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Respuesta Psicobiológica a la cooperación.

Psychobiological response to cooperation.

TESIS DOCTORAL

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Abbreviations

ANS = autonomous nervous system

AUC = area under the curve

BMI = body mass index

Coop = cooperation

Comp = competition

Csal = salivary cortisol

EDA = Electrodermal activity

HF = high frecuency

HPA axis = Hypothalamic-pituitary-adrenal axis

HR = heart rate

HRV = heart rate variability

LF = low frecuency

NSCRs = skin conductance responses

PNS = Parasympathetic nervous system

SCL = skin conductance level

SE = Sistema Endocrino

SNS = Sympathetic nervous system

ST / WA = simple task / working alone

Abreviaturas

AED = actividad electrodérmica

Csal = cortisol salivar

FC = frecuencia cardiaca

Eje HHA = eje hipotálamo-hipófiso-adrenal

SE = Sistema Endocrino

SNA = sistema nervioso autónomo

SNS = sistema nervioso simpático

VC = varibilidad cardiaca

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Capítulo 1

INTRODUCCIÓN GENERAL

El ser humano es un ser social, por lo que necesita interaccionar con sus semejantes para garantizar su supervivencia. Es tanto así que empatiza (Moya-Albiol, 2014), forma vínculos a largo plazo (Mikulincer & Shaver, 2007), e incluso sacrifica sus propios intereses inmediatos para promover la seguridad y los intereses globales de los grupos y comunidades a los que pertenece (Arrow, 2007; Shinada et al., 2004).

La competición y la cooperación son dos estrategias de interacción social que ayudan a alcanzar metas y objetivos individuales y/o compartidos. La primera de ellas implica que uno o más individuos lleven a cabo acciones dirigidas hacia el logro de un objetivo propio, confrontándose con otro individuo o grupo de la misma especie motivado por el mismo objetivo (Mazur, 1985). La cooperación pretende, fundamentalmente, aumentar la probabilidad de alcanzar un propósito o una meta común mediante la colaboración entre miembros no consanguíneos de la misma especie (Clutton-Brocky, 2009; Melis & Semman, 2010). La investigación en psicología social ha demostrado que en la competición los resultados del perceptor están inversamente relacionados con los de su oponente, mientras que en la cooperación los resultados del perceptor y su colaborador dependen de sus logros comunes (Vonk, 1998). No obstante, ambos tipos de interacción social implican predecir el comportamiento de los interlocutores sociales teniendo en cuenta su estado mental (Decety et al., 2004), así como la capacidad de guiar el pensamiento y la acción de acuerdo con las intenciones internas y las de los demás (Decety & Sommerville, 2003). Por lo tanto, requieren que el individuo posea las habilidades socio-cognitivas necesarias para interactuar de forma efectiva con su ambiente, ya que las alteraciones en alguno de los componentes de la empatía conllevarían que el individuo presente reacciones inesperadas y socialmente inadecuadas.

Un importante número de estudios ha abordado el comportamiento competitivo desde una perspectiva psicobiológica, aunque la mayoría de ellos se han desarrollado en contextos deportivos (Salvador & Costa, 2009). Sin embargo, dichas investigaciones no están exentas de limitaciones que restringen la validez externa de los resultados. De hecho, las personas que practican deportes competitivos suelen estar en forma y, consecuentemente, serían fisiológicamente distintas de la población general. Se ha sugerido que el entrenamiento físico-aeróbico tiende a producir cambios en el

equilibrio simpatico-vagal del nodo sinusal en los atletas de resistencia. Además, los atletas también presentan un perfil de variabilidad cardiaca y hormonal en reposo diferente en comparación con la población no deportista (Dong, 2016). Por lo tanto, cabe esperar que la respuesta psicobiológica de los/as deportistas a las tareas de laboratorio sean distintas respecto a la población general o no deportista. Este hecho justifica la importancia de analizar dicha respuesta en individuos no atléticos, incrementado de este modo la validez externa de los resultados. Además, un número reducido de investigaciones han analizado los efectos de la competición mediante tareas cognitivas de laboratorio como los juegos de tiempo de reacción, los de de azar, los videojuegos y las tareas aritméticas (Dickerson & Kemeny, 2004; Denson, Spanovic & Miller, 2009). Por ello, resulta necesario desarrollar protocolos de laboratorio más complejos que permitan profundizar en los mecanismos psicobiológicos que subyacen a este tipo de interacción social.

Las estrategias cooperativas pueden ser interpretadas como adaptativas en ciertas situaciones, ya que todos los miembros implicados en las mismas aumentan la probabilidad de recibir un refuerzo común (Bergmüller & Taborsky, 2007; Kutschera, 2009). Aunque la cooperación está ampliamente extendida en las sociedades occidentales actuales, pocos estudios la han analizado en condiciones controladas de laboratorio (Fehl, van der Post & Semmann, 2011). En realidad, la mayor parte de la investigación sobre cooperación se ha relacionado con contextos educativos y organizacionales donde se han utilizado tareas que implican juicios éticos o dilemas morales, tales como el dilema del prisionero, los juegos de ultimátum y el efecto del castigo (Burton-Chellew & West, 2012; Gradin et al., 2015, 2016; Velez, Mahood, Ewoldsen & Moyer-Gusé, 2012). Otros estudios están analizado la cooperación empleando juegos estratégicos multijugador (Dulleck, Schaffner & Torgler, 2014; Fooken & Schaffner, 2016; Sütterlin, Herbert, Schmitt, Kübler & Vögele, 2011), pero ninguno de los estudios mencionados ha analizado los mecanismos psicobiológicos relacionados con la conducta cooperativa.

A la vista de lo expuesto, la investigación de ambos tipos de interacción social en el laboratorio permitiría incrementar la comprensión de estos mecanismos, dado que permiten manipular la situación y controlar los efectos de determinadas variables relevantes para dichas interacciones sociales. En el momento actual no hay un

conocimiento concluyente de las bases psicobiológicas de la competición y la cooperación, y son pocos los estudios que han investigado las respuestas del sistema nervioso autónomo (SNA) y del sistema endocrino (SE) a ambos tipos de interacción social en humanos, bajo condiciones controladas de laboratorio. El sistema cardiovascular forma parte del SNA, y se encuentra en continua conexión con el SE (Gordan, Gwathmey & Xie, 2015). El modelo de integración neurovisceral y la teoría polivagal enfatizan el papel que desempeña el SNA en la regulación del gasto cardíaco para fomentar o desalentar el compromiso social y los comportamientos prosociales.

Una forma de estudiar los cambios psicobiológicos a estas interacciones sociales es mediante el uso de medidas no invasivas que pueden ser consideradas índices de estimulación y regulación emocional, como la actividad electrodérmica (AED), la frecuencia cardiaca (FC) y la variabilidad cardiaca (VC) para el SNA, y los niveles de cortisol salivar (Csal) para el eje hipotalámico-hipófiso-suprarrenal (HHA) del SE. Se cree que la incapacidad de regular la actividad autonómica durante las interacciones sociales sería un correlato psicobiológico de la desregulación emocional, cuya interacción es recíproca (Appelhans & Luecken, 2006; Quintana, Guastella, Outhred, Hickie & Kemp, 2012; Shaffer, McCraty & Zerr, 2014). Por lo tanto, deben ser contemplados los cambios en el estado de ánimo y las emociones ante este tipo de interacciones sociales, dado que pueden modular la respuesta del SNA y el SE ante dichas estrategias de interacción social y además, verse afectados por estos tipos de interacción.

Según se ha descrito, la competición provoca una mayor reactividad cardiovascular que la cooperación (Harrison et al., 2001) o que realizar una tarea de forma individual (Veldhuijzen van Zanten et al., 2002). Además, los niveles de Csal tienden a incrementar tras competir en el ajedrez japonés (Hasegawa et al., 2008) o tras jugar a cartas y a un videojuego multijugador (Oxford et al., 2010). También parece que los incrementos en la actividad cardiovascular durante las tareas competitivas se relacionaría con el aumento de la ira (García-León, Reyes del Paso, Robles & Vila, 2003). Y, a su vez, los sentimientos de ira previos a la competición tenderían a facilitar la competición y a limitar la cooperación (Harth & Regner, 2016; Van Doorn, Heerdink & Van Kleef, 2012). Contrariamente, la cooperación en sí misma también es capaz generar cambios psicobiológicos en los individuos. En realidad, se ha

descrito un incremento progresivo de la FC y la AED tras recibir las instrucciones para cooperar, y una disminución significativa tras finalizar la tarea (Moya-Albiol et al., 2013).

Para poder comprender mejor los cambios psicobiológicos en las tareas de laboratorio, tienen que ser tenidas en cuenta dos variables como el resultado de la interacción social (positivo/negativo en el caso de la cooperación o victoria/pérdida en la competición) y el género de los participantes, puesto que han demostrado desempeñar un papel relevante en la modulación dela respuesta psicobiológica en tareas de laboratorio. De hecho, las personas que ganan muestran un aumento de la FC durante la competición, mientras que en las que pierden la FC tiende a ser más baja durante la tarea competitiva (Ricarte et al., 2001). Adicionalmente, ganar tiende a producir una gama de resultados emocionales agradables, incluyendo una reducción en los sentimientos de ira, mientras que perder conlleva cambios emocionales desagradables que incluyen aumentos en dichos sentimientos (Wilson & Kerr, 1999). Un estudio en mujeres mostró que las ganadoras tienen baja ansiedad estado y alto locus interno de control tras la competición, mientras que las perdedoras muestran alta ansiedad y alto locus de control externo (Costa & Salvador, 2012). A pesar de que se haya sugerido que el hecho de perder (el resultado obtenido) tiene un efecto activador en la actividad del eje HHA, ya que los individuos perciben que la situación como incontrolable (obviamente en función del locus de control) (Salvador & Costa, 2009), no se han observado diferencias en los niveles de Csal entre ganadores y perdedores en tareas de laboratorio competitivas (Costa & Salvador, 2012; Hasegawa et al., 2008).

Por lo que se refiere a la cooperación, los cambios en la actividad cardiovascular no parecen relacionarse con el resultado y el género, pero sí que se han hallado cambios en la actividad electrodérmica, a nivel del SE y del estado de ánimo. De hecho, los participantes que obtuvieron un resultado positivo mostraron menores niveles de Csal que los que obtuvieron un resultado negativo (Moya-Albiol et al., 2013; de Andrés et al., 2011). En relación con el género de los participantes, los hombres tienden a presentar mayor AED general y menores niveles de Csal que las mujeres durante la cooperación (Moya-Albiol et al., 2013). Además, los sentimientos de ira tienden a aumentar más en hombres que en mujeres tras obtener un resultado negativo (Moya-Albiol et al., 2013).

Por otra parte, los participantes con resultados positivos en una situación de cooperación se han mostrado más satisfechos con el resultado obtenido y en un estado de ánimo menos negativo (tensión e ira) que aquellos con resultados negativos. Asimismo, los hombres con resultados positivos muestran una mayor satisfacción que los hombres o las mujeres con resultados negativos y menor humor negativo (depresión) que los hombres con resultados negativos (Moya-Albiol et al., 2013). Por lo tanto, tanto la competición como la cooperación producen una activación psicofisiológica, aunque de forma diversa, estando influenciada por factores como el resultado de la interacción social y el género de los participantes.

El éxito en las interacciones sociales estratégicas a menudo requiere una comprensión de las motivaciones, sentimientos, pensamientos y comportamientos probables del oponente y/o compañero con el que cooperar. De hecho, la empatía cognitiva (capacidad de adoptar espontáneamente el punto de vista de otro) promueve el éxito en situaciones estratégicas competitivas y cooperativas, mientras que la empatía emocional (capacidad de conectar emocionalmente con los demás y experimentar preocupación) facilita la formación de coaliciones (Motomura et al., 2015; Moya-Albiol, 2014; Gilin, Maddux Carpenter & Galinsky, 2013). La evidencia sugiere que las personas cooperativas se preocupan por los demás, y son desinteresadas y provechosas (Moya-Albiol, 2014). Asimismo, tienden a cooperar de forma natural en lugar de competir (Suchak et al., 2016; Proto & Rustichini, 2013). De dicha interacción social derivan un amplio repertorio de emociones y cambios de estado de ánimo, esenciales para superar las demandas ambientales, así como para facilitar las estrategias de afrontamiento adaptativas (Bos, Jentgens, Beckers & Kindt, 2013; Frijda, 1988; Lazarus, 1991).

Considerando todo lo expuesto hasta el momento, los principales objetivos e hipótesis de la presente Tesis Doctoral son los siguientes:

1. *Explorar los cambios cardiovasculares (FC y VC) y los sentimientos de ira en un grupo de jóvenes sanos en función del tipo de interacción social realizada (competición o cooperación) o realizar la tarea de laboratorio de forma individual. Además, se analizará el papel desempeñado por el resultado obtenido en la interacción (positivo/negativo en el caso de la cooperación o*

victoria/pérdida en la competición) y el género de los participantes. Esperamos hallar que los participantes que compitan o cooperen y obtengan un resultado positivo en la cooperación o ganen presenten una mayor reactividad cardiovascular y una disminución de los sentimientos de ira que aquellos que compitan y obtengan un resultado negativo o pierdan (Costa & Salvador, 2012; Moya-Albiol et al., 2013; Ricarte et al., 2001; Salvador & Costa, 2009; de Andrés-García et al., 2011). En segundo lugar, esperamos que las mujeres que compitan y obtengan un resultado positivo presenten mayor reactividad cardiovascular y menores sentimiento de ira que aquellas que compitan y obtengan un resultado negativo (Costa & Salvador, 2012).

2. *Analizar la respuesta electrodérmica y el estado de ánimo a los dos tipos de situaciones de interacción social (cooperación o competición) o a la tarea simple o individual, en función del resultado obtenido y el género de los participantes.* Esperamos hallar que en ambas interacciones sociales los participantes (con independencia del género) que obtengan un resultado positivo o ganen presentarán mayor activación electrodérmica y una mejora del estado de ánimo que los que obtengan un resultado negativo (Moya-Albiol et al., 2013; Costa & Salvador, 2012). Además, los hombres presentarán mayor AED que las mujeres, específicamente, en la tarea cooperativa (Moya-Albiol et al., 2013).

3. *Dilucidar qué tipo de interacción social (cooperativa o competitiva) es más estresante para los participantes (evaluado mediante los cambios en Csal y ansiedad estado), frente a una condición de control (realizar la tarea sin competir o cooperar).* Considerando las publicaciones realizadas hasta el momento hipotetizamos que los participantes que compitan o cooperen y obtengan un resultado negativo tendrán mayores niveles de Csal y ansiedad que aquellos que obtengan un resultado positivo (Costa & Salvador, 2012; de Andrés-García et al., 2011; Moya-Albiol et al., 2013). Además, los hombres que cooperen y obtengan un resultado positivo mostrarán menores niveles de Csal y ansiedad

que las mujeres que cooperen y obtengan un resultado negativo (Moya-Albiol et al., 2013).

4. *Explorar cómo la empatía y la cooperatividad como rasgo podrían explicar la respuesta del Csal, en diadas de personas desconocidas forzadas a competir o cooperaren un contexto de laboratorio*. Por las propias características de las estrategias sociales analizadas, es necesario un alto nivel de comprensión de las inclinaciones tácticas y los pensamientos propios y de los demás (Butler, 2014; Cesarini, Johannesson, Lichtenstein, Sandewall & Wallace, 2008). Debido a ello, se espera observar que el aumento de los niveles de Csal esté inversamente relacionado con los niveles empatía (cognitiva y emocional). Además, ya que las personas cooperativas prefieren emplear esta estrategia en lugar de competir para resolver los problemas (Suchak et al., 2016; Proto & Rustichini, 2013), el hecho de ser forzado/a a competir podría experimentarse como estresante. De este modo, la cooperatividad rasgo se asociará con menores niveles de Csal cuando se fuerce a cooperar. De este modo, una baja cooperatividad no provocará incrementos en los niveles de Csal en la competición, pero sí en el caso de aquellos/as que se vean forzados a cooperar.

Capítulo 2

Estudio 1: Cooperation between strangers in face-to-face dyads produces more cardiovascular activation than competition or working on the task without any social interaction

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Introduction

Ethological observations have indicated that cooperation can appear between non-consanguineous members of the same species (Clutton-Brock, 2009). This may be interpreted as mutualism or manipulation, but it could also increase reproductive lifespan, and as such would be a highly adaptive behaviour (Bergmüller & Taborsky, 2007; Kutschera, 2009). In humans, one-off and prolonged cooperative behaviours can be considered an adaptive strategy, which increase the probability of achieving a shared goal (Schaik & Kappeler, 2006). By contrast, competition is an adaptive social behaviour that may be aggressive or defensive, and in which we seek to achieve goals individually (Mazur, 1985).

Although cooperation is widespread in all societies and especially in current Western societies (Fehl, van der Post & Semmann, 2011; Kossinets & Watts 2006), few studies have analysed cooperative behaviour under controlled laboratory conditions. Contrarily, an important amount of research has been focalised in analysing competitive behaviour. The majority of the research into cooperation in humans has been related to educational and organizational contexts. Specifically, researchers have employed games involving ethical judgements or moral dilemmas, such as the prisoner's dilemma, ultimatum games, and the effect of punishment (Burton-Chellew & West, 2012; Gradin et al., 2015; 2016; Velez, Mahood, Ewoldsen & Moyer-Gusé, 2012). Moreover, several studies have analyzed cooperation by using the strategic multiplayer games in recent years (Dulleck, Schaffner, & Torgler, 2014; Fooken & Schaffner, 2016; Sütterlin, Herbert, Schmitt, Kübler, & Vögele C., 2011). Regarding competition, there has been a considerable amount of psychobiological research, but mainly in the context of sports (Salvador & Costa, 2009). However, this research is not free of limitations, which restrict the interpretation of results. Indeed, people who play competitive sports are fitter and consequently physiologically distinct from the general population. In fact, it has been suggested that aerobic physical training tends to produce changes in autonomic modulation of the sinus node in endurance athletes. Moreover, athletes also present a different resting-state HRV profile in comparison with the sedentary population (Dong, 2016). Hence, someone who plays a sport may be acclimated to reacting

psychophysiologically differently to laboratory tasks in comparison with those who do not play a sport. This fact could justify the importance of analyzing the psychophysiological response to laboratory tasks in the non-athletic population in order to increase the external validity of the results. Moreover, competition is more central to the normative, shared, and consensual tasks of sport than it may be to other contexts.

The investigation of cooperation and competition in laboratory settings provides valid models for understanding how we act in real-life situations. Nevertheless, few studies have investigated cardiovascular responses to cooperation and competition under controlled conditions in humans. The cardiovascular system is heavily influenced by the autonomous nervous system (ANS) as well as the endocrine system (Gordan, Gwathmey, & Xie, 2015). The neurovisceral integration model and the polyvagal theory emphasize the role that is played by the ANS in regulating cardiac output to encourage or discourage social engagement and prosocial behaviors. In fact, efficient cardiac control facilitates more flexible engagement with the environment and more efficient emotion regulation. Furthermore, the inability to regulate autonomic activity during social interactions is believed to contribute to social and emotional dysregulation (Appelhans & Luecken, 2006; Quintana, Guastella, Outhred, Hickie, & Kemp, 2012; Shaffer, McCraty, & Zerr, 2014). One way of studying this is by using non-invasive measures, for instance, heart rate (HR) and heart rate variability (HRV), as indexes of arousal and emotion regulation. HRV indexes the flexibility of the heart to adapt to changes. Thus, we considered that the analysis of these variables would enable a more comprehensive assessment of cardiovascular changes to these types of social interactions.

Previous studies have reported a higher HR reactivity to a competitive task than a cooperative task (Harrison et al., 2001) or working alone (Veldhuijzen van Zanten et al., 2002). Moreover, another study demonstrated that cooperation per se produces an increase in HR (Moya-Albiol et al., 2013). Additionally, several variables such as the gender of participants and the outcome of the confrontation (win/lose or positive/negative outcome) may moderate the psychophysiological response to and the performance appraisal of these social interactions (Costa & Salvador, 2012; Ricarte et al., 2001; Salvador & Costa, 2009). In fact, women who win in a competition tend to have higher

HRs than those who lose (Costa & Salvador, 2012). However, this study only analyzed women's responses to social stress, neglecting men's responses. Furthermore, only winners seem to show a rise in HR during the competition, followed by a decrease during the post-task phase, while in losers, HR tends to be lower during the competition than at baseline (Ricarte et al., 2001). Regarding cooperation, HR was not found to be associated with either gender or outcome in individuals cooperating on a task (Moya-Albiol et al., 2013). Finally, women who cooperated and obtained a negative outcome and those who won in the competitive task showed a higher internal locus of control than the rest of the participants (Costa & Salvador, 2012; de Andrés et al., 2011). Hence, it seems that cooperating, like competing, can modify the cardiovascular system.

Anger has been proposed as a precursor of hostility, which tends to limit cooperation but promote competition (Harth & Regner, 2016; Van Doorn, Heerdink, &bVan Kleef, 2012). Moreover, increases in HRV depend on the anger state. In fact, high anger has been associated with the greatest cardiovascular effects in competitive tasks (García-León, Reyes del Paso, Robles, & Vila, 2003). Hence, it seems important to control for anger changes in response to these types of social interactions as well as for its effect on cardiovascular reactivity. Both outcome and gender affect feelings of anger in cooperation or competition tasks (Moya-Albiol et al., 2013). Specifically, feelings of anger are more likely to increase in men than in women after a negative outcome in cooperation (Moya-Albiol et al., 2013). Regarding competition, winning tends to produce a range of pleasant emotional outcomes including a reduction in feelings of anger, while losing produces strong unpleasant emotional changes, including increases in such feelings (Wilson & Kerr, 1999).

Exploring psychophysiological responses to cooperative and competitive behaviours in a laboratory setting, the main aim of this study was to investigate changes in HR and HRV and anger responses in a sample of strangers who were set to cooperate, compete or work alone (on a simple task). Specifically, we sought to characterise cardiovascular changes related to cooperation and competition. In addition, the role of the outcome (positive or negative) obtained in social situations and the gender of participants were examined as potential moderators of these cardiovascular responses. Appraisal of

the task and the performance (such as internal and external attribution, and outcome satisfaction) were also assessed. We hypothesized that participants who competed or cooperated and obtained a positive outcome would have higher changes in HR and HRV and anger levels and internal locus of control than those who competed and obtained a negative outcome (Costa & Salvador, 2012; Moya-Albiol et al., 2013; Ricarte et al., 2001; Salvador & Costa, 2009). Secondly, with respect to the role of gender, there was a lack of data in the literature on which to base a hypothesis. In the case of women, we hypothesized that those who competed and obtained a positive outcome would have higher HRs than those who competed and obtained a negative outcome (Costa & Salvador, 2012). In this context, a psychological variable, namely, anger state is considered to be an important moderator of physiological responses to social interactions (Moya-Albiol et al., 2001; Moya-Albiol et al., 2003; Moya-Albiol et al., 2013; Romero-Martínez, Nunes-Costa, Lila, González-Bono, & Moya-Albiol, 2014). Hence, we also hypothesized that there would be an increase in anger state scores after a negative outcome in men, and that this relationship between the two variables would be present, but less strong in women.

Method

Participants

An advertisement was placed at Valencia University looking for healthy young adults. In a first session, all volunteers were asked about their habits and other health aspects, through a questionnaire. Only non-smoking adults who did not take regular medication, did not have addictive habits (coffee, tea, drugs) or any chronic, endocrine and/or cardiovascular disease were selected.

A total of 90 women and 90 men composed the final sample. They were all university students, with ages between 18 and 25 years (mean = 20.41, SD = 1.63) and with a body mass index (BMI) of 23.36 ± 3.29 kg/m^2. Participants were predominantly (98.78%) right handed. Those female volunteers who did not report at least a 3-month history of regular menstrual cycles lasting 21 to 35 days and/or were using oral

contraceptives were excluded (Asso, 1986; Gómez-Amor, Martínez-Selva, Román & Zamora, 1990; Gómez-Amor, Martínez-Selva, Román, Zamora & Sastre, 1990).

Participants were randomized (or gender-block randomized) to one of the 6 conditions. There are 12 groups with the basic design being a 2 (gender) x 3 (condition) x 2 (positive vs negative outcome) one. Groups did not vary in age and socioeconomic factors distributions (i.e., randomization was successful). Table 1 summarises the number of participants per group, as well as their characteristics by gender, task, and outcome.

The University's ethics committee approved the protocol, and the study was conducted following ethical principles for human research. All participants took part in the study voluntarily and signed an informed consent form before inclusion.

Table 1. Mean (SD) of descriptive features, psychological traits profiles, and assessment of the task, for outcome interaction and gender. ** p<.001, * p<.05

Groups	Age (years)	BMI (kg/m^2)	Motivation on the task	Stress on the task	Satisfaction with the outcome	Internal locus of control	External locus of control
Women Coop. + (n = 15)	20.20 ± .77	23.19 ± 1.92	7.87 ± 1.64	4.53 ± 2.13	6.87 ± 2.47	5.40 ± .99 * F(2, 165) = 5.193, p =.006, η2 partial =.059	5.67 ± 1.40
Women Coop. – (n = 15)	20.40 ± .91	22.22 ± 2.88	8.40 ± 1.30	5.80 ± 3.03	2.73 ± 1.87	6.33 ± 1.72	5.00 ± 3.38
Men Coop. + (n = 15)	20.60 ± 2.16	25.83 ± 3.69	7.92 ± 1.66	2.96 ± 2.07	8.00 ± 1.41	6.46 ± 1.86	4.15 ± 2.16
Men Coop. – (n = 15)	20.60 ± 2.26	23.67 ± 2.74	6.87 ± 2.13	3.20 ± 2.21	4.20 ± 2.57	4.77 ± 1.90	6.03 ± 2.35
Women Comp. + (n = 15)	20.33 ± .98	21.67 ± 3.11	5.70 ± 2.25	4.77 ± 2.58	7.47 ± 2.07	6.57 ± 1.68	5.03 ± 2.17
Women Comp. – (n = 15)	20.00 ± 1.19	22.49 ± 3.80	4.80 ± 1.70	4.53 ± 2.03	3.33 ± 1.99	5.67 ± 1.45	5.27 ± 2.05
Men Comp. + (n = 15)	20.40 ± 1.35	23.27 ± 2.49	5.57 ± 2.98	5.00 ± 2.60	6.57 ± 2.21	5.25 ± 1.60	4.75 ± 1.60

Men Comp. – (n = 15)	20.60 ± 2.29	23.75 ± 3.38	5.47 ± 2.29	3.20 ± 2.27	4.53 ± 1.85	6.10 ± 2.00	3.90 ± 2.00
Women ST. + (n = 15)	20.87 ± 1.64	22.55 ± 3.38	Not evaluated	4.27 ± 2.05	7.13 ± 1.46	7.73 ± 1.39 *	4.27 ± 1.53
Women ST. – (n = 15)	19.87 ± .83	25.26 ± 4.48	Not evaluated	4.47 ± 2.33	3.13 ± 1.73	5.63 ± 1.89	4.37 ± 1.89
Men ST. + (n = 15)	20.33 ± 2.26	23.27 ± 3.07	Not evaluated	4.00 ± 2.45	6.00 ± 2.20	5.97 ± 2.24	4.03 ± 2.24
Men ST. – (n = 15)	20.80 ± 1.93	23.12 ± 2.43	Not evaluated	5.13 ± 1.92	3.87 ± 2.37	4.17 ± 2.96	5.83 ± 2.96
Effect of Task	Not Significant	Not Significant	** F(1, 109) = 39.282, p < .001, η2 partial =.265	Not Significant	Not Significant	Not Significant	Not Significant
Effect of Gender	Not Significant	Not Significant	Not Significant	** F(1, 165) = 5.376, p=.022, η_p^2 partial =	** F(1, 165) = 119.052, p < .001, η2 partial =.419	Not Significant	Not Significant
Effect of Outcome	Not Significant	Not Significant	Not Significant		Not Significant	Not Significant	Not Significant
Task x Gender	Not	Not					

	Significant	Significant	Not Significant	.032	Not Significant		
Task x Outcome	Not Significant	* F(2, 168) = 3.393, p=.048, η_p^2 partial = .036	Not Significant	Not Significant	Not Significant	Not Significant	Not Significant
Task x Gender x Outcome	Not Significant	* F(2, 168) = 3.302, p=.039, η_p^2 partial = .038	Not Significant	Not Significant	Not Significant	* F(2, 165) = 5.193, p =.006, η2 partial =.059	Not Significant
	Not Significant	Not Significant	Not Significant	Not Significant			

Procedure

After arriving at the laboratory, participants signed an informed consent to participate in the study, and anthropometric and demographic variables were registered. After that, they were questioned about their activities during the previous 2 hours and the night before; women were also asked about their menstrual cycle. Then, each participant was taken to the recording phase room; there they met the other participant for the cooperative and competitive tasks. To minimise emotional interference in the laboratory task, individuals were not familiar to one another. Within this room, sound was attenuated, the temperature controlled at 21±2ºC, and the light levels kept constant throughout all the sessions. Each experimental session was 2 hours long and took place in the afternoon/evening between 16:00 and 20:00. Participants were not allowed to eat or drink stimulants (such as coffee, tea or alcohol) during these sessions.

The experimental session began once the electrodes for measuring HR and HRV were attached to participants. For cooperative and competitive tasks, two participants of the same gender (not familiar to one another) were seated one in front of the other, maintaining visual contact. For the simple task, each participant performed the task alone, as a control group. At the beginning of session, participants had to stay relaxed and silent for 10 minutes. Moreover, in order not to lose electrophysiological signal, participants were advised that they could not make any sudden movements. To obtain baseline values for HR and HRV in this period (rest period), physiological signals from the electrodes were recorded during a period of 5 minutes. After that, an experimenter of the same gender as the participants explained the task instructions (instruction period), for approximately 5 minutes; this experimenter remained throughout the study. After the instruction period, participants remained silent again for 5 more minutes (preparation period). Subsequently, they performed the cooperation, competition or simple task for 10 minutes (task period). Participants were not told about the time they had to complete the task. After this, a male and a female experimenter assessed the task performance and assigned participants arbitrary and manipulated outcomes, win/lose for competitive task and positive/negative for cooperation and simple tasks. As the participants did not finish the task, two groups with different performance (positive or negative) were established; this means that the outcome was a manipulated variable, in order to balance the number of participants in each group. For the following 10 minutes, physiological signals continued to be recorded (recovery period), and experimenters

assessed performance appraisal, stress perceived, motivation for the task (cooperativeness and competitiveness), and internal and external outcome attribution. The recording and monitoring of data during the experimental session was performed out of participants' sight. Moreover, participants were asked to complete an anger questionnaire before and after the task (pre- and post-task assessments), the post-task questionnaire was administered after the feedback on the outcome.

Instructions for tasks and their outcome.

The main task consisted building a copy of a model house with Lego© bricks (as in de Andres-García et al., 2011; Moya-Albiol et al., 2013; Sariñana-González, Romero-Martínez & Moya-Albiol, 2016), and was the same for all the groups. This construction required the same psychomotor, cognitive and visuospatial skills. The groups differed in the type of instructions given. Participants could not talk during the task period. They were told that the experimenters evaluation criteria would be: for all tasks, the quality of the Lego© construction or its similarity to the model; for the simple and cooperative tasks, the mistakes in the placement of the bricks; and for the competitive task, the theft of bricks.

Lego© bricks had to be placed one at a time in all tasks, and only one brick could be taken each time participants reached into the box with their dominant hand.

Cooperative task. In this task, each participant had his/her own box, and the model could only be built joining the bricks in the two boxes. They had to place bricks in turns, with only visual communication. Before they started, they were told that cooperation with their partner would facilitate good performance in the task.

Competitive task. In this task, each participant had to build a house on his/her own. There was only a single common box, which did not contain enough bricks for both participants to copy the Lego© model. This required participants to compete to build their houses, prioritizing speed and strategy.

Simple Task. In this task, a single participant had to build a house, and he/she was given a box with enough bricks to complete it.

Task and outcome appraisal scores.

The task and the outcomes were evaluated through *ad hoc* questions rated on a 10-point scale. Motivation for the task was tested ("On a scale from 0 (not at all) to 10 (highly), how motivated did you feel to complete the task?") as well as the stress caused ("On a scale from 0 (no stress) to 10 (extreme stress), how much stress did you experience during the task?"). They were also asked about their satisfaction with the outcome ("On a scale from 0 (not at all) to 10 (highly), how satisfied are you with the outcome obtained in the task?"), and about their attribution to the outcome (internal and external locus of control) ("On a scale from 0 (not at all) to 10 (highly), how dependent do you feel the outcome of the task was on you, your cognitive abilities and your intelligence?", and "On a scale of 0 (not at all) to 10 (highly), how dependent do you feel the outcome of the task was on external factors, the events that occurred during the session, and the type of task?").

Electrophysiological signals.

To capture, process and analyse electrocardiograms, a physiological recording system (BIOPAC Systems, Inc, Santa Barbara, CA) was used. Signals from this system were registered to a computer with data acquisition hardware (MP150) and data storage software (AcqKnowledge 4.2 for Windows, Biopac Systems, Montreal, Canada), through a Universal Interface Module (UIM100C).

HR (in beats per minute) represents a mixture of Sympathetic Nervous System (SNS) and Parasympathetic Nervous System (PNS) input. It was calculated according to published guidelines (Task Force, 1996). Electrocardiogram data were visually screened, and we deleted R-waves of problematic recordings with artefacts, from the data file. Then, we calculated HR from the resultant file. We transformed the electrocardiogram signal into a tachogram with the AcqKnowledge software. After that, we applied a fast Fourier transformation to the tachogram, and characterised the HRV in the frequency domain, considering the high frequency (HF) component.

The HF component (0.15–0.40 Hz) is considered as a marker of parasympathetic activity whose oscillations could be related to respiratory influences (Berntson et al., 1997; Japundzic, Grichois, Zitoun, Laude, & Elghozi, 1990; Malliani, Pagani,

Lombardi, & Ceruttti, 1991; Montano et al., 2009; Randall, Brown, Raisch, Yingling, & Randall, 1991; Reyes del Paso, Langewitz, Mulder, van Roon A, & Duschek, 2013; Task Force, 1996). HF-HRV tends to reflect effects of respiration on HR. Hence, it is frequently called the respiratory band. According to the Task Force recommendations (1996), HF power was expressed in absolute and normalised units, with the latter reflecting each component's relative value. HF power in normalised units (HFnu) is representative of vagal activation. Moreover, it has been previously hypothesized that effects in LFnu are mostly carried by changes in the HF component (Burr, 2007; Reyes del Paso et al., 2013).

Self-reports

An adapted version (Miguel-Tobal et al., 2001) of the State-Trait Anger Expression Inventory-2 (STAXI-2) (Spielberger, 1999) was used to measure state-trait anger and its expression. This test comprises three subscales for state anger (feelings, verbal and physical expression), and all of them are rated on a four-point Likert-type scale (1 = ‘‘not at all’’ to 4 = ‘‘very much so’’). Cronbach’s alpha was between 0.67 and 0.89.

Data Analysis

Normality of the data was assessed through the Kolmogorov-Smirnov test ($p < .05$), and non-normal data were SQRT transformed (HR and HFnu). To detect group effects by task, gender and outcome, we used univariate analysis of variance (ANOVA; 3 X 2 X 2) with Bonferroni post-hoc tests to find significant differences in anthropometric variables (BMI and age), evaluation scores (task motivation, stress perceived, internal and external attribution, and satisfaction with task outcomes), and baseline HR and HRV (HFnu).

We used a repeated-measures ANOVA with a general linear model (3 x 2 x 2 x 4) to analyse differences in HR and HRV within groups between periods. Period was defined as the within-participant factor (at four levels: rest, preparation, task period and recovery period; the instruction period was included within the preparation period); and

task (cooperation, competition and simple), outcome (negative and positive) and gender (women and men) as the between-participant factors. We applied Greenhouse–Geisser corrections for degrees of freedom due to sphericity issues if appropriate, and Bonferroni corrections for multiple comparisons where appropriate. Partial eta squared (h_p^2) was reported as a measure of effect size.

We estimated the magnitude of tasks responses in terms of HR and HRV (HFnu) through the calculation of the area under the curve with respect to the ground (AUCg), using the trapezoidal rule (Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003). Specifically, AUCg is the total area under the curve taking into account all measurements and evaluating the distance of these measures from the ground. We assessed AUCg values with univariate ANOVA (3 X 2 X 2) to examine group effects by task, gender and outcome.

In order to detect differences in anger within groups between time points (pre- and post-task), we performed a repeated-measures ANOVA with a general linear model (3 x 2 x 2 x 2) with time point as the within-participant factor (at two levels: pre-task and post-task), and task (competition, cooperation and simple), outcome (positive and negative) and gender (women and men) as the between-participant factors. Again, where appropriate, we applied Greenhouse–Geisser corrections for degrees of freedom and Bonferroni corrections for multiple comparisons. Partial eta squared (η^2_{partial}) was reported as a measure of effect size.

We used IBM SPSS for Windows Version 21.0 to perform all the statistical analyses. We set the alpha level at 0.05, and expressed data as mean ± SD.

Results

Cardiovascular response

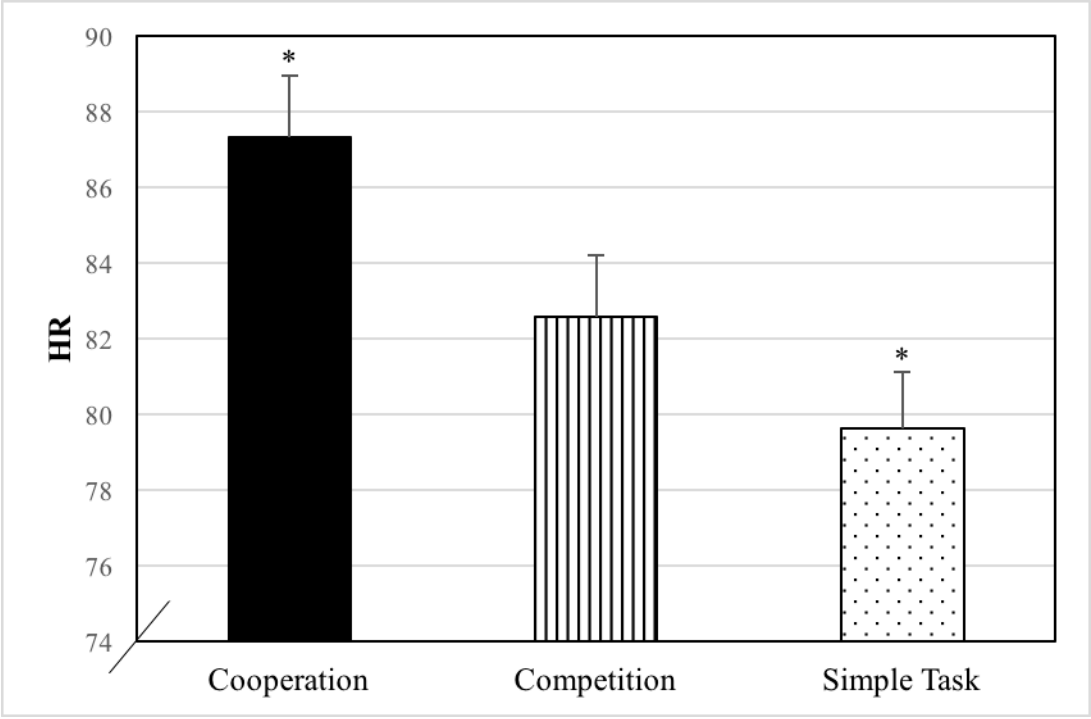
A significant effect of 'period' on HR was found in the total sample, $\varepsilon = .792$, $F(2.375, 399.081) = 100.893$, $p < .001$, $\eta^2_{\text{partial}} = .375$. Post-hoc analysis identified a significant difference between all periods ($p < .001$ in all cases), with a lower HR in the recovery period than other periods.

Secondly, HFnu was found to have a significant effect on period in the total sample, ε = .973, F(2.919, 519.617) = 5.534, p=.001, $\eta^2_{partial}$ =.030. For HFnu, post-hoc analysis identified a lower HFnu in the preparation period than the rest, task and recovery periods (p=.032, p=.002 and p=.008, respectively).

Role of task. A main effect of task was found on HR, F(2, 156) = 6.023, p =.003, $\eta^2_{partial}$ =.072, with it being significantly higher in participants who took part in the cooperative task than the simple task (p =.002). Moreover, the HR AUCg varied by type of task, F(2, 157) = 5.962, p =.003, $\eta 2_{partial}$ =.071, being significantly higher in participants who took part in the cooperative task than the simple task (p=.002).

Regarding HR, the 'Period x Task' interaction was significant, ε = .796, F(4.778, 392.763) = 7.142, p <.001, $\eta^2_{partial}$ =.084. In the post-hoc analysis, HR was higher in the cooperative than in the simple task group in all periods (p=.018, p = .001, p=.011 and p <.001, respectively) and than the competition group during rest and recovery periods (p =.013 and p =.050, respectively) (See figure 1).

Figure 1. HR levels in participants for cooperative, competitive or simple task (M ± SEM). * p <.01



Regarding HRV, the 'Period x Task' interaction was significant for HFnu, ε = .960, F(5.761, 478.192) = 3.156, p =.005, $\eta^2_{partial}$ =.037. In the post-hoc analysis, HFnu values were lower in the cooperation group than simple task group during preparation period (p <.001).

Role of gender and outcome. There was a main effect of 'gender' on HR, F(1, 156) = 5.959, p =.016, $\eta^2_{partial}$ =.037,with women presenting higher HR than men. (p =.016). The same pattern was found when analysing HR AUCg, F(1, 157) = 6.297, p =.013, $\eta^2_{partial}$ =.039, (p =.013).

No significant effect of 'outcome' or 'Task x Outcome x Gender' was observed for cardiovascular variables.

Moreover, a significant 'Task x Outcome x Gender' interaction the for HFnu AUCg, F(2, 167) = 3.391, p =.036, η^2 partial =.039 was found. Post-hoc analysis showed that men on the cooperative task with negative outcomes had a lower HFnu AUCg than men on the simple task with negative outcomes (p =.035).

Anger responses

First, a significant effect of 'Time point' on feeling and total score of anger was found in the total sample, ε = 1, F(1, 178) = 13.307, p <.001, $\eta^2_{partial}$ =.070 and ε = 1, F(1, 178) = 9.453, p=.002, $\eta^2_{partial}$ =.050. Post-hoc analysis identified a higher feeling and total score of anger post-task than pre-task (p <.001 and p=.002, respectively).

Role of task. Regarding anger, we found a significant 'Time Point x Task' interaction in feeling and total scores, ε = 1, F(2, 166) = 4.514, p=.012, $\eta^2_{partial}$ =.052 and ε = 1, F(2, 166) = 4.351, p=.014, $\eta^2_{partial}$ =.050, respectively. Post-hoc analysis showed higher post-task feelings of anger in competitive than simple task participants (p=.027), but the differences in total scores for 'Time Point x Task' interaction did not reach significance (p >.05 in all cases).

Role of gender and outcome. Exploring physical anger as a function of gender, we observed a significant main effect of 'gender', $F(1, 166) = 3.965$, $p = .048$, $\eta^2_{partial} = .023$, with anger being significantly higher in men than women ($p = .048$).

A significant 'Time Point x Task x Gender' interaction was found in feeling, physical anger and total score, $\varepsilon = 1$, $F(2, 166) = 6.314$, $p = .002$, $\eta 2_{partial} = .071$; $\varepsilon = 1$, $F(2, 166) = 4.287$, $p = .015$, $\eta 2_{partial} = .049$; and $\varepsilon = 1$, $F(2, 166) = 5.475$, $p = .005$, $\eta^2_{partial} = .062$. Post-hoc analyses showed that simple task group men had significantly higher post-task state anger scores and total score than cooperative and competitive group men ($p = .001$ and $p < .001$ for state anger score, and $p = .037$ and $p = .0.26$ for total score, respectively). Moreover, in the simple task group, men had significantly higher post-task physical anger than women ($p = .010$).

Further, a 'Task x Gender' interaction was found in feeling anger, $F(2, 166) = 4.050$, $p = .019$, $\eta^2_{partial} = .047$. Post-hoc analyses showed that simple task group men had significantly higher state anger scores than cooperative and competitive group men ($p = .037$ and $p = .004$, respectively).

Lastly, 'outcome' was not found to have a significant effect on state anger scores.

Relationship between cardiovascular responses and anger state

Spearman's correlation analysis did not indicate a significant relationship between AUC_i or AUC_g of HFnu and anger scores, in either group.

Discussion

This study examined changes in HR and HRV and anger responses in a sample of strangers who were set to cooperate, compete, or to work alone. Furthermore, the role of the outcome (positive or negative) obtained in social situations, and the gender of participants as potential moderators of these cardiovascular responses were also examined. Our results revealed that participants who cooperated had higher HRs than those who competed and/or did the simple task. Moreover, they also had lower HF

levels than participants who worked alone. Regarding gender and outcome, men who cooperated and lost had lower HF levels than men on the simple task with negative outcomes. Furthermore, women who cooperated and obtained a positive outcome and men who competed and lost had the highest internal locus of control. Additionally, participants who cooperated and obtained a positive outcome showed the highest motivation and satisfaction. Lastly, cardiovascular variables and anger state were unrelated.

Our first hypothesis was that participants who competed or cooperated and obtained a positive outcome would have higher HR and HRV changes and anger levels and internal locus of control than those who competed and lost (Costa & Salvador, 2012; Moya-Albiol et al., 2013; Ricarte et al., 2001; Salvador & Costa, 2009). In relation to this, we found that between strangers in face-to-face dyads of the same gender, participants who cooperated had higher HRs than those who competed and/or did the simple task. Moreover, they also had lower HF levels than observed in the simple task. This may mean that among strangers, a lack of information regarding the reputation of others (based on their past actions) limits cooperation, cooperative behavior being strengthened by providing information about partners' actions in the immediate past (Balliet, Wu, & De Dreu, 2014; Bolton, Katoka, & Ockenfelsb, 2005; De Dreu, 2012; Zhu & Mutka, 2005). In fact, recent studies have demonstrated that an increase in HR synchrony has been associated with affiliation, rapport, and an improvement in group dynamics by strengthening social attachment among group members (Mitkidis et al., 2015; Wiltermuth & Heath, 2009). Moreover, a previous study reported that cooperation among strangers is more stressful (as shown by greater increase in cortisol levels) in comparison with those who compete or work alone (Sariñana-González, Romero-Martínez & Moya-Albiol, 2016). Accordingly, cooperation among strangers could be considered as a social evaluative threat. This latter is a key component of mental stress and a potent generator of negative emotions which tend to increase HR (Eisenbarth, Chang, & Wager, 2016; Thayer, Ahs, Fredrikson, & Sollers, 2012; Wager et al., 2009).

The outcome obtained during tasks and the gender of participants were found to be relevant variables, which may moderate the psychophysiological responses. Specifically, women had higher HR levels than men. This could indicate that in women, ANS activity may be more sensitive to the laboratory assessment. Moreover, it is

possible that men were less involved in the tasks; nevertheless, they had higher state anger scores than women throughout the task, apart from in the rest period. Consequently, it can then be proposed that gender affects the emotional experience during tasks. In addition, men who cooperated and lost had lower HF levels than men on the simple task with negative outcomes. In line with this, men tend to be more susceptible to being affected by the outcome of their performance, for instance, in competitive situations (González-Bono et al., 1999; Suay et al., 1999).

All participants with a negative outcome showed lower satisfaction. On the other hand, when someone is satisfied with the outcome obtained in cooperating, he/she will probably feel better and will not show negative affect. In this way, a positive outcome relaxes the individual, permits it to use the energy in a beneficial way, and produces a feeling of psychological well-being; while a negative outcome activates the ANS and increases the anger experienced. In addition, these findings could be related to the state of challenge rather than that of threat, since in the first case, there is a quick ANS recovery (as in the case of positive outcome), whereas a state of threat produces a slow recovery in these parameters (Fiske et al., 2010).

We hypothesized that state anger scores would increase after a negative outcome in men. However, our study did not support this hypothesis in that differences in state anger scores as a function of outcome were not significant. On the other hand, we observed that mean state anger scores in men were higher than in women and higher when they worked alone than when they cooperated or competed. Additionally, we hypothesized that there would be a positive relationship between cardiovascular and anger variables, but these variables were unrelated in our study. This could be explained by the large number of correlations and the limited sample size of each group.

Finally, the laboratory context provides a valid model for analysing human cooperation and competition, as it allows one to control the type of task and the outcome obtained. This approach minimises possible effects of the stress of a novel situation and of social desirability on the ANS, and anger responses (de Andrés et al., 2011, Moya-Albiol et al., 2013; Sariñana-González, Romero-Martínez, & Moya-Albiol, 2016). HR increased from preparation period to the task, and decreased from this point to recovery period. The Lego© house building task proved to be efficient for eliciting psychophysiological responses, demonstrated by there being an activation of the ANS

and changes in anger state. This pattern of response is likely to be associated with cognitive effort during instruction interpretation and performance of the task (Moya-Albiol et al., 2013). These findings indicate that both cooperative and competitive tasks resulted in a pattern of response characteristic of activation, but not of stress, as the tasks were not perceived as a negative or stressful situation.

Our study demonstrated that cooperative as well as competitive tasks between strangers in face-to-face dyads of the same gender produce increases in ANS activity, specifically in HR, and HFnu, unlike working alone. However, some limitations should be considered when interpreting the results. Firstly, the cross-sectional and correlational nature of the study makes it difficult to establish causality in the results. Moreover, our data were obtained from young and non-psychiatric populations and we only analyzed two types of social interaction. Another limitation of the current study is that although we assessed anger state and appraisal of the task and performance, we did not employ additional affective assessments which try to explain these cardiovascular changes to the different tasks. Future research should consider other hormones such as oxytocin, a hormone related to empathy (Takahashi et al., 2005) and probably also linked to cooperation (De Dreu, 2012). A few studies have started to associate violence and consequently competition with the activity and responses of the immune system (Romero-Martínez, Lila, Conchell, González-Bono, & Moya-Albiol, 2014), but to our knowledge, this relationship has not been investigated for empathy and cooperation.

To conclude, as our results have been obtained in the laboratory context with non-athletic population, these results can be generalized to a higher number of individuals in comparison with those studies based only in the athletic population. Furthermore, research in this field would improve the understanding of physiological responses of the body to different types of social interactions, such as cooperation and competition, providing an opportunity to establish interaction strategies that would be physiologically desirable.

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Capítulo 3

Estudio 2: Cooperation Induces an Increase in Emotional Response, as Measured by Electrodermal Activity and Mood

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Introduction

Humans are social beings who need interaction with others for survival. A broad range of emotions and mood changes result from this social interaction, and these are essential for overcoming environmental challenges, as well as for facilitating adaptive coping strategies (Bos et al., 2013; Frijda 1988; Lazarus 1991). Competition and cooperation are two somewhat opposed strategies for interpersonal social interaction that help us to achieve both individual and shared aims and objectives. Competition is an adaptive social behaviour, which may be aggressive or defensive, and in which we seek to reach goals individually (biosocial model of status of Mazur 1985). By contrast, cooperation is a social behaviour that principally seeks to increase the probability of success in reaching common aims or objectives by collaborating with other members of a group (Kappeler and Van Schaik 2006; Melis and Semmann 2010). Regarding competition, there has been a considerable amount of psychobiological research, both in the context of physically demanding sports and in laboratory cognitive tasks, using reaction-time games, gambling, videogames and/or arithmetic tasks (Booth et al. 1989; Hasegawa et al. 2008; Oxford et al. 2010; Salvador and Costa 2009). In the case of cooperation, a type of social interaction that is widespread in all societies, most related research has taken a social approach, based on games involving ethical judgments or moral dilemmas, such as the prisoner's dilemma, ultimatum games and the effect of punishment (Burton-Chellew andWest 2012; Velez et al. 2012), few studies having analysed cooperation from a psychobiological perspective.

Both types of social interaction provoke emotional responses. Concerning competition, most studies have found that participants with positive outcomes, winners, have a better mood after competition and greater internal attribution for the outcome, while the opposite is observed in losers, who have a worse mood and greater external attribution for the outcome, both in men and women (Costa and Salvador 2012; González-Bono et al. 1999; Ricarte et al. 2001). Exploring cooperation, Moya-Albiol et al. (2013) observed that outcome and gender had an effect on mood. Participants with positive outcomes in a cooperative situation were more satisfied with the outcome obtained and in a less negative mood state (tension and anger) after these social interactions, tan those with negative outcomes. In addition, men with positive outcomes showed greater satisfaction than men or women with negative outcomes and lower negative mood (depression and anger) scores than men with negative outcomes. Using a

similar task to promote social interaction with participants cooperating or competing, de Andrés-García et al. (2011) found that the results may be moderated by variables related to appraisal of the situation and outcomes obtained. Women who cooperated and obtained negative outcomes or who competed and obtained positive outcomes attributed their performance to internal factors. In contrast, those who cooperated and obtained positive outcomes or who competed and obtained negative outcomes attributed their performance to external factors.

Electrodermal activity (EDA) is the measure that has been most widely used as a marker of emotional arousal response in the autonomic nervous system (ANS). Sympathetic activity and electrodermal responses may be viewed as a component of emotional response (Kreibig 2010). EDA refers to variations in the electrical properties of the skin associated with sweat-gland activity. By applying a constant low voltage, changes in skin conductance can be measured noninvasively (Benedek and Kaernbach 2010; Fowles et al. 1981). Time series of skin conductance measurements can be characterized by a slowly varying tonic activity (called the skin conductance level, SCL) and a fast varying phasic activity (expressed as the number of nonspecific skin conductance responses, NSCRs, or skin conductance response) (Manning and Melchiori 1974; Roth et al. 2012; Sequeira et al. 2009). SCL can be defined as the baseline level of sympathetic nerve activity, while NSCRs are conceptualized as short-lasting changes elicited by a specific stimulus or the absence of a specific external stimulus. NSCRs are expressed as a rate per minute (usually between 1 and 3 responses while subjects are at rest and measured as a rapid change in SCL with an amplitude greater than or equal to 0.02 ls within a 1.0–3.0 s latency window) (Boucsein et al. 2012).

To date, only a few studies have considered EDA, reflecting psychophysiological response, as a marker of emotional response to various types of social interaction and/or stimuli, namely cooperation or competition (Bos et al. 2013; Finset et al. 2011). In the case of cooperation, we are aware of one previous study that has analysed EDA response under laboratory conditions. This study demonstrated that both SCL and NSCRs increased in a cooperative interaction, with a progressive increase after instructions and a significant drop when the task was finished. Moreover, gender was a moderating factor in EDA, with men having higher SCLs and NSCRs than women at all time points assessed, except baseline (Moya-Albiol et al. 2013). On the other hand, to our knowledge, no studies have yet analysed EDA during competition, or

compared the electrodermal response to competition with that to cooperation, or to these two types of social interaction with that to nonsocial interaction (e.g., working on a task alone).

To address this gap in the literature, the primary objective of our research was to assess whether autonomic activity is a good indicator of emotional activation in response to different situations of social interaction (cooperation, competition or non-social interaction), considering gender and outcome (positive or negative) as moderating variables. For this purpose, we measured EDA as a psychophysiological indicator of the emotional response of participants to the task given. Considering the only study we have found in the literatura on the role of EDA in cooperation, which reported that men presented higher EDA (NSCRs) than women (Moya-Albiol et al. 2013), we expected to find greater EDA in men than women in response to the cooperative task. Another objective of this study was to assess whether there were differences in variables related to appraisal of the situation and outcomes obtained (motivation, satisfaction with the outcome and locus of control), and in mood states assessed by self-reports of participants to the task given, as a function of gender, the type of social interaction (cooperating, competing or working alone), and outcome obtained in the task. In relation to these variables, previous studies have reported greater motivation and greater satisfaction with outcome and a more positive mood in those who cooperated and obtained positive outcomes (that is those who won or did well the task) than in those who cooperated and obtained negative outcomes (that is, lost or did less well in the task) (Moya-Albiol et al. 2013) and in those who competed and obtained positive rather than negative outcomes (Costa and Salvador 2012; Ricarte et al. 2001). Hence, we expected to find greater motivation and satisfaction with the outcome of the social interaction, as well as better mood, in participants who competed or cooperated and obtained positive outcomes than those who competed or cooperated and obtained negative outcomes. In addition, we expected to find greater internal attribution for the outcome in those who cooperated and obtained negative outcomes and in those who competed and obtained positive outcomes than in participants who cooperated with positive outcomes or competed with negative outcomes (de Andrés-García et al. 2011). Finally, taking into account the findings of previous research in this area in which gender was considered (Moya-Albiol et al. 2013), we expected to find that, when obtaining positive outcomes,

men showed greater satisfaction with the outcome and a more positive mood than women.

Method

Participants

We advertised in the University of Valencia for healthy young adults. In a preliminary session, all volunteers were given a general questionnaire about their habits and various aspects of their health. We selected young adults who did not smoke; did not take regular medication or have addictive habits (coffee, tea, drugs); and did not have chronic, endocrine and/or cardiovascular diseases. In order to control for potential effects of hormonal fluctuations (i.e., known effects on mood, physiological function, etc.), we excluded female volunteers who did not report at least a 3-month history of regular menstrual cycles lasting 21 to 35 days and/or were using oral contraceptives (Asso 1986; Gómez-Amor, Martínez-Selva, Román & Zamora, 1990; Gómez-Amor, Martínez-Selva, Román, Zamora & Sastre, 1990). The final sample was composed of 90 women and 74 men, all students from the university, between 18 and 25 years of age (mean = 20.40, SD = 1.59), with a body mass index (BMI) of 23.39 ± 3.42 kg/m2. All participants except two (98.78% of the sample) were predominantly right handed.

Sex-matched pairs of participants were randomly allocated to one of six experimental groups according to the type of task and the outcome obtained (positive or negative): cooperation with a positive outcome (Coop. +); cooperation with a negative outcome (Coop. -); competition with a positive outcome, i.e., winners (Comp. +); competition with a negative outcome, i.e., losers (Comp. -); working alone, hereon called the simple task, with a positive outcome (ST. +); and the simple task with a negative outcome (ST. -). Groups had similar distributions in age and socioeconomic factors. Table 1 shows the number of participants per group and summarises participant characteristics by task, outcome and gender.

The study was approved by the university's ethics committee and conducted following ethical principles for human research. All participants took part in the study voluntarily and signed an informed consent form before inclusion.

Table 1. Mean (SD) of descriptive characteristics, psychological traits profiles, and appraisal related to the task for the outcome interaction and gender.

	Cooperation				**Competition**				**Simple Task**			
	(n = 62)				**(n = 52)**				**(n = 50)**			
	Women		**Men**		**Women**		**Men**		**Women**		**Men**	
	(n = 30)		**(n = 32)**		**(n = 30)**		**(n = 22)**		**(n = 30)**		**(n = 20)**	
	Positive outcome	**Negative outcome**	**Positive outcome**	**Negative outcome**	**Positive outcome**	**Negative outcome**	**Positive outcome**	**Negative outcome**	**Positive outcome**	**Negative outcome**	**Positive outcome**	**Negative outcome**
	(n = 15)	**(n = 15)**	**(n = 17)**	**(n = 15)**	**(n = 15)**	**(n = 15)**	**(n = 11)**	**(n = 11)**	**(n = 15)**	**(n = 15)**	**(n = 9)**	**(n = 11)**
Age (years)	20.20 ± .77	20.40 ± .91	20.65 ± 2.06	20.67 ± 2.26	20.33 ± .98	20.00 ± 1.19	20.45 ± 1.51	21.00 ± 2.37	20.87 ± 1.64	19.87 ± .83	19.44 ± 1.58	20.81 ± 2.18
BMI (kg/m^2)	23.19 ± 1.92	22.22 ± 2.88	24.87 ± 3.08	24.58 ± 4.02	21.67 ± 3.11	22.49 ± 3.80	23.46 ± 2.82	23.59 ± 3.60	22.55 ± 3.38	25.26 ± 4.48	23.21 ± 3.55	23.40 ± 2.72
Motivation on the task	7.87	8.40	8.00	6.93	5.70	4.80	5.36	5.54	-	-	-	-

	± 1.64	± 1.30	± 1.36	± 2.31	± 2.25	± 1.70	± 3.35	± 2.25				
Stress on the task	4.53	5.80	2.63	3.47	4.77	4.53	4.36	3.00	4.27	4.47	4.56	4.82
	± 2.13	± 3.03	± 1.65	± 2.53	± 2.58	± 4.03	± 2.58	± 2.37	± 2.05	± 2.33	± 2.79	± 2.13
Satisfaction with the outcome	6.87	2.73	7.40	4.67	7.47	3.33	7.27	4.82	7.13	3.13	5.22	3.09
	± 2.47	± 1.87	± 1.96	± 2.92	± 2.07	± 1.99	± 1.79	± 1.72	± 1.46	± 1.73	± 2.11	± 2.07
Internal locus of control	5.40	6.33	5.93	5.17	6.57	5.67	4.95	6.23	7.73	5.63	4.72	4.14
	± 1.00	± 1.72	± 1.55	± 2.31	± 1.68	± 1.45	± 1.62	± 1.86	± 1.39	± 1.89	± 1.75	± 3.19
External locus of control	5.67	5.00	4.73	5.50	5.03	5.27	5.04	3.77	4.27	4.37	5.28	5.86
	± 1.40	± 3.38	± 2.16	± 2.53	± 2.17	± 2.05	± 1.62	± 1.86	± 1.53	± 1.89	± 1.75	± 3.19

Procedure

After participants arrived at the laboratory, anthropometric and demographic data were collected from each person individually, and compliance with the instructions was checked. Further, they were asked about their activities during the 2 h before the session and the previous night, and about their menstrual cycle in the case of women. Second, each participant was conducted to the room where the recording phase took place and where, for the cooperative and competitive tasks, he/she met the other participant, an individual who was previously unfamiliar to him/her, minimising emotional interference in the laboratory task. This room was soundattenuated, and temperature-controlled (21 ± 2 °C) and light levels were kept constant throughout all sessions. Experimental sessions lasted for 2 h and were held in the afternoon/evening between 16:00 and 20:00. During these sessions, participants did not eat or drink stimulants (such as coffee, tea or alcohol).

The experimental session began when participants had the electrodes to measure EDA attached. Adhesive collars were used to hold the electrodes in place on the phalanx of their non-dominant hand, because they needed their dominant hand to perform the task. This procedure has been employed in a lot of research with psychophysiological variables. In fact, participants are confident with their skills and do better the tasks if they work with their dominant hand instead of their nondominant hand (Moya-Albiol et al. 2013; Romero-Martínez et al. 2013; Romero-Martínez et al. 2014). In cooperative and competitive tasks, two participants of the same gender (previously unknown to each other) were seated one in front of the other, maintaining visual contact. In the simple task, individual participants performed the task alone, as a control group. Firstly, participants were asked to remain relaxed and silent for 10 min. Physiological signals from the electrodes were recorded for the second half of this period (5 min) to obtain baseline values for SCL and NSCRs (rest period). Subsequently, for approximately 5 min, an experimenter of the same gender as the participants gave the task instructions (instruction period). After these instructions, the participants again stayed silent for 5 min (preparation period). Then, they carried out the cooperation, competition or simple task for 10 min (task period). Participants did not know how much time they had to complete the task. After this, two experimenters (one of each gender) assessed the performance of the task and assigned participants arbitrary and manipulated outcomes, these being positive/negative (in cooperation and simple

tasks) and win/lose (in the competitive task). Because the participants never finished the task, it was possible to establish two groups that differed in performance (positive or negative); that is, outcome was a manipulated variable, in order that there would be parity in the number of participants in each group. Physiological signals continued to be recorded for another 10 min (recovery period), and experimenters evaluated performance appraisal, perceived stress, motivation for the task (cooperativeness or competitiveness), and internal and external attribution for the outcome. During the experimental session, data were continuously recorded and monitored out of sight of the participants. In addition, participants completed a mood questionnaire before and after task (pre- and post-task assessments), the post-task questionnaire being administered after the feedback on outcome.

Instructions for Tasks and Their Outcome

The core task was to build a copy of a model house with Lego pieces (de Andrés-García et al. 2011; Moya-Albiol et al. 2013), and this was the same in all the groups, the construction requiring the same visuospatial, psychomotor and cognitive skills. The difference between groups related to the type of instructions given. During the task period, participants were not allowed to talk. In the instructions, participants were forewarned that the evaluation criteria used by experimenters would be: the quality of the construction of the Lego or similarity to the model in all tasks, the errors in the placement of the pieces in the cooperation and simple tasks, and the theft of pieces in the competitive task.

Cooperative task. In this version of the task, each participant had his/her own box, and overall the two boxes had sufficient Lego pieces to build the model. They had to take turns to place pieces, with only visual communication, and before they started, it was explained that cooperating with the partner would facilitate good performance in the task.

Competitive task. In this version of the task, each participant had to build his/her own house, but they had a single common box with insufficient pieces for both of them to build a house like the Lego model. This forced them to compete to build their houses, prioritizing strategy and speed.

Simple Task. In this version of the task, a single participant had to build a house, and he/she had a box with sufficient pieces to complete it. In all the tasks, the pieces of Lego had to be placed one at a time, and participants were only allowed to take one piece each time they reached into the box, with his/her dominant hand.

Materials

Physiological signals

Following the guidelines of the Society of Psychophysiological Research (Boucsein et al. 2012; Fowles et al. 1981), two Ag/AgCl electrodes (TSD203) with a 6-mm diameter contact area were used to measure SCLs and NSCRs. Hypoallergenic gel was used to improve the contact between the skin and electrodes. A skin conductance module (GSR100C) amplified the electrical signal with a constant voltage of less than 0.5 V.

The SC module was a part of a 16-channel physiological recording system (BIOPAC Systems, Inc., Santa Barbara, CA). Signals from this system were connected, through a Universal Interface Module (UIM100C), to a computer equipped with data acquisition hardware (MP150) and data storage software (AcqKnowledge 4.2 for Windows, Biopac Systems, Montreal, Canada).

Task and outcome appraisal scores

The task and the results obtained were assessed with ad hoc questions rated on a 10-point scale. Participants were asked about their motivation for the task (BOn a scale from 0 (not at all) to 10 (highly), how motivated did you feel to complete the task?^) and the stress it caused ("On a scale from 0 (no stress) to 10 (extreme stress), how much stress did you experience during the task?"). They also answered a series of questions related to satisfaction with the outcome ("On a scale from 0 (not at all) to 10 (highly), how satisfied are you with the outcome obtained in the task?") and to their attribution for the outcome (internal and external locus of control) ("On a scale from 0 (not at all) to 10 (highly), how dependent do you feel the outcome of the task was on you, your cognitive abilities and your intelligence?", and "On a scale of 0 (not at all) to 10

(highly), how dependent do you feel the outcome of the task was on external factors, the events that occurred during the session, and the type of task?").

Psychological state variable Mood was evaluated with the abbreviated version of the Profile of Mood States (POMS), translated into Spanish and culturally adapted by Fuentes et al. (1995). It is composed of 29 Likert items, with 5 response options, grouped into five subscales to describe the following factors: tension (6 items), depression (6 items), anger (6 items), vigour (6 items) and fatigue (5 items). Tension refers to heightened musculoskeletal tension and depression to a depressed mood accompanied by feelings of personal inadequacy, while cholera represents a mood of anger and antipathy towards others, vigour a state of positive arousal and high energy, and fatigue a mood of inertia and low energy. A total score was also obtained by summing scores on all but the vigour scale; the higher this total score, the worse the mood. The Cronbach's alpha of this instrument ranged from 0.70 to 0.80 for all the scales, which is considered to indicate good reliability.

Data analysis

After assessing the normality of the data using the Kolmogorov-Smirnov test ($p < .05$), non-normal data were log10 transformed (SCL and NSCRs). To examine group effects by task, outcome and gender, univariate ANOVA (3 X 2 X 2) with Bonferroni post-hoc tests was used to check for significant differences in anthropometric variables (age and BMI), appraisal scores (motivation for tasks, perceived stress, internal and external attribution, and satisfaction with task outcomes) and baseline SCL and NSCRs.

To analyse differences in SCL and NSCRs within groups between periods, repeated-measures ANOVA was performed using a general linear model (3 X 2 X 2 X 4), with period as the within-participant factor (at four levels: rest, preparation, task and recovery periods, the instruction period being included within the preparation period), and task (cooperation, competition and simple), outcome (negative and positive) and gender (women and men) as the between-participants factors. Greenhouse–Geisser corrections for degrees of freedom and Bonferroni corrections for multiple comparisons were applied where appropriate. Partial eta squared (η_p^2) is reported as a measure of effect size.

Magnitude of responses to tasks in terms of SCL was estimated by calculating the area under the curve with respect to the increase (AUCi) and ground (AUCg), using the trapezoidal rule (Hellhammer et al. 2007; Pruessner et al. 2003).

Specifically, AUCi is calculated with reference to the baseline measurement, ignoring the distance from zero for all measurements, and hence emphasizes changes over time. On the other hand, AUCg is the total area under the curve of all measurements, assessing the distance of these measures from ground. To examine group effects by task, outcome and gender, in AUCi and AUCg were assessed with univariate ANOVA (3 X 2 X 2).

To analyse differences in mood within groups between time points (pre- and post-task), repeated-measures ANOVA was performed using a general linear model (3 X 2 X 2 X 2), with moment as the within-participant factor (at two levels: pre-task and post-task), and task (cooperation, competition and simple), outcome (negative and positive) and gender (women and men) as the between-participant factors. Again, Greenhouse–Geisser corrections for degrees of freedom and Bonferroni corrections for multiple comparisons were applied where appropriate, and partial eta squared (η_p^2) is reported as a measure of effect size.

All statistical analyses were performed with IBM SPSS for Windows Version 21.0. The alpha level was set at 0.05. Data are expressed as mean ± SD.

Results

Sample Characteristics

No significant differences were found in anthropometric characteristic (age and BMI) by task, outcome, gender or interaction between them (see Table 1). Moreover, groups did no differ in perceived stress.

Electrodermal response

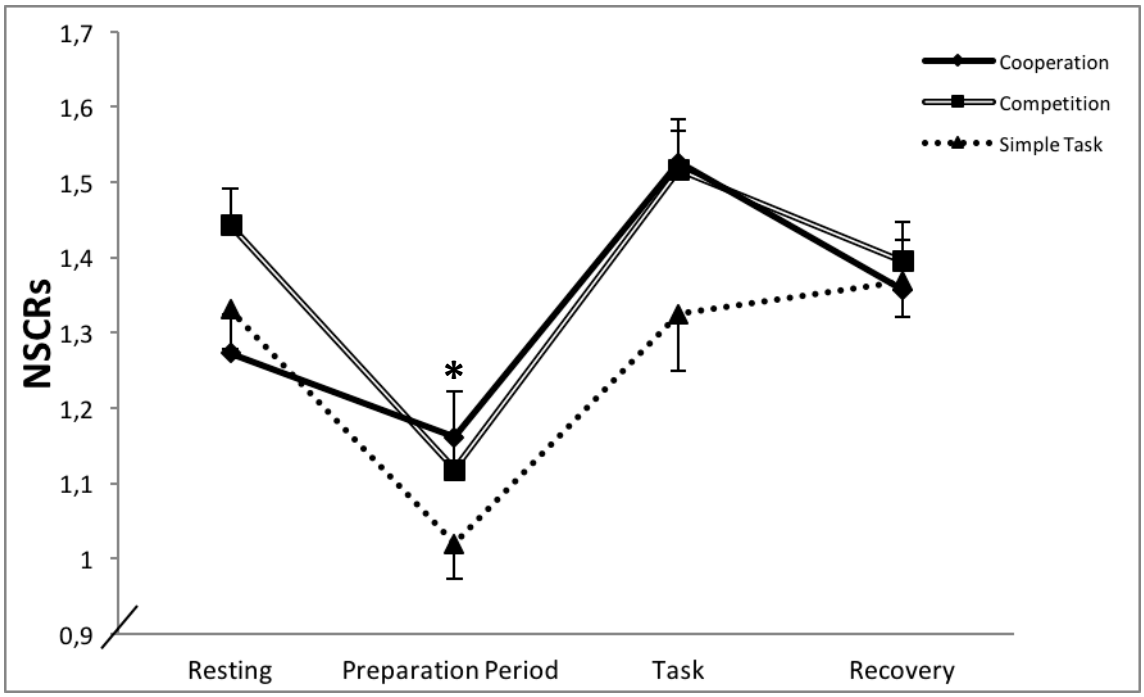
Role of task. A significant effect of period on SCL and NSCRs was found in the total sample, $\varepsilon = .688$, $F(2.065, 313, 909) = 62.797$, $p < .0001$, $\eta^2_{partial} = .292$; and $\varepsilon = .845$, $F(2.679, 404.563) = 81.287$, $p < .0001$, $\eta^2_{partial} = .350$, respectively.

For SCL, post-hoc analysis identified a significant difference between the rest period and the others, with SCLs being lower while participants were resting ($p < .001$ in all cases). Regarding NSCRs, post-hoc analysis showed a significant difference in response between all periods ($p < .001$ in all cases), except the rest and recovery periods.

A main effect of task was found on SCL, $F(2, 152) = 4.365$, $p = .014$, $\eta^2_{partial} = .054$, with SCLs being higher in the cooperative than competitive task group ($p = .011$).

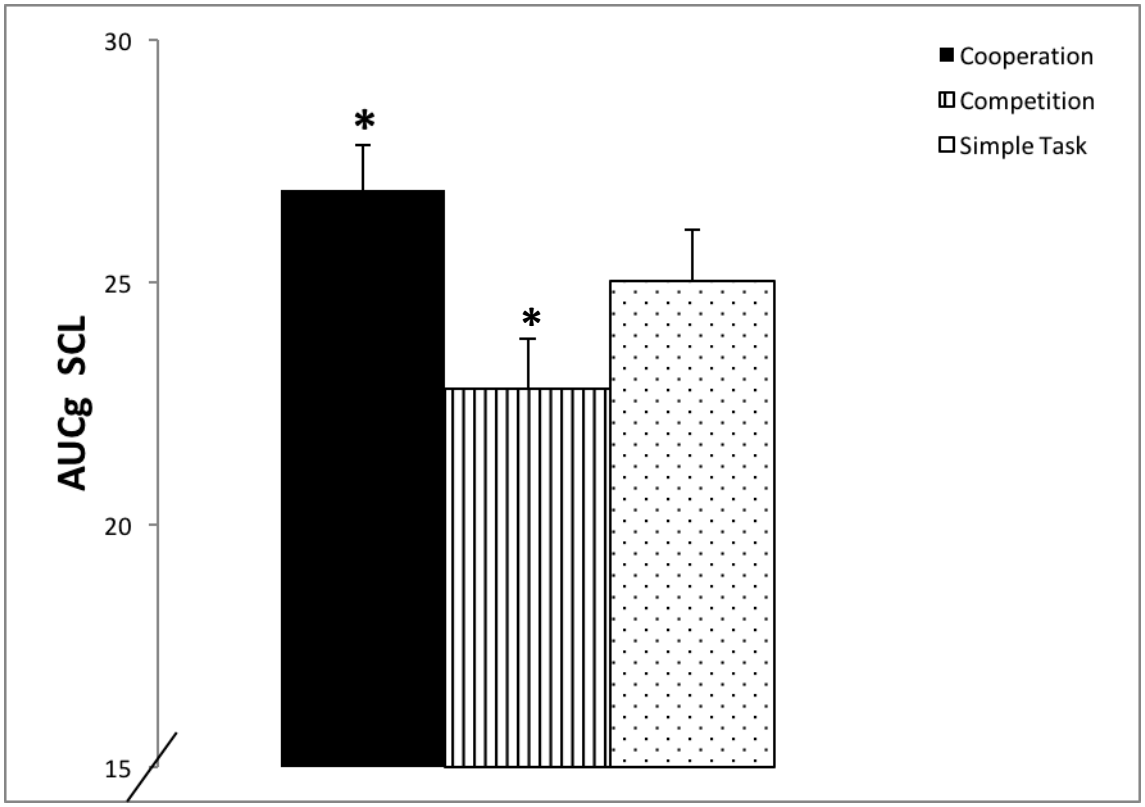
Regarding NSCRs, the Period x Task interaction was significant, $\varepsilon = .902$, $F(5.411, 378.784) = 6.637$, $p < .001$, $\eta^2_{partial} = .087$. In the post-hoc analysis, NSCRs were higher in the cooperative than simple task group during the preparation period ($p = .048$).

Figure 1. NSRCS levels in participants for cooperative, competitive or simple task (M ± SEM). * p <.05



The SCL AUCg varied by type of task, $F(2, 152) = 4.340$, $p = .014$, $\eta^2_{partial} = .055$, being significantly higher in participants who took part in the cooperative task than the competitive task ($p = .01$).

Figure 2. AUCg SCL levels in groups (cooperation, competition and simple task) (M ± SEM). * p <.05



Role of outcome. Analysing SCL and NSCRs as a function of outcome, significant Period x Outcome interactions were found, ε = .688, F(2.065, 313.909) = 4.238, p = .014, $\eta^2_{partial}$ = .027, and ε = .902, F(2.706, 378.784) = 3.301, p = .024, $\eta^2_{partial}$ =.023, respectively. In the post-hoc analysis, SCLs and NSCRs tended to be higher in the positive outcome groups during all periods, though the differences did not reach significance (p > .05 in all cases).

Role of gender. Exploring SCL as a function of gender, we observed a significant Period x Gender interaction, ε = .688, F(2.065, 313.909) = 4.051, p = .017, $\eta^2_{partial}$ = .026, and also a Task x Gender interaction, F(2, 152) = 8.520, p < .0001, $\eta^2_{partial}$ = .101. In the post-hoc analysis, SCL tended to be higher in the women during all periods, though the differences did not reach significance (p > .05 in all cases). Moreover, posthoc analysis showed lower SCLs in men in the competitive group than other men (cooperative and simple task groups; p = .000 and p = .004, respectively).

Regarding NSCRs, there was a significant Period x Gender interaction, $\varepsilon = .902$, $F(2.706, 378.784) = 4.799$, $p = .004$, $\eta^2_{partial} = .033$, and also a Task x Gender interaction, $F(2, 140) = 4.088$, $p = .019$, $\eta^2_{partial} = .055$. Post-hoc analysis showed lower NSCRs in cooperative group women in the rest and recovery periods than competitive group women and cooperative group men only in the recovery period, and in women in the simple task group than cooperative groupmen during the task ($p < .05$ in all cases).

Considering the SCL AUCg, the Gender and Task interaction proved to be significant, $F(2, 152) = 8449$, $p < .0001$, $\eta^2_{partial} = .100$. Post-hoc analysis showed a lower SCL AUCg in men given the competitive task than other men (cooperative and simple task groups) ($p = .000$ and $p = .004$, respectively).

Appraisal scores

Regarding appraisal scores, significant effects were found for motivation, satisfaction with outcome and attribution of outcome (internal locus of control).

Role of task. Level of motivation varied by type of task, $F(1, 104) = 39.430$, $p = .000$, $\eta 2$ partial $=.275$, being significantly higher in participants who cooperated than those who competed ($p = .000$). Moreover, for satisfaction with outcome Task was significant, $F(2, 150) = 3.856$, $p = .023$, $\eta^2_{partial} = .049$ (see Table 1). Post-hoc analysis showed satisfaction with outcome was higher in the competitive group than the simple task group ($p = .023$).

Role of outcome. First, for satisfaction with outcome, Outcome was significant, $F(1, 150) = 116.789$, $p = .000$, $\eta^2_{partial} = .438$. Post-hoc analysis showed satisfaction with outcome was higher in participants with positive outcomes than those with negative outcomes ($p = .000$).

Role of gender. Regarding satisfaction with outcome, Task x Gender and Outcome x Gender interactions were significant, $F(2, 150) = 4.296$, $p = .015$, $\eta^2_{partial} = .054$ and $F(1, 150) = 4.469$, $p = .036$, $\eta^2_{partial} = .029$, respectively (see Table 1). Simple task group men showed lower satisfaction than cooperative and competitive group men ($p = .004$ and $p = .007$, respectively). Lastly, satisfaction with outcome was lower in women with negative outcomes than men with negative outcomes ($p = .030$).

Moreover, for internal locus of control, Gender, and Task x Gender and Task x Outcome x Gender interactions were significant, $F(1, 150) = 12.996$, $p = .000$, $\eta^2_{partial} = .080$, $F(2, 150) = 4.440$, $p = .013$, $\eta^2_{partial} = .056$, and $F(2, 150) = 6.967$, $p = .001$, $\eta^2_{partial} = .085$, respectively (see Table 1). In the post-hoc analysis, women showed higher internal locus of control than men in the simple task group ($p = .000$). Moreover, in this task, women obtained higher internal locus of control scores both comparing women and men with positive outcomes and women and men with negative outcomes ($p = .000$ and $p = .037$, respectively). Further, cooperative group women with negative outcomes obtained higher internal locus of control scores than cooperative group men with positive outcomes ($p = .018$), and competitive group women with positive outcomes obtained higher internal locus of control scores than competitive group men with negative outcomes ($p = .025$).

Mood responses

Role of task. Regarding mood, we found significant Time Point x Task interactions in tension, anger and total scores, $\varepsilon = 1$, $F(2, 151) = 7.076$, $p = .001$, $\eta^2_{partial} = .086$, $\varepsilon = 1$, $F(2, 151) = 4.540$, $p = .012$, $\eta^2_{partial} = .057$, and $\varepsilon = 1$, $F(2, 151) = 3.545$, $p = .031$, $\eta 2partial = .045$, respectively. Posthoc analysis showed lower pre-task tension scores in the simple task group than cooperative and competitive groups ($p = .026$ and $p = .038$, respectively), while differences in anger and total scores did not reach significance ($p > .05$ in all cases). However, the simple task group showed higher anger than cooperative and competitive groups in the post-task assessment, and also showed higher total scores than cooperative and competitive groups pre-task.

Role of outcome. Significant Time Point x Outcome interactions were found in depression, vigour and total scores, $\varepsilon = 1$, $F(1, 151) = 10.443$, $p = .002$, $\eta^2_{partial} = .065$, $\varepsilon = 1$, $F(1, 151) = 6.788$, $p = .01$, $\eta^2_{partial} = .043$, and $\varepsilon = 1$, $F(1, 151) = 8.026$, $p = .005$, $\eta^2_{partial} = .050$, respectively.

Moreover, significant Time Point x Task x Outcome interactions were observed in depression, $\varepsilon = 1$, $F(2, 151) = 5.142$, $p = .007$, $\eta^2_{partial} = .064$. Post-hoc analyses showed that participants with positive outcomes had significantly higher pre-task depression scores than those with negative outcomes ($p = .028$); notably, this pattern

was observed even in the simple task group (p = .007). Further, post-hoc analyses showed that participants with positive outcomes had significantly higher post-task vigour scores than those with negative outcomes (p = .021), but the differences in total scores did not reach significance (p > .05).

Role of gender. A significant Time Point x Gender interaction was found in depression scores, ε = 1, F(1, 151) = 3.906, p = .05, $\eta^2_{partial}$ = .025. Further, significant Time Point x Task x Gender interactions were found in anger scores, ε = 1, F(2, 151) = 4.956, p = .008, $\eta^2_{partial}$ =.062.

Post-hoc analyses showed that simple task group men had significantly higher post-task anger scores than simple task group women (p = .021), but the differences in depression scores for Time Point x Gender did not reach significance (p > .05 in all cases).

Discussion

The main objective of this study was to assess how the type of social interactions individuals are involved in affect them emotionally. We found that cooperation results in higher SCL and AUCg for this parameter than competition. This effect is moderated by gender, men who competed having SCLs and AUCg that were lower than men who cooperated or performed the simple task. Women who cooperated had lower NSCRs than women who competed and men who cooperated in rest and recovery periods, and women in the simple task had lower NSCRs than cooperative group men during the task. In addition, participants who cooperated showed the highest levels of motivation for the task. Satisfaction with outcome was higher in the competitive group than the simple task group, in participants with positive outcomes than those with negative outcomes, in men with negative outcomes than women with negative outcomes, and in cooperative and competitive group men than simple task group men. Internal locus of control was higher in women than men in the simple task group, in cooperative group women with negative outcomes than cooperative group men with positive outcomes, in competitive group women with positive outcomes than competitive group men with negative outcomes, and in simple task group women with negative or positive outcomes than simple task group men with negative or positive outcomes. Finally, participants

with positive outcomes showed higher post-task vigour scores than those with negative outcomes, and, simple task group men showed higher anger scores than simple task group women.

Recalling that the primary objective of this study was to assess whether there are differences in emotionality as a function of social interaction strategy (cooperation, competition or working alone), we consider that our findings help to answer this question. As we have previously mentioned, there are few data available from previous studies on the effect of cooperation and competition on EDA with which to compare our results. Nevertheless, we can state that our findings are in line with previous research in this field in terms of the activating effect of cooperative behaviour on the emotionality of individuals (Moya-Albiol et al. 2013), specifically, we demonstrated that those men who cooperated had higher NSCRs than women who cooperated. Moreover, we also found that cooperation has an activating effect on emotionality, higher EDA being observed in those cooperating than in those competing at all time points at which SCL was measured and in the SCL AUCg. This effect may be due to the fact that cooperation requires collaboration with other individuals, as it is not an individual behaviour, unlike competition, the antithesis of cooperation, and the control task used in this study (working alone). In turn, cooperation relies on range of characteristics and skills including trust, altruism, emotional contagion, and empathy. These skills, which have been little studied to date from a psychobiological point of view, tend to be in less demand in our current society, greater emphasis being placed on other values such as competitiveness, efficiency, egocentricity, patriarchal masculinity, and in general, the ethics of the market and of consumerism. This could mean that the fact of having to cooperate with another individual to achieve a goal/target triggers a stronger affective or emotional process. However, while previous studies found that outcome had an effect in the case of the cooperative task (de Andrés-García et al. 2011; Moya-Albiol et al. 2013), our results are only consistent with a role of outcome on SCL, there being a non-significantly lower SCL in participants with negative outcomes, and this was also observed in the other tasks.

With regard to psychological variables related to social interaction, we also found differential effects as a function o he type of task. First, we found greater motivation in participants performing the cooperative task. This finding is similar to that of the aforementioned study by de Andrés-García et al. (2011), in which, as in our

study, it was found that participants behaving in a cooperative way had higher scores in motivation than those competing. On the other hand, in our study we did not find that the motivation for the task was influenced by gender or by outcome of the task. Another psychological variable with a potential impact on social interaction is satisfaction with outcomes obtained.We observed greater satisfaction when the outcome was positive for the participant, regardless of the type of social interaction used, in contrast to the findings of Moya-Albiol et al. (2013), who found that cooperating men with positive outcomes had the highest levels of satisfaction with the outcome. In addition, besides satisfaction, the locus of control over the task is also important, women tending to show internal attribution for positive outcomes. This reinforces the idea that research should be broadened to explore whether differences in the perception of and satisfaction with outcomes obtained are attributable to the task, the outcome itself or the gender of participants.

With regard to the limitations of our study, first, we must be aware of the difficulty of comparing results obtained under experimental conditions with what happens under natural conditions. We believe that the former tend to reduce the potential effects of tension related to a new situation and social desirability on the ANS and mood responses (Thunholm 2008; Moya-Albiol et al. 2013). However, the fact that the task has been validated in two previous studies strengthens the ecological validity of our findings. Moreover, we should underline that we found lower tension scores in individuals who performed the simple task, this confirming the fact that the significant results have not been due to the fact that the Lego construction task alone activates participants emotionally. Further, as suggested by Moya-Albiol et al. (2013), the complexity of the task calls for a high level of participation, it being necessary to join efforts to perform well in the case of the cooperative task. Moreover, it would preferable to counterbalance the administration of appraisal variables, in order to avoid confounding effects. Finally, a potential limitation of this research is the fact that we have only considered a normative population, and in future research, it would be interesting to include other populations that are more or less predisposed to using one of the social interaction strategies considered (cooperation or competition) in daily life. For example, competition and cooperation may serve as laboratory models for analysing psychobiological changes that occur during, on the one hand, confrontational and/or violent situations, and on the other, altruism and empathy.

Given the findings to date, there is a need for further research in human cooperation including the assessment of other psychobiological parameters, for example, levels of oxytocin, the hormone that promotes altruistic and cooperative behaviour in humans (De Dreu et al. 2010), or other indicators of the ANS, such as the heart rate, heart rate variability or even parameters related to the immune system. This would provide a more comprehensive view of the response to cooperation. In addition, we should explore in more detail the role of variables that may have a moderating effect on cooperation, such as the outcome obtained, the satisfaction achieved, and the gender and age of participants. With regard to the last of these variables, to date, no studies have investigated whether age has an impact on cooperation, it being possible that level of maturity or training could influence responses.

The study of social interaction using psychophysiological markers may improve our understanding of emotional arousal, and it might be possible to extrapolate findings to negotiation and conflict resolution situations. Furthermore, research in this field would help us understand more about physiological responses of the body to different types of social interactions, such as cooperation and competition, providing an opportunity to establish interaction strategies that would be physiologically desirable, in order to promote our long-term psychophysiological wellbeing.

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Capítulo 4

Estudio 3: Does being a stranger make it difficult to cooperate?

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Introduction

Competition and cooperation are two somewhat opposed strategies for interpersonal social interaction that help us to achieve both individual and shared aims and objectives. Competition is an adaptive social behavior, which may be aggressive or defensive, and in which we seek to reach goals individually (biosocial model of status of Mazur, 1985). By contrast, cooperation is a social behavior that principally seeks to increase the probability of success in reaching common aims or objectives by collaborating with other members of a group (Kappeler & Van Schaik, 2006; Melis & Semman, 2010).

Regarding competition, there has been a considerable amount of psychobiological research. However, relatively few studies have analyzed the effects of laboratory cognitive tasks, such as reaction-time games, gambling, videogames and arithmetic tasks, activities known to induce social-evaluative threat (Dickerson & Kemeny, 2004; Denson, Spanovic, & Miller, 2009), on the hypothalamic-pituitary-adrenal (HPA) axis in terms of levels of its end product cortisol (Costa, & Salvador, 2012; Costa, Serrano & Salvador, 2016; Hasegawa, Toda & Morimoto, 2008; Oxford, Ponzi & Geary, 2010). One of these few studies, which explored salivary cortisol (Csal) response in men to a Japanese chess competition, found that their Csal levels were higher after the competition (Hasegawa et al., 2008). Further, a study with a card game and competitive multiplayer video game found that Csal levels in men increased during the competition and also remained high after the game ended (Oxford et al., 2010). In contrast, a study based on women performing a competitive cognitive task found that Csal did not change between before and after the task, taking into account the outcome obtained (winning or losing) (Costa & Salvador, 2012). Hence, it seems that sex plays an important role in the Csal response to laboratory competitive tasks.

Further, it has been hypothesized that outcome (winning or losing) is a possible modulator of the Csal response to a competitive situation (Salvador & Costa, 2009), although most of the research in this field is based on competitive physical sports. There is no consensus on the effects of outcome *per se*. Nonetheless, it has been suggested that obtaining a negative outcome or losing has an important activational effect on HPA axis activity when individuals perceive the situation to be uncontrollable (Salvador & Costa, 2009). Feelings of uncontrollability could affect social status in humans, in turn leading

to substantial HPA activation. In fact, performing poorly or losing could reveal an inability to overcome a threat, and this would tend to increase Csal and anxiety levels (Dickerson & Kemeny, 2004; Denson et al., 2009). Moreover, the relationship between perceived control of a threat and Csal could be moderated by locus of control. People with a high internal locus of control perceive that they have control over the threat, and this has been associated with lower Csal levels (Bollini, Walker, Hamann, & Kestler, 2004). Regarding competitive laboratory tasks, no differences in Csal levels were observed between winners and losers in healthy young men (Hasegawa et al., 2008) or women (Costa & Salvador, 2012). On the other hand, an association was observed between post-competition appraisal and the outcome obtained. Specifically, the study with women revealed that winners have low state anxiety and a high internal locus of control after competition, while losers have high anxiety and a high external locus of control (Costa & Salvador, 2012).

Regarding cooperation, a type of social interaction that is widespread in all societies, most related research has taken a social approach, based on games involving ethical judgments or moral dilemmas, such as the prisoner's dilemma, ultimatum games and the effect of punishment (Burton-Chellew & West, 2012; Velez, Mahood, Ewoldsen & Moyer-Gusé, 2012). To our knowledge, only two studies have analyzed Csal response to a cooperative laboratory task such as Lego house-building (de Andrés et al., 2011; Moya-Albiol et al., 2013). One of these compared Csal response in women who cooperated in the building of a Lego house with that in women who competed to perform this task, in both cases controlling for the effect of outcome. It was found that Csal levels fell significantly after the task in participants who cooperated and obtained a positive outcome (i.e., did the task well) as well as those who competed and obtained a negative outcome (i.e., lost) (de Andrés et al., 2011). Furthermore, women who cooperated and obtained a negative outcome and those who won when competing showed a higher internal locus of control than the rest of the participants (de Andrés et al., 2011). The other study compared the Csal response of men and women who cooperated on this Lego task (Moya-Albiol et al., 2013). Overall, Csal levels fell slightly when the outcome of the cooperative task was positive, while when the outcome was negative, there was a significant increase in Csal levels after the task followed by a progressive decrease. Moreover, it was observed that men with positive outcomes had lower Csal levels than women with a negative outcome (Moya-Albiol et al., 2013).

With all this in mind, the main aim of this study was to explore which type of social interaction (cooperative or competitive) is more stressful for participants considering outcome (positive or negative) and sex as moderating variables and performance of the task while working alone as a control condition. For this purpose, we measured Csal and anxiety levels as psychobiological indicators of perceived stress in a sample of strangers who were set to cooperate or compete in face-to-face same-sex dyads. Firstly, we hypothesized that participants who competed or cooperated and obtained a negative outcome or lost would have higher levels of Csal, anxiety and external locus of control and less satisfaction than those who obtained a positive outcome or won (Costa & Salvador, 2012; de Andrés-García et al., 2011; Moya-Albiol et al., 2013). Secondly, with respect to the role of sex, we hypothesized that men who cooperated and obtained a positive outcome would have lower Csal levels than women who cooperated and obtained a negative outcome (Moya-Albiol et al., 2013). Finally, we expected to find a positive relationship between anxiety and Csal levels in all groups (Kirschbaum & Hellhammer, 1994). Analysis of these variables and their relationships may help to improve our understanding of interpersonal social interactions, including differences in biological responses.

Method

Participants

We advertised in the University of Valencia for healthy young adults, establishing contact by email before screening applicants in interviews. The final sample consisted of a total of 178 students from the University of Valencia. In the preliminary session, all the students were given a general questionnaire about habits and various aspects of their health. We selected those who did not smoke, take medication or have addictive habits (coffee, tea, drugs), or have chronic, endocrine and/or cardiovascular diseases. In order to control for potential effects of hormonal influences/fluctuations (i.e., due to known effects on mood, physiological functions, etc.), female applicants who did not report at least a 3-month history of regular cycles lasting 21 to 35 days and/or were using oral contraceptives were excluded (Gómez-Amor, Martínez-Selva, Román & Zamora, 1990; Gómez-Amor, Martínez-Selva, Román, Zamora & Sastre, 1990). The final sample was composed of 88 women and 90

men, between 18 to 25 years of age (mean = 20.42, *SD* = 1.64) with a body mass index (BMI) of 23.36 ± 3.30 kg/m^2.

Sex-matched participants were randomly allocated to one of six experimental groups according to the type of task and the outcome obtained (positive or negative): cooperation with a positive outcome (Coop. +); cooperation with a negative outcome (Coop. -); competition with a positive outcome, i.e., winners (Comp. +); competition with a negative outcome, i.e., losers (Comp. -); working alone with a positive outcome (WA. +); and working alone with a negative outcome (WA. -). The groups had similar distributions in terms of age and socioeconomic characteristics. Table 1 shows the number of participants per group and summarizes participant characteristics by task, outcome and sex.

The study was approved by the university's ethics committee and conducted in accordance with ethical principles for human research of the Declaration of Helsinki. All participants took part in the study voluntarily and signed an informed consent form before inclusion.

Procedure

After the participants arrived, anthropometric and demographic data were collected from each of them individually, and compliance with the instructions was checked. Further, they were asked about their activities during the 2 hours before the session and the previous night, and their menstrual cycle in the case of women.

Second, each participant was escorted to the room where the recording phase took place and where, for the cooperative and competitive tasks, he/she met the other participant, an individual who was previously unknown to him/her, minimizing emotional interference in the laboratory task. This was sound-proofed temperature-controlled (21 ± 2ºC) room and light levels were kept constant throughout all sessions. Experimental sessions lasted for 2 hours and were held in the afternoon between 16:00 and 19:00 to minimize hormonal variations due to circadian rhythms. During these sessions, participants did not eat or drink stimulants (such as coffee, tea or alcohol). In cooperative and competitive tasks, the two participants (previously unknown to each

other) were seated one in front of the other, maintaining visual contact. In the 'working alone' task, single participants performed the task on their own, serving as controls.

The experimental session began when participants were accustomed to the laboratory environment. During this session, anxiety and Csal levels of the participants were evaluated.

Firstly, participants were asked to remain relaxed and silent for 10 minutes. After this 10 min habituation period, a pre-task saliva sample was collected for measuring cortisol level (Csal-1), while the participants completed the psychological questionnaires for assessing pre-task states of anxiety. Subsequently, an experimenter of the same sex as the participants gave the task instructions, and then participants performed the task they had been set (cooperating, competing or working alone) for 10 minutes. Participants did not know how much time they had to complete the task.

At the end of the task period, two experimenters (one of each sex) assessed participants' performance and assigned arbitrary and manipulated outcomes, thereby establishing two groups that differed in performance for each task: win vs. lose (for the competitive task) and positive vs. negative (for the cooperative task and working alone). Outcomes were assigned to balance the number of participants in each group and this was possible because the participants never finished the tasks (the 10 minutes allowed being insufficient in all cases).

Immediately after stopping work on the task, a saliva sample (Csal-2) was collected, while participants completed questionnaires for assessing post-task states of anxiety. In addition, at this time point, the task was appraised, in terms of perceived stress, satisfaction with the outcome, motivation for the task and internal and external attribution for the outcome. Finally, participants were escorted to the first room where saliva samples were collected 10, 30 and 45 min after the task (Csal-3, Csal-4 and Csal-5, respectively).

Instructions for tasks and their outcome

The core task was to build a copy of a model house with Lego pieces (de Andres-García et al., 2011; Moya-Albiol et al., 2013), and this was the same in all the

groups, the construction requiring the same visuospatial, psychomotor and cognitive skills. The difference between groups related to the type of instructions given. During the task period, participants were not allowed to talk. In the instructions, participants were forewarned that the evaluation criteria used by experimenters would be: the quality of the construction of the Lego or similarity to the model in all tasks, the errors in the placement of the pieces in the cooperative task and when working alone, and the theft of pieces in the competitive task.

Cooperative task. In this version of the task, each participant had his/her own box, and overall the two boxes had sufficient Lego pieces to build the model. They had to take turns to place pieces, with only visual communication, and before they started, it was explained that cooperating with their partner would facilitate good performance in the task.

Competitive task. In this version of the task, each participant had to build his/her own house, but they had a single common box with insufficient pieces for both of them to build a house like the Lego model. This forced them to compete to build their houses, prioritizing strategy and speed.

Working alone task. In this version of the task, a single participant had to build a house, and he/she had a box with sufficient pieces to complete it.

In all the tasks, the pieces of Lego had to be placed one at a time, and participants were only allowed to take one piece each time they reached into the box, with his/her dominant hand.

Materials

Cortisol analysis

To avoid a stress-induced increase in cortisol levels associated with venipuncture, we used saliva samples (Aardal & Holm, 1995). Csal concentration correlates well with free plasma cortisol concentration (Kirschbaum, & Hellhammer, 1994), and sample collection is non-invasive.

Saliva samples were collected with a Salivette system (cotton roll and two-part tube; Sastedt, Rommersdolf, Germany), immediately frozen at −20°C and stored at this temperature until thawed for use in radioimmunoassay analysis. All samples from each individual were run in duplicate in the same assay and values were averaged, provided that the inter-duplicate variation coefficient did not exceed 8%; else, the sample was analyzed again.

Radioimmunoassays were performed with a Coat-A-Count Kit (DPC-Siemens Medical Solutions Diagnostics, Bad Nauheim, Germany), which has a sensitivity of detection of cortisol levels as low as 1.4 nmol/l and uses a rabbit polyclonal antibody immobilized on the wall of a polypropylene tube. It is highly specific for cortisol (cross-reactivity with other peptide and steroid hormones being lower than 1%). The intra- and inter-assay variation coefficients were 4.3% and 5.2%, respectively.

Task and outcome appraisal scores

The task and the outcomes obtained were assessed with ad hoc questions rated on a 10-point scale. Participants were asked about their motivation for the task ("On a scale from 0 (not at all) to 10 (highly), how motivated did you feel to complete the task?") and the stress it caused ("On a scale from 0 (no stress) to 10 (extreme stress), how much stress did you experience during the task?"). They also answered a series of questions related to satisfaction with the outcome ("On a scale from 0 (not at all) to 10 (highly), how satisfied are you with the outcome obtained in the task?") and to their attribution for the outcome (internal and external locus of control) ("On a scale from 0 (not at all) to 10 (highly), how dependent do you feel the outcome of the task was on you, your cognitive abilities and your intelligence?", and "On a scale of 0 (not at all) to 10 (highly), how dependent do you feel the outcome of the task was on external factors, the events that occurred during the session, and the type of task?").

Psychological response to task

Anxiety was assessed using the State subscale of the Spanish version of the State-Trait Anxiety Inventory (STAI-S) (Spielberger, Gorsuch, Lushene, Vagg &

Jacobs, 1983; Seisdedos, 1982). This subscale is composed of 20 items ranked on a four-point Likert scale from 0 (not at all) to 3 (very much so) examining how participants feel at that moment. Cronbach's alpha for this subscale was 0.72.

Data analysis

After assessing the normality of the data using the Kolmogorov-Smirnov test ($p < .05$), non-normal data were $\log_{10}$ transformed (only Csal levels). To examine group effects by task, outcome and sex, univariate analysis of variance (ANOVA) (3 x 2 x 2) with Bonferroni post-hoc tests was used to check for significant differences in anthropometric variables (age and BMI), appraisal scores (motivation for tasks, internal and external attribution, and satisfaction with task outcomes) and baseline cortisol (Csal-1). When any of these factors was found to be significant, it was considered as a covariate in subsequent analyses.

To assess differences in Csal levels within groups between time points, repeated-measures ANOVA was performed using a general linear model (3 x 2 x 2 x 5), with Time as the within-participant factor (at five levels: Csal-1, Csal-2, Csal-3, Csal-4 and Csal-5), and task (cooperating, competing and working alone), outcome (negative and positive) or sex (women and men) as the between-participant factor. Greenhouse–Geisser corrections for degrees of freedom and Bonferroni corrections for multiple comparisons were applied when a significant interaction effect was found in ANOVAs. In addition, partial eta squared (η_p^2) is reported as a measure of effect size.

The magnitude of responses to tasks in terms of changes in Csal levels was estimated by calculating the area under the curve with respect to the increase (AUC_i), using the trapezoidal rule (Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003). Specifically, AUC_i is calculated with reference to the baseline measurement, ignoring the distance from zero for all measurements, and hence emphasizes changes over time. The group differences in AUC_i were assessed with univariate ANOVA.

To assess differences in anxiety within groups between time points (pre-task and post-task), repeated-measures ANOVA was performed using a general linear model (3 x 2 x 2 x 2), with Time as the within-participant factor (at two levels: pre-task and post-task), and task (cooperating, competing and working alone), outcome (negative and

positive) or sex (women and men) as the between-participant factor. As for the analysis of Csal, Greenhouse–Geisser corrections for degrees of freedom and Bonferroni corrections for multiple comparisons were applied where appropriate and partial eta squared (η_p^2) is reported as a measure of effect size.

Lastly, linear regressions were used to examine relationships between the anxiety state levels and Csal response to the task.

All statistical analyses were performed with IBM SPSS for Windows Version 21.0. The alpha level was set at 0.05. Data are expressed as mean ± SD.

Results

Sample characteristics and appraisal scores

No significant differences were found in anthropometric variables (age and BMI) by task, outcome, sex or interactions between them (see Table 1). However, men had a higher BMI than women, $F(1, 165) = 4.386$, $p = .038$, $\eta_p^2 = .026$.

Regarding appraisal scores, a significant group effect was found for motivation towards the task, $F(1, 106) = 36.577$, $p < .001$, $\eta_p^2 = .257$, with higher scores in the cooperative group than the competitive group ($p < .001$).

Concerning satisfaction with outcome, participants with positive outcomes showed higher satisfaction than those with negative outcomes, $F(1, 161) = 113.130$, $p < .001$, $\eta_p^2 = .413$. Moreover, there was a significant Outcome x Sex effect, $F(1, 161) = 4.565$, $p = .034$, $\eta_p^2 = .028$ (see Table 1), men with negative outcomes reporting greater satisfaction than women with negative outcomes ($p = .004$).

On the other hand, analyzing attribution, participants with positive outcomes obtained higher internal locus of control scores than those with negative outcomes, $F(1, 161) = 9.310$, $p = .003$, $\eta_p^2 = .055$, and women obtained higher internal locus of control scores than men, $F(1, 161) = 7.581$, $p = .007$, $\eta_p^2 = .045$. Furthermore, there were significant Task x Outcome, Task x Sex and Task x Outcome x Sex effect, $F(2, 161) = 5.249$, $p = .006$, $\eta_p^2 = .061$; $F(2, 161) = 3.904$, $p = .022$, $\eta_p^2 = .046$; and $F(2, 161) = 5.255$, $p = .006$, $\eta_p^2 = .061$; respectively (see Table 1). Moreover, post-hoc analysis

showed that in the group working alone, participants with positive outcomes had a higher internal locus of control than those with negative outcomes ($p < .001$), and women showed a higher internal locus of control than men on this task ($p < .001$). Further, women working alone obtained greater internal locus of control scores than men working alone regardless of the outcome ($p = .005$ and $p = .001$, respectively), and women with negative outcomes on the cooperative task obtained greater internal locus of control scores than men with negative outcomes on this task ($p = .008$).

Table 1. Mean (SD) of descriptive characteristics, psychological trait profiles, and appraisal scores by group, stratifying by type of interaction (task), outcome and sex.

Groups	Age (years)	Body mass index (kg/m^2)	Motivation for the task	Stress due to the task	Satisfaction with the outcome	Internal locus of control	External locus of control
Women Coop. + (n = 14)	20.21 ± .21	23.05 ± .51	7.86 ± .46	4.64 ± .58	6.79 ± .68	5.43 ± .27	5.71 ± .38
Women Coop. – (n = 15)	20.40 ± .23	22.22 ± .74	8.40 ± .33	5.80 ± .78	2.73 ± .48	6.33 ± .44	5.00 ± .87
Women Comp. + (n = 15)	20.28 ± .27	21.53 ± .85	5.68 ± .63	4.54 ± .67	7.36 ± .56	6.54 ± .46	4.82 ± .56
Women Comp. – (n = 15)	20.00 ± .31	22.49 ± .98	4.80 ± .44	4.53 ± .53	3.33 ± .51	5.67 ± .37	5.27 ± .53
Women WA. + (n = 15)	20.87 ± .42	22.55 ± .87	Not evaluated	4.27 ± .53	7.13 ± .38	7.73 ± .36	4.27 ± .4
Women WA. – (n = 15)	19.87 ± .22	25.26 ± 1.16	Not evaluated	4.47 ± .60	3.13 ± .45	5.63 ± .49	4.37 ± .49
Men Coop. + (n = 15)	2053 ± .56	24.92 ± .70	7.85 ± .39	2.65 ± .41	7.46 ± .54	6.00 ± .46	4.77 ± .64

Men Coop. – (n = 15)	20.67 ± .58	24.58 ± 1.04	6.93 ± .6	3.47 ± .65	4.67 ± .75	5.17 ± .6	5.50 ± .65
Men Comp. + (n = 15)	20.40 ± .35	23.27 ± .64	5.57 ± .8	5.00 ± .69	6.57 ± .59	5.25 ± .43	4.75 ± .43
Men Comp. – (n = 15)	20.60 ± .59	23.75 ± .87	5.47 ± .59	3.20 ± .58	4.53 ± .48	6.10 ± .52	3.90 ± .52
Men WA. + (n = 15)	20.33 ± .58	23.27 ± .79	Not evaluated	4.00 ± .63	6.00 ± .57	5.97 ± .58	4.03 ± .58
Men WA. – (n = 15)	20.80 ± .5	23.34 ± .63	Not evaluated	5.13 ± .5	3.87 ± .61	4.17 ± .76	5.84 ± .76

Coop.: cooperative task; comp.: competitive task, WA: working alone

Psychobiological responses (Csal and anxiety) to the laboratory task

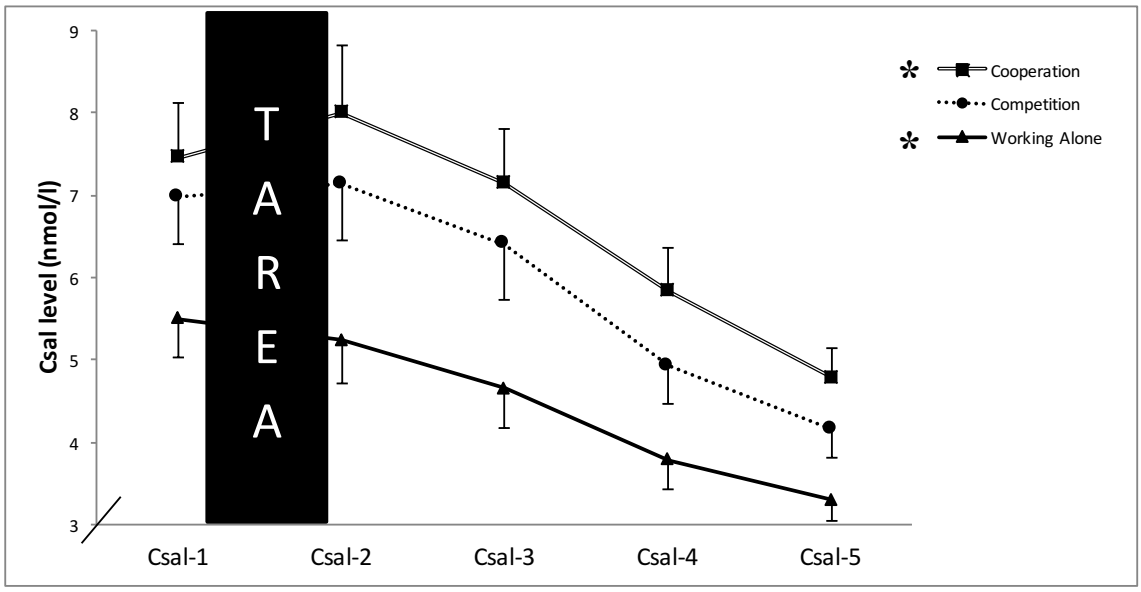
Csal response

For Csal, the laboratory tasks proved to be efficient in eliciting Csal changes, since Time showed a significant effect in the total sample, ε = .503, $F(2.010, 353.840) = 104.947$, $p < .001$, $\eta_p^2 = .374$. Post-hoc analysis identified a significant difference between all periods ($p < .001$ in all cases), except between Csal-1 and Csal-2.

As groups did not differ in Csal baseline levels, F(2, 176) = 2.68, p = .071, $\eta_p^2 = .030$, they were not included as a covariate.After dividing the sample by task type, Time was found to have a significant effect on Csal levels in all three groups, namely, those cooperating, competing and working alone: ε = .455, $F(1.819, 108.736) = 25.502$, $p < .001$, $\eta_p^2 = .305$; ε = .488, $F(1.953, 113.300) = 37.734$, $p < .001$, $\eta_p^2 = .394$; and ε = .557, $F(2.227, 129.179) = 48.048$, $p < .001$, $\eta_p^2 = .453$, respectively. Post-hoc analysis of cooperative task data identified significant differences between all periods ($p < .001$ in all cases), except between Csal-1 and Csal-2, Csal-1 and Csal-3, and Csal-2 and Csal-3, and of competitive task data identified significant differences between all periods ($p < .001$ in all cases), except between Csal-1 and Csal-2, and Csal-1 and Csal-3. For the working alone group, post-hoc analysis identified significant differences between all periods ($p < .05$ in all cases).

Role of task. A main effect of Task was found, $F(2, 165) = 5.540$, $p = .005$, $\eta_p^2 = .063$, with Csal levels being higher in the cooperative group than among those working alone ($p = .004$) (see Figure 1). No significant effect was found for Csal AUCi.

Figure 1. Levels of Csal over time in groups cooperating, competing or working alone to perform the task (M ± SEM). * $p < .05$



Role of outcome. With respect to the effect of participants' outcome on Csal levels, there was a significant Time x Task x Outcome effect, ε = .509, $F(4.075, 336.160) = 2.917$, $p = .021$, $\eta_p^2 = .034$. In the post-hoc analysis, it was found that Csal tended to be higher in participants that cooperated and obtained negative outcomes than those working alone with negative outcomes during all periods, except Csal-1 ($p = .005$, $p = .002$, $p = .001$ and $p = .005$, respectively).

Moreover, there was a significant Task x Outcome interaction for Csal AUC_i, $F(2, 165) = 3.878$, $p = .023$, $\eta_p^2 = .045$. Post-hoc analysis showed a smaller increase in Csal AUC_i in participants who obtained negative outcomes cooperating than those who obtained negative outcomes competing or working alone ($p = .027$ and $p = .042$, respectively).

Role of sex. With respect to the effect of participants' sex on Csal levels, we observed a significant Time x Sex effect, ε = .509, $F(2.037, 336.160) = 8.936$, $p < .001$, $\eta_p^2 = .051$, with men presenting higher Csal-1 levels than women ($p = .010$). Considering the Csal AUC_i, sex proved to be significant, $F(1, 163) = 6.166$, $p = .014$, $\eta_p^2 = .036$, and post-hoc analysis showed a larger increase in Csal AUC_i in men than women. *Time x Task x Outcome x Sex and Task x Outcome x Sex*.

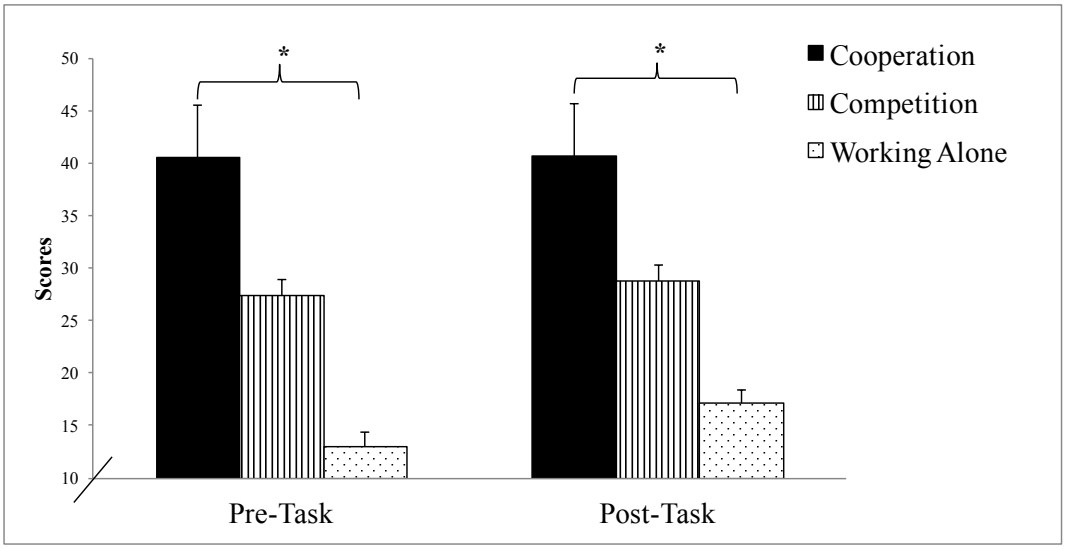
There was no significant Time x Task x Outcome x Sex effect in Csal levels or Task x Outcome x Sex interaction in AUC_i Csal.

Anxiety responses

Role of task. Regarding state anxiety, we found a significant Time x Task effect, ε = 1, $F(2, 166) = 5.024$, $p = .008$, $\eta_p^2 = .057$. Post-hoc analyses identified a significant difference between all groups for both time points ($p < .001$ for all).

Furthermore, a main effect of Task was found, $F(2, 166) = 94.937$, $p < .001$, $\eta_p^2 = .534$, with scores being higher in the cooperative group than among those competing or working alone ($p < .001$ in both cases) (see Figure 2).

Figure 2. State anxiety pre- and post-task in groups cooperating, competing or working alone to perform the task (M ± SEM). * $p < .001$



Role of outcome. A significant Time x Outcome effect was found in state anxiety scores, ε = 1, $F(1, 166) = 5.099$, $p = .025$, $\eta_p^2 = .030$. Post-hoc analyses showed that participants with negative outcomes had significantly higher anxiety scores than participants with positive outcomes ($p = .035$). Nevertheless, non

significant *Time x Task x Outcome* interaction were found, ε = 1, $F(2, 166) = 1.721$, $p = .182$, $\eta_p^2 = .020$.

Role of Sex. Significant Task x Sex and Sex effects were found, $F(1, 166) = 25.354$, $p < .001$, $\eta_p^2 = .234$, and $F(1, 166) = 70.171$, $p < .001$, $\eta_p^2 = .297$, respectively. Post-hoc analysis showed higher anxiety scores in women than men ($p < .001$), and in cooperative women than other groups except competitive women ($p < .001$ for all).

Role of Time x Task x Outcome x Sex. There was no significant Time x Task x Outcome x Sex effect in anxiety levels.

Baseline anxiety levels as a predictor of Csal response to the laboratory task (AUCi)

The baseline anxiety levels predicted 7.3% of the AUCi Csal (β = .280, $p < .01$). After including task, sex and BMI as covariates, prediction remained significant (β = .267, $p < .01$).

Discussion

The main objective of our study was to assess which type of social interaction, between strangers in face-to-face same-sex dyads is more stressful: cooperation or competition. We found that participants who cooperated and obtained negative outcomes had higher Csal levels and self-reported state anxiety, these differences only being statistically significant with respect to working alone. Further, women who cooperated and obtained a negative outcome reported the highest motivation and internal locus of control and the lowest satisfaction. Finally, higher baseline anxiety levels were associated with larger Csal increases for all groups.

The tasks increased Csal and anxiety levels in all the participants. Moreover, in the competitive and cooperative tasks, there was an increase from pre-task to 0 min post-task levels, and then a progressive decrease in Csal levels which was significant in all cases other than between 0 and 15 min post-task. Notably, the Lego house-building

task has been validated in three previous studies, which strengthens the ecological validity of our findings (de Andrés et al., 2011, Moya-Albiol et al., 2013; Sariñana-González, Romero-Martínez & Moya-Albiol, 2016). Furthermore, we should underline that we found the lowest Csal and anxiety levels in participants who worked by themselves, indicating that the significant results are not attributable to the fact that the Lego construction task alone activates participants emotionally.

We hypothesized that participants who cooperated or competed and obtained a negative outcome would obtain the highest Csal levels (Costa & Salvador, 2012; de Andrés et al., 2011, Moya-Albiol et al., 2013; Salvador & Costa, 2009). In fact, we found that only participants who cooperated and obtained a negative outcome had higher mean Csal levels than those in participants working alone. Furthermore, we expected that participants who competed and obtained a negative outcome would present the highest anxiety levels (Costa & Salvador, 2012). However, what we found was that women who cooperated and obtained a negative outcome showed the highest anxiety levels. Hence, our study suggests that cooperation between strangers is the most stressful type of task, at least compared to competing or working alone to perform a task in a laboratory.

In line with this, previous studies have established that knowing background information about one's partner enables individuals to engage in cooperation and to benefit others. Among strangers, a lack of information regarding the reputation of others (based on their past actions) seems to limit cooperation, cooperative behavior being strengthened by providing information about partners' actions in the immediate past (Balliet, Wu, & De Dreu, 2014; Bolton, Katoka, & Ockenfelsb, 2005; De Dreu, 2012). Moreover, it has been hypothesized that stress-induced Csal elevations are inversely related to levels of interpersonal trust (Cesarini et al., 2008). That is, familiarity and trust are key drivers of social categorization, with familiar others being more likely to be categorized as in-group members (a group of people sharing similar interests and attitudes, producing feelings of solidarity, community, and exclusivity) than unfamiliar others, who could be categorized as out-group (people outside one's own group) (Mateo, 2004). Given this, future studies analyzing the hormonal correlates of social interactions should consider the variable familiarity and/or trust vs non-familiarity and/or absence of trust together with the rest of variables analyzed in our study.

Although our study makes a valuable contribution to understanding the psychobiological correlates of social interaction strategies, some limitations of the study should be taken into account in interpreting the results. Firstly, the main limitation of this study is that it is cross-sectional, so that individual differences may mask other effects evaluated at a single moment in life. Moreover, it is important to remark its marginal and exploratory nature, as in other recent work that has investigated the individual differences in the explanation of the relationship between competition/cooperation and cortisol (Wirth, Welsh & Schultheiss, 2006; Zilioli & Watson, 2013). Secondly, our data were derived from young and non-psychiatric populations and we have only analyzed two types of social interaction. In addition, future studies analyzing the type of psychobiological variables we have studied here should consider using two participants working in parallel, instead of a single participant working alone. Furthermore, we did not measure testosterone (T) and recent work suggests that levels of this hormone are involved in prosocial behavior such as cooperative tasks that are related to the pursuit of status (Reimers, & Diekhof, 2013; Eisenegger, Haushofer, Fehr, 2011; Liening and Josephs, 2010; Smeets-Janssen et al., 2015; van Honk et al., 2012). Moreover, HPA axis activity tends to show an inverse and reciprocal relationship with the hypothalamic-pituitary-gonadal axis and its end product, namely, T (Romero-Martínez & Moya-Albiol, 2016; Romero-Martínez, González-Bono, Lila & Moya-Albiol, 2013). Hence, future research should attempt to replicate our findings in a larger sample and including other variables such as levels of T, oxytocin, the hormone that promotes altruistic and cooperative behavior in humans (De Dreu, 2012), and other indicators of the autonomic nervous system, for example, heart rate and heart rate variability. This would provide a more comprehensive view of individuals' response to cooperation and competition. In addition, we should explore in more detail the role of variables that may have a moderating effect on cooperation, such as the outcome obtained, the satisfaction achieved, and the sex and age of participants. With regard to the last of these variables, to date, no studies have investigated whether age has an impact on cooperation, it being possible that level of maturity or training could influence responses.

The study of social interaction using psychophysiological markers may improve our understanding of emotional arousal, and it might be possible to extrapolate findings

to negotiation and conflict resolution situations. Furthermore, research in this field would help us understand more about physiological responses of the body to different types of social interaction, such as cooperation and competition, providing an opportunity to establish interaction strategies that would be physiologically desirable, in order to promote our long-term psychophysiological wellbeing.

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Capítulo 5

Estudio 4: Is low empathy a reason to refuse to cooperate with strangers?

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Introduction

Cooperation and competition are two somewhat different strategies for interpersonal social interaction that help us achieve both individual and shared aims and objectives.

A previous study analyzed how being forced to cooperate or compete without contemplates participants' preferences or skills between strangers in a face-to-face same-gender dyad affects their salivary cortisol (Csal) or stress response to a laboratory task. Moreover, during the tasks participants were not allowed to talk, they should communicate with facial expressions. This research demonstrated that cooperation could be more stressful (high salivary cortisol levels) than competition when is forced and consequently not free selected (Sariñana-González, P., Romero-Martínez, Á., & Moya-Albiol, in press). Nonetheless, it was not explored the role of empathy and cooperativeness in the relationship between these social interactions and Csal levels.

Success in strategic social interactions often necessitates an understanding of the underlying motives, feelings, and likely behaviors of one's opponent. The cognitive ability to spontaneously adopt another's viewpoint, to emotionally connect with others and experience concern is defined as empathy (Motomura et al., 2015; Moya-Albiol, 2014) Gilin, Maddux Carpenter & Galinsky, (2013) concluded that cognitive empathy promotes success at strategic competitive and cooperative situations tasks, while emotional empathy seems to facilitate coalition building, nevertheless, Csal response was unexplored. Evidence suggests, furthermore, that cooperative people care about others, and are unselfish and helpful. In fact, they naturally tend to cooperate instead of compete (Suchak et al., 2016; Proto & Rustichini, 2013).

Given this, we aimed to explore how empathy and cooperativeness could explain the differential Csal response to cooperation and competition in a laboratory context. Stress-induced Csal elevations are inversely related to levels of interpersonal trust (Cesarini, Johannesson, Lichtenstein, Sandewall, & Wallace, 2008), which is closely related to empathic and cooperative skills (Proto & Rustichini, 2013). For this, we expect to find that low empathy (cognitive and emotional) and cooperativeness were related to high Csal levels in a forced cooperation situation. Moreover, as participants during competition need a high level of understanding the tactical inclinations and

thoughts of others (Butler, 2014), we expect to find a negative relationship with empathy and Csal levels in competition group. Nonetheless, cooperative people tend to prefer the cooperation than competition as social interaction for solves problems (Suchak et al., 2016; Proto & Rustichini, 2013). For that, being forced to compete could be a stressful situation. Hence, cooperativeness would be associated positively associated with Csal levels in competition group.

Method

Participants

The final sample was composed of 115 healthy young adults (58 women and 57 men) from the University of Valencia. We selected those who did not smoke, take medication or have addictive habits (coffee, tea, drugs), or have chronic, endocrine and/or cardiovascular diseases. Participants mean age was 20.41±1.64 years, BMI was 23.35±3.31, most of them in lutheal phase (53 %) and the rest in follicular phase (33 %) or menstrual phase (14 %), and all of them with a high educational level. We advertised in the University of Valencia for healthy young adults, establishing contact by email before screening applicants in interviews.

Procedure

Those participants who were accepted in the study participated in an experimental session, which lasted for two hours and were held in the afternoon. During these sessions, participants did not eat or drink stimulants. Participants were divided into two experimental groups according to the type of task. Moreover, after the session finished participants received a set of questionnaires (to assess empathy and cooperativity) to complete at home.

The study was approved by the university's ethics committee and conducted following ethical principles for human research. All participants took part in the study voluntarily and signed an informed consent form before inclusion (see detailed

Sariñana-González, P., Romero-Martínez, Á., & Moya-Albiol, in press; Sariñana-González, Romero-Martínez, & Moya-Albiol, 2016).

Materials

Empathy assessment

The Spanish version of Empathy Quotient (EQ) consists of 60 items, with responses on a Likert scale from 0 (‘‘non-empathic’’ response) to 1 or 2 (depending on the strength of an empathic response), 40 of which relate to empathy while the remaining 20 are control items, which do not count towards the total score. A high score means a high degree of empathy (Baron-Cohen & Wheelwright, 2004).

Cooperativeness was assessed with the scale of the revised Spanish version of ‘temperament and character inventory’ (Gutiérrez-Zotes et al., 2004). It consists of 36 items rated on a Likert scale of 1 to 5. Final score obtained from the sum of the above and a high score means a high degree of cooperativeness.

Cortisol analysis

Saliva samples were collected with a Salivette system (cotton roll and two-part tube; Sastedt, Rommersdolf, Germany), immediately frozen at −20°C and stored at this temperature until thawed for use in radioimmunoassay analysis.

Radioimmunoassays were performed with a Coat-A-Count Kit (DPC-Siemens Medical Solutions Diagnostics, Bad Nauheim, Germany), which has a sensitivity of detection of cortisol levels as low as 1.4 nmol/l.

Data Analysis

To examine effects by task, and gender, univariate ANOVA with Bonferroni post-hoc tests was used to check for significant differences in anthropometric variables.

Furthermore, Chi-square statistics were calculated for the analysis of the frequencies of the demographic variables.

We estimated the magnitude of tasks responses in terms of Csal through the calculation of the area under the curve with respect to the ground (AUC), using the trapezoidal rule (Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003).

We used linear regression models to investigate whether the empathy and cooperativity predicted Csal baseline and Csal AUC in cooperative and competitive tasks. Subsequently, it was controlled ‘‘gender’’ and “menstrual cycle phase” effects in these relationships.

All statistical analyses were performed with IBM SPSS for Windows Version 22.0. Statistical significance was defined as p values < 0.05.

Results

There were no group differences in age, BMI, demographic variables, menstrual cycle phase, EQ adult and TCI-R cooperativeness scores. However, as expected, men had lower empathy (EQ) than women, $F(1, 171) = 10.99$, $p = .001$ $\eta p^2 = .07$.

In cooperation group, the EQ score predicted 7,8% of Csal baseline levels ($\beta = -.308$, $p < .05$) and 9,7 of AUCg ($\beta = -.336$, $p < .01$). Moreover, TCI-R cooperativeness predicted 5,1% of Csal baseline levels ($\beta = -.259$, $p < .05$) and 9,2% of AUCg ($\beta = -.328$, $p < .05$). After including as covariates “gender” and “phases of menstrual cycle” the EQ ($\beta = -.260$ and $\beta = -.341$, respectively) and TCI-R cooperativeness ($\beta = -.257$ and $\beta = -.328$, respectively) remain still significant ($p < .05$ for all).

In competition group, EQ score and TCI-R were unrelated with Csal levels and AUCg, even after including gender and phases of menstrual cycle as covariates.

Discussion

Our data demonstrated that being forced to cooperate among strangers, but not to compete, is stressful for those individuals with low empathy and cooperativeness. These

findings are consistent with earlier empirical research which found that high levels of empathy help individuals to cooperate (Rumble, Van Lange, & Parks, 2010). Apparently, in the cooperation task, the lack of the adequate socio-cognitive skills may be stressful due to the fact that communication between participants was limited to their facial expressions. For that, participants need an advanced empathic system to rapidly and automatically understand another's thought, and it facilitates successful interactions. Moreover, as the result in cooperation depends on the coalition building, the sense uncontrollability and social-evaluative threat could be higher than in competition, which result depends upon self.

As it was previously established cognitive empathy develops an important role in competitive situations (Gilin et al., 2013). However, our data did not reveal a significant effect of empathy on Csal response to the competitive task. Possible methodological reason for the finding is that the empathy questionnaire employed in our study does not differentiate between cognitive and emotional empathy, but the previous study employed a questionnaire which differentiate both types of empathy.

Although our study makes a valuable contribution to understanding the hormonal correlates of social interaction strategies, some limitations of the study should be taken into account in interpreting the results. Firstly, its cross-sectional and correlational nature makes difficult to establish causality in the results. Secondly, our data were derived from young and non-psychiatric populations.

Our research targeted that poor socio-cognitive skills may interfere in the coalition building and to difficulty trust among strangers. Moreover, research in this field would help us understand more about physiological responses to different types of social interaction, such as cooperation and competition. This, in turn, provides an opportunity to establish interaction strategies that would be physiologically desirable to promote long-term psychophysiological wellbeing.

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Capítulo 6

DISCUSIÓN GENERAL Y PRINCIPALES CONCLUSIONES

6.1. DISCUSIÓN GENERAL

A partir de los resultados de la presente **Tesis Doctoral se** podría concluir que el tipo de interacción social y las respuestas emocionales que le acompañan llevan asociados cambios psicobiológicos. En concreto, las situaciones cooperativas parecen resultar más activadoras del SNA y el SE que la competición o la realización de una tarea en la que no se produce ninguna interacción social.

En lo referente al **primer objetivo** de esta Tesis Doctoral, que trataba de *explorar los cambios cardiovasculares (FC y VC) y los sentimientos de ira en un grupo de jóvenes sanos en función del tipo de interacción social realizada (competición o cooperación) o realizar la tarea de laboratorio de forma individual.* Se observó una mayor FC y menor activación del sistema nervioso periférico (SNP) en los participantes que cooperaron en comparación con aquellos que compitieron o realizaron la tarea de laboratorio a solas sin ningún tipo de interacción social. Nuestros resultados apoyan parcialmente nuestra hipótesis inicial, puesto que esperábamos que la mayor activación cardiovascular se diese en las interacciones sociales (competición y cooperación) en comparación con la tarea sin interacción social, y no solo en la cooperación frente al resto de condiciones. Se ha hipotetizado que la cooperación entre extraños podría ser más estresante (como lo demuestran un mayor aumento de los niveles de cortisol) en comparación con la competición ante extraños/as o el trabajo individual. De esta perspectiva, la cooperación entre extraños podría considerarse una amenaza social de evaluación. Este último es un componente clave del estrés mental y un generador potente de emociones con connotación negativa que tienden a incrementar la FC (Eisenbarth, Chang & Wager, 2016; Thayer, Ahs, Fredrikson & Sollers, 2012; Wager et al., 2009). Por otro lado, estudios recientes han demostrado que un aumento en la sincronía de FC se ha asociado con la afiliación, la relación y una mejora en la dinámica de grupo mediante el fortalecimiento del apego social entre sus miembros (Mitkidis et al., 2015; Wiltermuth & Heath, 2009).

El primer objetivo de la presente tesis doctoral también pretendía analizar el papel desempeñado por el resultado obtenido en la interacción (positiva/negativa en el caso de la cooperación o victoria/pérdida en la competición) y el género de los participantes en la respuesta cardiovascular y de la ira. Hipotetizamos que los individuos (con independencia del género) que ganaran u obtuvieran un resultado positivo tendrían mayor activación cardiovascular y una disminución de los sentimientos de ira frente a los que perdieran u obtuvieran un resultado negativo. No obstante, nuestros resultados nos permitieron concluir que, solo los hombres que cooperaron y obtuvieron un resultado negativo mostraron una mayor activación cardiovascular (menor HF) que aquellos que realizaron la tarea de forma individual y obtuvieron dicho resultado. En contra de lo esperado, el resultado no pareció afectar a los sentimientos de ira, sino que el género fue la variable que pareció desempeñar un rol importante en relación con dichos sentimientos. De hecho, los hombres experimentaron mayores sentimientos de ira, específicamente los hombres que realizaron la tarea de forma individual.

Con respecto al **segundo objetivo**, se trataba de *analizar la respuesta electrodérmica y el estado de ánimo a los dos tipos de situaciones de interacción social (cooperación o competición) o a la tarea realizada de forma individual, en función del resultado obtenido y el género de los participantes.* De hecho, esperábamos hallar que aquellos participantes que compitieran o cooperaran (con independencia del género) y que ganaran u obtuvieran un resultado positivo presentarían mayor AED y una mejora del estado de ánimo en comparación con los que perdieran u obtuvieran un resultado negativo (Costa & Salvador, 2012; Moya-Albiol et al., 2013). En primer lugar, hallamos que con independencia del género de los/as participantes y del resultado obtenido, el tipo de interacción social que mayor activación electrodérmica provocó fue la cooperación. En relación con el género, los hombres que compitieron presentaron una menor AED que los hombres que cooperaron o realizaron la tarea simple. Además, en el caso de las mujeres, aquellas que cooperaron mostraron una AED menor que las mujeres que compitieron y que los hombres que cooperaron. Por último, cuando el resultado fue negativo los participantes presentaron un empeoramiento del estado de ánimo (con independencia del tipo de tarea), siendo este empeoramiento especialmente

acusado en el caso de las mujeres. Por todo ello, nuestros resultados apoyan parcialmente las hipótesis planteadas, ya que la cooperación fue el tipo de interacción social que mayor activación electrodérmica provocó. Además, la cooperación provoca una mayor activación electrodérmia en los hombres, mientras que competición lo hace en mujeres. Sin embargo, el resultado obtenido no pareció relacionarse con los cambios experimentados en la actividad electrodérmica, aunque sí que se relacionaron de la forma esperada con el estado de ánimo, puesto que el empeoramiento del estado de ánimo se produjo en los que perdieron u obtuvieron un resultado negativo.

La mayor activación emocional tras la cooperación puede deberse al hecho de que este tipo de interacción social requiere la colaboración con otros individuos, ya que no es un comportamiento individual y el resultado depende de la contribución de los dos individuos involucrados en la misma, a diferencia de la competición y de la tarea de control utilizada en este estudio, cuyos resultado dependen de uno/a mismo/a. A su vez, la cooperación se basa en una gama de características y habilidades que incluyen la confianza, el altruismo, el contagio emocional y la empatía. Estas habilidades, poco estudiadas desde un punto de vista psicobiológico, tienden a ser menos demandadas en las sociedades actuales, donde se apuesta por otros valores como la competición, la eficiencia, el egocentrismo y, en general, la ética del mercado y del consumismo. Nuestros resultados podrían estar indicando que el hecho de tener que cooperar con otro individuo para lograr una meta u objetivo, desencadena un proceso afectivo o emocional más fuerte.

El **tercer objetivo** consistía en *dilucidar qué tipo de interacción social (cooperativa o competitiva) es más estresante para los participantes (evaluado mediante los cambios en Csal y ansiedad estado), frente a una condición de control (realizar la tarea sin competir o cooperar).* Hipotetizamos que los participantes que compitieran o cooperaran y obtuvieran un resultado negativo tendrían mayores niveles de Csal y ansiedad que aquellos que obtuvieran un resultado positivo (Costa & Salvador, 2012; de Andrés-García et al., 2011; Moya-Albiol et al., 2013). Además, los hombres que cooperaran y obtuvieran un resultado positivo mostrarían menores niveles de Csal y ansiedad que las mujeres que cooperasen y obtuvieran un resultado negativo

(Moya-Albiol et al., 2013). Nuestros resultados apoyan parcialmente los estudios previos. De hecho, encontramos que únicamente los participantes que cooperaron y obtuvieron un resultado negativo tuvieron niveles de Csal más altos que los de los participantes que trabajaban de forma aislada. Además, las mujeres que cooperaron y obtuvieron un resultado negativo mostraron los niveles de ansiedad más altos. Por lo tanto, nuestro estudio sugiere que la cooperación entre extraños es el tipo de tarea más estresante, al menos en comparación con la competición o la tarea sin interacción social para realizar una tarea en un laboratorio. En consonancia con esto, estudios anteriores han establecido que el conocimiento de antecedentes sobre el socio permite a los individuos participar en la cooperación y en beneficio de los demás. Entre extraños, la falta de información sobre la reputación de los demás (basada en sus acciones pasadas) parece limitar la cooperación, reforzándose el comportamiento cooperativo al proporcionar información sobre las acciones de los socios en el pasado inmediato (Balliet, Wu & De Dreu, 2014; Bolton, Katoka & Ockenfelsb, 2005; De Dreu, 2012). Junto a ello, se ha planteado la hipótesis de que el aumento en los niveles de Csal inducidas por el estrés están inversamente relacionadas con los niveles de confianza interpersonal (Cesarini et al., 2008). Es decir, la familiaridad y la confianza son los principales impulsores de la categorización social, y los familiares son más propensos a ser categorizados como miembros del grupo (un grupo de personas que comparten intereses y actitudes similares, que producen sentimientos de solidaridad, comunidad y exclusividad), mientras que los desconocidos, podrían clasificarse como fuera del grupo (personas ajenas al propio grupo) (Mateo, 2004). Teniendo todo ello en cuenta, futuros estudios interesados en analizar los correlatos hormonales y psicofisiológicos de las interacciones sociales deberían considerar la familiaridad y/o confianza vs no familiaridad y/o ausencia de confianza junto con el resto de variables analizadas en la presente tesis doctoral.

En cuanto al **cuarto objetivo**, se trataba de *explorar cómo la empatía y la cooperación como rasgo podrían explicar la respuesta del Csal, en diadas de personas desconocidas forzadas a competir o cooperar en un contexto de laboratorio*. Nuestros datos demuestran que el hecho de ser forzado a cooperar con un extraño, pero no a competir con él/ella, es percibido como estresante para aquellos individuos con poca

empatía y cooperación rasgo. Estos resultados son consistentes con una investigación previa que demostró que los altos niveles de empatía ayudan a los individuos a cooperar (Rumble, Van Lange & Parks, 2010). La falta de las habilidades socio-cognitivas adecuadas en la tarea de cooperación puede ser estresante debido a que la comunicación entre los participantes se limita a sus expresiones faciales. Para ello, los participantes necesitan un avanzado sistema empático que les permita comprender rápida y automáticamente el pensamiento de otra persona, y que facilite las interacciones exitosas. Además, como el resultado de la cooperación depende de la construcción de la coalición, la sensación de incontrolabilidad y la amenaza social-evaluativa, que podrían ser mayores que en la competencia, cuyo resultado depende del yo. Tal y como se ha indicado la empatía cognitiva desarrolla un papel fundamental en las situaciones competitivas (Gilin, Maddux, Carpenter & Galinsky, 2013). Sin embargo, nuestros datos no revelaron un efecto significativo de la empatía en la respuesta Csal a la tarea competitiva. Por lo tanto, en caso de la competición entre individuos, al menos en este tipo de tarea, no parece tan necesario tener un sistema socio-cognitivo desarrollado, ya que no hace falta coordinarse con otra persona, proceso que reviste una alta complejidad. Una explicación alternativa a nuestros hallazgos podríamos basarla en el instrumento empleado para evaluar la empatía, ya que no distingue entre empatía cognitiva y emocional, mientras que en el estudio anteriormente comentado se utilizó un cuestionario que diferencia ambos componentes de la empatía.

Finalmente, podemos concluir que el contexto del laboratorio proporciona un modelo válido para analizar la competición y la cooperación en humanos, puesto que permite controlar el tipo de tarea y el resultado obtenido. Este enfoque minimiza los posibles efectos del estrés de una situación novedosa y de la deseabilidad social en el SNA y en la respuesta de ira (de Andrés et al., 2011; Moya-Albiol et al., 2013; Sariñana-González, Romero-Martínez & Moya-Albiol, 2016). Además, la tarea de construcción de casas de Lego© ha demostrado ser válida para provocar cambios psicobiológicos en los participantes, en concreto cambios en la activación del SNA, del SE y del estado de ánimo. Cabe destacar, además, que la tarea de construcción de casas Lego© ha sido validada en los estudios previos realizados por nuestro equipo de investigación, lo que refuerza la validez ecológica de nuestros hallazgos (de Andrés et al., 2011; Moya-Albiol et al., 2013). Por último, debemos subrayar que hallamos que los

niveles más bajos de activación psicobiológica se produjeron en los/as participantes que trabajaron de forma aislada (sin competir o cooperar), lo que indica que los resultados significativos no son atribuibles al hecho de que la tarea de construcción de Lego por si sola activa a los participantes emocionalmente. Asimismo, como sugieren Moya-Albiol y cols. (2013), la complejidad de la tarea requiere un alto nivel de participación, siendo necesario unir esfuerzos para desempeñarse bien en el caso de la tarea cooperativa.

Aunque la presente Tesis Doctoral hace una valiosa contribución a la comprensión de los correlatos psicobiológicos de las estrategias de interacción social, deben tenerse en cuenta algunas limitaciones a la hora de interpretar los resultados obtenidos. En primer lugar, debemos ser conscientes de la dificultad de comparar las condiciones experimentales de laboratorio con las condiciones reales que se producen en la vida cotidiana. Creemos que las primeras tienden a reducir los efectos potenciales de la tensión relacionada con una nueva situación y deseabilidad social en el SNA, el SE y las respuestas emocionales (Moya-Albiol et al., 2013; Thunholm, 2008). Sin embargo, el hecho de que la tarea haya sido validada en dos estudios previos fortalece, tal y como hemos enunciado previamente, la validez ecológica de nuestros hallazgos. Por otra parte, nuestros estudios son de naturaleza transversal y correlacional, lo que hace difícil establecer la causalidad en los resultados, de modo que las diferencias individuales pueden enmascarar otros efectos evaluados en un solo momento de la vida. Por otra parte, es importante remarcar su carácter marginal y exploratorio, como en otros trabajos recientes que han investigado las diferencias individuales en la explicación de la relación entre competición/cooperación y Csal (Wirth, Welsh & Schultheiss, 2006). Otra posible limitación de esta investigación es el hecho de que sólo se ha considerado una población normativa joven y únicamente se han analizado dos tipos de interacción social frente a realizar la tarea de forma individual. Aunque nuestro estudio hace una valiosa contribución a la comprensión de los correlatos hormonales de las estrategias de interacción social, algunas limitaciones del estudio deben tenerse en cuenta al interpretar los resultados. En primer lugar, su naturaleza transversal y correlacional hace difícil establecer la causalidad en los resultados. En segundo lugar, nuestros datos se derivaron de poblaciones jóvenes y no psiquiátricas.

Sería interesante incluir en futuros estudios otras poblaciones más o menos predispuestas a utilizar una de las estrategias de interacción social consideradas

(cooperación o competencia) en la vida cotidiana. Por ejemplo, la competición y la cooperación pueden servir como modelos de laboratorio para el análisis de los cambios psicobiológicos que ocurren durante las situaciones de confrontación y/o violentos y durante el altruismo y la empatía. Además, investigaciones futuras que analizan el tipo de variables psicobiológicas que hemos analizado podrían considerar el uso de dos participantes trabajando en paralelo, en lugar de un solo participante trabajando solo sin interacción social, al igual que incluir variables adicionales. A modo de ejemplo, indicar que no han medido los niveles de testosterona, mientras que estudios recientes sugieren que los niveles de esta hormona están involucrados en el comportamiento prosocial, tales como las tareas cooperativas que están relacionadas con la búsqueda del estatus (Eisenegger, Haushofer & Fehr, 2011; Liening & Josephs, 2010; Reimers & Diekhof, 2013; Smeets-Janssen et al., 2015; van Honk et al., 2012). Por otra parte, la actividad del eje HHA tiende a mostrar una relación inversa y recíproca con el eje hipotálamo-hipófisis-gonadal y su producto final, a saber, la T (Romero-Martínez, Lila, González-Bono & Moya-Albiol, 2013; Romero-Martínez & Moya-Albiol, 2016). Por lo tanto, la investigación futura debe intentar replicar nuestros hallazgos en una muestra más numerosa e incluir otras variables como los niveles de testosterona y de oxitocina, hormona que promueve el comportamiento altruista y cooperativo en seres humanos (Bos et al., 2013; De Dreu, 2012; Takahashi et al., 2005). Algunos estudios han comenzado a asociar la violencia y, en consecuencia, la competición con la actividad y las respuestas del sistema inmunológico (Romero-Martínez, Lila, Conchell, González-Bono & Moya-Albiol, 2014), por lo que podría contemplarse incluir algunas mediciones del mismo. Todo ello proporcionaría una visión más completa de la respuesta psicobiológica a la cooperación y a la competición. Además, debemos explorar con más detalle el papel de las variables que pueden tener un efecto moderador sobre la cooperación, como el resultado obtenido, la satisfacción alcanzada y el género y la edad de los participantes. Con respecto a la última de estas variables, hasta la fecha, ningún estudio ha investigado si la edad tiene un impacto en la cooperación, siendo posible que el nivel de madurez o de formación pueda influir en las respuestas.

Para concluir, el estudio de la interacción social utilizando marcadores psicobiológicos puede mejorar nuestra comprensión de la activación emocional, y podría ser posible extrapolar los hallazgos a otras situaciones en las que la negociación,

la mediación y las estrategias de cooperación son relevantes para tomar decisiones y/o resolver problemas. Nuestra investigación apuntó que las habilidades socio-cognitivas pobres pueden interferir en la construcción de la coalición y dificultar la confianza entre extraños. El resultado obtenido y el género de los participantes son importantes moderadores en las respuestas psicobiológicas a la cooperación. Además, la investigación en este campo nos ayudaría a comprender en mayor profundidad las respuestas psicobiológicas ante diferentes tipos de interacción social, tales como la cooperación y la competición, proporcionando una oportunidad para establecer estrategias de interacción que promoverían el bienestar psicobiológico a largo plazo.

6.2. PRINCIPALES CONCLUSIONES

A partir de los resultados de esta Tesis Doctoral, podemos concluir que:

1. La tarea diseñada y empleada en esta investigación ha mostrado ser válida para evaluar la respuesta psicobiológica (hormonal, electrodérmica y cardiovascular) a las interacciones sociales analizadas.

2. La cooperación en condiciones de laboratorio produce una mayor actividad cardiovascular y electrodérmica que la competición o la realización de esa misma tarea sin interacción social.

3. Dos factores moduladores significativos de la respuesta psicobiológica a las interacciones sociales son el resultado obtenido en la interacción social (positivo/negativo en el caso de la cooperación o victoria/pérdida en la competición) y el género de los participantes.

4. El fracaso en la cooperación conlleva un incremento de los niveles de Csal en ambos géneros y una alta activación cardiovascular y electrodérmica en el caso de los hombres.

5. La cooperación lleva asociada una mayor ansiedad y tensión emocional, siendo más notoria en las mujeres que fracasan como resultado de la misma.

6. La cooperación entre extraños resulta más estresante (mayores niveles de Csal) que la competición o la tarea de laboratorio sin interacción social para aquellos participantes menos empáticos y cooperativos.

7. La realización de más estudios de laboratorio que incluyen medidas psicobiológicas adicionales facilitaría la compresión de los mecanismos psicobiológicos que subyacen a las interacciones sociales.

8. Los resultados de esta tesis doctoral podrían extrapolarse a situaciones en las que la negociación, la mediación y las estrategias de cooperación son relevantes para la toma de decisiones y/o la resolución de problemas.

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Dear Dr. Sariñana-González,

After receiving your revised manuscript, we are happy to inform you that your manuscript has been accepted for publication and will soon be sent for production.

Thank you for submitting your work to *Journal of Psychophysiology*.

Kind regards,
Daniel S. Quintana, Ph.D.
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Cooperation Induces an Increase in Emotional Response, as Measured by Electrodermal Activity and Mood

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Cooperation Induces an Increase in Emotional Response, as Measured by Electrodermal Activity and Mood

Patricia Sariñana-González[1] · **Ángel Romero-Martínez**[1] · **Luis Moya-Albiol**[1]

Abstract Humans need social interaction with others for survival. Competition and cooperation are two somewhat opposed interpersonal strategies that help us to achieve both individual and shared aims and objectives. The aim of this research was to study whether autonomic activity is a good indicator of emotional activation in response to social interaction (cooperation, competition) or working alone, considering gender and outcome obtained in tasks (positive or negative) as moderating variables. We tested electrodermal activity (EDA) and mood before, during and after social (cooperation, competition) or working alone in men (64) and women (60), young-adult students from the University of Valencia. Higher EDA was observed in individuals taking part the cooperative than the competitive task. Further, men who competed showed lower SCLs than men who performed the other type of task. In contrast, women who cooperated demonstrated lower NSCRs than women who competed and men who cooperated. Participants with negative outcomes and women were found to have worse mood states. Our results may be generalizable to situations in which negotiation, mediation and cooperative strategies are relevant for decision making and/or problem solving.

Keywords Social interaction · Cooperation · Competition · Electrodermal activity (EDA) · Mood

Humans are social beings who need interaction with others for survival. A broad range of emotions and mood changes result from this social interaction, and these are essential for overcoming environmental challenges, as well as for facilitating adaptive coping strategies (Bos et al. 2013; Frijda 1988; Lazarus 1991). Competition and cooperation are two somewhat opposed strategies for interpersonal social interaction that help us to achieve both individual and shared aims and objectives. Competition is an adaptive social behaviour, which may be aggressive or defensive, and in which we seek to reach goals individually (biosocial model of status of Mazur 1985). By contrast, cooperation is a social behaviour that principally seeks to increase the probability of success in reaching common aims or objectives by collaborating with other members of a group (Kappeler and Van Schaik 2006; Melis and Semmann 2010). Regarding competition, there has been a considerable amount of psychobiological research, both in the context of physically demanding sports and in laboratory cognitive tasks, using reaction-time games, gambling, videogames and/or arithmetic tasks (Booth et al. 1989; Hasegawa et al. 2008; Oxford et al. 2010; Salvador and Costa 2009). In the case of cooperation, a type of social interaction that is widespread in all societies, most related research has taken a social approach, based on games involving ethical judgments or moral dilemmas, such as the prisoner's dilemma, ultimatum games and the effect of punishment (Burton-Chellew and West 2012; Velez et al. 2012), few studies having analysed cooperation from a psychobiological perspective.

Both types of social interaction provoke emotional responses. Concerning competition, most studies have found that participants with positive outcomes, winners, have a

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better mood after competition and greater internal attribution for the outcome, while the opposite is observed in losers, who have a worse mood and greater external attribution for the outcome, both in men and women (Costa and Salvador 2012; González-Bono et al. 1999; Ricarte et al. 2001). Exploring cooperation, Moya-Albiol et al. (2013) observed that outcome and gender had an effect on mood. Participants with positive outcomes in a cooperative situation were more satisfied with the outcome obtained and in a less negative mood state (tension and anger) after these social interactions, than those with negative outcomes. In addition, men with positive outcomes showed greater satisfaction than men or women with negative outcomes and lower negative mood (depression and anger) scores than men with negative outcomes. Using a similar task to promote social interaction with participants cooperating or competing, de Andrés-García et al. (2011) found that the results may be moderated by variables related to appraisal of the situation and outcomes obtained. Women who cooperated and obtained negative outcomes or who competed and obtained positive outcomes attributed their performance to internal factors. In contrast, those who cooperated and obtained positive outcomes or who competed and obtained negative outcomes attributed their performance to external factors.

Electrodermal activity (EDA) is the measure that has been most widely used as a marker of emotional arousal response in the autonomic nervous system (ANS). Sympathetic activity and electrodermal responses may be viewed as a component of emotional response (Kreibig 2010). EDA refers to variations in the electrical properties of the skin associated with sweat-gland activity. By applying a constant low voltage, changes in skin conductance can be measured non-invasively (Benedek and Kaernbach 2010; Fowles et al. 1981). Time series of skin conductance measurements can be characterized by a slowly varying tonic activity (called the skin conductance level, SCL) and a fast varying phasic activity (expressed as the number of nonspecific skin conductance responses, NSCRs, or skin conductance response) (Manning and Melchiori 1974; Roth et al. 2012; Sequeira et al. 2009). SCL can be defined as the baseline level of sympathetic nerve activity, while NSCRs are conceptualized as short-lasting changes elicited by a specific stimulus or the absence of a specific external stimulus. NSCRs are expressed as a rate per minute (usually between 1 and 3 responses while subjects are at rest and measured as a rapid change in SCL with an amplitude greater than or equal to 0.02 ls within a 1.0–3.0 s latency window) (Boucsein et al. 2012).

To date, only a few studies have considered EDA, reflecting psychophysiological response, as a marker of emotional response to various types of social interaction and/or stimuli, namely cooperation or competition (Bos et al. 2013; Finset et al. 2011). In the case of cooperation, we are aware of one previous study that has analysed EDA response under laboratory conditions. This study demonstrated that both SCL and NSCRs increased in a cooperative interaction, with a progressive increase after instructions and a significant drop when the task was finished. Moreover, gender was a moderating factor in EDA, with men having higher SCLs and NSCRs than women at all time points assessed, except baseline (Moya-Albiol et al. 2013). On the other hand, to our knowledge, no studies have yet analysed EDA during competition, or compared the electrodermal response to competition with that to cooperation, or to these two types of social interaction with that to non-social interaction (e.g., working on a task alone).

To address this gap in the literature, the primary objective of our research was to assess whether autonomic activity is a good indicator of emotional activation in response to different situations of social interaction (cooperation, competition or non-social interaction), considering gender and outcome (positive or negative) as moderating variables. For this purpose, we measured EDA as a psychophysiological indicator of the emotional response of participants to the task given. Considering the only study we have found in the literature on the role of EDA in cooperation, which reported that men presented higher EDA (NSCRs) than women (Moya-Albiol et al. 2013), we expected to find greater EDA in men than women in response to the cooperative task. Another objective of this study was to assess whether there were differences in variables related to appraisal of the situation and outcomes obtained (motivation, satisfaction with the outcome and locus of control), and in mood states assessed by self-reports of participants to the task given, as a function of gender, the type of social interaction (cooperating, competing or working alone), and outcome obtained in the task. In relation to these variables, previous studies have reported greater motivation and greater satisfaction with outcome and a more positive mood in those who cooperated and obtained positive outcomes (that is those who won or did well the task) than in those who cooperated and obtained negative outcomes (that is, lost or did less well in the task) (Moya-Albiol et al. 2013) and in those who competed and obtained positive rather than negative outcomes (Costa and Salvador 2012; Ricarte et al. 2001). Hence, we expected to find greater motivation and satisfaction with the outcome of the social interaction, as well as better mood, in participants who competed or cooperated and obtained positive outcomes than those who competed or cooperated and obtained negative outcomes. In addition, we expected to find greater internal attribution for the outcome in those who cooperated and obtained negative outcomes and in those who competed and obtained positive outcomes than in participants who cooperated with positive outcomes or competed with negative outcomes (de Andrés-García et al. 2011). Finally, taking into account the findings of previous research in this area in which gender was considered (Moya-Albiol et al. 2013), we expected to find that, when obtaining positive outcomes, men showed greater satisfaction with the outcome and a more positive mood than women.

Methods

Participants

We advertised in the University of Valencia for healthy young adults. In a preliminary session, all volunteers were given a general questionnaire about their habits and various aspects of their health. We selected young adults who did not smoke; did not take regular medication or have addictive habits (coffee, tea, drugs); and did not have chronic, endocrine and/or cardiovascular diseases. In order to control for potential effects of hormonal fluctuations (i.e., known effects on mood, physiological function, etc.), we excluded female volunteers who did not report at least a 3-month history of regular menstrual cycles lasting 21 to 35 days and/or were using oral contraceptives (Asso 1986; Gómez-Amor, Martínez-Selva, Román & Zamora, 1990; Gómez-Amor, Martínez-Selva, Román, Zamora & Sastre, 1990). The final sample was composed of 90 women and 74 men, all students from the university, between 18 and 25 years of age (= 20.40, SD = 1.59), with a body mass index (BMI) of 23.39 ± 3.42 kg/m^2. All participants except two (98.78 % of the sample) were predominantly right handed.

Sex-matched pairs of participants were randomly allocated to one of six experimental groups according to the type of task and the outcome obtained (positive or negative): cooperation with a positive outcome (Coop. +); cooperation with a negative outcome (Coop. -); competition with a positive outcome, i.e., winners (Comp. +); competition with a negative outcome, i.e., losers (Comp. -); working alone, hereon called the simple task, with a positive outcome (ST. +); and the simple task with a negative outcome (ST. -). Groups had similar distributions in age and socioeconomic factors. Table 1 shows the number of participants per group and summarises participant characteristics by task, outcome and gender.

The study was approved by the university's ethics committee and conducted following ethical principles for human research. All participants took part in the study voluntarily and signed an informed consent form before inclusion.

Procedure

After participants arrived at the laboratory, anthropometric and demographic data were collected from each person individually, and compliance with the instructions was checked. Further, they were asked about their activities during the 2 h before the session and the previous night, and about their menstrual cycle in the case of women. Second, each participant was conducted to the room where the recording phase took place and where, for the cooperative and competitive tasks, he/she met the other participant, an individual who was previously unfamiliar to him/her, minimising emotional interference in the laboratory task. This room was sound-attenuated, and temperature-controlled (21 ± 2 °C) and light levels were kept constant throughout all sessions. Experimental sessions lasted for 2 h and were held in the afternoon/evening between 16:00 and 20:00. During these sessions, participants did not eat or drink stimulants (such as coffee, tea or alcohol).

The experimental session began when participants had the electrodes to measure EDA attached. Adhesive collars were used to hold the electrodes in place on the phalanx of their non-dominant hand, because they needed their dominant hand to perform the task. This procedure has been employed in a lot of research with psychophysiological variables. In fact, participants are confident with their skills and do better the tasks if they work with their dominant hand instead of their non-dominant hand (Moya-Albiol et al. 2013; Romero-Martínez et al. 2013; Romero-Martínez et al. 2014). In cooperative and competitive tasks, two participants of the same gender (previously unknown to each other) were seated one in front of the other, maintaining visual contact. In the simple task, individual participants performed the task alone, as a control group. Firstly, participants were asked to remain relaxed and silent for 10 min. Physiological signals from the electrodes were recorded for the second half of this period (5 min) to obtain baseline values for SCL and NSCRs (rest period). Subsequently, for approximately 5 min, an experimenter of the same gender as the participants gave the task instructions (instruction period). After these instructions, the participants again stayed silent for 5 min (preparation period). Then, they carried out the cooperation, competition or simple task for 10 min (task period). Participants did not know how much time they had to complete the task. After this, two experimenters (one of each gender) assessed the performance of the task and assigned participants arbitrary and manipulated outcomes, these being positive/negative (in cooperation and simple tasks) and win/lose (in the competitive task). Because the participants never finished the task, it was possible to establish two groups that differed in performance (positive or negative); that is, outcome was a manipulated variable, in order that there would be parity in the number of participants in each group. Physiological signals continued to be recorded for another 10 min (recovery period), and experimenters evaluated performance appraisal, perceived stress, motivation for the task (cooperativeness or competitiveness), and internal and external attribution for the outcome. During the experimental session, data were continuously recorded and monitored out of sight of the participants. In addition, participants completed a mood questionnaire before and after task (pre- and post-task assessments), the post-task questionnaire being administered after the feedback on outcome.

Instructions for Tasks and Their Outcome The core task was to build a copy of a model house with Lego pieces (de Andrés-García et al. 2011; Moya-Albiol et al. 2013), and this

Table 1 Mean (SD) of descriptive characteristics, psychological traits profiles, and appraisal related to the task for the outcome interaction and gender

	Cooperation ($n = 62$)				Competition ($n = 52$)				Simple Task ($n = 50$)			
	Women ($n = 30$)		Men ($n = 32$)		Women ($n = 30$)		Men ($n = 22$)		Women ($n = 30$)		Men ($n = 20$)	
	Positive outcome ($n = 15$)	Negative outcome ($n = 15$)	Positive outcome ($n = 17$)	Negative outcome ($n = 15$)	Positive outcome ($n = 15$)	Negative outcome ($n = 15$)	Positive outcome ($n = 11$)	Negative outcome ($n = 11$)	Positive outcome ($n = 15$)	Negative outcome ($n = 15$)	Positive outcome ($n = 9$)	Negative outcome ($n = 11$)
Age (years)	20.20 ± .77	20.40 ± .91	20.65 ± 2.06	20.67 ± 2.26	20.33 ± .98	20.00 ± 1.19	20.45 ± 1.51	21.00 ± 2.37	20.87 ± 1.64	19.87 ± .83	19.44 ± 1.58	20.81 ± 2.18
BMI (kg/m^2)	23.19 ± 1.92	22.22 ± 2.88	24.87 ± 3.08	24.58 ± 4.02	21.67 ± 3.11	22.49 ± 3.80	23.46 ± 2.82	23.59 ± 3.60	22.55 ± 3.38	25.26 ± 4.48	23.21 ± 3.55	23.40 ± 2.72
Motivation on the task	7.87 ± 1.64	8.40 ± 1.30	8.00 ± 1.36	6.93 ± 2.31	5.70 ± 2.25	4.80 ± 1.70	5.36 ± 3.35	5.54 ± 2.25	-	-	-	-
Stress on the task	4.53 ± 2.13	5.80 ± 3.03	2.63 ± 1.65	3.47 ± 2.53	4.77 ± 2.58	4.53 ± 4.03	4.36 ± 2.58	3.00 ± 2.37	4.27 ± 2.05	4.47 ± 2.33	4.56 ± 2.79	4.82 ± 2.13
Satisfaction with the outcome	6.87 ± 2.47	2.73 ± 1.87	7.40 ± 1.96	4.67 ± 2.92	7.47 ± 2.07	3.33 ± 1.99	7.27 ± 1.79	4.82 ± 1.72	7.13 ± 1.46	3.13 ± 1.73	5.22 ± 2.11	3.09 ± 2.07
Internal locus of control	5.40 ± 1.00	6.33 ± 1.72	5.93 ± 1.55	5.17 ± 2.31	6.57 ± 1.68	5.67 ± 1.45	4.95 ± 1.62	6.23 ± 1.86	7.73 ± 1.39	5.63 ± 1.89	4.72 ± 1.75	4.14 ± 3.19
External locus of control	5.67 ± 1.40	5.00 ± 3.38	4.73 ± 2.16	5.50 ± 2.53	5.03 ± 2.17	5.27 ± 2.05	5.04 ± 1.62	3.77 ± 1.86	4.27 ± 1.53	4.37 ± 1.89	5.28 ± 1.75	5.86 ± 3.19

was the same in all the groups, the construction requiring the same visuospatial, psychomotor and cognitive skills. The difference between groups related to the type of instructions given. During the task period, participants were not allowed to talk. In the instructions, participants were forewarned that the evaluation criteria used by experimenters would be: the quality of the construction of the Lego or similarity to the model in all tasks, the errors in the placement of the pieces in the cooperation and simple tasks, and the theft of pieces in the competitive task.

> *Cooperative task*. In this version of the task, each participant had his/her own box, and overall the two boxes had sufficient Lego pieces to build the model. They had to take turns to place pieces, with only visual communication, and before they started, it was explained that cooperating with the partner would facilitate good performance in the task.
>
> *Competitive task*. In this version of the task, each participant had to build his/her own house, but they had a single common box with insufficient pieces for both of them to build a house like the Lego model. This forced them to compete to build their houses, prioritizing strategy and speed.
>
> *Simple Task*. In this version of the task, a single participant had to build a house, and he/she had a box with sufficient pieces to complete it.

In all the tasks, the pieces of Lego had to be placed one at a time, and participants were only allowed to take one piece each time they reached into the box, with his/her dominant hand.

Materials

Physiological signals Following the guidelines of the Society of Psychophysiological Research (Boucsein et al. 2012; Fowles et al. 1981), two Ag/AgCl electrodes (TSD203) with a 6-mm diameter contact area were used to measure SCLs and NSCRs. Hypoallergenic gel was used to improve the contact between the skin and electrodes. A skin conductance module (GSR100C) amplified the electrical signal with a constant voltage of less than 0.5 V.

The SC module was a part of a 16-channel physiological recording system (BIOPAC Systems, Inc., Santa Barbara, CA). Signals from this system were connected, through a Universal Interface Module (UIM100C), to a computer equipped with data acquisition hardware (MP150) and data storage software (AcqKnowledge 4.2 for Windows, Biopac Systems, Montreal, Canada).

Task and outcome appraisal scores The task and the results obtained were assessed with ad hoc questions rated on a 10-point scale. Participants were asked about their motivation for

the task ("On a scale from 0 (not at all) to 10 (highly), how motivated did you feel to complete the task?") and the stress it caused ("On a scale from 0 (no stress) to 10 (extreme stress), how much stress did you experience during the task?"). They also answered a series of questions related to satisfaction with the outcome ("On a scale from 0 (not at all) to 10 (highly), how satisfied are you with the outcome obtained in the task?") and to their attribution for the outcome (internal and external locus of control) ("On a scale from 0 (not at all) to 10 (highly), how dependent do you feel the outcome of the task was on you, your cognitive abilities and your intelligence?", and "On a scale of 0 (not at all) to 10 (highly), how dependent do you feel the outcome of the task was on external factors, the events that occurred during the session, and the type of task?").

Psychological state variable Mood was evaluated with the abbreviated version of the Profile of Mood States (POMS), translated into Spanish and culturally adapted by Fuentes et al. (1995). It is composed of 29 Likert items, with 5 response options, grouped into five subscales to describe the following factors: tension (6 items), depression (6 items), anger (6 items), vigour (6 items) and fatigue (5 items). Tension refers to heightened musculoskeletal tension and depression to a depressed mood accompanied by feelings of personal inadequacy, while cholera represents a mood of anger and antipathy towards others, vigour a state of positive arousal and high energy, and fatigue a mood of inertia and low energy. A total score was also obtained by summing scores on all but the vigour scale; the higher this total score, the worse the mood. The Cronbach's alpha of this instrument ranged from 0.70 to 0.80 for all the scales, which is considered to indicate good reliability.

Data analysis

After assessing the normality of the data using the Kolmogorov-Smirnov test ($p < .05$), non-normal data were $\log_{10}$ transformed (SCL and NSCRs). To examine group effects by task, outcome and gender, univariate ANOVA (3 X 2 X 2) with Bonferroni post-hoc tests was used to check for significant differences in anthropometric variables (age and BMI), appraisal scores (motivation for tasks, perceived stress, internal and external attribution, and satisfaction with task outcomes) and baseline SCL and NSCRs.

To analyse differences in SCL and NSCRs within groups between periods, repeated-measures ANOVA was performed using a general linear model (3 × 2 × 2 × 4), with period as the within-participant factor (at four levels: rest, preparation, task and recovery periods, the instruction period being included within the preparation period), and task (cooperation, competition and simple), outcome (negative and positive) and gender (women and men) as the between-participants factors. Greenhouse–Geisser corrections for degrees of freedom and Bonferroni corrections for multiple comparisons were applied where appropriate. Partial eta squared (η_p^2) is reported as a measure of effect size.

Magnitude of responses to tasks in terms of SCL was estimated by calculating the area under the curve with respect to the increase (AUCi) and ground (AUCg), using the trapezoidal rule (Hellhammer et al. 2007; Pruessner et al. 2003). Specifically, AUCi is calculated with reference to the baseline measurement, ignoring the distance from zero for all measurements, and hence emphasizes changes over time. On the other hand, AUCg is the total area under the curve of all measurements, assessing the distance of these measures from ground. To examine group effects by task, outcome and gender, in AUCi and AUCg were assessed with univariate ANOVA (3 X 2 X 2).

To analyse differences in mood within groups between time points (pre- and post-task), repeated-measures ANOVA was performed using a general linear model (3 × 2 × 2 × 2), with moment as the within-participant factor (at two levels: pre-task and post-task), and task (cooperation, competition and simple), outcome (negative and positive) and gender (women and men) as the between-participant factors. Again, Greenhouse–Geisser corrections for degrees of freedom and Bonferroni corrections for multiple comparisons were applied where appropriate, and partial eta squared (η_p^2) is reported as a measure of effect size.

All statistical analyses were performed with IBM SPSS for Windows Version 21.0. The alpha level was set at 0.05. Data are expressed as mean ± SD.

Results

Sample characteristics

No significant differences were found in anthropometric characteristics (age and BMI) by task, outcome, gender or interactions between them (see Table 1). Moreover, groups did not differ in perceived stress.

Electrodermal response

Role of task A significant effect of period on SCL and NSCRs was found in the total sample, $\varepsilon = .688$, $F(2.065, 313.909) = 62.797$, $p < .0001$, $\eta^2_{partial} = .292$; and $\varepsilon = .845$, $F(2.679, 404.563) = 81.287$, $p < .0001$, $\eta^2_{partial} = .350$, respectively. For SCL, post-hoc analysis identified a significant difference between the rest period and the others, with SCLs being lower while participants were resting ($p < .001$ in all cases). Regarding NSCRs, post-hoc analysis showed a significant difference in response between all periods ($p < .001$ in all cases), except the rest and recovery periods.

A main effect of task was found on SCL, F(2, 152) = 4.365, p = .014, $\eta^2_{partial}$ = .054, with SCLs being higher in the cooperative than competitive task group (p = .011).

Regarding NSCRs, the Period x Task interaction was significant, ε = .902, F(5.411, 378.784) = 6.637, p < .001, $\eta^2_{partial}$ = .087. In the post-hoc analysis, NSCRs were higher in the cooperative than simple task group during the preparation period (p = .048) Fig. 1.

The SCL AUCg varied by type of task, F(2, 152) = 4.340, p = .014, η2 partial =.055, being significantly higher in participants who took part in the cooperative task than the competitive task (p = .01) Fig. 2.

Role of outcome Analysing SCL and NSCRs as a function of outcome, significant Period x Outcome interactions were found, ε = .688, F(2.065, 313.909) = 4.238, p = .014, $\eta^2_{partial}$ = .027, and ε = .902, F(2.706, 378.784) = 3.301, p = .024, η2 partial =.023, respectively. In the post-hoc analysis, SCLs and NSCRs tended to be higher in the positive outcome groups during all periods, though the differences did not reach significance (p > .05 in all cases).

Role of gender Exploring SCL as a function of gender, we observed a significant Period x Gender interaction, ε = .688, F(2.065, 313.909) = 4.051, p = .017, $\eta^2_{partial}$ = .026, and also a Task x Gender interaction, F(2, 152) = 8.520, p < .0001, $\eta^2_{partial}$ = .101. In the post-hoc analysis, SCL tended to be higher in the women during all periods, though the differences did not reach significance (p > .05 in all cases). Moreover, post-hoc analysis showed lower SCLs in men in the competitive group than other men (cooperative and simple task groups; p = .000 and p = .004, respectively).

Regarding NSCRs, there was a significant Period x Gender interaction, ε = .902, F(2.706, 378.784) = 4.799, p = .004, $\eta^2_{partial}$ = .033, and also a Task x Gender interaction, F(2, 140) = 4.088, p = .019, $\eta^2_{partial}$ = .055. Post-hoc analysis showed lower NSCRs in cooperative group women in the rest and recovery periods than competitive group women and cooperative group men only in the recovery period, and in women in the simple task group than cooperative group men during the task (p < .05 in all cases).

Considering the SCL AUCg, the Gender and Task interaction proved to be significant, F(2, 152) = 8449, p < .0001, η^2 partial =.100. Post-hoc analysis showed a lower SCL AUCg in men given the competitive task than other men (cooperative and simple task groups) (p = .000 and p = .004, respectively).

Appraisal scores

Regarding appraisal scores, significant effects were found for motivation, satisfaction with outcome and attribution of outcome (internal locus of control).

Role of task Level of motivation varied by type of task, F(1, 104) = 39.430, p = .000, η2 partial =.275, being significantly higher in participants who cooperated than those who competed (p = .000).

Moreover, for satisfaction with outcome Task was significant, F(2, 150) = 3.856, p = .023, η2 partial =.049 (see Table 1). Post-hoc analysis showed satisfaction with outcome was higher in the competitive group than the simple task group (p = .023).

Role of outcome First, for satisfaction with outcome, Outcome was significant, F(1, 150) = 116.789, p = .000, η2 partial =.438. Post-hoc analysis showed satisfaction with outcome was higher in participants with positive outcomes than those with negative outcomes (p = .000).

Role of gender Regarding satisfaction with outcome, Task x Gender and Outcome x Gender interactions were significant, F(2, 150) = 4.296, p = .015, η2 partial =.054 and F(1, 150) = 4.469, p = .036, η2 partial =.029, respectively (see Table 1). Simple task group men showed lower satisfaction than cooperative and competitive group men (p = .004 and p = .007, respectively). Lastly, satisfaction with outcome was lower in women with negative outcomes than men with negative outcomes (p = .030).

Moreover, for internal locus of control, Gender, and Task x Gender and Task x Outcome x Gender interactions were significant, F(1, 150) = 12.996, p = .000, η2 partial =.080, F(2, 150) = 4.440, p = .013, η2 partial =.056, and F(2, 150) = 6.967, p = .001, η2 partial =.085, respectively (see Table 1). In the post-hoc analysis, women showed higher internal locus of control than men in the simple task group (p = .000). Moreover, in this task, women obtained higher internal locus of control scores both comparing women and men with positive outcomes and women and men with negative outcomes (p = .000 and p = .037, respectively). Further, cooperative group women with negative outcomes obtained higher internal locus of control scores than cooperative group men with positive outcomes (p = .018), and competitive group women with positive outcomes obtained higher internal locus of control scores than competitive group men with negative outcomes (p = .025).

Mood responses

Role of task Regarding mood, we found significant Time Point x Task interactions in tension, anger and total scores, ε = 1, F(2, 151) = 7.076, p = .001, $\eta^2_{partial}$ = .086, ε = 1, F(2, 151) = 4.540, p = .012, $\eta^2_{partial}$ = .057, and ε = 1, F(2, 151) = 3.545, p = .031, $\eta^2_{partial}$ = .045, respectively. Post-hoc analysis showed lower pre-task tension scores in the simple task group than cooperative and competitive groups (p = .026 and p = .038, respectively), while differences in

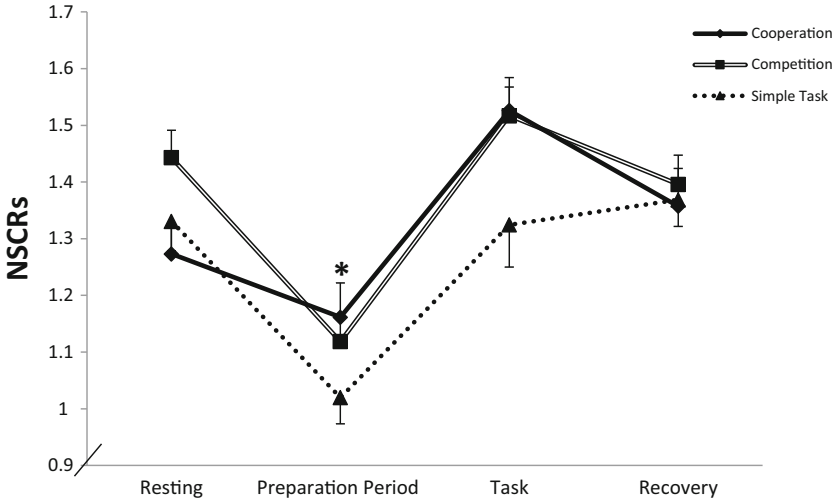

Fig. 1 NSRCS levels in participants for cooperative, competitive or simple task (M ± SEM). * $p < .05$

anger and total scores did not reach significance ($p > .05$ in all cases). However, the simple task group showed higher anger than cooperative and competitive groups in the post-task assessment, and also showed higher total scores than cooperative and competitive groups pre-task.

Role of outcome Significant Time Point x Outcome interactions were found in depression, vigour and total scores, $\varepsilon = 1$, $F(1, 151) = 10.443$, $p = .002$, $\eta 2$ partial $=.065$, $\varepsilon = 1$, $F(1, 151) = 6.788$, $p = .01$, $\eta 2$ partial $=.043$, and $\varepsilon = 1$, $F(1, 151) = 8.026$, $p = .005$, $\eta^2_{\text{partial}} = .050$, respectively. Moreover, significant Time Point x Task x Outcome interactions were observed in depression, $\varepsilon = 1$, $F(2, 151) = 5.142$, $p = .007$, $\eta 2$ partial $=.064$. Post-hoc analyses showed that participants with positive outcomes had significantly higher pre-task depression scores than those with negative outcomes ($p = .028$); notably, this pattern was observed even in the simple task group ($p = .007$). Further, post-hoc analyses showed that participants with positive outcomes had significantly higher post-task vigour scores than those with negative outcomes ($p = .021$), but the differences in total scores did not reach significance ($p > .05$).

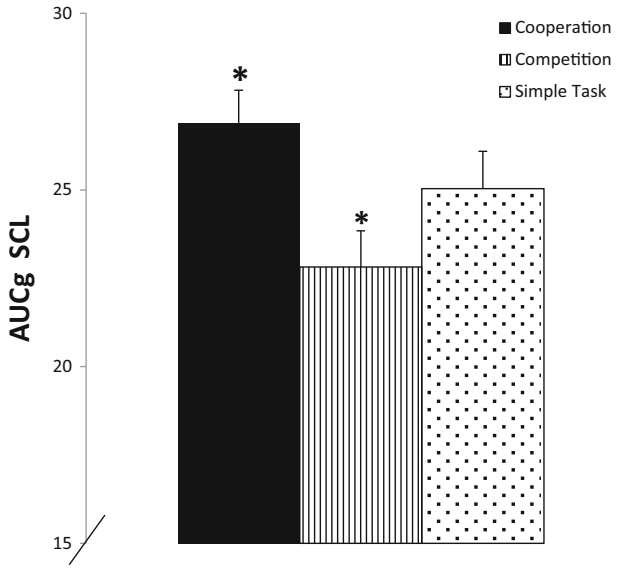

Fig. 2 AUCg SCL levels in groups (cooperation, competition and simple task) (M ± SEM). * $p < .05$

Role of gender A significant Time Point x Gender interaction was found in depression scores, $\varepsilon = 1$, $F(1, 151) = 3.906$, $p = .05$, $\eta^2_{\text{partial}} = .025$. Further, significant Time Point x Task x Gender interactions were found in anger scores, $\varepsilon = 1$, $F(2, 151) = 4.956$, $p = .008$, $\eta 2$ partial $=.062$.

Post-hoc analyses showed that simple task group men had significantly higher post-task anger scores than simple task group women ($p = .021$), but the differences in depression scores for Time Point x Gender did not reach significance ($p > .05$ in all cases).

Discussion

The main objective of this study was to assess how the type of social interactions individuals are involved in affect them emotionally. We found that cooperation results in higher SCL and AUCg for this parameter than competition. This effect is moderated by gender, men who competed having SCLs and AUCg that were lower than men who cooperated or performed the simple task. Women who cooperated had lower NSCRs than women who competed and men who cooperated in rest and recovery periods, and women in the simple task had lower NSCRs than cooperative group men during the task. In addition, participants who cooperated showed the highest levels of motivation for the task. Satisfaction with outcome was higher in the competitive group than the simple task group, in participants with positive outcomes than those with negative outcomes, in men with

negative outcomes than women with negative outcomes, and in cooperative and competitive group men than simple task group men. Internal locus of control was higher in women than men in the simple task group, in cooperative group women with negative outcomes than cooperative group men with positive outcomes, in competitive group women with positive outcomes than competitive group men with negative outcomes, and in simple task group women with negative or positive outcomes than simple task group men with negative or positive outcomes. Finally, participants with positive outcomes showed higher post-task vigour scores than those with negative outcomes, and, simple task group men showed higher anger scores than simple task group women.

Recalling that the primary objective of this study was to assess whether there are differences in emotionality as a function of social interaction strategy (cooperation, competition or working alone), we consider that our findings help to answer this question. As we have previously mentioned, there are few data available from previous studies on the effect of cooperation and competition on EDA with which to compare our results. Nevertheless, we can state that our findings are in line with previous research in this field in terms of the activating effect of cooperative behaviour on the emotionality of individuals (Moya-Albiol et al. 2013), specifically, we demonstrated that those men who cooperated had higher NSCRs than women who cooperated. Moreover, we also found that cooperation has an activating effect on emotionality, higher EDA being observed in those cooperating than in those competing at all time points at which SCL was measured and in the SCL AUCg. This effect may be due to the fact that cooperation requires collaboration with other individuals, as it is not an individual behaviour, unlike competition, the antithesis of cooperation, and the control task used in this study (working alone). In turn, cooperation relies on range of characteristics and skills including trust, altruism, emotional contagion, and empathy. These skills, which have been little studied to date from a psychobiological point of view, tend to be in less demand in our current society, greater emphasis being placed on other values such as competitiveness, efficiency, egocentricity, patriarchal masculinity, and in general, the ethics of the market and of consumerism. This could mean that the fact of having to cooperate with another individual to achieve a goal/target triggers a stronger affective or emotional process. However, while previous studies found that outcome had an effect in the case of the cooperative task (de Andrés-García et al. 2011; Moya-Albiol et al. 2013), our results are only consistent with a role of outcome on SCL, there being a non-significantly lower SCL in participants with negative outcomes, and this was also observed in the other tasks.

With regard to psychological variables related to social interaction, we also found differential effects as a function of the type of task. First, we found greater motivation in participants performing the cooperative task. This finding is similar to that of the aforementioned study by de Andrés-García et al. (2011), in which, as in our study, it was found that participants behaving in a cooperative way had higher scores in motivation than those competing. On the other hand, in our study we did not find that the motivation for the task was influenced by gender or by outcome of the task. Another psychological variable with a potential impact on social interaction is satisfaction with outcomes obtained. We observed greater satisfaction when the outcome was positive for the participant, regardless of the type of social interaction used, in contrast to the findings of Moya-Albiol et al. (2013), who found that cooperating men with positive outcomes had the highest levels of satisfaction with the outcome. In addition, besides satisfaction, the locus of control over the task is also important, women tending to show internal attribution for positive outcomes. This reinforces the idea that research should be broadened to explore whether differences in the perception of and satisfaction with outcomes obtained are attributable to the task, the outcome itself or the gender of participants.

With regard to the limitations of our study, first, we must be aware of the difficulty of comparing results obtained under experimental conditions with what happens under natural conditions. We believe that the former tend to reduce the potential effects of tension related to a new situation and social desirability on the ANS and mood responses (Thunholm 2008; Moya-Albiol et al. 2013). However, the fact that the task has been validated in two previous studies strengthens the ecological validity of our findings. Moreover, we should underline that we found lower tension scores in individuals who performed the simple task, this confirming the fact that the significant results have not been due to the fact that the Lego construction task alone activates participants emotionally. Further, as suggested by Moya-Albiol et al. (2013), the complexity of the task calls for a high level of participation, it being necessary to join efforts to perform well in the case of the cooperative task. Moreover, it would preferable to counterbalance the administration of appraisal variables, in order to avoid confounding effects. Finally, a potential limitation of this research is the fact that we have only considered a normative population, and in future research, it would be interesting to include other populations that are more or less predisposed to using one of the social interaction strategies considered (cooperation or competition) in daily life. For example, competition and cooperation may serve as laboratory models for analysing psychobiological changes that occur during, on the one hand, confrontational and/or violent situations, and on the other, altruism and empathy.

Given the findings to date, there is a need for further research in human cooperation including the assessment of other psychobiological parameters, for example, levels of oxytocin, the hormone that promotes altruistic and cooperative behaviour in humans (De Dreu et al. 2010), or other indicators of the ANS, such as the heart rate, heart rate variability or even

parameters related to the immune system. This would provide a more comprehensive view of the response to cooperation. In addition, we should explore in more detail the role of variables that may have a moderating effect on cooperation, such as the outcome obtained, the satisfaction achieved, and the gender and age of participants. With regard to the last of these variables, to date, no studies have investigated whether age has an impact on cooperation, it being possible that level of maturity or training could influence responses.

The study of social interaction using psychophysiological markers may improve our understanding of emotional arousal, and it might be possible to extrapolate findings to negotiation and conflict resolution situations. Furthermore, research in this field would help us understand more about physiological responses of the body to different types of social interactions, such as cooperation and competition, providing an opportunity to establish interaction strategies that would be physiologically desirable, in order to promote our long-term psychophysiological wellbeing.

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CERTIFIES THAT:

The article titled ¨ ***Does being a stranger make it difficult to cooperate?***¨ by the authors **Patricia Sariñana-González, Ángel Romero-Martínez, and Luis Moya-Albiol** has been accepted for publication in our journal.

In witness whereof, I hereby sign and issue this certificate in Madrid on May 29, 2017.

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Is Low Empathy a Reason to Refuse to Cooperate with Strangers?

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Abstract

A previous study analyzed how being forced to cooperate or compete without contemplates participants' preferences or skills between strangers in a face-to-face same-gender dyad affects their salivary cortisol (Csal) or stress response to a laboratory task. Moreover, during the tasks participants were not allowed to talk, they should communicate with facial expressions. This research demonstrated that cooperation is more stressful (high salivary cortisol levels) than competition. Nevertheless, it was not explored how empathy and cooperativeness explain participants' Csal response. Hence, this study aims to analyze how these socio-cognitive variables predict Csal response to a cooperative and a competitive task. Participants were 115 healthy young adults (mean age of 20 years, 51% females). Csal was measured in 5-point times (before and after the task). The results point out that being forced to cooperate with strangers was stressful for those individuals with low empathy and cooperativeness. Our research targeted that poor socio-cognitive skills may interfere in the coalition building and difficulty trust among strangers.

Keywords

Competition, Cooperation, Empathy, Salivary Cortisol, Stress

1. Introduction

Cooperation and competition are two somewhat different strategies for interpersonal social interaction that help us achieve both individual and shared aims and objectives.

A previous study analyzed how being forced to cooperate or compete without contemplates participants' preferences or skills between strangers in a face-to-face same-gender dyad affects their salivary cortisol (Csal) or stress response to a laboratory task. Moreover, during the tasks participants were not allowed to talk, they should communicate with facial expressions. This research demonstrated that cooperation could be more stressful (high salivary cortisol levels) than competition when is forced and consequently not free selected [1]. Nonetheless, it was not explored the role of empathy and cooperativeness in the relationship between these social interactions and Csal levels.

Success in strategic social interactions often necessitates an understanding of the underlying motives, feelings, and likely behaviors of one's opponent. The cognitive ability to spontaneously adopt another's viewpoint, to emotionally connect with others and experience concern is defined as empathy [2-3]. Gilin, Maddux Carpenter & Galinsky, [4] concluded that cognitive empathy promotes success at strategic competitive and cooperative situations tasks, while emotional empathy seems to facilitate coalition building, nevertheless, Csal response was unexplored. Evidence suggests, furthermore, that cooperative people care about others, and are unselfish and helpful. In fact, they naturally tend to cooperate instead of compete [5-6].

Given this, we aimed to explore how empathy and cooperativeness could explain the differential Csal response to cooperation and competition in a laboratory context. Stress-induced Csal elevations are inversely related to levels of interpersonal trust [7], which is closely related to empathic and cooperative skills [6]. For this, we expect to find that low empathy (cognitive and emotional) and cooperativeness were

related to high Csal levels in a forced cooperation situation. Moreover, as participants during competition need a high level of understanding the tactical inclinations and thoughts of others [8], we expect to find a negative relationship with empathy and Csal levels in competition group. Nonetheless, cooperative people tend to prefer the cooperation than competition as social interaction for solves problems [5-6]. For that, being forced to compete could be a stressful situation. Hence, cooperativeness would be associated positively associated with Csal levels in competition group.

2. Methods

2.1. Participants

The final sample was composed of 115 healthy young adults (58 women and 57 men) from the University of Valencia. We selected those who did not smoke, take medication or have addictive habits (coffee, tea, drugs), or have chronic, endocrine and/or cardiovascular diseases. Participants mean age was 20.41±1.64 years, BMI was 23.35±3.31, most of them in lutheal phase (53%) and the rest in follicular phase (33%) or menstrual phase (14%), and all of them with a high educational level. We advertised in the University of Valencia for healthy young adults, establishing contact by email before screening applicants in interviews.

2.2. Procedure

Those participants who were accepted in the study participated in an experimental session, which lasted for two hours and were held in the afternoon. During these sessions, participants did not eat or drink stimulants. Participants were divided into two experimental groups according to the type of task. Moreover, after the session finished participants received a set of questionnaires (to assess empathy and cooperativity) to complete at home.

The study was approved by the university's ethics committee and conducted following ethical principles for human research. All participants took part in the study voluntarily and signed an informed consent form before inclusion [see detailed 1, 9].

2.3. Materials

Empathy assessment

The Spanish version of Empathy Quotient (EQ) consists of 60 items, with responses on a Likert scale from 0 (''non-empathic'' response) to 1 or 2 (depending on the strength of an empathic response), 40 of which relate to empathy while the remaining 20 are control items, which do not count towards the total score. A high score means a high degree of empathy [10].

Cooperativeness was assessed with the scale of the revised Spanish version of 'temperament and character inventory' [11]. It consists of 36 items rated on a Likert scale of 1 to 5. Final score obtained from the sum of the above and a high score means a high degree of cooperativeness.

Cortisol analysis

Saliva samples were collected with a Salivette system (cotton roll and two-part tube; Sastedt, Rommersdolf, Germany), immediately frozen at −20°C and stored at this temperature until thawed for use in radioimmunoassay analysis.

Radioimmunoassays were performed with a Coat-A-Count Kit (DPC-Siemens Medical Solutions Diagnostics, Bad Nauheim, Germany), which has a sensitivity of detection of cortisol levels as low as 1.4 nmol/l.

2.4. Data Analysis

To examine effects by task, and gender, univariate ANOVA with Bonferroni post-hoc tests was used to check for significant differences in anthropometric variables. Furthermore, Chi-square statistics were calculated for the analysis of the frequencies of the demographic variables.

We estimated the magnitude of tasks responses in terms of Csal through the calculation of the area under the curve with respect to the ground (AUC), using the trapezoidal rule [12].

We used linear regression models to investigate whether the empathy and cooperativity predicted Csal baseline and Csal AUC in cooperative and competitive tasks. Subsequently, it was controlled ''gender'' and "menstrual cycle phase" effects in these relationships.

All statistical analyses were performed with IBM SPSS for Windows Version 22.0. Statistical significance was defined as p values < 0.05.

3. Results

There were no group differences in age, BMI, demographic variables, menstrual cycle phase, EQ adult and TCI-R cooperativeness scores. However, as expected, men had lower empathy (EQ) than women, $F(1, 171) = 10.99$, $p = .001$ $\eta p^2 = .07$.

In cooperation group, the EQ score predicted 7,8% of Csal baseline levels ($\beta = -.308$, $p < .05$) and 9,7 of AUCg ($\beta = -.336$, $p < .01$). Moreover, TCI-R cooperativeness predicted 5,1% of Csal baseline levels ($\beta = -.259$, $p < .05$) and 9,2% of AUCg ($\beta = -.328$, $p < .05$). After including as covariates "gender" and "phases of menstrual cycle" the EQ ($\beta = -.260$ and $\beta = -.341$, respectively) and TCI-R cooperativeness ($\beta = -.257$ and $\beta = -.328$, respectively) remain still significant ($p < .05$ for all).

In competition group, EQ score and TCI-R were unrelated with Csal levels and AUCg, even after including gender and phases of menstrual cycle as covariates.

4. Discussion

Our data demonstrated that being forced to cooperate among strangers, but not to compete, is stressful for those individuals with low empathy and cooperativeness. These findings are consistent with earlier empirical research which found that high levels of empathy help individuals to cooperate [13]. Apparently, in the cooperation task, the lack of the adequate socio-cognitive skills may be stressful due to

the fact that communication between participants was limited to their facial expressions. For that, participants need an advanced empathic system to rapidly and automatically understand another's thought, and it facilitates successful interactions. Moreover, as the result in cooperation depends on the coalition building, the sense uncontrollability and social-evaluative threat could be higher than in competition, which result depends upon self.

As it was previously established cognitive empathy develops an important role in competitive situations [4]. However, our data did not reveal a significant effect of empathy on Csal response to the competitive task. Possible methodological reason for the finding is that the empathy questionnaire employed in our study does not differentiate between cognitive and emotional empathy, but the previous study employed a questionnaire which differentiate both types of empathy.

Although our study makes a valuable contribution to understanding the hormonal correlates of social interaction strategies, some limitations of the study should be taken into account in interpreting the results. Firstly, its cross-sectional and correlational nature makes difficult to establish causality in the results. Secondly, our data were derived from young and non-psychiatric populations.

Our research targeted that poor socio-cognitive skills may interfere in the coalition building and to difficulty trust among strangers. Moreover, research in this field would help us understand more about physiological responses to different types of social interaction, such as cooperation and competition. This, in turn, provides an opportunity to establish interaction strategies that would be physiologically desirable to promote long-term psychophysiological wellbeing.

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Disclosure Statement

The author(s) declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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