conductas. En este sentido, pensamos que la T es una hormona clave para la conducta social humana (Eisenegger et al., 2011; Salvador, 2012), pero aún falta mucha investigación al respecto ya que los estudios que evalúan la conducta social después de una interacción social, concretamente las interacciones complejas como el conflicto intergrupal, no suelen evaluar la respuesta endocrina de la T. Sería interesante analizar como la respuesta de la T y el C después de una interacción social, interaccionan para regular la toma de decisiones social usando juegos como el *prisoner´s dilema* (Rapoport & Chammah, 1965), el *ultimátum game* (Güth, Schmittberger, & Schwarze, 1982), el *trust game* (Berg, 1995), el *Hawk-Dove Game* (Maynard-Smith, 1982) o el *dictator game* (Kahneman, Knetsch, & Thaler, 1986).

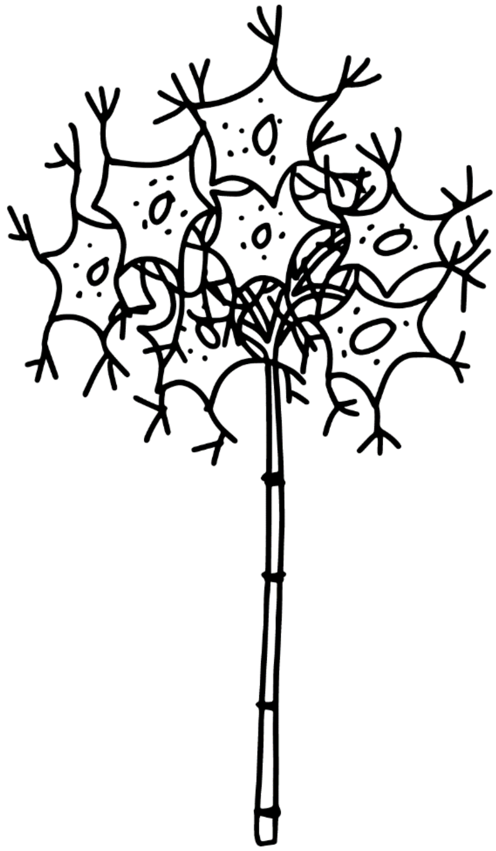
Asimismo, los hombres suelen tener mayor T que las mujeres, y en su lugar las mujeres segregan mayor cantidad de estrógenos y progestágenos. Estas hormonas son las encargadas de regular el ciclo menstrual y podrían estar involucradas modulando la relación de la T sobre la toma de decisiones, así como podrían estar involucradas directamente en la conducta social (Barel et al., 2017). Por ello, sería interesante medir los estrógenos y progestágenos, así como la oxitocina y realizar investigaciones controlando el ciclo menstrual. De hecho, investigaciones previas han mostrado diferentes patrones de afrontamiento al estrés social según el ciclo menstrual en el que se encontraban mujeres sanas (Villada et al., 2017).

Por otro lado, hemos visto que los sistemas endocrinos y CV se ven afectados por el grupo de pertenencia. Una posible explicación es que estas respuestas se sincronizan entre los miembros de los grupos para coordinar mejor sus respuestas a la interacción social. Otros estudios han puesto de manifiesto que la sincronización de la FC en un grupo está implicada en procesos de creación confianza (Mitkidis et al., 2015); de hecho, la sincronización de la HF se ha relacionado con el favoritismo hacía los miembros de nuestro aunque sea un grupo creado por el paradigma del grupo mínimo (Sahdra et al., 2015). Asimismo altos niveles de HF se relacionan con altos niveles de cooperación entre personas (Beffara et al., 2016). Este campo de investigación abre nuevas posibilidades a la comprensión de la psicología de los grupos, las interacciones sociales y la cooperación. Lograr aplicar una intervención que coordine estas respuestas podría ser interesante para la mejora de la cooperación intergrupal en grupos de trabajo y empresas.

Finalmente, una de las ideas principales de la tesis es que la forma de tomar decisiones puede fomentar el tener un mejor o peor afrontamiento ante las interacciones sociales con consecuencias CV a corto y largo plazo. Debemos recordar que el cuerpo humano actúa como un todo coordinado y que tanto el corazón, como el SNA, el SNC, los sistemas endocrinos y la cognición están adaptándose al ambiente de forma coordinada (Shaffer et al., 2014). Basándose en ello, McCraty (2011) propone el modelo de la coherencia psicofisiológica, el cual expone que un incremento del tráfico aferente vagal implica un aumento de la capacidad de autorregulación. Propone que el corazón tiene un ritmo en el que es coherente con las respuestas cerebrales y esto tiene efectos a nivel cognitivo en el control emocional, dando lugar a una mayor flexibilidad (McCraty, Atkinson, Tomasino, & Bradley, 2009). Dado que tanto las habilidades en toma de decisiones como los hábitos en los estilos decisionales son variables estables que pueden educarse también sería interesante aplicar terapia cognitivo conductual centrada en cambiar este tipo de hábitos. Estas modificaciones podrían tener como consecuencia un mejor ajuste a nivel de coherencia del SNA y SNC. Además, si combinamos estas técnicas con biorretroalimentación de la VFC, se podría mejorar la capacidad del sujeto para obtener un ritmo cardiaco coherente, y en consecuencia una mayor autorregulación. De hecho la biorretroalimentación de VFC, ha mostrado resultados muy satisfactorios en el tratamiento de diversos trastornos psiquiátricos como la depresión o la ansiedad (Beckham, Greene, & Meltzer-Brody, 2013; Groves & Brown, 2005; Ratanasiripong, Ratanasiripong, & Kathalae, 2012; Siepmann, Aykac, Unterdörfer, Petrowski, & Mueck-Weymann, 2008). Por tanto, a partir de nuestros resultados consideramos que la intervención en mejorar los hábitos de toma de decisiones es una estrategia que podría favorecer la salud física y mental del individuo, ya que puede afectar de forma directa a la VFC, favoreciendo la regulación fisiológica y emocional, lo cual, su vez, podría ser un factor de resistencia al desarrollo de enfermedades.

Chapter 9:

Main Conclusions



Main conclusions:

The following main conclusions can be drawn from the studies included in this thesis:

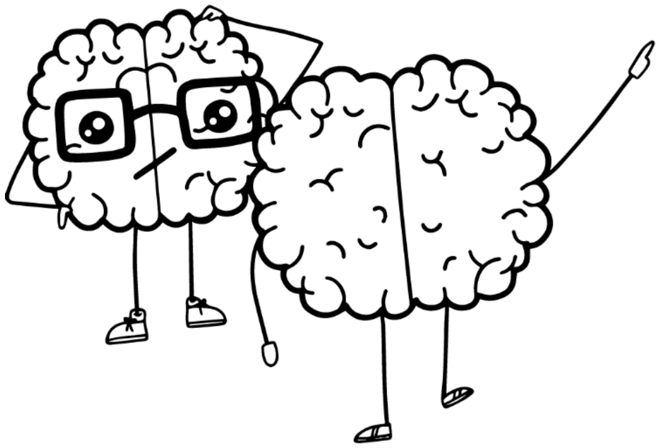
1. Intergroup conflict induces a psychophysiological stress response: increases in positive and negative mood, sympathetic activation, parasympathetic withdrawal and HPA axis activation.
2. There are sex differences in the response to intergroup conflict; women in conflict have a T drop compared to men whose T did not change.
3. The team is a cluster variable important to consider in the physiological response to intergroup conflict which influence in the conflict perception, the CV and the T response.
4. In men, the higher C and T after a social interaction the riskier decision-making under an uncertainty of risk.
5. In women, the higher C and T after a competition the more conservative decision-making under an uncertainty of risk.
6. Participants with better decision-making skills showed a CV response pattern related to higher mental load (lower LF HRV) during competition and a faster recovery to basal levels than poor deciders.
7. Good deciders who win a competition showed better vagal control (higher HF HRV) during and after a competition
8. The Spanish validation of GDMS have 22 items and showed great psychometric properties showing, construct validity, convergent-discriminant validity, temporal reliability and high internal consistency.
9. GDMS showed sex invariance properties, and from the decision-making styles, women have higher scores in the dependent style than men.

Main conclusions

10. Intuitive decision-making style is related to higher resting HRV values. By contra, avoidant decision-making styles are related to lower HR

Chapter 10:

General Summary



1. Introduction:

1.1 *Social interactions and psychobiological correlates:*

One of the most important characteristics of human beings is their capacity and their necessity to organize themselves in groups (Kurzban & Neuberg, 2015, Wilson & Wilson, 2007). Group interactions have promoted, for example, development of personal skills, learning, social and technological innovations that, finally, enhanced adaptation to environment. That is why, probably, evolution favored the development of structures and psychobiological mechanisms that encourage the formation of groups (De Dreu & Kret, 2016).

For all these reasons, humans are considered substantially social species. In addition, these interpersonal interactions may be with members of the group (in-group) or with members of another group (out-group) (Tajfel & Turner, 1979). However, elucidate whether the social situation is interpersonal or intergroup is a challenge, because the criteria are subjective and flexible. In general, an outgroup member transforms the situation into intergroup changing, therefore, the situation appraisal. Complementarily, social interactions can become a social stressor (Brondolo et al., 2003). As a result, an individual or a group will assess a social interaction as threatening, or not, depending on the context and on the resources available to the individual (or group) to face it (Folkman, Lazarus, Dunkel-Schetter, DeLongis, & Gruen, 1986, Lazarus & Folkman, 1984).

In this way, a social interaction perceived as important, but without the necessary resources available to confront it, would be appraised as negative or threatening eliciting psychobiological stress response. Whereas a social interaction perceived as important, with the necessary resources available to face it, will be assessed as positive or challenging, reducing the stress response (Taylor, 2006). Usually, people rely less on groups than on individuals, consequently intergroup interactions would be more hostile than interpersonal ones (Bornstein & Ben-Yossef, 1994, Pemberton, Insko, & Schopler, 1996; Wildschut, Pinter, Vevea, Insko, & Schopler, 2003). In this regard, the situation appraisal (as a threat or a challenge) (McEwen & Wingfield, 2003; Salvador & Costa 2009) elicits different physiological responses. In the case of intergroup conflict, there are neither studies on the psychobiological response to conflict nor the psychological variables that operate in this response. Besides, these appraisal depends on the characteristics of the person and of the social situation itself. Appraisal begins in the Central Nervous System (CNS), integrating outside information and coordinating neuroendocrine and behavioral mechanisms to respond to threatening, novel or potentially harmful situations. Classically, stress response was described in two phases (Russell & Shipston, 2015). First, the response begins activating the sympathetic nervous system (SNS) and, subsequently, continues with the activation of the hypothalamic-pituitary-adrenal (HHA) axis.

1.2 Decision making:

Behaviors carried out during social interactions affect our life with short and long term effects. As explained in previous section, social interactions can act as an acute stressor influencing behaviors, during and after social interaction. Making good or bad decisions increase (or reduce) the adaptation to social contexts. The choice of a specific behavior, at consciously or not consciously level, is made through a decision-making process. Decision-making is a key variable in the processes of planning and adaptation to the environment. In fact, the better adaptation to contextual feedback the better performance in decision-making tests (Brand, Labudda, & Markowitsch, 2006).

In addition, decision-making processes are affected by the physiological and emotional state of the individual. Thus, investigation has focused on emotional and physiological changes to acute social stress in the subsequent decision-making response (Porcelli & Delgado, 2017; Starcke & Brand, 2012, 2016). Therefore, in the process of decision-making information is collected from the environment, from internal state of the organism, from the emotions and from the cognitive situation processing, in order to provide, *a priori*, an appropriate and adaptive response.

In this sense, acute stressors, including social interactions, have a great influence on decision-making, altering feedback processing, learning or risk assessment (Mather & Lighthall, 2012; Porcelli & Delgado, 2017; Starcke & Brand, 2012). The somatic marker hypothesis (Damasio et al., 1996) highlights the importance of emotional processing in decision-making (Lerner, Li, Valdesolo, & Kassam, 2015). Moreover, there are sex differences in the way of how social stress affects decision-making (van den Bos, et al., 2009). Other main variables involved in the decision-making process are grouped into continuous: from uncertainty to certainty (with a distinction between ambiguity and risk); and from intuitive decision to rational one.

In addition, people, by means of cognitive processes, collect and integrate information from the environment to provide a response as adaptive as possible to stressful social situations (Schmeichel & Tang, 2015). For all this, these systems regulate the level of physiological activation optimal to the context depending on past experience and on individual differences in executive functions, in particular, on decision-making (Thayer, Hansen, Saus -Rose, & Johnsen, 2009). Thus, decision making could play an essential role in emotional and physiological self-regulation in changing environments (Santos-Ruiz et al., 2012). This previous research investigated decision-making and executive functions using neuropsychological instruments. However, apart from neuropsychological assessments, as Iowa Gambling Task (IGT), other instruments are being developed to assess habits in decision making as *General Decision Making Styles* scale (GDMS: Scott & Bruce, 1995), measuring individual general proneness to respond to decision-making situations.

Decision-making styles are related to self-regulation and self-control (Baiocco, Laghi, & D'Alessio, 2009, Scott & Bruce, 1995), to coping styles in conflict management (Loo, 2000), to stress management and general mental health variables (Bavolar &

Orosova, 2015). In addition, decision-making styles modulated the C stress response, being associated with vulnerability / resilience to stressors (Thunholm, 2008). Complementary, decision-making styles are closely related to decision-making skills (Bavolar & Orosova, 2015) and to personality traits (Dewberry, Juanchich, & Narendran, 2013). Therefore, there are a close relationship among personality variables, the way of making decisions, competence in decision-making and cognitive, emotional and physiological self-regulation systems. The relationship among the former factors promote physiological and behavioral responses to face social interactions. In short, the style and competence in decision-making is going to have direct consequences in our life. In this sense is possible that decision-making styles and abilities would be associated with physiological response to social interactions and physiological resting conditions.

2. Aims and Hypothesis:

Objective 1: Intergroup conflict is common in our society; however, there is scarce investigation intergroup conflict. The first aim is to analyze the emotional and physiological response to intergroup conflict between groups using the minimal group paradigm. Furthermore, we aimed to study sex differences in these responses. We expected to find sex differences in the responses to intergroup conflict in order to adapt their behavior to this kind of social interaction.

Objective 2: After research on intergroup conflict our project provided two principal results, sex-differences in the biological response and an influence of conflict in the following decision-making (Martínez-Tur et al., 2014). Taking into account these results, we focused our interest on decision-making after another social interaction considering sex differences. Thus, the second objective of this thesis was to test how the physiological and emotional changes after a competition would affect risk-taking behavior in men and women. We expected that higher in T changes and lower in C changes would induce a greater risk-taking behavior in a decision-making task.

Objective 3: One important variable that would help to adapt to social interactions is the decision-making skills. Having better decision-making skills would help to have a better physiological adaptation to conflictive social interactions, such as competition. In this sense, CV responses have been related to an adaptive physiological response pattern that would help people to cope with social stress. Considering this pattern, our third aim was to analyze whether decision-making skills influence the way to cope with social interaction, specifically a competition. In this sense we hypothesize higher response of HF HRV that is a marker of executive control, but also, lower LF HRV that would indicate more mental load in order to confront the competition.

Objective 4: Decision-making styles can be considered as a personality trait that can predict the long-term decision-making strategies. There is a questionnaire named "*General Decision-making Scale*" (GDMS) that has been proved to be useful to measure proneness to decision-making styles. However, there is not a Spanish validation of this scale. For that reason we aimed to adapt the GDMS to Spanish population and provide psychometric characteristics of this adaptation to validate this questionnaire. Also, we aimed to expand the research in decision-making styles analyzing sex differences in decision-making styles, but firstly performing sex invariance analyses.

Objective 5: Related to the validation of the decision-making styles as a personality factor, recently it has been indicated that personality traits could be related to an endophenotypic physiological marker of executive control as HRV. Thus, the last objective is to explore the relationships between the decision-making styles, measured with the validated version of GDMS, and HRV indexes, in order to give support of physiological correlates of decision-making style.

3. Methods and Results:

Study 1: Due to the important consequences of conflicts in societies and its relation to people's health, it is important to understand the psychophysiological response to conflict. However, despite many studies on interpersonal conflict, there are no previous studies that have examined the psychophysiological response to intergroup conflict. The aim of this study was to analyze this response to a laboratory intergroup conflict. For this purpose, an intergroup conflict was generated between two groups of three people each, and their responses were compared to those of control groups. 150 healthy young people were distributed in 50 groups in two conditions (conflict vs. non-conflict). Conflict perception, mood, and cardiovascular (heart rate, HR, and the root mean square successive difference, RMSSD) and endocrine (cortisol, C, and testosterone, T) measures were taken across experimental sessions. Results showed that conflict induced mood (positive and negative), HR, and C increases, whereas the RMSSD decreased. In addition, women in the conflict situation showed lower T than women without conflict and men in both conditions. Thus, our results confirm that intergroup conflict acts as a social stressor, and they suggest that men and women interpret conflict differently. Women seem to interpret conflict as more threatening than men, and their responses may promote "tend and befriend" behaviors.

Study 2: Recent neuroendocrinology research has pointed out that testosterone (T) and cortisol (C) changes after social interactions can predict risk-taking behavior in decision-making depending on the sex of participants. However, most of previous research has focused on the effects of the changes of just one hormone. without taking into account that C can suppress T activity. Our aim was to test the role of T changes moderated by C changes after competition on decision-making, considering sex-differences. 48 males and 46 females completed the Iowa Gambling Task (IGT) after a laboratory competition or a non-competitive task (Control task). Saliva samples were collected before and after the competition/control task. IGT was employed to measure risk-taking decision-making, considering the degree of uncertainty. Our results showed sex-differential effects of T and C changes on risk-taking behavior. On the one hand, men from both task (Competition/Control) with higher C and T changes after competition showed higher IG Risky, that is, more risk-taking decision-making. On the other hand, women with high C and T showed more conservative decision-making in competition task. Therefore, competition hormonal changes are related to different decision-making profiles, with riskier decision-making in men and more conservative in women.

Study 3: Competition elicits different psychological and cardiovascular responses depending on a person's skills. Decision-making has been considered a distal factor that influences competition, but there are no studies analyzing this relationship. Our objective was to analyze whether decision-making affects the response to competition. Specifically, we aimed to test whether good performers on a decision-making test, the Iowa Gambling Task (IGT), showed an adaptive cardiovascular response to competition. 116 participants (44 women) performed the IGT and were classified into Good or Poor decision-makers. Subsequently, they were exposed to a stress task in two different conditions: a face-to-face Competition (Winners/Losers) or a Control condition, while an electrocardiogram was recorded. In the Competition group, Good decision-makers increased their High Frequency respect to the total Heart Rate Variability (HF/HRV) levels during the task, compared to Poor decision-makers. Again, Competition group Good decision-makers, showed lower LF and higher HF/HRV reactivity than the Control group, which represents lower HRV stress pattern. Moreover, in the group of Losers, Good decision-makers had a decline in Low Frequency (LF) during the task and faster recovery than Poor decision-makers. In conclusion, Good decision-makers have a more adaptive stress response and higher levels of mental effort, based on total HRV interpretation. Decision-making skills could be a factor in a more adaptive cardiovascular response to competition.

Study 4: The *General Decision Making Styles* (GDMS) scale is a questionnaire to measure five decision-making styles: Rational, Intuitive, Dependent, Avoidant and Spontaneous. This scale was translated and validated in some languages, however the psychometric properties from a Spanish translation had not been demonstrated. Our aim is to translate to Spanish the GDMS and to provide psychometric evidence for this translation. Another purpose was to search for sex differences in decision making styles and investigate the relationships between the 5 decision-making styles and personality and coping variables. We performed two studies, in the *first* study a sample of 361 participants fulfilled GDMS, and the *Ten item personality trait inventory* and the *brief COPE* scales. After eight weeks participants were asked to fulfil GDMS once again (137 participants) to measure temporal stability. In the *second* study another sample of 300 participants were recruited to fulfill the GDMS and the *Rational-Experiential Inventory.* Exploratory factor analyses showed a five factor composition of GDMS with 22 items regardless the original 25. Correlated five-factor structure with two errors of covariance freely estimated were confirmed and there was equivalence across sex using invariance analyses. Furthermore, an acceptable construct reliability and temporal stability have been found. Our results also showed higher dependent style in women than men. Moreover, rational and intuitive styles were more related to active coping patterns and with emotional stability, while dependent, avoidant and spontaneous styles were associated with passive coping patterns and less emotional stability. This research provides a Spanish translation of GDMS with good psychometric properties and expand the research regarding decision making styles and other individual differences as sex, personality and coping patterns.

Study 5: Decision-making styles are the general tendency of individuals to decide in daily life. *Rational* and *intuitive* styles had been related to less stress and better mental health and sleep patterns. By contra, *dependent, avoidant* and *spontaneous* styles have been related to high stress levels and worse mental health and sleep patterns. For that reason, we hypothesize that a physiological marker of health, the Heart rate variability (HRV) would be associated with decision making styles. Our aim was to test if decision making styles predict resting HRV. A sample of 199 (119 women) participants fulfilled the GDMS in a laboratory and a questionnaire for controlling variables for the HRV. ECG was measured in resting conditions in order to extract frequency domain HRV variables. Results showed that engaging in the *intuitive* style predicts High frequency HRV, while engaging in *avoidant* style predicts less Low frequency HRV. These results provide evidence that *intuitive* style is related to healthier resting cardiovascular levels, in contrast, *avoidant* styles are associated with worse resting cardiovascular levels. Results are discussed arguing why intuitive and avoidant styles are related to HRV but no rational, spontaneous and dependent.

4. Main conclusions:

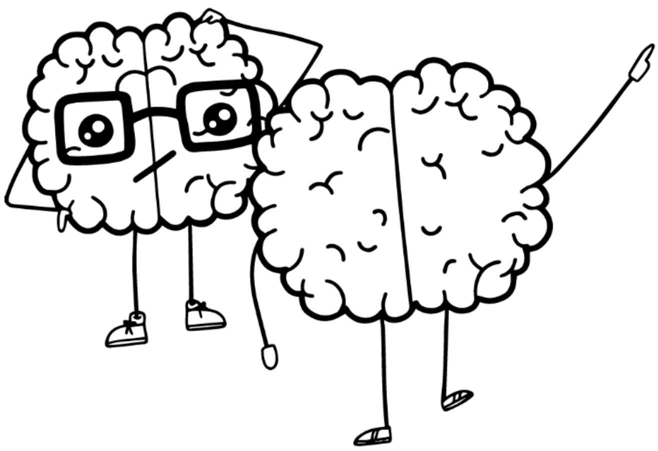
The following main conclusions can be drawn from the studies included in this thesis:

1. Intergroup conflict induces a psychophysiological stress response: increases in positive and negative mood, sympathetic activation, parasympathetic withdrawal and HPA axis activation.
2. There are sex differences in the response to intergroup conflict; women in conflict have a T drop compared to men whose T did not change.
3. The team is a cluster variable important to consider in the physiological response to intergroup conflict which influence in the conflict perception, the CV and the T response.
4. In men, the higher C and T after a social interaction the riskier decision-making under an uncertainty of risk.

5. In women, the higher C and T after a competition the more conservative decision-making under an uncertainty of risk.
6. Participants with better decision-making skills showed a CV response pattern related to higher mental load (lower LF HRV) during competition and a faster recovery to basal levels than poor deciders.
7. Good deciders who win a competition showed better vagal control (higher HF HRV) during and after a competition
8. The Spanish validation of GDMS have 22 items and showed great psychometric properties showing, construct validity, convergent-discriminant validity, temporal reliability and high internal consistency.
9. GDMS showed sex invariance properties, and from the decision-making styles, women have higher scores in the dependent style than men.
10. Intuitive decision-making style is related to higher resting HRV values. By contra, avoidant decision-making styles are related to lower HRV.

Capítulo 11:

Resumen General



1. Introducción:

1.1 *Las interacciones sociales y sus correlatos psicobiológicos:*

Una de las características más importantes del ser humano es su capacidad y, a la vez necesidad, de organizarse en grupos (Kurzban & Neuberg, 2015; Wilson & Wilson, 2007). Esto lleva a nuestra especie a relacionarse e interaccionar de diversas maneras, con consecuencias tanto positivas como negativas. Es por ello que, probablemente, la evolución ha favorecido el desarrollo y mantenimiento de genes que activan estructuras y mecanismos psicobiológicos que fomentan la formación de grupos, predisponiendo al individuo para las interacciones sociales (De Dreu & Kret, 2016).

Por todo ello la especie humana es considerada una especie social y, por lo general, las personas interaccionan con otros individuos o grupos diariamente. Asimismo, puede que estas interacciones interpersonales sean con miembros considerados del propio grupo (*in-group*) o con miembros de otro grupo o intergrupales (*out-group*). (Tajfel & Turner, 1979). La importancia de diferenciar una situación como interpersonal o intergrupal radica en que la interpretación de dicha situación social será diferente. Por ejemplo, cualquier interacción social puede ser un estresor social para una persona (Brondolo et al., 2003). Desde este punto de vista, un individuo, o grupo, interpretarán una interacción social como amenazante, o no, en función del contexto en el que ocurre dicha interacción y los recursos de los que dispone el individuo (o grupo) para afrontarla. (Folkman, Lazarus, Dunkel-Schetter, et al., 1986; Lazarus & Folkman, 1984).

De este modo una interacción social percibida como importante, pero donde no se dispone de los recursos necesarios para afrontarla será evaluada como negativa o amenazante. Dicha valoración puede provocar una respuesta psicobiológica de estrés; mientras que una interacción social percibida como importante, donde se dispone de los recursos necesarios para afrontarla, será evaluada como positiva o reto, reduciéndose la respuesta de estrés (Taylor, 2006). Las personas, por norma general, confían menos en los grupos que en los individuos y esperan que las interacciones intergrupales sean mucho más hostiles que las interacciones interpersonales (Bornstein & Ben-Yossef, 1994; Pemberton et al., 1996; Wildschut et al., 2003).

En este sentido, la situación puede interpretarse como un reto o como una amenaza (McEwen & Wingfield, 2003; Salvador & Costa, 2009) dando lugar a distintas respuestas fisiológicas. Dicho proceso de evaluación comienza en el Sistema nervioso central (SNC) que integra la información procedente del exterior y coordina los mecanismos neuroendocrinos y conductuales para dar una respuesta ante estas situaciones amenazantes, novedosas o potencialmente dañinas. Clásicamente, se considera que la respuesta de estrés tiene dos componentes (Russell & Shipston, 2015) que se activan de forma complementaria para afrontar el estresor la activación del Sistema nervioso simpático (SNS) y del eje hipotálamo-hipófiso-adrenal (HPA). Sin embargo, se ha demostrado que es una respuesta integrada del organismo que envuelve todo tipo de sistemas, incluidos la activación/inhibición de otros ejes hormonales o del sistema inmunitario induciendo la liberación de beta-endorfinas, prolactina, vasopresina, glucagón y oxitocina o inhibiendo la liberación de los esteroides gonadales, la insulina y la hormona del crecimiento (Carter, 2003; Sapolsky, 1992, 2002). Por tanto, la respuesta de estrés es muy compleja y difícil de abarcar.

En resumen, durante una interacción social un humano se puede preguntar a sí mismo, de forma consciente o no consciente cuestiones como ¿soy capaz de afrontar la situación?, ¿esta persona es amigo o enemigo?, ¿la situación es perjudicial para mí?, ¿cómo debo comportarme con ella?, ¿qué puede aportarme o qué puede quitarme?, ¿debo ser amable o debo ser asertivo? Estas cuestiones favorecen unos patrones de respuesta biológicos y emocionales que pueden guiar nuestras decisiones tanto durante como tras la interacción social. Las decisiones que se toman conllevan que los individuos sean más proclives a luchar, huir, crear lazos o paralizarse, y también dan lugar a una mayor sensibilidad o aversión a las recompensas/pérdidas. Finalmente, el resultado que se obtenga después de la interacción social dará información a la persona sobre la interacción social, su conducta y las decisiones que ha tomado, aumentando su experiencia para futuras ocasiones.

1.2 La toma de decisiones:

Las conductas que se realizan durante una interacción social pueden dar lugar a distintos resultados que pueden afectar nuestra vida a corto y largo plazo. Como se ha explicado en el apartado anterior, las interacciones sociales pueden actuar como un estresor agudo con efectos en el comportamiento, tanto durante como después de dicha interacción social. Decidir entre un comportamiento u otro cobra gran importancia, ya que facilitará o dificultará la adaptación a la situación. La elección del comportamiento adecuado se realizará de forma consciente o inconsciente a través de un proceso de toma de decisiones. De hecho, una mayor capacidad de adaptación a la retroalimentación contextual se relaciona directamente con un mejor rendimiento en pruebas de toma de decisiones (Brand et al., 2006).

Además, los procesos de toma de decisiones están afectados por el estado fisiológico y emocional del individuo, por lo que se ha investigado, por ejemplo, los efectos de los cambios emocionales y fisiológicos inducidos por estresores sociales agudos en la posterior toma de decisiones (Porcelli & Delgado, 2017; Starcke & Brand, 2012, 2016), como se detallará en apartados posteriores. Por tanto, para tomar una decisión se recaba información externa, del entorno social, e interna, del estado del organismo, las emociones y el procesamiento cognitivo de la situación, con la finalidad de dar una respuesta apropiada y adaptativa.

Pero para entender cómo la toma de decisiones es un proceso que nos permite adaptarnos a entornos cambiantes y estresantes primero debemos conocer las variables implicadas en el proceso de toma de decisiones, que se detallarán en el próximo apartado. En este sentido, los estresores agudos, incluidos los sociales, han demostrado tener una gran influencia en la toma de decisiones, alterando el procesamiento de retroalimentación, el aprendizaje o la evaluación de riesgos (Mather & Lighthall, 2012; Porcelli & Delgado, 2017; Starcke & Brand, 2012). Es posible que la influencia del estrés sobre la toma de decisiones sea debida al cambio que induce en el estado de ánimo. La hipótesis del marcador somático (Damasio et al., 1996) pone de manifiesto la importancia del procesamiento emocional en la toma de decisiones (Lerner et al., 2015). Además, existen diferencias de sexo en la forma en la que el estrés social puede llegar a afectar la toma de decisiones (van den Bos et al., 2009)

Los procesos cognitivos superiores recogen e integran la información que proviene del ambiente para dar una respuesta lo más adaptativa posible a dichas situaciones sociales estresantes (Schmeichel & Tang, 2015). Por todo esto, estos sistemas autorregulan el nivel de activación fisiológica adecuado al contexto y esto en parte depende de la experiencia pasada de una persona y sus diferencias individuales en funciones ejecutivas y, en concreto, de la toma de decisiones (Thayer, Hansen, Saus-Rose, & Johnsen, 2009). De entre los procesos cognitivos superiores, la toma de decisiones podría jugar un papel esencial en la autorregulación emocional y fisiológica en entornos cambiantes (Santos-Ruiz et al., 2012). Un estudio relacionó un mejor rendimiento en toma de decisiones medido con el IGT, con una respuesta fisiológica más saludable ante un estresor social ampliamente utilizado, el *Trier Social Stress Task* (TSST: Kirschbaum, Pirke, & Hellhammer, 1993). Esta investigación previa investigó la toma de decisiones y las funciones ejecutivas usando instrumentos neuropsicológicos para evaluarlas. Sin embargo, además de estos los instrumentos neuropsicológicos, como el *Iowa Gambling Task* (IGT), otros instrumentos se están desarrollando para evaluar otros aspectos de la toma de decisiones. Un ejemplo son los hábitos en toma de decisiones evaluados con el *General decision making style* (GDMS: Scott & Bruce, 1995).

Los estilos de toma de decisiones están relacionados con la autorregulación y el autocontrol (Baiocco et al., 2009; Scott & Bruce, 1995), con los estilos de afrontamiento en la gestión de conflictos (Loo, 2000) y con la gestión del estrés y variables generales de salud mental (Bavolar & Orosova, 2015). Además, los estilos de toma de decisiones han demostrado ser factores moduladores de la respuesta de C ante un estresor, mostrando ser factores de vulnerabilidad/resiliencia ante los estresores (Thunholm, 2008). Los estilos decisionales están estrechamente relacionados con las competencias en toma de decisiones (Bavolar & Orosova, 2015) y, junto a variables de personalidad, parecen predecir dichas competencias (Dewberry et al., 2013). Estos hechos muestran la estrecha relación entre las variables de personalidad, la forma en la que tomamos las decisiones, la competencia en la toma de decisiones y los sistemas de autorregulación cognitivos, emocionales y fisiológicos como factores que se interrelacionan para dar las respuestas fisiológicas y conductuales necesarias para afrontar las interacciones sociales. En definitiva, el estilo y la competencia de una persona a la hora de tomar decisiones tendrán consecuencias directas en su vida. En este sentido, es posible que tanto los estilos en toma de decisiones como las habilidades en toma de decisiones puedan estar relacionadas con la respuesta fisiológica en las interacciones sociales y los valores fisiológicos en condiciones de reposo.

2. Objetivos e hipótesis:

Como hemos revisado en la introducción, los humanos usualmente están involucrados en interacciones sociales complejas que ocasionan consecuencias tanto positivas como negativas, dependiendo del contexto. Estas interacciones tienen diferentes implicaciones dependiendo del tipo de interacción (grupal o individual), además de diferentes implicaciones psicobiológicas. En este sentido, la forma en que las personas evalúan estas interacciones modula la respuesta psicológica y fisiológica. Además, esta evaluación se modula, al mismo tiempo, por variables rasgo (o más estables), como el estilo de toma de decisiones o la experiencia pasada. En este sentido, los procesos de toma de decisiones en las interacciones sociales pueden guiar el comportamiento. En un contexto específico, las respuestas fisiológicas y emocionales pueden influir en la toma de decisiones posterior para poder comportarse a priori, adaptativamente, aunque no necesariamente. Por esa razón, vale la pena señalar las variables situacionales (es decir, el objetivo de la interacción, ya sea una interacción interpersonal o intergrupal) que involucren interacciones sociales.

Esta tesis doctoral se centra en dos aspectos de las interacciones sociales. Primero, considerando la escasa literatura sobre la psicobiología del conflicto intergrupal, el primer objetivo principal es estudiar la respuesta psicobiológica a un conflicto intergrupal para comprender como puede afectar la complejidad de los procesos grupales en la respuesta biológica durante un conflicto. En segundo lugar, nos interesa la toma de decisiones como una variable que influye en las interacciones sociales. Nuestro objetivo general fue analizar cómo la toma de decisiones modula la respuesta psicobiológica a las interacciones sociales y su relación con mejores resultados en tareas que impliquen interacciones sociales. En este último caso, teniendo en cuenta que la toma de decisiones es un proceso individual, hemos optado por estudiar la toma de decisiones en competiciones cara a cara, un contexto similar al conflicto, pero que permite un mayor control durante la interacción (solo dos personas) y así poder estudiar la toma de decisiones individualmente, sin influencia grupal. En ambos objetivos se consideraran las diferencias entre sexos.

Estos dos objetivos principales se han dividido en cinco objetivos específicos; estos objetivos se abordaron en cinco estudios diferentes que componen los siguientes capítulos.

Cada capítulo proporcionó una versión más completa de objetivos e hipótesis en base a la literatura relevante. Aquí se resume un extracto de estos objetivos e hipótesis:

Objetivo 1: el conflicto intergrupal es bastante común en la sociedad actual; sin embargo, hay pocos estudios que investiguen este tipo de conflicto. El primer objetivo es analizar la respuesta emocional y fisiológica al conflicto intergrupal, entre dos grupos creados por el paradigma de grupo mínimo. Además, intentamos estudiar las diferencias de sexo en estas respuestas. Esperamos encontrar diferencias de sexo en las respuestas al conflicto intergrupal para adaptar su comportamiento a este tipo de interacción social.

Objetivo 2: Después de la investigación sobre el conflicto intergrupal, nuestro proyecto proporcionó dos resultados principales, las diferencias por sexo en la respuesta biológica y la influencia del conflicto en la toma de decisiones posterior (Martínez-Tur et al., 2014). Teniendo en cuenta estos resultados, centramos nuestro interés en la toma de decisiones después de otra interacción social teniendo en cuenta las diferencias de sexo. Por tanto, el segundo objetivo de esta tesis fue probar cómo los cambios fisiológicos y emocionales después de una competición afectarían la conducta de riesgo en hombres y mujeres. Esperamos que mayores cambios en T y menores cambios en C induzcan mayores decisiones arriesgadas en una tarea de toma de decisiones.

Objetivo 3: Una variable importante que ayudaría a adaptarse a las interacciones sociales es la capacidad de toma de decisiones. Tener mejores habilidades de toma de decisiones ayudaría a tener una mejor adaptación fisiológica a las interacciones sociales conflictivas, como la competición. En este sentido, las respuestas CV se han relacionado con un patrón de respuesta fisiológica adaptativa que ayudaría a las personas a lidiar con el estrés social. Teniendo en cuenta este patrón, nuestro tercer objetivo fue analizar si las habilidades de toma de decisiones influyen en la forma de lidiar con una interacción social, específicamente una competición. En este sentido, hipotetizamos una mayor respuesta de HF VFC que es un marcador de control ejecutivo, pero también un menor LF VFC que indicaría más carga mental para enfrentar a la competición.

Objetivo 4: los estilos de toma de decisiones pueden considerarse un rasgo de personalidad que puede predecir las estrategias de toma de decisiones a largo plazo. Existe un cuestionario llamado *"General Decision Making Styles"* (GDMS) que ha demostrado ser útil para medir la propensión a los estilos de toma de decisiones. Sin embargo, no hay una validación en español de esta escala. Por ese motivo, intentamos adaptar el GDMS a la población española y proporcionar las características psicométricas de esta adaptación para validar el cuestionario. Además, nuestro objetivo fue ampliar la investigación en los estilos de toma de decisiones analizando las diferencias de sexo en los estilos de toma de decisiones, pero primero realizando análisis de invarianza entre ambos sexos.

Objetivo 5: Relacionado con la validación de los estilos de toma de decisiones como un factor de personalidad, recientemente se ha indicado que los rasgos de personalidad podrían estar relacionados con un marcador fisiológico endofenotípico del control ejecutivo como VFC. Por tanto, el último objetivo es explorar las relaciones entre los estilos de toma de decisiones, medidos con la versión validada de GDMS, y los índices de VFC, para dar soporte a los correlatos fisiológicos del estilo de toma de decisiones.

3. Métodos y Resultados:

Estudio 1: Debido a que día a día los humanos se exponen a situaciones de conflicto y a que el conflicto ocasiona importantes consecuencias en las sociedades actuales y la salud de las personas involucradas, pensamos que es importante comprender como es la respuesta psicofisiológica al conflicto. Sin embargo, a pesar de los numerosos estudios sobre conflicto interpersonal, no hay estudios previos que hayan examinado la respuesta psicofisiológica al conflicto intergrupal. El objetivo de este estudio fue analizar esta respuesta psicofisiológica a un conflicto intergrupal de laboratorio. Para este propósito, se generó un conflicto intergrupal entre dos grupos de tres personas cada uno, y sus respuestas se compararon con una condición control, donde había dos grupos de personas sin conflicto. En total, 150 jóvenes saludables fueron distribuidos en 50 grupos en dos condiciones (conflicto vs. no conflicto). Se tomaron medidas de percepción del conflicto, estado de ánimo y medidas cardiovasculares (frecuencia cardíaca, FC, y raíz media cuadrática sucesiva, RMSSD) y endocrinas (cortisol, C y testosterona, T). Los resultados mostraron que el estado de ánimo aumentaba a raíz conflicto (positivo y negativo), aumentos del HR y C, y un descenso del RMSSD. Además, las mujeres en la situación de conflicto mostraron menor T que las mujeres sin conflicto y los hombres en ambas condiciones. Por tanto, nuestros resultados confirman que los conflictos intergrupales actúan como estresores sociales, y sugieren que los hombres y las mujeres interpretan los conflictos de manera diferente. Las mujeres parecen interpretar los conflictos como más amenazantes que los hombres, y sus respuestas pueden promover comportamientos relacionados con el *"Tend-and-Befriend"*.

Estudio 2: La investigación reciente en neuroendocrinología ha señalado que la testosterona (T) y el cortisol (C) cambian después de que las interacciones sociales y pueden predecir conductas arriesgados en la toma de decisiones. Además podría haber diferencias de sexo en la relación entre hormonas y conductas arriesgadas. Sin embargo, la mayoría de las investigaciones anteriores se han centrado en los efectos de los cambios de una sola hormona, sin tener en cuenta que C puede suprimir la actividad T. Nuestro objetivo fue evaluar el papel de los cambios de T moderados por los cambios de C después de la competencia en la toma de decisiones, teniendo en cuenta las diferencias de sexo. 48 varones y 46 mujeres completaron la Iowa Gambling Task (IGT) después de una competición de laboratorio o una tarea no competitiva (tarea de control). Se recogieron muestras de saliva antes y después de la tarea competitiva / control. El IGT se empleó para medir la toma de decisiones arriesgadas, teniendo en cuenta el grado de incertidumbre (ambigüedad o riesgo). Nuestros resultados mostraron efectos diferenciales de los cambios de T y C en las conductas de riesgo. Por un lado, los hombres sometidos a ambas tareas (Competición / Control) con mayores cambios de C y T después de la tarea mostraron un menor puntuación IG bajo ambigüedad de riesgo, es decir, decisiones con mayor riesgo. Por otro lado, las mujeres con alto C y T mostraron una toma de decisiones más conservadora después de la competición. Por tanto, los cambios hormonales después de una competición están relacionados con diferentes perfiles de toma de decisiones, con una toma de decisiones más arriesgada en los hombres y más conservadora en las mujeres.

Estudio 3: La competición provoca diferentes respuestas psicológicas y cardiovasculares según las habilidades de una persona. La toma de decisiones se ha considerado un factor distal que influye en la competición, pero no hay estudios que analicen esta relación. Nuestro objetivo fue analizar si la toma de decisiones afecta la respuesta cardiovascular a la competición. Específicamente, nuestro objetivo fue evaluar si los buenos resultados en una prueba de toma de decisiones, el Iowa Gambling Task (IGT), mostraban una respuesta cardiovascular adaptativa a la competición. En total, 116 participantes (44 mujeres) realizaron el IGT y se clasificaron en buenos o malos tomadores de decisiones. Posteriormente, fueron expuestos a una tarea de estrés en dos condiciones diferentes: una competición cara a cara (ganadores / perdedores) o una condición control, mientras se registraba un electrocardiograma. En el grupo competición, los buenos tomadores de decisiones aumentaron su frecuencia alta con respecto a los niveles totales de variabilidad de la frecuencia cardíaca (VFC) durante la tarea, en comparación con los malos tomadores de decisiones. De nuevo, en el grupo de competición los buenos tomadores de decisiones, mostraron una LF más baja y una reactividad HF / HRV más alta que el grupo Control, lo que representa un patrón VFC menos estresante. Además, en el grupo de perdedores, los buenos tomadores de decisiones tuvieron un declive en las bajas frecuencias (LF) durante la tarea y una recuperación más rápida que los malos tomadores de decisiones. En conclusión, los buenos tomadores de decisiones tienen una respuesta de estrés más adaptativa y niveles más altos de esfuerzo mental, basados en la interpretación de la VFC total. Las habilidades de toma de decisiones podrían ser un factor de afrontamiento importante que puede dar lugar a una respuesta cardiovascular más adaptativa a la competición.

Estudio 4: La escala *General Decision Making Styles* (GDMS) es un cuestionario para medir cinco estilos de toma de decisiones: Racional, Intuitivo, Dependiente, Evitativo y Espontáneo. Esta escala fue traducida y validada en algunos idiomas, sin embargo, no se han demostrado las propiedades psicométricas de una traducción al español. Nuestro objetivo es traducir al español el GDMS y proporcionar evidencia psicométrica para esta traducción. Otro objetivo fue buscar las diferencias de sexo en los estilos de toma de decisiones e investigar las relaciones entre los 5 estilos de toma de decisiones con la personalidad y los estilos de afrontamiento. Realizamos dos estudios, en el primer estudio una muestra de 361 participantes cumplimento el GDMS, el *Ten item personality trait inventory* (TIPI) y la escala *briefCOPE*. Después de ocho semanas, se le pidió a los participantes que completaran el GDMS una vez más (137 participantes) para medir la estabilidad temporal. En el segundo estudio, se reclutó otra muestra de 300 participantes para cumplimentar el GDMS y el *Rational-Experiential Inventory* (REI). El análisis factorial exploratorio mostró una composición de cinco factores del GDMS con 22 ítems a diferencia del original que tenía 25 ítems. Se confirmó la estructura de cinco factores correlacionados con dos errores de covarianza estimados libremente y la escala mostró que había equivalencia entre los sexos usando análisis de invarianza. Además, se ha encontrado una fiabilidad de constructo aceptable y buena estabilidad temporal.

Nuestros resultados también mostraron el estilo dependiente más alto en las mujeres que en los hombres. Por otra parte, los estilos racionales e intuitivos estaban más relacionados con patrones activos de afrontamiento al estrés y con mayor estabilidad emocional, mientras que los estilos dependientes, evitativos y espontáneos se asociaron con patrones pasivos de afrontamiento y una menor estabilidad emocional. Esta investigación proporciona una traducción al español de GDMS con buenas propiedades psicométricas y amplía la investigación sobre los estilos de toma de decisiones y otras diferencias individuales como el sexo, la personalidad y los patrones de afrontamiento.

Estudio 5: Los estilos de toma de decisiones son la tendencia general de un individuo a decidir en su vida diaria. Los estilos racionales e intuitivos se han relacionado con menos estrés, una mejor salud mental y mejores patrones de sueño. Por contra, los estilos dependientes, evitativos y espontáneos se han relacionado con altos niveles de estrés, una peor salud mental y peores patrones de sueño. Por esa razón, hipotetizamos que un marcador fisiológico de salud, la variabilidad de la frecuencia cardíaca (VFC) se asociaría con los estilos de toma de decisiones. Nuestro objetivo fue probar si los estilos de toma de decisiones predicen la VFC en reposo. Una muestra de 199 (119 mujeres) participantes cumplimento el GDMS en un laboratorio y un cuestionario para controlar variables que afectan la VFC. El ECG se midió en condiciones de reposo para extraer las variables de la VFC. Los resultados mostraron que usar más el estilo intuitivo predice mayor potencia en las altas frecuencias (HF) de la VFC, mientras que el estilo evitativo predice menor potencia en las bajas frecuencias de la VFC. Estos resultados proporcionan evidencia de que el estilo intuitivo se relaciona con niveles cardiovasculares en reposo más sanos, en contraste, los estilos de evitación se asocian con niveles cardiovasculares en reposo menos saludables. Los resultados se discuten argumentando por qué los estilos intuitivos y de evitación están relacionados con la VFC y no los racionales, espontáneos ni dependientes.

4. Conclusiones generales:

Las siguientes conclusiones principales se pueden extraer de los estudios incluidos en esta tesis:

1. El conflicto intergrupal induce una respuesta de estrés psicofisiológico: aumenta el estado de ánimo positivo y negativo, la activación simpática, la retirada parasimpática y la activación del eje HPA.
2. Hay diferencias de sexo en la respuesta al conflicto intergrupal; las mujeres en conflicto tienen una disminución de la T en comparación con los hombres cuya T no cambió.
3. El equipo es una variable importante a considerar en la respuesta fisiológica al conflicto intergrupal que influye en la percepción del conflicto, el CV y la respuesta T.
4. En los hombres, cuanto mayor es el C y la T después de una interacción social, más arriesgada es la toma de decisiones bajo una incertidumbre de riesgo.
5. En las mujeres, cuanto mayor es el C y la T después de una competición, más conservadora es la toma de decisiones bajo una incertidumbre de riesgo.
6. Los participantes con mejores habilidades de toma de decisiones mostraron un patrón de respuesta CV relacionado con una mayor carga mental (menor VFC) durante la competición y una recuperación más rápida a niveles basales que los malos decisores.
7. Los buenos decisores que ganan una competencia mostraron un mejor control vagal (mayor HF VFC) durante y después de una competencia
8. La validación española de GDMS tiene 22 ítems y muestra buenas propiedades psicométricas que muestran, validez de constructo, validez discriminante convergente, estabilidad temporal y alta consistencia interna.

9. El GDMS mostró propiedades de equivalencia por sexo, y de todos los estilos de toma de decisiones, las mujeres tienen puntuaciones más altas en el estilo dependiente que los hombres.
10. El estilo intuitivo de toma de decisiones se relaciona con valores más altos de VFC en reposo. Por contra, los estilos de toma de decisión evitativos están relacionados con menor VFC.

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