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Ansiedad Social y Sesgo de Interpretación de Expresiones Faciales

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RESUMEN

La ansiedad social se define como un miedo persistente y excesivo a ser evaluado negativamente por otras personas, y la consiguiente evitación de las situaciones que implican ser objeto de observación y examen público. En el presente estudio investigamos si la ansiedad social (a) conlleva una facilitación en el reconocimiento de las expresiones faciales negativas desde niveles de baja intensidad, (b) si facilita la detección de expresiones en los ojos no congruentes con una sonrisa en la boca, (c) los umbrales en la percepción de desconfianza para las distintas expresiones, y (d) los patrones de atención selectiva (*dónde*, *cuándo*, y *cuánto* se mira) a las caras cuando se hacen juicios de confianza sobre otras personas. Llevamos a cabo seis experimentos en los que empleamos como estímulos caras con expresiones emocionales en movimiento, lo cual constituye una novedad significativa respecto a las habituales fotografías. Cada experimento fue precedido de una fase previa de selección de los sujetos participantes mediante instrumentos de autoinforme para medir la ansiedad social. En las tareas experimentales los sujetos categorizaban las expresiones o juzgaban en qué medida las personas parecían confiables. En dos experimentos se registraron los movimientos oculares sobre las distintas regiones de las caras durante las tareas. Los resultados indicaron que las personas con elevada ansiedad social se distinguen por una elevada sensibilidad en la percepción de enfado y asco desde niveles bajos de intensidad expresiva, así como por un incremento exagerado de la desconfianza hacia caras con estas expresiones y hacia las caras con una sonrisa en la boca pero ojos no alegres (neutros, miedo, etc.). Además, esta tendencia de las personas con ansiedad social a desconfiar de quienes muestran una sonrisa ambigua (no congruente con la expresión de los ojos) está asociada a un patrón oculomotor específico: miran selectivamente, de modo temprano y más tiempo a la región de los ojos, lo cual les facilita la detección de incongruencias expresivas. En cambio, las personas con ansiedad social baja miran selectivamente a la boca sonriente. Concluimos que la ansiedad social se caracteriza cognitivamente por un sesgo interpretativo (percepción de desconfianza) ligado a un sesgo atencional (mirada selectiva). Estos sesgos son, en realidad, adaptativos en cuanto facilitan la detección de sonrisas falsas que podrían indicar una evaluación negativa (burla, arrogancia, etc.) y de expresiones de enfado y asco (hostilidad, desprecio, etc.). Este beneficio ocurre sin aparente coste, dado que los juicios de confianza hacia las caras con sonrisa genuina (congruente con ojos alegres) no se ven afectados y tampoco el correcto reconocimiento de otras expresiones (sorpresa, miedo o tristeza).

1. INTRODUCCIÓN GENERAL

De acuerdo con el Reglamento de Enseñanzas Oficiales de Doctorado de la Universidad de La Laguna sobre la Modalidad de Tesis Doctoral por Compendio de Publicaciones (Artículo 29, epígrafe a; BOULL Año II núm. 14, 28 de julio de 2017), la presentación de una tesis bajo esta modalidad:

> *(a) Debe incluir una introducción general en la que se presenten los trabajos y se justifique la unidad temática, así como un resumen global de los objetivos de la investigación, de la metodología aplicada, de los resultados obtenidos, de la discusión de estos resultados y de las conclusiones finales.*

Los cinco trabajos (cuatro publicados y uno enviado para publicación) se ajustan al proyecto aprobado en su día por la Comisión Académica del Doctorado de Psicología de la Universidad de La Laguna, incluyendo los cuatro objetivos y los seis experimentos propuestos. Todos los trabajos realizados conforman una unidad temática integrada sobre la investigación del procesamiento de expresiones faciales emocionales por parte de las personas con ansiedad social en comparación con personas que no presentan dicha sintomatología. Esencialmente, la investigación realizada versa sobre la existencia de un sesgo de interpretación (medido en términos de juicios de des/confianza) y su posible dependencia de un sesgo previo de atención selectiva (a qué regiones de la cara se mira durante los juicios de confianza, cuándo y cuánto), como procesos cognitivos que caracterizan a la ansiedad social.

A continuación, dentro de este primer apartado (1. Introducción General) especificamos de forma sucinta los distintos aspectos que configuran la unidad temática de los trabajos, de acuerdo con la secuenciación de los objetivos (con independencia del momento de la publicación de los estudios). Seguidamente (apartado 2. Resumen de la Investigación), presentaremos más extensamente la documentación sobre la investigación previa relevante al tema que nos ocupa, junto con los avances que el presente estudio aporta. Para ello, definimos y enmarcamos el objeto y el problema de estudio (sección 2.1), integramos los objetivos con los antecedentes, y desarrollamos las hipótesis y predicciones (sección 2.2). Una información más detallada de estos aspectos puede encontrarse en los

trabajos presentados en la sección posterior de ANEXOS, donde incluimos la copia completa de los trabajos.

El primer trabajo presentado (Gutiérrez-García y Calvo, 2017) aborda el primer objetivo propuesto: La *sensibilidad en el reconocimiento de expresiones emocionales negativas desde niveles bajos de intensidad*. El segundo trabajo (Gutiérrez-García y Calvo, 2016a) emprende el segundo objetivo propuesto: El *incremento de la desconfianza hacia otras personas cuando muestran expresiones emocionales negativas, y los umbrales perceptivos en la detección de desconfianza para las distintas expresiones*. El tercer trabajo (Gutiérrez-García y Calvo, 2016b) acomete el tercer objetivo propuesto: La *desconfianza hacia otras personas cuando muestran expresiones con una sonrisa en la boca que no es congruente con la expresión de los ojos*. El cuarto (Gutiérrez-García, Calvo, y Eysenck, 2018) y quinto (Gutiérrez-García, Eysenck, y Calvo, enviado para publicación) trabajos afrontan el cuarto objetivo propuesto: El *análisis de los patrones espacio-temporales en la dirección y distribución de la mirada a las distintas partes de la cara de otras personas*.

A continuación se detallan las referencias completas de los artículos publicados o enviados para publicación, junto con los índices de impacto de las correspondientes revistas:

- Gutiérrez-García, A., & Calvo, M. G. (2017). Social anxiety and threat-related interpretation of dynamic facial expressions: Sensitivity and response bias *Personality and Individual Differences, 107,* 10-16.
  Journal Citation Reports (ISI), 2016, **Journal Impact Factor: 2.005**; **Psychology Social**: **Rank Q2** (20/62), © Clarivate Analytics Journal Citation Reports 2017

- Gutiérrez-García, A., & Calvo, M. G. (2016a). Social anxiety and trustworthiness judgments of dynamic facial expressions of emotion. *Journal of Behavior Therapy and Experimental Psychiatry, 52,* 119-127.
  Journal Citation Reports (ISI), 2016, **Journal Impact Factor: 2.517**; **Psychology Clinical: Rank Q2** (37/121); **Psychiatry: Rank Q2** (47/139), © Clarivate Analytics Journal Citation Reports 2017.

- Gutiérrez-García, A., & Calvo, M. G. (2016b). Social anxiety and perception of (un)trustworthiness in smiling faces. *Psychiatry Research, 244,* 28-36. Journal

Citation Reports (ISI), 2016, **Journal Impact Factor: 2.528**; **Psychiatry: Rank Q2** (65/142), © Clarivate Analytics Journal Citation Reports 2017

- Gutiérrez-García, A., Calvo, M. G., & Eysenck, M. W. (2018). Social anxiety and detection of facial untrustworthiness: Spatio-temporal oculomotor profiles. *Psychiatry Research, 262*, 55-62.
  Journal Citation Reports (ISI), 2016, **Journal Impact Factor: 2.528**; **Psychiatry: Rank Q2** (65/142), © Clarivate Analytics Journal Citation Reports 2017

- Gutiérrez-García, A., Eysenck, M. W., & Calvo, M. G. (enviada revisión). Social anxiety and coping with fear of negative evaluation: An eye-tracking study. *Anxiety, Stress, and Coping*.
  Journal Citation Reports (ISI), 2016, **Journal Impact Factor: 2.044**; **Psychiatry: Rank Q2** (64/139); **Psychology Multidisciplinary, Rank Q2** (39/129), © Clarivate Analytics Journal Citation Reports 2017

2. RESUMEN DE LA INVESTIGACIÓN

De acuerdo con la normativa expuesta en el apartado anterior, procedemos a presentar *"…un resumen global de los objetivos de la investigación, de la metodología aplicada, de los resultados obtenidos, de la discusión de estos resultados y de las conclusiones finales"*.

2.1. Objeto y Problema de Estudio

Los seres humanos debemos enfrentarnos diariamente a multitud de situaciones que implican una interacción social, lo cual no es un reto sencillo de afrontar para muchos. El estudio Esemed-España (Haro et al., 2006) sitúa la prevalencia a lo largo de la vida de la fobia social en nuestro país en algo más del 1%, siendo medida según los criterios del DSM-IV. Sin embargo, el porcentaje de personas que presentan síntomas propios del Trastorno de Ansiedad Social sin llegar a cumplir criterios diagnósticos presumiblemente será significativamente mayor, con el sufrimiento y el deterioro en la calidad de vida de los afectados que conlleva.

Según la versión más reciente del Manual Diagnóstico y Estadístico de los Trastornos Mentales (DSM-5; American Psychiatric Association, 2013; Heimberg, Brozovich, y Rapee, 2014; Skocic, Jackson, y Hulbert, 2015), el Trastorno de ansiedad social o Fobia social se caracteriza específicamente por un miedo persistente y excesivo a ser evaluado negativamente por otras personas, así como por la consiguiente evitación de las situaciones que implican ser objeto de observación y examen público. Entre otros modelos o factores explicativos propuestos, estos síntomas emocionales y conductuales han sido atribuidos al efecto de sesgos cognitivos en la interpretación de los estímulos sociales ambiguos como si fueran amenazantes (Clark, 2001; Eysenck, 1997; Heimberg et al., 2014; Hofmann, 2007). La tendencia a percibir peligro (crítica, desprecio, rechazo, etc.) ante señales que, en realidad, podrían indicar sólo un mero desacuerdo o duda por parte de otras personas hacia la persona con ansiedad social, mantendría e incrementaría el miedo y la evitación de situaciones que puedan implicar evaluación social. Hay evidencias de este sesgo cognitivo ante estímulos que conllevan descripciones verbales de escenarios sociales ambiguos, los cuales son interpretados de forma más negativa por parte de los individuos con elevada ansiedad social respecto a los de baja ansiedad (véanse revisiones en Eysenck, 2013; Mobini, Reynolds y Mackintosh, 2013; Morrison y Heimberg, 2013; Steinman, Teachman, y Gorlin, 2014).

En la presente tesis doctoral investigamos la ansiedad social elevada en adultos jóvenes que pueden hacer una vida normal. Si bien no están diagnosticados como pacientes mediante entrevistas estructuradas, sus puntuaciones en medidas de autoinforme se encuentran dentro del rango clínico de fobia social (Brown et al., 1997; Gallego, Botella, Quero, Baños, y García-Palacios, 2007; Weeks et al., 2005). Nuestro planteamiento tiene así relevancia para poblaciones clínicas, dado el continuo existente entre ansiedad social y fobia social, así como los sesgos compartidos en el funcionamiento cognitivo (García-López, Beidel, Muela-Martínez, y Espinosa-Fernández, en imprenta; Morrison y Heimberg, 2013). Lo que diferencia a las personas con *fobia* social respecto a las que presentan *ansiedad* social sería el grado de interferencia (mayor en la fobia que en la ansiedad) que producen sobre sus rutinas en situaciones sociales ordinarias, en el trabajo o en los estudios. Nuestro planteamiento permite la generalización a una población amplia de jóvenes con elevados niveles de ansiedad que, no obstante, pueden afrontar las demandas de la vida cotidiana, incluyendo la formación universitaria.

En la interacción social las expresiones faciales son una fuente importante de información acerca de los sentimientos y las intenciones de otras personas, tales como el agrado y la aprobación, expresadas generalmente por las caras alegres, o el desagrado y la desaprobación, expresadas por las caras de enfado. De acuerdo con ello, y teniendo en cuenta la naturaleza de la ansiedad social, así como el hecho de que las expresiones faciales en contextos sociales son frecuentemente ambiguas (Calvo, Gutiérrez-García, Fernández-Martín, y Nummenmaa, 2014; Carroll y Russell, 1997; Fernández-Dols y Crivelli, 2013; Krumhuber y Scherer, 2011), cabe esperar que la ansiedad social sesgue la interpretación de las expresiones faciales de múltiples maneras. En el presente trabajo investigaremos distintos aspectos de dicho sesgo en relación con cuatro objetivos.

2.2. Objetivos, Antecedentes y Predicciones

2.2.1. Objetivo 1: Ansiedad Social y *Reconocimiento de Expresiones* Faciales Emocionales (Experimento 1).

En la primera fase de la investigación, en el Experimento 1 (Gutiérrez-García y Calvo, 2017), el objetivo consistió en determinar si la ansiedad social (a) conlleva una facilitación en el reconocimiento de las expresiones faciales negativas, (b) si esto ocurre especialmente para las que trasmiten amenaza directa (enfado y asco), (c) si sucede incluso cuando dichas

expresiones tienen baja intensidad, y (d) si hay una tendencia a percibir hostilidad o rechazo en las expresiones neutras. Previsiblemente, la ansiedad social facilitará el reconocimiento de las expresiones negativas, especialmente las asociadas a hostilidad y rechazo (enfado y asco), dado que éstos constituyen el elemento fóbico crítico en las personas con ansiedad social. De este modo, dichas personas tendrán umbrales de reconocimiento más bajos (es decir, reconocimiento ante niveles más bajos de intensidad de la expresión, cuando las caras son más ambiguas), en comparación con las personas no ansiosas. De manera similar, la ansiedad social se caracterizará por una interpretación negativa de las caras emocionalmente neutras como si fueran de enfado o de asco, demostrando así una hipervigilancia o hipersensibilidad hacia las expresiones negativas.

La investigación previa en relación con este objetivo no ha obtenido evidencias sólidas que apoyen la existencia de diferencias en el reconocimiento de expresiones faciales emocionales en función de la ansiedad social (véanse revisiones en Gilboa-Schechtman y Shachar-Lavie, 2013; Machado-de-Sousa et al., 2010; Morrison y Heimberg, 2013; Staugaard, 2010). Cuando las expresiones son prototípicas, la ansiedad social no está generalmente asociada a un mejor o peor reconocimiento explícito en tareas de categorización (Staugaard, 2010). Cuando las expresiones son ambiguas, sólo algunos datos indican que las personas con ansiedad social tienden a interpretarlas de modo más negativo (enfado: Bell et al., 2011; Yoon, Yang, Chong, y Oh, 2014; o desprecio: Heuer, Lange, Isaac, Rinck, y Becker, 2010), o de forma menos benigna (como menos alegres: Gutiérrez-García y Calvo, 2014), en comparación con las personas no ansiosas. Incluso con expresiones ambiguas, en varios estudios no se han encontrado diferencias en función de la ansiedad social (Button, Lewis, Penton-Voak, y Munafò, 2013) y la fobia social (Jusyte y Schönenberg, 2014).

Los estudios previos tienen limitaciones en relación con el tipo de estímulos y medidas utilizadas, que podrían haber reducido su sensibilidad para detectar el sesgo interpretativo objeto de investigación. En la mayoría de los casos, el reconocimiento de las expresiones se ha medido sólo en términos del número de respuestas "correctas". Únicamente dos estudios recientes (Langner, Becker, Rinck y van Knippenberg, 2015; Yoon et al., 2014) han aplicado la técnica de detección de señales (TDS; Macmillan y Creelman, 2005) para obtener medidas más finas de discriminación, separando sensibilidad perceptiva y criterio de respuesta. Sus resultados han sido, no obstante, discrepantes. Yoon et al. (2014) encontraron que la ansiedad social estaba asociada a una mayor sensibilidad para las expresiones de enfado, y también un mayor sesgo de respuesta (es decir, mayor tendencia a categorizar otras

expresiones como enfado). En cambio, Langner et al. (2015) no encontraron efectos en ninguna de estas dos medidas. Debe tenerse en cuenta, sin embargo, que ambos estudios utilizaron un número limitado de expresiones (neutra, enfado y alegría en el caso de Yoon et al., 2014; o neutra y enfado en el estudio de Langner et al., 2015), las cuales, además, tenían un formato estático (es decir, caras presentadas en fotografías).

En relación con nuestro primer objetivo, en el presente trabajo hacemos una contribución a la investigación previa utilizando (a) la técnica TDS para medir discriminación, (b) expresiones dinámicas (más próximas a las de la vida cotidiana que las fotografías, aumentando así la validez ecológica y la sensibilidad; véase Krumhuber, Kappas, y Manstead, 2013), (c) una muestra amplia de las seis expresiones emocionales básicas (enfado, miedo, asco, tristeza, sorpresa y alegría), y (d) una manipulación de los niveles de intensidad expresiva que nos permita determinar el umbral de discriminación en función del tipo de expresión.

2.2.2. Objetivo 2: Ansiedad Social y *Juicios de Des/confianza* en función de la Intensidad Expresiva (Experimento 2).

En una segunda fase, en el Experimento 2 (Gutiérrez-García y Calvo, 2016a), investigamos si la ansiedad social comporta (a) un incremento de la desconfianza hacia otras personas cuando muestran expresiones emocionales negativas, o (b) específica y únicamente para las de amenaza (enfado y asco), (c) y cuáles son los umbrales perceptivos en la detección de desconfianza para las distintas expresiones. A partir de las caras y las expresiones faciales, los observadores hacen generalmente y de modo automático inferencias, no sólo sobre el estado emocional de otras personas, sino también sobre algunas características personales estables. Entre estas características destaca la *confiabilidad* (Said, Haxby, y Todorov, 2011; Todorov, Said, Engell, y Oosterhof, 2008); es decir, cuánta confianza nos merece alguien como para comprometernos en una relación personal o profesional. Los juicios de confianza son presumiblemente muy relevantes para la ansiedad social dado que ésta se caracteriza por miedo y evitación de la interacción con personas de las que se anticipa una evaluación negativa, y que los juicios de des/confianza conllevan acercamiento y/o evitación en la interacción social (Dijk, Koenig, Ketelaar, y de Jong, 2011; van't Wout y Sanfey, 2008). De acuerdo con ello, la ansiedad social podría promover juicios de desconfianza (o inhibir valoraciones de confianza) como un mecanismo de auto-protección preventiva. Para evitar la evaluación negativa, los observadores con ansiedad

social estarían especialmente alerta a la presencia de señales faciales sutiles indicadoras de desconfianza; o bien, exagerarían la interpretación de señales faciales ambiguas como indicios de desconfianza. Este efecto debería ocurrir especialmente ante signos faciales de enfado y asco, por su relación con la hostilidad y el rechazo.

Por ello, hipotetizamos que la ansiedad social inducirá desconfianza especialmente, y ante señales de baja intensidad, hacia las personas que exhiban muestras de enfado y asco (por asociarlas directamente con hostilidad y desaprobación). Como hipótesis alternativa, también es posible que la ansiedad social induzca desconfianza hacia cualquier expresión negativa, aunque no implique amenaza directa, como ocurre en las expresiones de miedo y tristeza. Otra posibilidad es que incluso las expresiones meramente ambiguas, como las de sorpresa y neutras, generen desconfianza. Una tercera posibilidad es que incluso las expresiones de alegría susciten desconfianza en las personas con ansiedad social, que podrían percibir en ellas desdén, superioridad o burla.

La investigación empírica previa sobre la relación propuesta entre ansiedad social y juicios de desconfianza es, sin embargo, muy escasa. En la revisión que hemos realizado han aparecido únicamente dos estudios directamente relacionados con la ansiedad social (Cooper et al., 2014; Meconi, Luria, y Sessa, 2014), y uno más con el rasgo de ansiedad general (Willis, Dodd, y Palermo, 2013), el cual está relacionado con la ansiedad social (Eysenck, 2013). Existen, además, discrepancias entre tales estudios. Willis et al. (2013) encontraron una relación negativa entre rasgo de ansiedad y juicios de confianza: las personas con elevada ansiedad valoraban las caras como menos confiables, en comparación con las personas con ansiedad baja. De modo consistente, Meconi et al. (2014) encontraron diferencias en un componente electrocortical, el SPCN (*Sustained Posterior Contralateral Negativity*): las caras predefinidas como desconfiables produjeron mayores amplitudes en este componente en las personas con elevada ansiedad social que en las no ansiosas. En contraste, sin embargo, Cooper et al. (2014) no hallaron una relación significativa entre ansiedad social y juicios de confianza.

En definitiva, hay evidencias escasas e incluso discrepantes sobre la relación entre ansiedad social y juicios de confianza/desconfianza de las caras. Además, hay que tener en cuenta algunas limitaciones de los estudios previos. Primero, la falta de pruebas en el estudio de Cooper et al. (2014) puede deberse a que no utilizaron grupos de participantes seleccionados en función de sus puntuaciones extremas en ansiedad social, sino más bien una muestra normalizada, que estaba compuesta por numerosas personas con puntuaciones intermedias en ansiedad social. Y, segundo, en los tres estudios referidos se presentaban

caras neutras como estímulos, sin expresión emocional explícita, aunque ambiguas respecto al grado de confiabilidad.

En consecuencia, en nuestro segundo experimento pretendemos avanzar en la investigación de la relación entre ansiedad social y juicios de confiabilidad superando las limitaciones de los estudios previos en varios aspectos: (a) mediante la selección de participantes con puntuaciones en ansiedad social suficientemente elevadas o bajas, de acuerdo con los parámetros de umbrales clínicos; (b) la utilización como estímulos de caras con expresiones propiamente emocionales de las seis categorías básicas, además de caras con expresión neutra como término de comparación; y (c) variando el nivel de intensidad de las expresiones a fin de graduar su ambigüedad.

2.2.3. Objetivo 3: Ansiedad Social e *Interpretación de la Sonrisa* Genuina y la Fingida (Experimentos 3 y 4).

En una tercera fase ahondamos en un aspecto específico dentro de las expresiones faciales emocionales: las caras con una sonrisa. Dada la multifuncionalidad de la sonrisa (Ambadar, Cohn, y Reed, 2009; Crivelli, Carrera, y Fernández-Dols, 2015; Ekman, 2001; Niedenthal, Mermillod, Maringer, y Hess, 2010), su ambigüedad podría hacerla interpretable como burla, especialmente por las personas con ansiedad social. En consecuencia, en los Experimentos 3 y 4 (Gutiérrez-García y Calvo, 2016b), investigamos si la ansiedad social está asociada a (a) un incremento de la desconfianza hacia otras personas cuando muestran expresiones con una sonrisa en la boca que no es congruente con la expresión de los ojos, (b) si la facilitación en la detección de las sonrisas incongruentes en función de la ansiedad social ocurre especialmente con algún tipo de expresión en los ojos (ej., los que trasmiten amenaza), y (c) si la ansiedad social no comporta ningún déficit en el procesamiento (sesgo en los juicios de confianza) de las expresiones en las cuales la sonrisa es congruente con la expresión alegre de los ojos.

Para abordar estos objetivos, el Experimento 3 se centra en el estudio de la in/congruencia entre los ojos neutros o alegres y la boca neutra o alegre, en sus múltiples combinaciones, según cuál sea la expresión inicial y la final en la secuencia dinámica de la expresión. El Experimento 4, por su parte, tiene como foco de estudio el efecto del tipo de expresión emocional en los ojos y el cambio leve (50% de intensidad) en dicha expresión (de alegres a no alegres: enfado, asco, miedo, tristeza, sorpresa, neutros) en presencia de una sonrisa constante. El denominador común de ambos experimentos y de este tercer objetivo

lo constituye la sonrisa, con el fin de determinar el posible sesgo interpretativo de la ansiedad en el procesamiento de este importante rasgo expresivo en la cara.

A pesar de su apariencia como un gesto facial simple en la región de la boca, la sonrisa es, en realidad, muy compleja morfológica y funcionalmente, y está asociada a emociones muy diferentes entre sí. Además de expresar alegría, una sonrisa puede estar suscitada por motivos de dominancia, sarcasmo y desdén, o de nerviosismo y temor, o bien puede indicar mera cortesía social (Ambadar et al., 2009; Calvo, Gutiérrez-García, Avero, y Lundqvist, 2013; Ekman, 2001). Esto convierte a la sonrisa en susceptible de múltiples interpretaciones, las cuales podrían ser sesgadas por la ansiedad social. De este modo, dado que la sonrisa puede tener significados negativos, es posible que la ansiedad social los active de manera preferente, sobre todo los relacionados con desaprobación y evaluación negativa (ej., burla). Presumiblemente, esto sucedería de modo especial cuando la información procedente de los ojos es incongruente con la sonrisa en la boca. Dado que la sonrisa aparece en las situaciones sociales con una frecuencia muy superior a la de otras expresiones faciales emocionales (Calvo, Gutiérrez-García, Fernández-Martín, y Nummenmaa, 2014; Somerville y Whalen, 2006), dicho sesgo podría tener una importante influencia en el desarrollo y el mantenimiento de la ansiedad social.

En una aproximación previa a esta cuestión (Gutiérrez-García y Calvo, 2014), investigamos si la ansiedad social facilita la discriminación entre sonrisas genuinas (congruencia entre la expresión en ojos y boca) y fingidas (no congruencia entre la expresión de los ojos—no alegres—y la boca sonriente). Los resultados mostraron una ausencia de diferencias en función de la ansiedad social para las caras alegres genuinas y para las caras no-alegres genuinas (ej., ojos y boca de enfado), lo cual es consistente con la mayoría de los estudios (véase revisión de Staugaard, 2010; Lange, Rinck, y Becker, 2013). Sin embargo, en comparación con los participantes con ansiedad baja, los de elevada ansiedad social juzgaron más probablemente como "no-contenta" todas las caras con sonrisa si tenían ojos no alegres. Además, los participantes con ansiedad social fueron especialmente rápidos en juzgar como "no-contenta" las caras con sonrisa que tenían los ojos de enfado, asco o miedo (pero no las que tenían ojos tristes, de sorpresa o neutros). Estos resultados sugieren que la ansiedad social disminuye la interpretación benigna de todas las expresiones ambiguas con una sonrisa, y además acelera la detección específicamente de las que tienen ojos de amenaza (véase Jusyte y Schönenberg, 2014).

En nuestro tercer objetivo investigamos si esos efectos vinculados a la ansiedad social en los juicios sobre la alegría de las expresiones con sonrisa no genuina pueden ser debidos

a una percepción de desconfianza. Aparte de extender los juicios de categorización de expresiones (en Gutiérrez-García y Calvo, 2014) a juicios de confiabilidad sobre las personas, en los Experimentos 3 y 4 ahora presentados utilizamos expresiones dinámicas (en lugar de estáticas), lo cual permite examinar más variantes relativas a la incongruencia de los ojos. Predecimos que, en comparación con los individuos con ansiedad baja, los de ansiedad social elevada (a) juzgarán como menos confiables a las personas con una sonrisa no congruente con la expresión de los ojos; (b) esto ocurrirá especialmente cuando los ojos trasmitan enfado o asco; (c) incluso a baja intensidad (50%); pero, en cambio, (d) no habrá diferencias en función de la ansiedad social en los juicios de confianza sobre las personas que manifiesten sonrisas acompañadas por ojos alegres.

2.2.4. Objetivo 4: Patrones Espacio-temporales en la *Dirección de la Mirada* (Experimentos 5 y 6).

Los objetivos previos tratan acerca de la *interpretación* de las expresiones faciales, bien como reconocimiento o categorización de la expresión, o bien como juicios sobre la confiabilidad de las personas con esa expresión. En la fase final de este trabajo hemos extendido el alcance de la investigación planteando los mecanismos de *atención* selectiva a regiones de las caras. Pretendemos así proponer una posible explicación de la tendencia de las personas con ansiedad social a interpretar negativamente las expresiones ambiguas con una sonrisa (particularmente a juzgarlas como indicadoras de desconfianza). Para investigar dichos mecanismos, en los Experimentos 5 (Gutiérrez-García, Eysenck, y Calvo, enviado) y 6 (Gutiérrez-García, Calvo, y Eysenck, 2018) exploramos los perfiles oculo-motores de observación; es decir, la distribución de las fijaciones visuales en las distintas partes de la cara durante el movimiento expresivo en ésta. Resulta de especial interés conocer *dónde*, *cuándo* y *cuánto* miran los observadores con baja o con elevada ansiedad social a cada expresión facial, y si el patrón de fijaciones visuales está relacionado con las diferencias en los juicios sobre las expresiones.

El Experimento 5 constituye una extensión del Experimento 3, y el Experimento 6 es una extensión del Experimento 4, con la importante novedad del registro de las fijaciones visuales. Nos interesa particularmente conocer las fijaciones en las dos fuentes expresivas principales: los ojos y la boca. La investigación previa sobre el reconocimiento de expresiones faciales ha demostrado que la información afectiva no se distribuye de modo uniforme en las distintas áreas de la cara, y que, en general, los observadores humanos utilizan más la boca que los ojos para discriminar entre expresiones (Blais, Roy, Fiset,

Arguin, y Gosselin, 2012). Aun así, se han hallado diferencias en función del tipo de expresión: el reconocimiento del enfado y el miedo depende más de los ojos; el asco y la alegría, de la boca; y la sorpresa y la tristeza necesitan la información de ojos y boca de modo similar (Calder, Young, Keane, y Dean, 2000; Calvo y Marrero, 2009; Kohler et al., 2004; Leppänen y Hietanen, 2007; Nummenmaa y Calvo, 2015; Nusseck, Cunningham, Wallraven, y Bülthoff, 2008; Smith, Cottrell, Gosselin, y Schyns, 2005).

Los Experimentos 5 y 6 pretenden avanzar sobre la investigación previa en cuanto a la función relativa de los ojos y la boca en la interpretación de las expresiones por parte de las personas con ansiedad social. Proponemos como hipótesis la utilización de un mecanismo de orientación atencional selectiva destinado a detectar anticipatoriamente evaluaciones negativas en otros individuos. Predecimos que los observadores con ansiedad social mirarán temprano a los ojos de los emisores, como potenciales indicadores de sus intenciones. Esta estrategia atencional es particularmente comprensible en las caras con una sonrisa. La razón es que la expresión de los ojos tiene una contribución crítica a la percepción de autenticidad de las caras alegres (McLellan, Johnston, Dalrymple-Alford, y Porter, 2010) y que la percepción de autenticidad guarda una estrecha relación con la percepción de confianza en otras personas (Krumhuber et al., 2007). En consecuencia, una estrategia atencional útil en la ansiedad social implicaría mirar temprano a los ojos, lo cual facilitaría la detección de incongruencias con la sonrisa y así promovería los juicios de desconfianza. En contraste, la atención visual de las personas con baja ansiedad social se vería atraída preferentemente por la saliencia de la boca sonriente. Esto llevaría a las personas con baja ansiedad social a juzgar dichas caras como alegres, dado el alto valor diagnóstico de la sonrisa para la categorización de las caras como alegres (Calvo, Fernández-Martín, y Nummenmaa, 2014) y la estrecha relación entre las caras alegres y la percepción de confianza (Sutherland, Young, y Rhodes, 2017).

2.3. Metodología

Los seis experimentos propuestos forman parte de un proyecto integrado, en pasos sucesivos, por lo que comparten numerosos aspectos comunes, pero también variaciones significativas (véase Tabla 1). Por economía expositiva, presentamos a continuación los aspectos generales relativos al método y, dentro de ellos, las peculiaridades de cada experimento. Es importante resaltar una novedad metodológica común en esta serie de experimentos, que se refiere a la utilización en todos ellos de expresiones faciales dinámicas, generadas mediante la técnica de *morphing* (ver debajo; Harris, Young, y Andrews, 2012; Kessels, Montagne, Hendriks, Perrett, y de Haan, 2014; Lander, Chuang, y Wickham, 2006). De este modo, tratamos de hacer una contribución relevante a la investigación previa, que ha empleado generalmente fotografías. Mediante las expresiones dinámicas aportamos mayor validez ecológica, dado que las expresiones faciales en la vida real son típicamente dinámicas. Asimismo, nos permiten proporcionar mayor sensibilidad para la interpretación de expresiones puesto que la información dinámica mejora la coherencia en la identificación de las expresiones faciales, particularmente cuando son sutiles (baja intensidad) y ambiguas (véase Krumhuber et al., 2013).

Tabla 1

Panorámica de los Experimentos

Experimento	Medida	Tarea	Expresión Dinámica				Intensidad Expresiva
			Inicial		Final		
			Ojos	Boca	Ojos	Boca	
1	Discriminación	Categorización Expresiones	Neutra	Neutra	Emocionales prototípicas	Emocionales prototípicas	0, 25, 50, 75, 100%
2	Juicio	Confianza	Neutra	Neutra	Emocionales prototípicas	Emocionales prototípicas	0, 10, 20, 30, 40, 50, 100%
3	Juicio	Confianza	Neutra o Alegría	Neutra o Sonrisa	Alegría o Neutra	Sonrisa o Neutra	
4	Juicio	Confianza	Alegría	Sonrisa	NO alegría 50%	Sonrisa	Ojos No alegres 50%
5	Movimientos Oculares	Confianza	Neutra o Alegría	Neutra o Sonrisa	Alegría o Neutra	Sonrisa o Neutra	
6	Movimientos Oculares	Confianza	Alegría	Sonrisa	NO alegría 50%	Sonrisa	Ojos No alegres 50%

2.3.1. Participantes

En cada experimento participaron 48 estudiantes universitarios de entre 18 y 25 años. De ellos, 24 fueron seleccionados en una fase previa en función de sus puntuaciones elevadas en varias medidas de autoinforme de ansiedad social (véase apartado 2.3.2.) y otros 24 por sus puntuaciones bajas. Dado que la ansiedad social tiene una mayor incidencia en las mujeres que en los varones en la población general (American Psychiatric Association, 2013; Xu et al., 2012; también en muestras españolas: Inglés et al., 2010; Olivares, Piqueras, y Rosa, 2006), la proporción de mujeres (*N* = de 15 a 17) fue mayor que la de hombres (*N* = de 7 a 9) en el grupo de ansiedad social elevada. En consecuencia, y como control, mantuvimos la misma proporción mujeres-varones (15-17 vs. 7-9) en el grupo sin ansiedad social. Para obtener cada muestra experimental de 24 participantes seleccionados por su ansiedad social elevada, fue necesario inicialmente aplicar las medidas de autoinforme a muestras amplias de más de 200 personas por experimento (a fin de que el grupo de ansiedad social tuviera puntuaciones suficientemente elevadas como para considerarlas con significación clínica).

2.3.2. Medidas de Ansiedad Social y Criterios de Selección

Como instrumentos de medida de la ansiedad social, utilizamos los siguientes cuestionarios de autoinforme psicométricamente validados y estandarizados en la investigación previa: 1) *Social Interaction Anxiety Scale* o Escala de Ansiedad ante la Interacción Social (*SIAS*; Mattick y Clarke, 1998; con versión española de Olivares, García-López, e Hidalgo, 2001); 2) *Social Phobia Scale* o Escala de Fobia Social (SPS; Mattick y Clarke, 1998; con versión española de Olivares et al., 2001); 3) *Liebowitz Social Anxiety Scale–Self-Report version* o Escala de Ansiedad Social de Liebowitz (*LSAS-SR*; Liebowitz, 1987); y 4) *Brief Fear of Negative Evaluation scale* (BFNE) o escala Breve de Miedo a la Evaluación Negativa (Leary, 1983; versión española de Gallego et al., 2007). Generalmente, la selección de los participantes y su asignación al grupo de ansiedad social o al de control (sin ansiedad social o con baja ansiedad) se hizo teniendo en cuenta la convergencia de las puntuaciones en todas las medidas.

En todos los casos, para la inclusión en el grupo de ansiedad social empleamos los siguientes criterios o umbrales de corte, de acuerdo con la investigación previa: puntuaciones ≥ 34 en la escala SIAS y ≥ 24 en la SPS, que indicarían fobia social (Brown et al., 1997; Jusyte y Schönenberg, 2014; Weeks et al., 2005); puntuaciones ≥ 60 en la

LSAS-SR, que han demostrado el mejor balance entre sensibilidad y especificidad para el trastorno de ansiedad social (Haker, Aderka, Marom, Hermesh, y Gilboa-Schechtman, 2014; Rytwinksi et al., 2009; Weeks et al., 2005); y puntuaciones ≥ 43 en la escala BFNE (Gallego et al., 2007; Jusyte y Schönenberg, 2014; Weeks et al., 2005).

2.3.3. Materiales y Estímulos Experimentales

Como estímulos empleamos video-clips cortos de entre 1 segundo (Experimentos 1 y 2) y 2 segundos (Experimentos 3, 4, 5 y 6) de duración cada uno. En general, para todos los experimentos, los vídeos se construyeron a partir de la aplicación del software FantaMorph© (versión 5.4.2 Deluxe; Abrosoft) a fotografías digitalizadas en color de caras con expresiones *prototípicas* (neutras, de alegría, enfado, miedo, tristeza, asco, y sorpresa: Experimentos 1 a 6), o expresiones *mezcla* (con o sin sonrisa en la boca combinadas con expresiones de alegría, enfado, miedo, tristeza, asco, y sorpresa en los ojos: Experimentos 3, 4, 5 y 6). Las fotografías a partir de las que se han construido los videos corresponden a 24 modelos (12 mujeres y 12 hombres, estudiantes de arte dramático) de la base de datos Karolinska Directed Emotional Faces (KDEF; Lundqvist, Flykt, y Öhman, 1998). Véanse estudios normativos en Calvo y Lundqvist (2008) y Goeleven, De Raedt, Leyman, y Verschuere (2008).

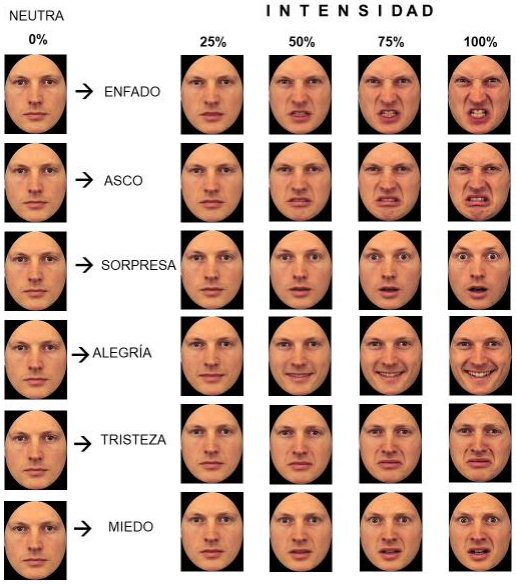

Figura 1. Tipos de expresiones y niveles de intensidad en el Experimento 1.

2.3.3.1. Experimentos 1 y 2

En los Experimentos 1 y 2 manipulamos la *intensidad* expresiva de cada emoción prototípica. Para cada expresión de cada modelo creamos una secuencia de 100 fotogramas de transición entre la cara neutra (como primer fotograma) y cada una de las expresiones emocionales (ej., alegre, triste, etc.) en su máxima intensidad (como último fotograma). A partir de esta secuencia, elegimos los fotogramas 0 (cara neutra; original del KDEF), 10, 20, etc., hasta el fotograma 100 (máxima intensidad; cara emocional; original del KDEF), que representan, respectivamente, el 0%, 10%, 20%, etc., y 100% de la intensidad de la expresión emocional correspondiente. En la Figura 1 (Experimento 1) y la Figura 2 (Experimento 2) se muestran ejemplos de los estímulos en sus diferentes categorías y niveles de intensidad.

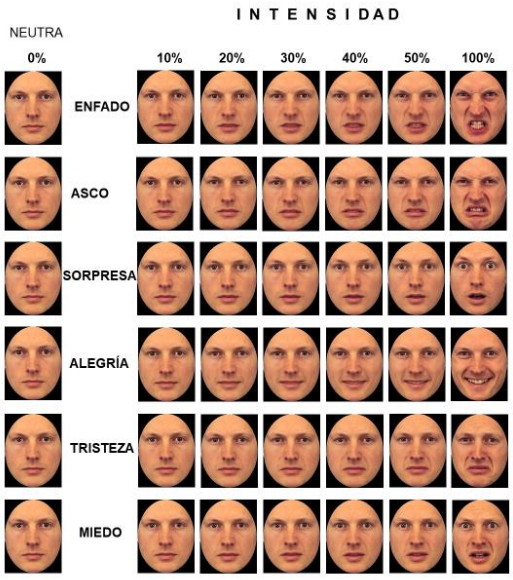

Figura 2. Tipos de expresiones y niveles de intensidad en el Experimento 2.

A partir de la secuenciación de los fotogramas estáticos, generamos versiones *dinámicas*. Entre la expresión neutra (fotograma 0) y la emocional (fotograma 30; hasta el nivel de intensidad establecido como máximo en cada condición, ej., 10%, 20%, etc., 100%), el movimiento o cambio expresivo en los videos se produce de una forma suave y continua a una tasa de 30 fotogramas por segundo. Para todas las expresiones y todos los niveles de

intensidad, el desarrollo dinámico de la expresión dura entre 900 y 1.000 ms (dependiendo del tipo de experimento; véase 2.4. Procedimiento). Esta tasa de movimiento se estableció en base a la investigación previa con caras con expresiones dinámicas, a fin de simular la velocidad promedio de las distintas expresiones en ambientes naturales y en pruebas de reconocimiento (Hoffmann, Traue, Bachmayr, y Kessler, 2010; Pollick, Hill, Calder, y Paterson, 2003; Recio, Schacht, y Sommer, 2013). En la condición de intensidad del 0%, una imagen de la cara neutra permaneció fija (sin movimiento) durante 1 s.

2.3.1.2. Experimentos 3 y 5

La principal novedad de los Experimentos 3 y 5 en cuanto a los estímulos consiste en la utilización de *expresiones mezcla*. Para obtenerlas, hemos fusionado la mitad inferior y la mitad superior de las caras de un mismo actor, mediante la técnica de composición de caras (Calder et al., 2000; Calvo, Fernández-Martín, y Nummenmaa, 2012; Tanaka, Kaiser, Butler, y Le Grand, 2012). Para los Experimentos 3 y 5, aparte de las caras prototípicas Neutras y de Alegría, las nuevas expresiones mezcla combinan (a) ojos con expresión neutra y boca con sonrisa (Ne+Al), y (b) ojos con expresión alegre y boca neutra (Al+Ne). La Figura 3 muestra un ejemplo de las cuatro expresiones.

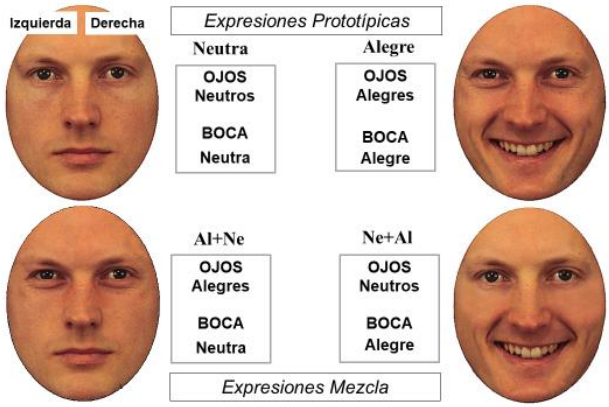

Figura 3. Tipos de expresiones en los Experimentos 3 y 5. Al: Alegre. Ne: Neutra.

Las cuatro versiones fotográficas resultantes fueron convertidas en video (30 fotogramas por segundo mediante el software FantaMorph©). Para ello, una fotografía de cada versión fue colocada como el primer fotograma de la secuencia (ej., Neutra) y otra fotografía de una versión diferente (ej., Ne+Ha) como el último fotograma. El software

FantaMorph generó un continuo dinámico de la primera hacia la segunda expresión. Esto produjo ocho condiciones experimentales (véase Tabla 2 en 2.3.6. Diseño Experimental, debajo).

2.3.1.3. Experimentos 4 y 6

En los Experimentos 4 y 6, se utilizaron también caras con expresiones mezcla, pero en este caso las caras-estímulo combinan los ojos de las distintas expresiones emocionales (neutra, alegría, tristeza, enfado, miedo, asco, y sorpresa) con una boca sonriente (véase Figura 4). La expresión en los ojos era dinámica, variando desde alegría inicial hasta cada una de las otras expresiones al 50% de intensidad en el transcurso de un segundo. En cambio, la sonrisa en la boca permanecía constante durante dicho período. De este modo, pretendimos simular micro-expresiones en los ojos a fin de conocer cómo afectan a la percepción de la sonrisa.

Figura 4. Tipos de expresiones en los Experimentos 4 y 6 (fila inferior; expresiones mezcla). Ne: Neutra. Al: Alegre. So: Sorpresa. Mi: Miedo. Tr: Triste. As: Asco. En: Enfado.

2.3.4. Procedimiento y Tareas

En los distintos experimentos, cada sujeto recibió entre 168 y 192 videos de entre 1 y 2 segundos de duración (según la tarea y experimento; véanse Figuras 5 a 8), con 24 modelos de las distintas expresiones prototípicas o combinaciones de expresiones mezcla. En

sesiones individuales, los videos se presentaron mediante el software E-Prime 2.0 (Experimentos 1 a 4) o Experiment Center (SensoMotoric Instruments; Experimentos 5 y 6) en una pantalla de ordenador. La secuencia de eventos en cada ensayo se muestra en la Figura 5 (Experimento 1), Figura 6 (Experimento 2), Figura 7 (Experimentos 3 y 5), y Figura 8 (Experimentos 4 y 6).

Los participantes realizaban una tarea de *categorización* de la expresión de las distintas caras (Experimento 1) o bien una tarea de valoración de la *confiabilidad* de la persona que manifiesta cada expresión (Experimentos 2 a 6). En la tarea de categorización los sujetos decidían qué expresión facial—de entre las seis emociones básicas y la expresión neutra—tenía cada cara. Para ello, los observadores elegían una de 7 opciones, presionando sobre la tecla correspondiente (etiquetada verbalmente con cada expresión) en un teclado de ordenador. Las posiciones de las etiquetas de expresión fueron contrabalanceadas para cada participante. En la tarea de juicios de confiabilidad los sujetos decidían en una escala de 1 a 9 en qué medida la persona que manifestaba una expresión determinada les merecía confianza. Para ello, tenían que presionar sobre las teclas numéricas de la fila superior del teclado de un ordenador.

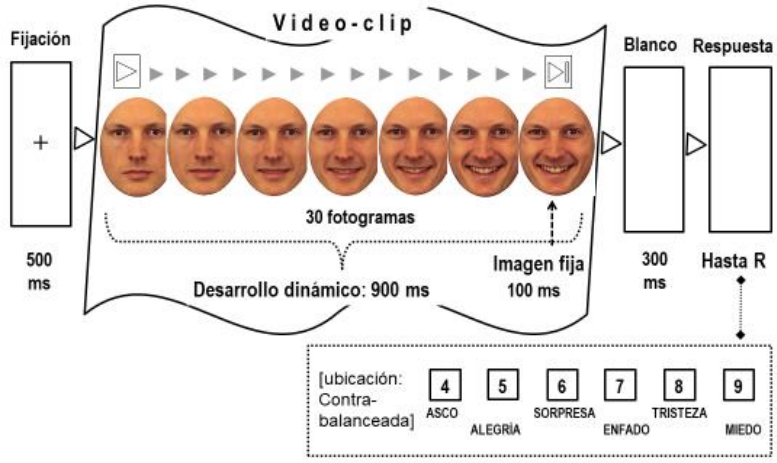

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Figura 5. Secuencia de eventos en cada ensayo experimental en el Experimento 1.

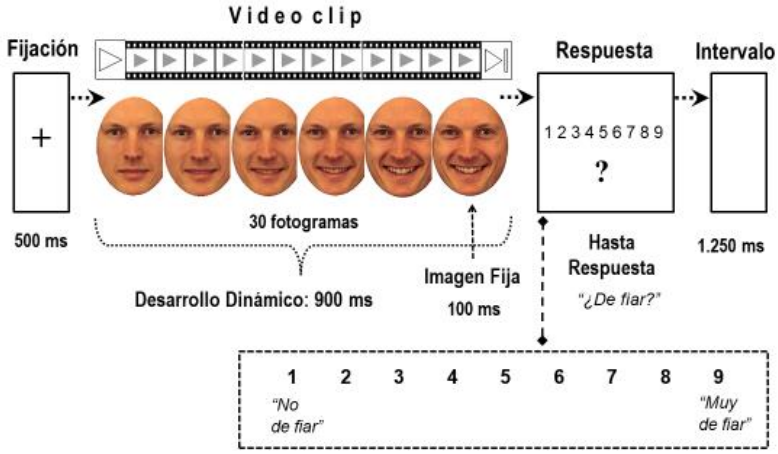

Figura 6. Secuencia de eventos en cada ensayo en el Experimento 2.

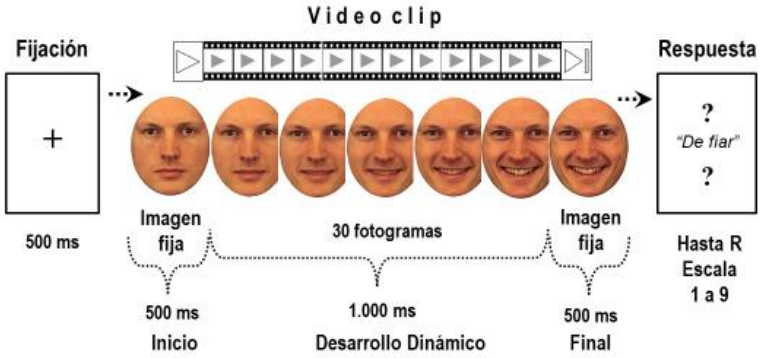

Figura 7. Secuencia de eventos en cada ensayo en los Experimentos 3 y 5.

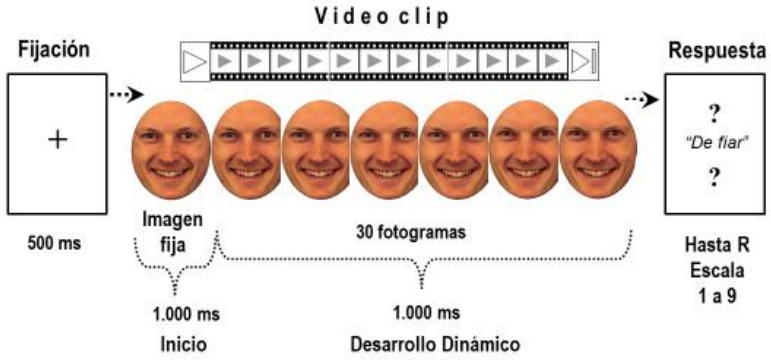

Figura 8. Secuencia de eventos en cada ensayo en los Experimentos 4 y 6.

2.3.5. Medidas

Registramos varias medidas con el software E-Prime (Experimentos 1 a 4) y el Experiment Center (Experimentos 5 y 6). En todos los experimentos se midió la respuesta de elección que emitía el participante en la tarea (categorización o juicio de confiabilidad) y sus tiempos de reacción. Además, en el Experimento 1, se obtuvieron medidas de discriminación o *sensibilidad A'*, así como el *criterio de respuesta B",* a partir de la combinación de aciertos y falsas alarmas, de acuerdo con la teoría de detección de señales (Macmillan y Creelman, 2005).

En los Experimentos 5 y 6 se registraron los *movimientos oculares* de los observadores para determinar la distribución espacio-temporal de la mirada. Para ello definimos las zonas críticas en cada cara como se ilustra en la Figura 9. La dirección de la mirada se grabó mediante el sistema RED 500-Hz (2 muestras por ms) de SensoMotoric Instruments GmbH (Teltow, Germany), con una resolución espacial de 0.03° y una precisión de 0.4°. Las cuatro regiones de interés (ojo izquierdo, ojo derecho, nariz-carrillos, y boca) recibieron el 97% del total de fijaciones. El lado izquierdo (ej., ojo izquierdo) y el derecho fueron considerados desde la perspectiva del sujeto observador (es decir, su campo visual). Medimos (a) la duración total de la mirada en cada región a lo largo del período de duración del estímulo, con separación entre los períodos de presentación estática de la cara y los de presentación dinámica; (b) la duración media por cada fijación; (c) el tiempo de entrada o tiempo transcurrido desde el inicio del estímulo hasta la primera fijación en cada región de la cara; y (d) la densidad o número de fijaciones en cada región por cada unidad de tiempo (60 sub-

períodos) de 33 ms, que proporciona un análisis fino del curso temporal a lo largo de los 2 segundos de presentación.

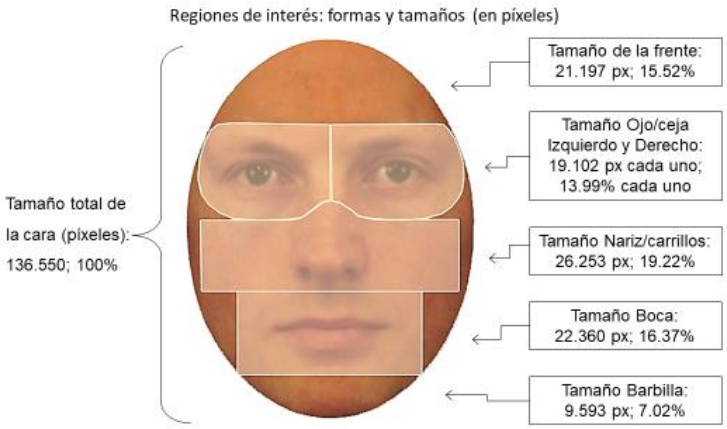

Figura 9. Regiones de interés en los estímulos de los Experimentos 5 y 6.

Además, medimos la *saliencia perceptiva* de las cuatro regiones faciales de interés, a fin de abordar la hipótesis propuesta (véase 2.2.4. Objetivo 4) de que la saliencia de la sonrisa pueda determinar la dirección de la mirada en mayor medida en los observadores con ansiedad baja que en los de ansiedad social elevada. El cómputo de la saliencia se realizó mediante el software iLab Neuromorphic Vision C++ Toolkit algorithm (iNVT; http://ilab.usc.edu/toolkit/; Itti y Koch, 2000; Walther y Koch, 2006). Los valores de saliencia fueron computados para cada región en comparación con la imagen total de la cara en función de propiedades puramente físicas de la imagen: contraste, color y orientación espacial de rasgos. La saliencia perceptiva así medida ha demostrado guiar la atención visual abierta y la encubierta (Borji y Itti, 2013; Calvo y Nummenmaa, 2008; Underwood y Foulsham, 2006).

2.3.6. Diseño Experimental

En el Experimento 1, el diseño incluye una combinación ortogonal de tres factores: 2 (Ansiedad Social: Baja vs. Elevada) × 6 (Expresión Emocional: alegría, tristeza, enfado, miedo, asco, y sorpresa) × 4 (Intensidad de la Expresión: 0%, 25%, 50%, y 100%), con el factor ansiedad como inter-grupo, y la expresión y la intensidad como factores intra-grupo.

De modo similar, en el Experimento 2, el diseño conlleva una combinación ortogonal de 2 (Ansiedad Social: Baja vs. Elevada) × 6 (Expresión Emocional: alegría, tristeza, enfado, miedo, asco, y sorpresa) × 7 (Intensidad de la Expresión: 0, 10, 20, 30, 40, 50, y 100%), con el factor ansiedad como inter-grupo, y la expresión y la intensidad como factores intra-grupo.

En el Experimento 3, el diseño incluye la combinación ortogonal de 2 (Ansiedad Social: Baja vs. Elevada) × 8 (Expresión Emocional: Neutra→Alegre, etc.; véase Tabla 2), con el factor ansiedad como inter-grupo y la expresión como factor intra-grupo. El diseño del Experimento 5 es idéntico al del Experimento 3, con la excepción de que incluye 6 niveles del factor Expresión (véase Condiciones resaltadas en azul y negrita en la Tabla 2) en lugar de 8 niveles.

En el Experimento 4, el diseño se ajusta a una combinación ortogonal de 2 (Ansiedad Social: Baja vs. Elevada) × 8 (Expresión Emocional: Neutra→Alegre, etc.; véase Tabla 3), con el factor ansiedad como inter-grupo y la expresión como factor intra-grupo. El diseño del Experimento 6 es idéntico al del Experimento 4, con la salvedad de que incluye 6 niveles en el factor Expresión (véase Condiciones resaltadas en azul y negrita en la Tabla 3) en lugar de 8 niveles.

Tabla 2

Condiciones Experimentales en función de las Combinaciones de Expresiones en los Ojos y en la Boca al Inicio y al Final de la Secuencia Dinámica en los Experimentos 3 y 5 (en azul, las condiciones seleccionadas para el Experimento 5).

Nota. Condiciones 1 y 8: Expresiones prototípicas. Condiciones 2 a 7: Expresiones mezcla.

Condición	Sonrisa Final	Expresión Inicial OJOS	Expresión Inicial BOCA	Desarrollo hacia	Expresión Final OJOS	Expresión Final BOCA	Acrónimo
1	Si	Neutra	Neutra	→	Alegre	Sonrisa	**Neutra→Alegre**
2	Si	Alegre	Neutra	→	Alegre	Sonrisa	**Al+Ne→Alegre**
3	Si	Neutra	Neutra	→	Neutra	Sonrisa	**Neutra→Ne+Al**
4	Si	Neutra	Sonrisa	→	Alegre	Sonrisa	Ne+Al→Alegre
5	No	Alegre	Sonrisa	→	Alegre	Neutra	**Alegre→Al+Ne**
6	No	Neutra	Sonrisa	→	Neutra	Neutra	Ne+Al→Neutra
7	No	Neutra	Neutra	→	Alegre	Neutra	**Neutra→Al+Ne**
8	No	Alegre	Sonrisa	→	Neutra	Neutra	**Alegre→Neutra**

Tabla 3

Condiciones Experimentales en función de las Combinaciones de Expresiones en los Ojos y en la Boca al Inicio y al Final de la Secuencia Dinámica en los Experimentos 4 y 6 (en azul, las condiciones seleccionadas para el Experimento 6).

Nota. Condiciones 1 y 8: Expresiones prototípicas. Condiciones 2 a 7: Expresiones mezcla.

Condición	Sonrisa Final	Expresión Inicial OJOS	Expresión Inicial BOCA	Desarrollo hacia	Expresión Final OJOS	Expresión Final BOCA	Acrónimo
1	Sí	Neutra	Neutra	→	Alegre	Sonrisa	**Neutra→Alegre**
2	Sí	Alegre	Sonrisa	→	Sorpresa (50%)	Sonrisa	**Alegre→So+Al**
3	Sí	Alegre	Sonrisa	→	Neutra (50%)	Sonrisa	**Alegre→Ne+Al**
4	Sí	Alegre	Sonrisa	→	Miedo (50%	Sonrisa	**Alegre→Mi+Al**
5	Sí	Alegre	Sonrisa	→	Triste (50%)	Sonrisa	Alegre→Tr+Al
6	Sí	Alegre	Sonrisa	→	Asco (50%)	Sonrisa	Alegre→As+Al
7	Sí	Alegre	Sonrisa	→	Enfado (50%)	Sonrisa	**Alegre→En+Al**
8	No	Alegre	Sonrisa	→	Neutra	Neutra	**Alegre→Neutra**

2.4. Resultados y Discusión

Con una finalidad didáctica, y para mantener la cohesión entre los efectos empíricos encontrados y su interpretación en relación con cada objetivo, presentamos a continuación los resultados principales y su discusión en correspondencia con los objetivos expuestos. Dado que los resultados son expuestos de modo pormenorizado en los artículos que figuran en los ANEXOS, relataremos a continuación los principales resultados sin acompañarlos del detalle estadístico.

2.4.1. Experimento 1 (Objetivo 1): *Reconocimiento de Expresiones* Faciales Emocionales.

Resultados

Aciertos, falsas alarmas, sensibilidad A', criterio B" de respuesta, y tiempos de reacción

En el correspondiente ANOVA de 2 (Ansiedad Social: Baja vs. Elevada) × 6 (Expresión Emocional: alegría, tristeza, enfado, miedo, asco, y sorpresa) × 4 (Intensidad de la Expresión: 0%, 25%, 50%, y 100%), los efectos principales del tipo de expresión y de la intensidad, pero no de la ansiedad, fueron modulados por una interacción entre expresión e intensidad sobre los *aciertos*; y, además, por una triple interacción sobre la *sensibilidad A'*, la cual constituye el efecto de mayor interés. Para descomponer esta interacción, llevamos a cabo ANOVAs de 2 (Ansiedad) × 3 (Intensidad) para cada expresión emocional separadamente. Como se muestra en las Figuras 10A a F, los participantes con elevada ansiedad social manifestaron mayor sensibilidad que los de ansiedad baja en el reconocimiento de las expresiones de *enfado* y de *asco* en el nivel del *25% de intensidad*, pero no en el 50% y el 75% de intensidad. En cambio, no hubo diferencias en función de la ansiedad para el resto de las expresiones. Para el *criterio B"* de respuesta y los *tiempos de reacción* no hubo efecto principal o interactivo de la ansiedad, sino efectos principales de la expresión o la intensidad.

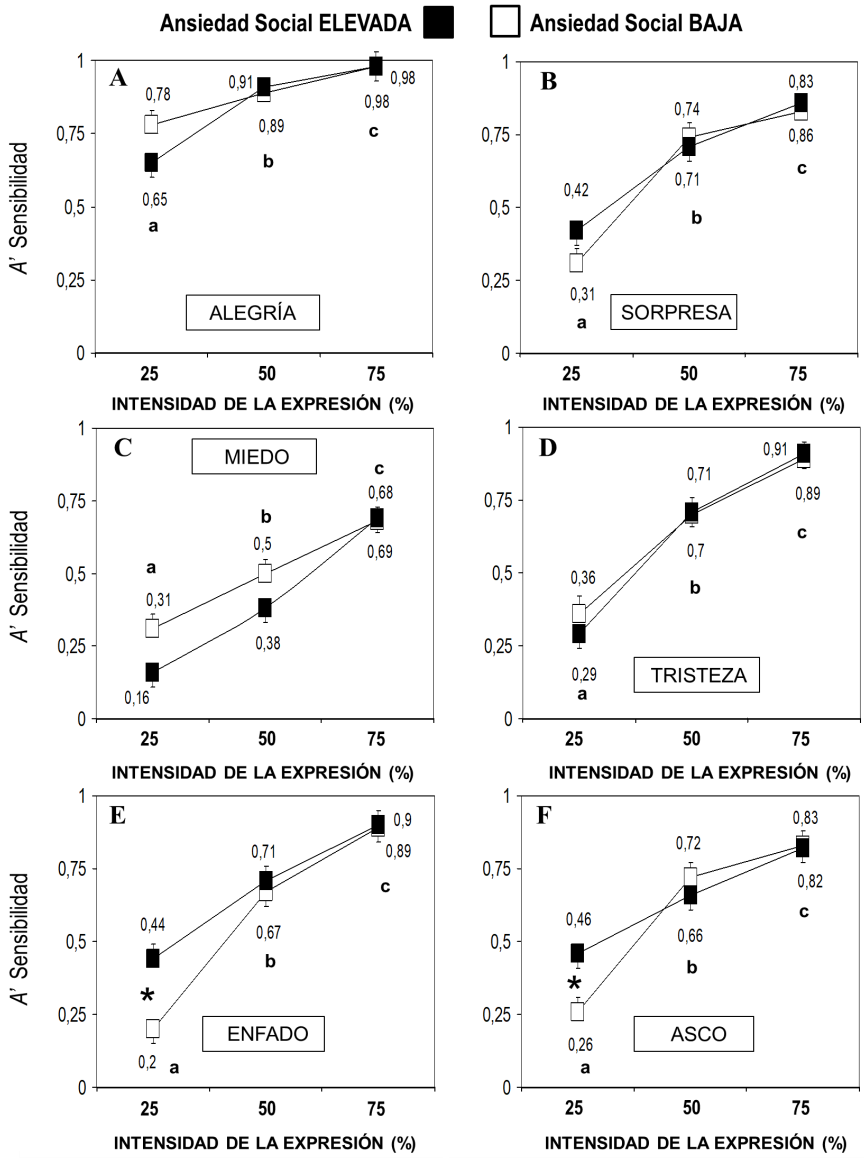

Figura 10. Sensibilidad (*A*') en el reconocimiento de expresiones faciales emocionales en cada nivel de intensidad, en función de la ansiedad social, en el Experimento 1. Los asteriscos indican diferencias significativas entre los grupos de ansiedad elevada y baja. Para ambos grupos, las letras diferentes indican diferencias significativas entre niveles de intensidad (letras iguales indican ausencia de diferencias).

Confusiones de las caras neutras con otras expresiones

La interacción entre ansiedad y expresión en el ANOVA fue examinada mediante contrastes *t* para grupos independientes (ansiedad social vs. control). Como se indica en la Figura 11, los participantes con ansiedad elevada interpretaron las caras neutras como enfado y como asco más probablemente que los participantes con ansiedad baja. Además, la interpretación de las caras neutras como alegría y como tristeza fue menor en el caso de los participantes con ansiedad social elevada. En cambio, no hubo diferencias entre los grupos en la interpretación de las caras neutras como sorpresa y como miedo.

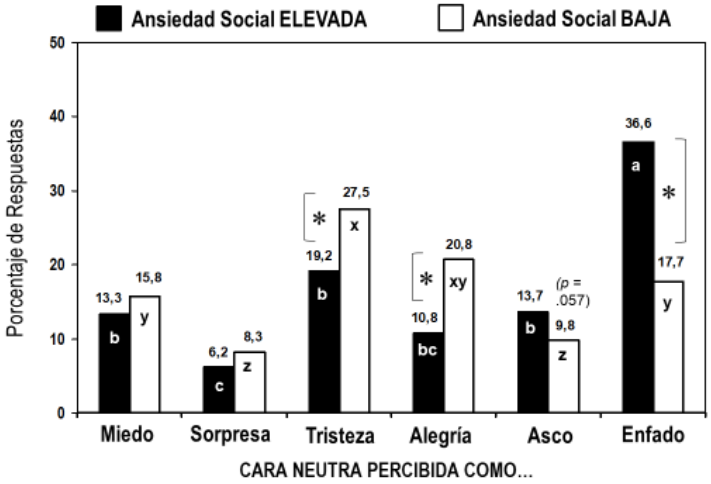

Figura 11. Probabilidad de confusión de las caras neutras como emocionales, en función de la ansiedad social, en el Experimento 1. Los asteriscos indican diferencias significativas entre los grupos de ansiedad elevada y baja. Las letras diferentes indican diferencias significativas entre distintas expresiones (letras iguales indican ausencia de diferencias).

Discusión

El hallazgo más específico reveló un sesgo interpretativo doble y consistente en los participantes con ansiedad elevada: primero, una mayor sensibilidad para reconocer las expresiones que transmiten hostilidad y rechazo, y segundo, una tendencia a juzgar las caras neutras como de enfado y asco. Así, la ansiedad social está asociada a una elevada *sensibilidad* (*A'*) para reconocer expresiones de enfado y asco, pero no para otras expresiones negativas (miedo y tristeza) o no negativas (sorpresa y alegría). Esto es

comprensible dada la naturaleza de la ansiedad social, a la que caracteriza el miedo a la evaluación negativa, que es más probable que provenga de personas que manifiesten enfado o asco, mientras que el resto de las expresiones no trasmiten amenaza directa al observador. Esta especial sensibilidad al enfado y el asco converge con otros datos previos (enfado: Bell et al., 2011; Yoon et al., 2014; asco: Heuer et al., 2010). No obstante, una novedad importante en nuestro estudio es que la facilitación en la detección del enfado y el asco ocurrieron en niveles bajos de intensidad expresiva, es decir, cuando las expresiones eran más ambiguas. En contraste, en niveles de intensidad expresiva mayor (es decir, en ausencia de ambigüedad), no encontramos diferencias en función de la ansiedad social para ningún tipo de expresión. Esto indica que las personas con ansiedad social no sufren ningún déficit en el reconocimiento de expresiones (Button et al., 2013; Jusyte y Schönenberg, 2014). En conjunto, estos datos apoyan la existencia de un sesgo interpretativo en los individuos con elevada ansiedad social que, en comparación con las personas no ansiosas, tenderían a juzgar los estímulos sociales como amenazantes cuando son ambiguos, en relación con una potencial evaluación negativa y rechazo social (Mobini et al., 2013; Morrison y Heimberg, 2013).

La tendencia a juzgar las caras "neutras" como enfado y asco por parte de los participantes con ansiedad elevada es también coherente con la hipótesis de que la ansiedad social sesga la interpretación de las expresiones ambiguas como indicadoras de hostilidad y rechazo. Las caras neutras no son como una hoja en blanco, carentes de significado, sino que generalmente poseen algún grado de tono afectivo debido a rasgos sutiles que las asemejan a las expresiones emocionales (Franklin y Zebrowitz, 2013). Así, una cara "neutra" puede parecer "seria" (lo cual la acerca a la apariencia de enfado); otra puede parecer "risueña" (lo que la asemeja a la de alegría); etc. Por consiguiente, las caras neutras son inherentemente ambiguas, y de ahí que puedan ser objeto de distintas interpretaciones (en gran medida dependiendo del contexto y también de la actitud de los observadores). Es interesante, pues, que, cuando las caras neutras fueron interpretadas como negativas, los participantes con ansiedad social elevada eligieron en mayor medida el significado amenazante (enfado y asco); en cambio, los participantes con ansiedad baja eligieron un significado (tristeza) no amenazante para el observador. Además, los participantes con ansiedad elevada optaron en menor medida por una interpretación positiva (alegría). Esto es acorde con el hallazgo de que la ansiedad social inhibe un juicio benigno de las expresiones ambiguas como alegres (Gutiérrez-García y Calvo, 2014), y con la hipótesis de que la

ansiedad social se caracteriza por una falta de evaluación positiva de estímulos moderadamente positivos (Huppert, Foa, Furr, Filip, y Mathews, 2003).

2.4.2. Experimento 2 (Objetivo 2): *Juicios de Confianza* en función de la Intensidad Expresiva.

Resultados

Juicios de confiabilidad

En el ANOVA de 2 (Ansiedad Social: Baja vs. Elevada) × 6 (Expresión Emocional: alegría, tristeza, enfado, miedo, asco, y sorpresa) × 7 (Intensidad de la Expresión: 0, 10, 20, 30, 40, 50, y 100%) sobre los *juicios* de confiabilidad (escala 1-9), los efectos principales de la ansiedad y la expresión fueron cualificados por una interacción triple. Para descomponer esta interacción llevamos a cabo ANOVAS de ansiedad por intensidad para cada expresión por separado. Las Figuras 12A a F muestran las puntuaciones y los contrastes múltiples a lo largo de los distintos niveles de intensidad de cada expresión. Para las expresiones de *sorpresa*, *miedo* y *tristeza* no se produjeron efectos estadísticamente significativos—incluyendo una ausencia de diferencias en función de la ansiedad—(Figuras 3B a D), ni tampoco para las caras neutras (nivel 0% de intensidad en todas las figuras). Para las caras de *alegría*, tampoco hubo efectos significativos de la ansiedad pero sí de la intensidad, con un incremento progresivo de la confiablidad para todos los participantes a medida que aumentaba la intensidad.

En cambio, para las expresiones de *enfado* y *asco* (Figuras 12E y F) sí hubo efectos de la ansiedad y de la intensidad, modulados por su interacción. Ésta refleja diferentes umbrales de cambio (disminución en la confiabilidad respecto a la línea base de las caras neutras) en función de la ansiedad. Así, los participantes con ansiedad social elevada tuvieron umbrales más bajos: comenzaron a detectar desconfianza en el 20% de intensidad tanto para el enfado como el asco, mientras que los de ansiedad baja no mostraron ese umbral hasta el 40% de intensidad.

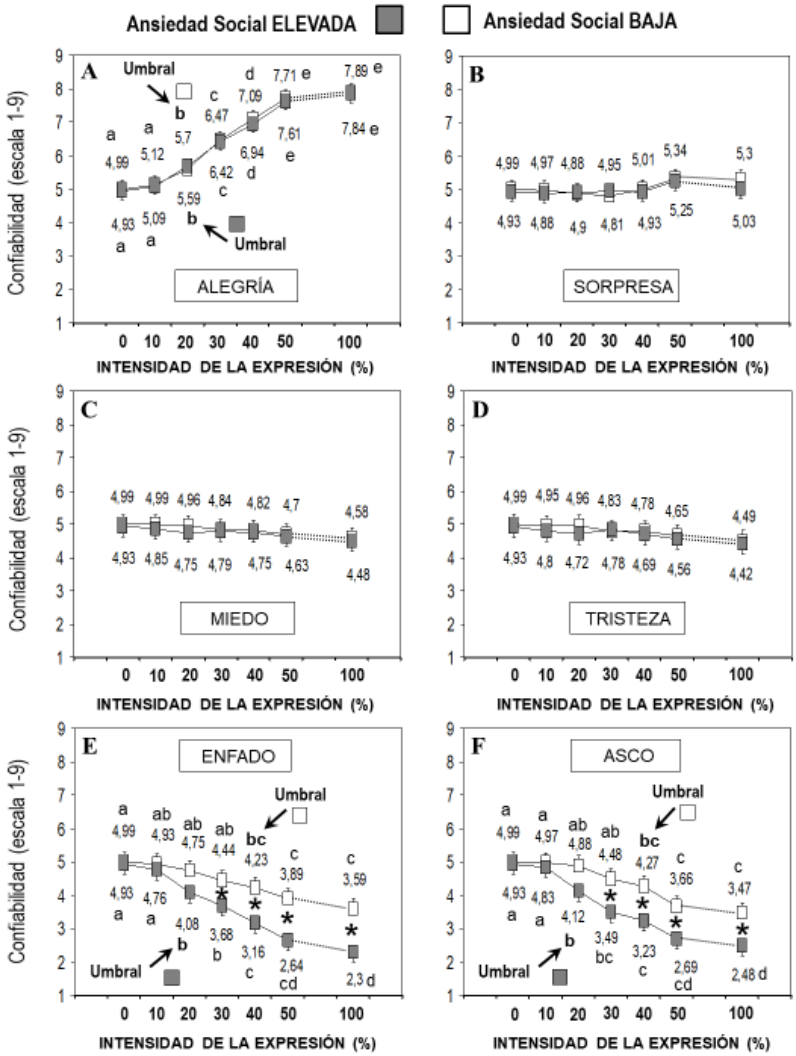

Figura 12. Juicios de confianza para cada tipo de expresiones emocionales en cada nivel de intensidad, en función de la ansiedad social, en el Experimento 2. Los asteriscos indican diferencias significativas entre los grupos de ansiedad elevada y baja. Para ambos grupos, las letras diferentes indican diferencias significativas entre niveles de intensidad (letras iguales indican ausencia de diferencias).

Discusión

El primer resultado destacable es que la ansiedad social se caracteriza por una tendencia a juzgar con especial desconfianza las caras con expresión de enfado o de asco. En cambio, los juicios de confianza/desconfianza no varían en función de la ansiedad para otras expresiones que no conllevan amenaza directa (miedo, tristeza, sorpresa, alegría o neutras). La relación entre ansiedad social y desconfianza hacia las expresiones de enfado y de asco complementa los hallazgos de la investigación previa obtenida con otras medidas. Comparadas con grupos de control sin ansiedad, las personas con fobia o con ansiedad social tienden a clasificar erróneamente las expresiones ambiguas como si fueran de enfado (Bell et al., 2011), o bien como asco o desprecio (Heuer et al., 2010). Además, la ansiedad social está asociada a una sobrestimación del "coste percibido de interacción social" con personas que expresan enfado (Button et al., 2013; Douilliez, Yzerbyt, Gilboa-Schechtman, y Philippot, 2012) o asco (Button et al., 2013; Schofield, Coles, y Gibb, 2007). Asimismo, comparadas con las personas no ansiosas, las caracterizadas por fobia social tienden a valorar a otras como más dominantes (Haker et al., 2014). En consecuencia, y dado que el enfado y el asco están ligados a una percepción de dominancia (Said et al., 2011), es posible que las personas con ansiedad social juzguen las caras de enfado y de asco como especialmente desconfiables porque perciben en ellas una dominancia exagerada.

En segundo lugar, nuestros resultados muestran que la ansiedad social está asociada a un incremento en la sensibilidad para detectar señales faciales sutiles de enfado y asco a la hora de formar impresiones de confiabilidad sobre otras personas. Esto fue evidenciado por unos umbrales de desconfianza más bajos para esas expresiones (en relación con las caras neutras) por parte de los participantes con ansiedad social elevada, en comparación con el grupo de control. Este dato es complementario del encontrado en el Experimento 1, donde los participantes con ansiedad social mostraron mayor sensibilidad para la detección del enfado y del asco. Quizá sus umbrales más bajos para la desconfianza en caras con estas expresiones se deban a su mayor sensibilidad para la detección de las propias expresiones como amenazantes.

En la introducción propusimos varias hipótesis alternativas sobre el sesgo interpretativo de desconfianza por parte de las personas con ansiedad social elevada. Según la hipótesis de la amenaza serían especialmente las expresiones que trasmiten amenaza directa las que suscitarán desconfianza por su relación con la percepción de evaluación negativa, incluso desde niveles bajos de intensidad. Los datos apoyan esta hipótesis. En cambio, las hipótesis de la negatividad, de la ambigüedad y de la positividad no han recibido

apoyo empírico. Así, las expresiones de miedo y tristeza, a pesar de ser emocionalmente negativas, no suscitan más desconfianza en los observadores con ansiedad elevada que en los de ansiedad baja; y tampoco lo hacen las expresiones ambiguas como las de sorpresa. Igualmente, las caras con expresiones positivas, como las de alegría, no generan más desconfianza por parte de las personas con ansiedad elevada, al menos cuando los ojos son alegres de modo congruente con la sonrisa. Esta comparación de hipótesis se presenta gráficamente en la Figura 13. Ahora bien, cabe la posibilidad de que las expresiones de alegría provoquen desconfianza en las personas con ansiedad social cuando la sonrisa no vaya acompañada por una expresión de alegría en los ojos. Estas caras podrían ser percibidas como desdén, arrogancia o burla y, por tanto, asociadas a evaluación negativa. Este aspecto será tratado directamente en los siguientes experimentos.

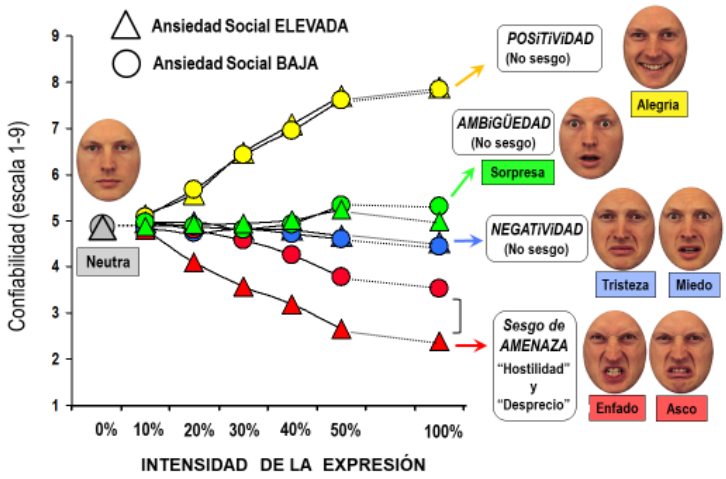

Figura 13. Apoyo a la hipótesis del sesgo de amenaza, pero no de positividad, ambigüedad o negatividad, ante expresiones con ojos y boca congruentes, en el Experimento 2.

2.4.3. Experimentos 3 y 4 (Objetivo 3): Interpretación de la *Sonrisa* Genuina y la Fingida.

Resultados del Experimento 3

Juicios de confianza y tiempos de reacción

En el ANOVA de 2 (Ansiedad Social: Baja vs. Elevada) × 8 (Expresión Emocional: véase Tabla 2) sobre los juicios de confiabilidad (escala 1-9), los efectos principales de la ansiedad y la expresión fueron cualificados por una interacción de los dos factores. La Figura 14 muestra las puntuaciones y los contrastes múltiples para cada expresión. Las puntuaciones de confiabilidad fueron más bajas en los participantes con ansiedad social elevada que con ansiedad baja en las expresiones con ojos neutros y una boca con sonrisa (bien al inicio o bien al final de la secuencia dinámica), pero las puntuaciones fueron equivalentes en ambos grupos para el resto de las expresiones. No se produjeron diferencias en los tiempos de reacción en función de la ansiedad, aunque sí en función del tipo de expresión, siendo las latencias de respuesta menores para las expresiones congruentes (ojos y boca) de alegría que para las no congruentes (ojos pero no boca alegre, o viceversa).

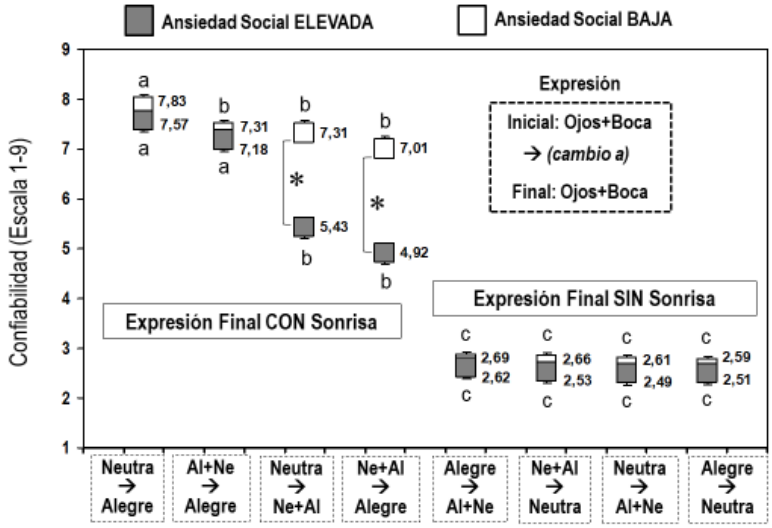

Figura 14. Juicios de confianza para cada expresión, en función de la ansiedad social, en el Experimento 3. Los asteriscos indican diferencias significativas entre los grupos de ansiedad elevada y baja. Para ambos grupos, las letras diferentes indican diferencias significativas entre expresiones (letras iguales indican ausencia de diferencias). Ne: Neutra. Al: Alegre.

Resultados del Experimento 4

Juicios de confianza y tiempos de reacción

En el ANOVA de 2 (Ansiedad Social: Baja vs. Elevada) × 8 (Expresión Emocional: véase Tabla 3) sobre los juicios de confiabilidad (escala 1-9), los efectos principales de la ansiedad y la expresión fueron cualificados por una interacción. La Figura 15 muestra las

puntuaciones y los contrastes múltiples para cada expresión. Las puntuaciones de confiabilidad fueron más bajas en los participantes con ansiedad social elevada que con ansiedad baja en todas las expresiones con ojos no congruentes (neutros, sorpresa, miedo, tristeza, asco, y enfado) con una sonrisa, pero las puntuaciones fueron equivalentes en ambos grupos para las expresiones congruentes. No se produjeron diferencias en los tiempos de reacción en función de la ansiedad, aunque sí en función del tipo de expresión, siendo las latencias de respuesta menores para las expresiones congruentes que para las no congruentes.

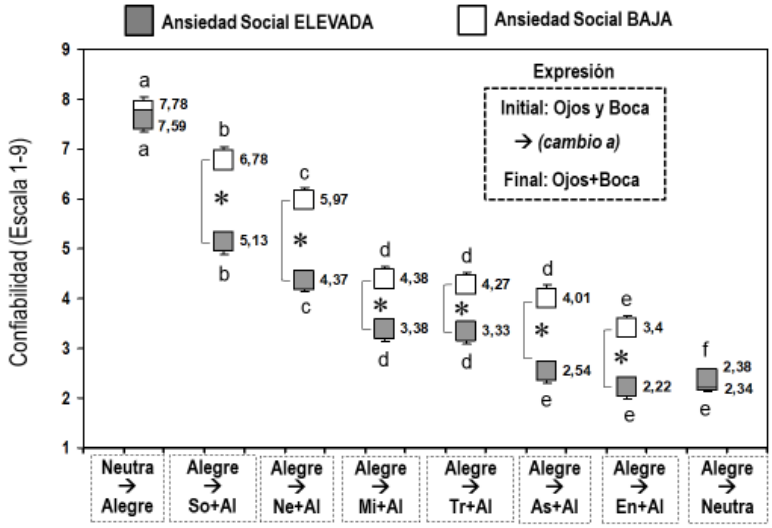

Figura 15. Juicios de confianza para cada expresión, en función de la ansiedad social, en el Experimento 4. Los asteriscos indican diferencias significativas entre los grupos de ansiedad elevada y baja. Para ambos grupos, las letras diferentes indican diferencias significativas entre expresiones (letras iguales indican ausencia de diferencias). Ne: Neutra. Al: Alegre. So: Sorpresa. Mi: Miedo. Tr: Triste. As: Asco. En: Enfado.

Discusión de los Experimentos 3 y 4

La ansiedad social conlleva una evaluación de desconfianza hacia las caras con una sonrisa si ésta se desarrolla en presencia de ojos neutros (Experimento 3), y si los ojos alegres cambian ligeramente hacia neutros, de sorpresa, miedo, tristeza, asco o enfado (Experimento 4). En contraste, la ansiedad social no afecta diferencialmente a los juicios de confiabilidad para las expresiones prototípicas de alegría o las que evolucionan de alegría a neutralidad de modo congruente. Los observadores con ansiedad baja son también sensibles a los ojos no alegres en caras con una sonrisa, pero su evaluación negativa de la confiabilidad de dichas caras se ve significativamente menos afectada.

Estos resultados tienen implicaciones relativas a la conceptualización de la ansiedad social. De acuerdo con los modelos cognitivos (Clark, 2001; Heimberg et al., 2014), la ansiedad social se caracteriza por un sesgo de interpretación negativa de los estímulos sociales ambiguos. Nuestros resultados han confirmado esto en forma de juicios de desconfianza sobre las caras ambiguas con una sonrisa no congruente con la expresión de los ojos. Una sonrisa puede ser percibida como una muestra de calidez afectiva y de aprobación, pero también de una forma menos benigna como un signo de altivez, desdén o incluso burla, que son particularmente relevantes al miedo a la evaluación negativa, desaprobación y rechazo que constituyen el sello característico de la ansiedad social. Dado que la sonrisa es ubicua en los contextos sociales y frecuentemente susceptible de distintas interpretaciones, el sesgo interpretativo de las personas con ansiedad social les pone a menudo en riesgo de aumentar sus miedos y su evitación del contacto social, en un círculo vicioso. Sin embargo, la ausencia de un sesgo interpretativo para las caras alegres genuinas (una sonrisa congruente con la expresión de los ojos) revela que la ansiedad social no está ligada a un déficit o disfunción en el reconocimiento de expresiones faciales emocionales (véase Staugaard, 2010). Esto es importante porque sugiere que la ansiedad social es esencialmente adaptativa en el reconocimiento y evaluación de la confianza de caras con una sonrisa: la ansiedad social facilita la detección de sonrisas incongruentes (posiblemente falsas o fingidas), sin perjudicar la correcta evaluación de las sonrisas genuinas. Como un mecanismo de auto-protección contra la desaprobación y el rechazo, la persona con ansiedad social manifiesta una tendencia a detectar señales faciales sutiles de desconfianza en otros individuos.

El presente estudio complementa los estudios previos sobre ansiedad social y juicios de confianza, por cuanto utilizamos expresiones faciales emocionales en lugar de caras con expresiones neutras (Cooper et al., 2014; Meconi et al., 2014; Willis et al., 2013), y también

porque empleamos expresiones dinámicas en lugar de estáticas. Nuestro planteamiento también extiende el de estudios previos a una expresión importante —debido a su ubicuidad y significado multifacético en contextos sociales—como es la sonrisa. Nuestros resultados pueden ser integrados con los obtenidos en los estudios de *coste percibido* de las interacciones sociales (Button et al., 2013; Douilliez et al., 2012; Schofield et al., 2007), dado que un coste percibido elevado en la interacción con una persona implica una reducción de confianza en esa persona. La ansiedad social está asociada a una sobrestimación del coste percibido con personas que expresan asco (Schofield et al., 2007), enfado, asco, miedo y tristeza (Button et al., 2013), o enfado y neutralidad (Douilliez et al., 2012), pero no con caras alegres (Button et al., 2013; Schofield et al., 2007). En este sentido, es interesante, primero, que en estos estudios las caras alegres no tenían ningún rasgo no alegre, lo cual es consistente con nuestros hallazgos relativos a las caras alegres prototípicas. Segundo, en dichos estudios, el coste percibido se generalizó a todas las expresiones no alegres, lo cual es también consistente con nuestros propios resultados relativos la desconfianza a todas las caras sonrientes con ojos no alegres.

2.4.4. Experimentos 5 y 6 (Objetivo 4): Patrones Espacio-temporales en la Dirección de la Mirada.

Resultados del Experimento 5

En el ANOVA de 2 (Ansiedad Social: Baja vs. Elevada) × 6 (Expresión Emocional: véase Tabla 2) sobre los *juicios de confiabilidad* (escala 1-9) y los *tiempos de reacción* en el Experimento 5 los efectos fueron equivalentes a los del Experimento 3. La Figura 16 muestra las puntuaciones y los contrastes múltiples para cada expresión. Los resultados específicos del presente experimento corresponden a las medidas de movimientos oculares y fijaciones visuales, así como la relación de la saliencia visual con la densidad de las fijaciones en cada región, que resumimos a continuación (después de la Figura 16).

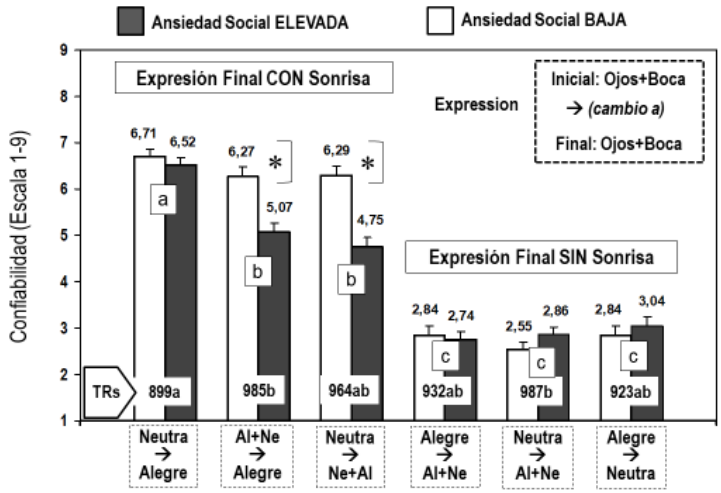

Figura 16. Juicios de confianza para cada expresión, en función de la ansiedad social, en el Experimento 5. Los asteriscos indican diferencias significativas entre los grupos de ansiedad elevada y baja. Para ambos grupos, las letras diferentes indican diferencias significativas entre expresiones (letras iguales indican ausencia de diferencias). Ne: Neutra. Al: Alegre. TRs: Tiempos de reacción (ms).

Duración de las fijaciones y momento de entrada en cada región

El ANOVA de 2 (Ansiedad Social: Baja vs. Elevada) × 6 (Expresión Emocional: véase Tabla 2) × 4 (Región: boca, nariz, ojo izquierdo, ojo derecho) × 3 (Intervalo: 0-a-500 ms [estático] vs. 501-a-1.500 ms [dinámico] vs. 1.501-a-2.000 ms [estático]) mostró interacciones estadísticamente significativas de ansiedad por región, ansiedad por intervalo por región, y una interacción cuádruple sobre la *duración total* de la *mirada*. Como se indica en la Figura 17, las comparaciones por pares señalaron que los participantes con ansiedad social elevada, comparados con los participantes con baja ansiedad, se fijaron menos tiempo en la boca en el segundo período (de 501 a 1.500 ms) y el tercer (de 1.501 a 2.000 ms) período, y se fijaron más tiempo en el ojo izquierdo (con la misma tendencia para el ojo derecho) en ambos períodos. Además, el *promedio* de *duración* de cada fijación individual fue mayor en los participantes con ansiedad elevada tanto en el ojo izquierdo como en el derecho. Finalmente, el análisis de los *tiempos de entrada* en cada región reveló que el ojo izquierdo fue mirado antes por los participantes con ansiedad social elevada que por los de ansiedad baja, mientras que ocurrió a la inversa con la boca.

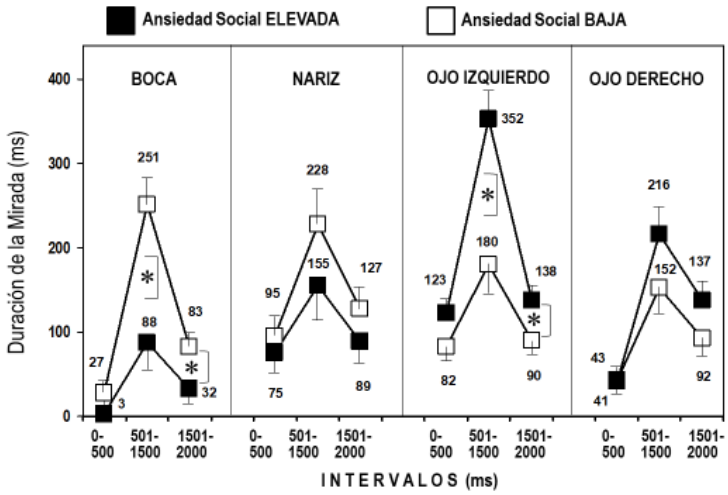

Figura 17. Duración de la mirada sobre cada región de la cara en cada período, en función de la ansiedad social, en el Experimento 5. Los asteriscos indican diferencias significativas entre los grupos de ansiedad elevada y baja. Para ambos grupos, las letras diferentes indican diferencias significativas entre expresiones (letras iguales indican ausencia de diferencias). Izquierdo y derecho se refieren a la perspectiva del observador (es decir, el campo visual).

Densidad de fijación a lo largo del período de 2 segundos

Para determinar el curso temporal de las fijaciones en cada región, llevamos a cabo un ANOVA de 2 (Ansiedad Social) × 6 (Expresión Emocional) × 4 (Región) × 60 (Intervalo: períodos consecutivos de 33 ms cada uno). Se produjeron interacciones significativas de ansiedad por región, ansiedad por expresión por región, ansiedad por región por intervalo, y una cuádruple interacción. Como se indica en la Figura 18, el *umbral de fijación* (es decir, el período más temprano en que una región recibió significativamente más fijaciones que el resto de regiones) para el *ojo izquierdo* comenzó antes en los participantes con elevada ansiedad social que en los de baja ansiedad. Además, la *amplitud* del intervalo (es decir, el número de sub-períodos consecutivos de 33 ms) con mayor densidad de fijaciones en el *ojo izquierdo* fue mayor en los participantes con elevada ansiedad social que en los de baja ansiedad. En contraste, el *umbral* de fijación para la *boca* comenzó antes para los participantes con ansiedad baja en comparación con los de ansiedad social elevada, y su *amplitud* permaneció durante más tiempo, De hecho, para los sujetos con alta ansiedad social no se produjo un umbral de fijación en la boca, dado que nunca se fijaron en esta región significativamente más que en las otras.

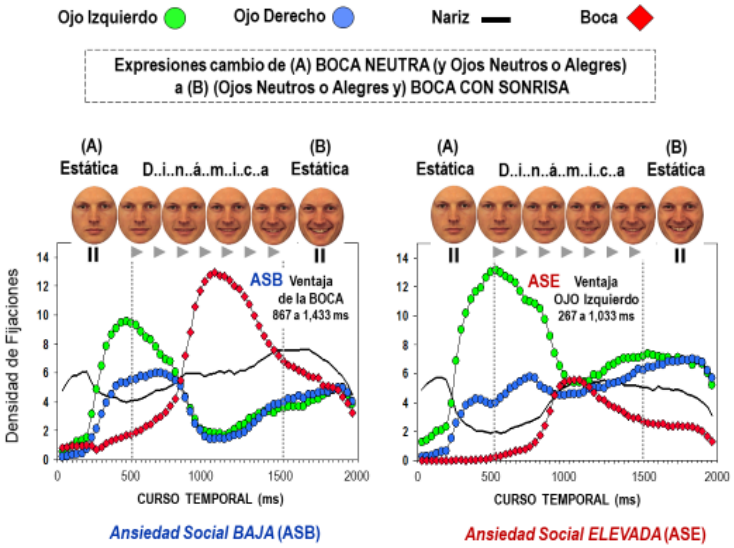

Figura 18. Densidad de fijaciones en períodos consecutivos de 33 ms a lo largo de los 2 seg. de presentación de la cara en el Experimento 5. Para cada par de números precedidos por un asterisco (ej., 867-1.433), el primer número (ej., 867) indica el *umbral* para esa región (ej., ojo izquierdo); es decir, el momento más temprano en que dicha región alcanzó una densidad de fijaciones mayor que el resto de las regiones. El rango entre el primero y el segundo (ej., 1.433) número indica la *amplitud*; es decir, hasta qué momento dicha región continuó recibiendo una densidad de fijaciones mayor que el resto. Izquierdo y derecho se refieren a la perspectiva del observador (es decir, el campo visual).

Saliencia visual

Computamos las puntuaciones diferenciales en *saliencia visual* entre el segundo período de presentación y el primero (es decir, de 501-a-1.500 ms menos de 0-a-500 ms) para cada región de las caras. Esto refleja cuánto contribuye a la saliencia el cambio dinámico expresivo. El ANOVA de 6 (Expresión) × 4 (Región) reveló una interacción significativa: en todas las expresiones que evolucionaban de una boca neutra a una sonrisa la boca fue más saliente que el resto de las regiones. En cambio, no hubo diferencias significativas entre regiones para las caras que evolucionaban hacia una boca con expresión neutra.

A continuación llevamos a cabo análisis de correlaciones de Pearson entre las puntuaciones diferenciales en saliencia visual y las puntuaciones en densidad de las fijaciones (i.e., el número de fijaciones en cada región). Como indica la Tabla 4, para las expresiones que evolucionaban hacia una sonrisa (es decir, cuando la región de la boca era

especialmente saliente), se produjeron correlaciones significativas en los participantes con ansiedad baja, pero no en los de ansiedad social elevada. En contraste, el análisis de las expresiones que terminaban en una boca neutra no deparó correlaciones significativas.

Tabla 4

Correlaciones de Pearson entre Saliencia Visual y Diferencia en la Densidad de las Fijaciones en el Período Dinámico (501-a-1,500 ms) menos el Período Estático (0-a-500 ms), para el Grupo de Ansiedad Social Elevada y el grupo de Ansiedad Baja, y Diferencias (z y p) entre los Grupos, en función de la Expresión, en el Experimento 5.

Expresión	Baja Ansiedad *r*	Elevada Ansiedad Social *r*	Fisher *z*	Diferencia Ansiedad Elevada vs. Baja *p*
Boca con *Sonrisa* Final	.72***	.29**	4.15	.0001
Neutra→Alegre	.56***	-.03 *ns*	4.52	.0001
Al+Ne→Alegre	.54***	.25*	2.38	.017
Neutra→Ne+Al	.54***	.22*	2.59	.010
Boca *Neutra* Final	-.13 *ns*	-.26*	0.92	*ns*
Alegre→Al+Ne	.01 *ns*	-.07 *ns*	0.55	*ns*
Neutra→Al+Ne	-.01 *ns*	-.11 *ns*	0.68	*ns*
Alegre→Neutra	-.05 *ns*	-.17 *ns*	0.83	*ns*

$N = 96$; *$p < .05$; **$p < .01$; ***$p < .0001$
Nota. Neutra: ojos y boca neutros. Alegre: ojos y boca alegres. Al+Ne: ojos alegres y boca neutra. Ne+Al: ojos neutros y boca alegre. → cambio dinámico en la expresión (de inicial → a final).

Discusión del Experimento 5

La ansiedad social está asociada a un sesgo atencional que conlleva atención selectiva temprana a la región de los ojos, lo que presumiblemente facilita la detección de ambigüedades o inconsistencias expresivas y lleva a juicios de desconfianza. En contraste, la mirada selectiva más temprana y más larga a la boca con una sonrisa por parte de los observadores con ansiedad baja les dificultaría apreciar esas incongruencias. Además, la atención visual de los observadores con elevada ansiedad social fue atraída por la saliencia física de la sonrisa en menor medida que la de los de ansiedad baja. Esto sugiere que la mirada de los primeros está guiada de una forma que se opone a los efectos automáticos de captura por parte de la sonrisa.

Hay controversia sobre si la ansiedad social está caracterizada por un incremento (Boll, Bartholomaeus, Peter, Lupke, y Gamer, 2016; Gutiérrez-García, Calvo, y Eysenck, 2018; Wieser, Pauli, Alpers, y Mühlberger, 2009; presente estudio) o una reducción (Horley, Williams, Gonsalvez, y Gordon, 2003; Howell, Zibulsky, Srivastav, y Weeks, 2016;

Moukheiber et al., 2010; Weeks, Howell, y Goldin, 2013) de contacto visual con la mirada de otras personas. Mogg, Bradley, de Bono, y Painter (1997) propusieron la influyente hipótesis de la vigilancia-evitación. Según ella, la ansiedad social induce una hipervigilancia temprana a señales sociales potencialmente amenazantes, aumentando la sensibilidad y la orientación atencional hacia ellas, seguida por una evitación atencional y la consiguiente reducción en el procesamiento cognitivo de tales estímulos. Existe apoyo empírico para dicha hipótesis (Garner, Mogg, y Bradley, 2006; Wieser et al., 2009), si bien la evidencia es mayor para el proceso de hipervigilancia que para el de evitación atencional (véase Armstrong y Olatunji, 2012). Si extrapolamos dicha hipótesis general, es posible que una fijación selectiva temprana en los ojos por parte de los observadores con ansiedad social elevada sea seguida por una evitación de la mirada. De este modo, las posibles inconsistencias empíricas dejarían de serlo y los datos aparentemente discrepantes relativos al contacto visual serían compatibles.

La investigación previa con la técnica de movimientos oculares no ha abordado específicamente esta hipótesis sobre el curso temporal del contacto temprano de la mirada a los ojos y la posterior evitación. No obstante, los datos existentes pueden ser considerados en relación con dicha hipótesis. Los estudios en los cuales los sujetos con ansiedad social elevada miraron más a los ojos que los no ansiosos utilizaron tiempos de presentación estimular relativamente cortos (150 o 3.000 ms: Boll et al., 2016; 2 s: Gutiérrez-García et al., 2018, y estudio actual; o 6,33 s: Wieser et al., 2009) y, por tanto, los efectos ocurrieron temprano. De modo consistente, con un acercamiento diferente utilizando medidas electrofisiológicas cerebrales (ERPs; potenciales relacionados con eventos), Felmingham, Stewart, Kemp, y Carr (2016) presentaron caras durante 1.500 ms, y también encontraron evidencias de atención cortical temprana (mayor N1, P2, y P3; entre 100 y 350 ms desde el inicio de la presentación de la cara) en los participantes con ansiedad social elevada. En contraste, los estudios de movimientos oculares que hallaron evidencias de evitación de la mirada a los ojos (Horley et al., 2003; Howell et al., 2016; Moukheiber et al., 2010; Weeks et al., 2013) utilizaron presentaciones notablemente más largas (de 10 a 12 s; o incluso una conversación en vivo de 4 minutos, en Howell et al., 2016). De este modo, es posible que las presentaciones cortas sean más sensibles a los efectos de vigilancia temprana, mientras que las más largas sean más apropiadas para medir la evitación atencional. Si es así, entonces la mirada inicial a los ojos o su evitación posterior probablemente son dependientes del tiempo de presentación del estímulo. Ambos mecanismos servirían para funciones adaptativas complementarias: una vigilancia temprana—dirigiendo la mirada a los ojos—

facilitaría la detección de amenazas; una evitación subsiguiente sería útil para impedir un excesivo temor a la evaluación.

El hallazgo adicional en nuestro estudio relativo a la saliencia visual sugiere que el sesgo atencional referido probablemente implica la activación de procesos cognitivos de arriba-abajo. La tendencia de los observadores con ansiedad social elevada a mirar temprano a los ojos—en lugar de a la boca—ocurrió incluso aunque la boca con sonrisa era más saliente visualmente que ninguna otra región de la cara. Es importante resaltar que la distribución de la mirada a la boca estaba relacionada con la saliencia visual en mayor medida en los participantes con baja ansiedad que con ansiedad social elevada. Esto sugiere que la atención de los observadores con baja ansiedad está guiada de abajo-arriba de modo automático por las propiedades físicas de las caras (es decir, capturada por la saliencia). Este efecto, por otra parte, representa el patrón oculomotor típico en los observadores "normales" (no seleccionados en función de su ansiedad (Calvo y Nummenmaa, 2008; Calvo et al., 2013). Ciertamente, la saliencia de la sonrisa está asociada con una captura atencional temprana, como lo refleja el componente de actividad cortical N1 (Calvo, Beltrán, y Fernández-Martín, 2014). En contraste, el foco atencional de los observadores con ansiedad social elevada estaría guiado más estratégicamente (presumiblemente, una búsqueda intencionada de la expresión de los ojos que pudiera revelar des/confianza), actuando así contra la captura automática de la atención ejercida por la saliencia visual de la sonrisa.

Resultados del Experimento 6

En el ANOVA de 2 (Ansiedad Social: Baja vs. Elevada) × 6 (Expresión Emocional: véase Tabla 3) sobre los *juicios de confiabilidad* (escala 1-9) y los *tiempos de reacción* en el Experimento 6 fueron equivalentes a los del Experimento 4. La Figura 19 muestra las puntuaciones y los contrastes múltiples para cada expresión. Los resultados específicos del presente experimento corresponden a las medidas de movimientos oculares y fijaciones visuales, que resumimos a continuación (después de la Figura 19).

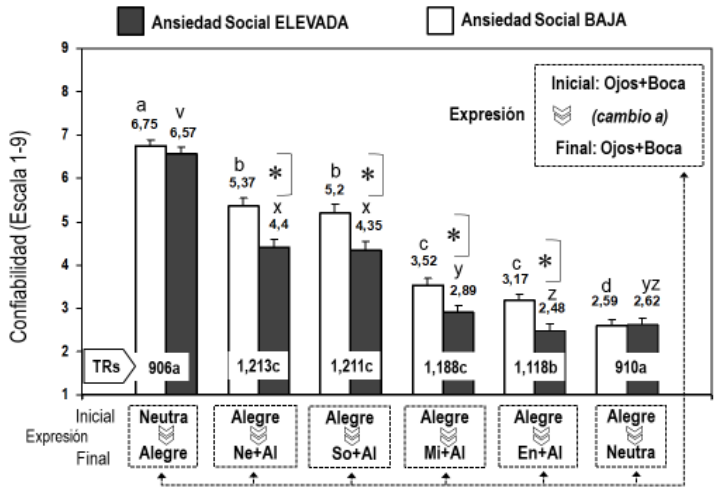

Figura 19. Juicios de confianza para cada expresión, en función de la ansiedad social, en el Experimento 6. Los asteriscos indican diferencias significativas entre los grupos de ansiedad elevada y baja. Dentro de cada grupo, letras distintas (a, b, c: ansiedad elevada; v, x, y: ansiedad baja) indican diferencias significativas entre expresiones. Ne: Neutra. Al: Alegre. So: Sorpresa. Mi: Miedo. En: Enfado. TRs: Tiempos de reacción (ms).

Duración de las fijaciones y entrada en cada región

Para las *expresiones mezcla*, el ANOVA de 2 (Ansiedad Social: Baja vs. Elevada) × 4 (Expresión Emocional) × 4 (Región: boca, nariz, ojo izquierdo, ojo derecho) × 2 (Intervalo: 0-a-1.000 ms [estático] vs. 1.000-a-2.000 ms [dinámico]) mostró una interacción significativa de ansiedad por región sobre la *duración* de la *mirada*. Como se indica en la Figura 20, las comparaciones por pares señalaron que los participantes con ansiedad social elevada se fijaron menos tiempo en la boca en ambos períodos, y se fijaron más tiempo en el ojo izquierdo en ambos períodos, comparados con los participantes con baja ansiedad. Además, el análisis de los tiempos de entrada en cada región reveló que el ojo izquierdo fue mirado antes por los participantes con ansiedad social elevada que por los de ansiedad baja, mientras que no hubo diferencias en función de la ansiedad para las otras regiones.

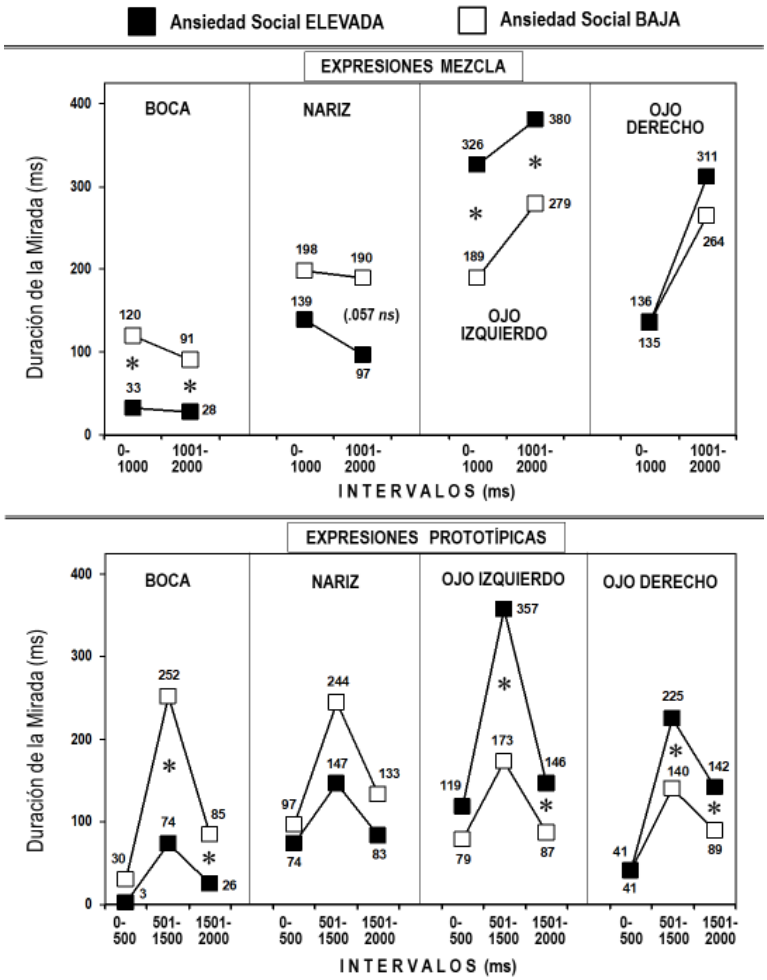

Figura 20. Duración de la mirada sobre cada región de la cara en cada período, en función de la ansiedad social, en el Experimento 6. Los asteriscos indican diferencias significativas entre los grupos de ansiedad elevada y baja. Izquierdo y derecho se refieren a la perspectiva del observador (es decir, el campo visual).

Para las *expresiones prototípicas*, el ANOVA de 2 (Ansiedad Social) × 2 (Expresión Emocional) × 4 (Región) × 3 (Intervalo: 0-a-500 ms [estático] vs. 501-a-1.500 ms [dinámico] vs. 1.501-a-2.000 ms [estático]) mostró una interacción significativa de ansiedad por intervalo por región sobre la *duración* de la *mirada*. Como se indica en la Figura 20, las comparaciones por pares señalaron que los participantes con ansiedad social elevada se fijaron menos tiempo en la boca y se fijaron más tiempo en ambos ojos, tanto en el segundo

como el tercer período (pero no el primero), comparados con los participantes con baja ansiedad. El análisis de los tiempos de entrada en cada región reveló que el ojo izquierdo fue mirado antes por los participantes con ansiedad social elevada que por los de ansiedad baja, mientras ocurrió a la inversa con la boca.

Densidad de fijación a lo largo del período de 2 segundos

Para determinar el curso temporal de las fijaciones en cada región, llevamos a cabo un ANOVA de 2 (Ansiedad Social) × 2 o 4 (Expresión Emocional; mezcla o prototípicas) × 4 (Región) × 60 (Intervalo: períodos consecutivos de 33 ms cada uno). Para las expresiones *mezcla* se produjeron interacciones significativas de ansiedad por región, y ansiedad por región por intervalo. Como se indica en la Figura 21, el *umbral de fijación* (es decir, el período más temprano en que una región recibió significativamente más fijaciones que el resto de regiones) para el *ojo izquierdo* comenzó antes en los participantes con ansiedad social elevada que en los de ansiedad baja. Además, la *amplitud* del intervalo (es decir, el número de sub-períodos consecutivos de 33 ms) con mayor densidad de fijaciones en el *ojo izquierdo* fue mayor en los participantes con ansiedad social elevada que en los de ansiedad baja.

Para las expresiones *prototípicas* también se produjeron interacciones significativas de ansiedad por región, y ansiedad por región por intervalo. Como se indica en la Figura 21, el *umbral de fijación* para el *ojo izquierdo* comenzó antes y la *amplitud* del intervalo con mayor densidad de fijaciones en el *ojo izquierdo* fue mayor en los participantes con ansiedad social elevada que en los de ansiedad baja. En contraste, para la *boca*, el umbral de fijación comenzó antes y su amplitud temporal fue mayor en los participantes con ansiedad baja que en los de ansiedad social elevada.

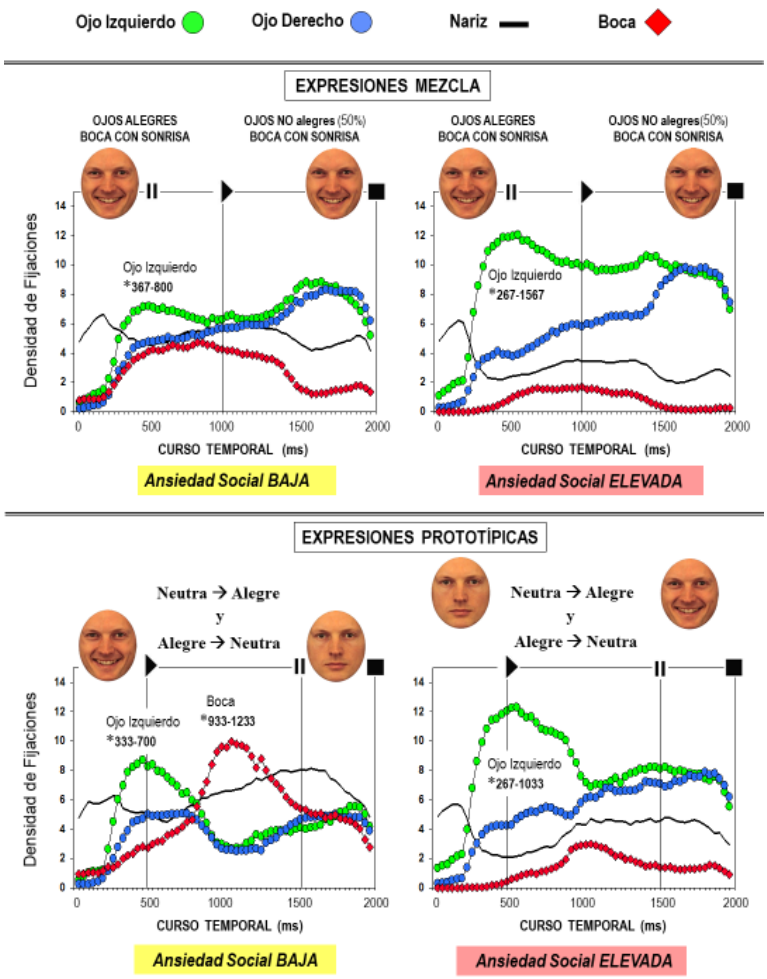

Figura 21. Densidad de fijaciones en períodos consecutivos de 33 ms a lo largo de los 2 seg. de presentación de la cara, para las expresiones mezcla (promedio) y las prototípicas (promedio), en el Experimento 6. Para cada par de números precedidos por un asterisco (ej., 367-800), el primer número (ej., 367) indica el *umbral* para esa región (ej., ojo izquierdo); es decir, el momento más temprano en que dicha región alcanzó una densidad de fijaciones mayor que el resto de las regiones. El rango entre el primero y el segundo (ej., 800) número indica la *amplitud*; es decir, hasta qué momento dicha región continuó recibiendo una densidad de fijaciones mayor que el resto. Izquierdo y derecho se refieren a la perspectiva del observador (es decir, el campo visual).

Discusión del Experimento 6

Los participantes con ansiedad social, en comparación con los participantes sin ansiedad, juzgaron las expresiones mezcla con sonrisas incongruentes como menos confiables, en ausencia de diferencias para las caras con expresiones congruentes. Además, tanto para las expresiones ambiguas como para las congruentes, los participantes con ansiedad social miraron más temprano y más tiempo a los ojos, mientras que los participantes sin ansiedad miraron más temprano y más tiempo a la boca. El sesgo atencional de los observadores con ansiedad social facilita la detección de incongruencias, y así lleva a percibir desconfianza, no teniendo efectos sobre los juicios de confianza cuando no hay incongruencias.

Presumiblemente, el sesgo interpretativo en las personas con ansiedad social (es decir, la tendencia a desconfiar de las caras sonrientes con una expresión no alegre en los ojos) es debido a un sesgo atencional (es decir, la asignación selectiva temprana de atención visual a la región de los ojos). En las caras sonrientes ambiguas la incongruencia probablemente depende sobre todo de los ojos (McLellan et al., 2010; Niedenthal et al., 2010). En consecuencia, los observadores que atienden preferentemente a los ojos tienen ventaja para detectar cualquier incongruencia, y así desconfiar del emisor. En la medida en que la expresión de los ojos es relevante para el procesamiento afectivo (Calvo et al., 2012; Johnston, Miles, y Macrae, 2010) y puede trasmitir información sobre los motivos e intenciones del emisor, la atención a esta región debe ser importante para evaluar la confiabilidad. En contraste, como hemos comprobado en el Experimento 5, los observadores con ansiedad baja miran preferentemente a la boca porque su atención se vería automáticamente atraída por la saliencia perceptiva de ésta. Como resultado, estas personas procesarían en menor medida la incongruencia entre ojos y boca y basarían sus juicios de confianza principalmente en la propia sonrisa de modo relativamente independiente de los ojos.

Finalmente, tanto en el Experimento 5 como en el 6 observamos un efecto sistemático del campo visual, con mayor fijación en el ojo del campo visual izquierdo del observador (por tanto, el lado derecho de la cara del sujeto observado) que en el ojo del campo visual derecho (es decir, el lado derecho de la cara del sujeto observado). Todos los participantes (ansiedad social elevada y baja) miraron más temprano y durante más tiempo al lado izquierdo que al derecho. Este efecto no interactuó con la ansiedad y, por tanto, no constituye un hallazgo específico del presente trabajo. Sin embargo, como efecto genérico es totalmente consistente con la tendencia natural de los observadores a orientar inicialmente la mirada de

modo preferente hacia la izquierda, lo cual sucede con distintos tipos de estímulos y en tareas donde la mirada puede dirigirse libremente (Guo, Smith, Powell, y Nicholls, 2012; Peterson y Eckstein, 2012; Schurgin et al., 2014; Xiao, Quinn, Wheeler, Pascalis, y Lee, 2014). Este fenómeno valida nuestro paradigma experimental para el resto de los efectos referidos a los que sí contribuye la ansiedad social.

2.5. Conclusiones

Ansiedad Social y *Reconocimiento de Expresiones* Faciales Emocionales (Objetivo 1)

La ansiedad social se caracteriza por una elevada sensibilidad (*A'*) en la percepción de enfado y asco en niveles bajos de intensidad expresiva (es decir, con alta ambigüedad). En contraste, la ansiedad social no afecta diferencialmente a la percepción de otras expresiones (miedo, tristeza, sorpresa, y alegría), o a las de enfado y asco en intensidades elevadas. Tales efectos sobre la sensibilidad son selectivos para algunas expresiones (pero no para todas las negativas). Este hecho, junto con el dato de que la ansiedad social no influya sobre el criterio de respuesta (*B*"), sugiere que los efectos mencionados involucran procesos cognitivos (de interpretación del significado de las expresiones) durante la codificación, y que no reflejan meramente procesos de decisión o sesgos de respuesta.

Ansiedad Social y *Juicios de Confianza* en función de la Intensidad Expresiva (Objetivo 2)

La ansiedad social se distingue por un incremento de la desconfianza hacia las caras con expresiones de enfado y de asco, desde niveles bajos de intensidad. En cambio, no se producen efectos de desconfianza hacia las caras con otras expresiones (miedo, tristeza, sorpresa, alegres, o neutras) cuando éstas tienen ojos y boca congruentes. Las personas con ansiedad social elevada perciben amenaza social a partir de señales faciales de intensidad expresiva menores que las personas con ansiedad baja. La mayor sensibilidad para ese tipo de señales les lleva a los observadores con ansiedad social a desconfiar especialmente de otras personas cuando éstas expresan hostilidad o rechazo en forma de enfado o asco.

Ansiedad Social y *Discriminación de la Sonrisa* Genuina y la Fingida (Objetivo 3)

La ansiedad social se caracteriza por una acentuada percepción de desconfianza hacia las caras en las que se desarrolla una sonrisa a partir de una expresión neutra, si los ojos

permanecen neutros; y desconfianza hacia las caras en las que la sonrisa se mantiene pero los ojos cambian levemente de alegres a neutros, de sorpresa, miedo, tristeza, asco, o enfado. En contraste, la ansiedad social no está relacionada con percepción de desconfianza hacia las caras con una sonrisa si esta evoluciona a la vez que unos ojos alegres congruentes. De este modo, las personas con ansiedad social elevada muestran una especial desconfianza hacia cualquier tipo de sonrisa ambigua (en presencia de ojos no alegres). Las personas con ansiedad baja también son sensibles a las sonrisas ambiguas, pero el efecto de desconfianza es significativamente menor.

Ansiedad Social y Patrones Espacio-temporales en la *Dirección de la Mirada* (Objetivo 4)

La tendencia de las personas con ansiedad social a desconfiar de quienes muestran una sonrisa ambigua (no congruente con la expresión de los ojos) está asociada a un sesgo atencional en la dirección de la mirada. Las personas con ansiedad social miran selectivamente, de modo temprano y más tiempo a la región de los ojos, en comparación con las personas con ansiedad baja, que miran selectivamente a la boca sonriente. La mirada selectiva a los ojos permite a los primeros detectar incongruencias expresivas con la sonrisa, lo cual daría cuenta de su mayor desconfianza hacia las personas con esas expresiones. El sesgo atencional en la dirección de la mirada podría explicar así el sesgo interpretativo de desconfianza. El sesgo atencional en las personas con ansiedad social está, presumiblemente, guiado de modo estratégico (oponiéndose a la captura automática por parte de la saliencia perceptiva de la sonrisa). Esto se infiere de una correlación significativamente menor entre saliencia visual de la sonrisa y densidad de las fijaciones en los observadores con ansiedad social elevada que en los de ansiedad baja.

Implicaciones Teóricas y Prácticas

Los sesgos atencional (mirada selectiva) e interpretativo (juicios de desconfianza) que hemos identificado en la ansiedad social son adaptativos, en cuanto facilitan la detección de sonrisas fingidas o falsas, indicadoras de una posible evaluación negativa (desdén, burla, arrogancia, rechazo, etc.). Este beneficio ocurre sin aparente coste, dado que los juicios de confianza hacia las caras con sonrisa genuina (congruente con ojos alegres) no se ven afectados por la ansiedad social. De cara a la conceptualización de la ansiedad social, estos sesgos pueden ser entendidos como un mecanismo útil de afrontamiento. Servirían para que el observador con ansiedad social detecte de modo temprano a aquellos individuos en su

entorno que más probablemente efectuarán una evaluación negativa, lo cual constituye el mayor temor de las personas con ansiedad social. En consecuencia, los posibles tratamientos terapéuticos de la ansiedad social deben afinar los ajustes de dicho mecanismo para impedir una hipervigilancia o una evitación social generalizadas por parte de la persona con ansiedad social, pero no eliminar dicho mecanismo.

Extensiones metodológicas

En el presente conjunto de experimentos utilizamos caras con expresiones dinámicas mediante video-clips animados. Este tipo de estímulos se han revelado válidos en la investigación previa con medidas cognitivas (v.g., Calvo, Avero, Fernández-Martín, y Recio, 2016) y neurofisiológicas (v.g., Johnston, Mayes, Hughes, y Young, 2013). No obstante, tales estímulos no implican una interacción con los observadores. Por ejemplo, los emisores (es decir, las personas observadas) no proporcionan ninguna retroalimentación y no plantean ninguna amenaza real—no hay evaluación negativa—hacia los observadores. La investigación de los sesgos cognitivos en la ansiedad social podría ser extendida de modo fructífero mediante el registro de la mirada durante una interacción simulada (con una audiencia pregrabada; Lin, Hofmann, Qian, Kind, y Yu, 2016) o, mejor aún, directamente durante una interacción en vivo (Howell et al., 2016). La complejidad de dichas situaciones, no obstante, supone un reto importante para el diseño experimental, dado que se requiere un control riguroso de las propiedades estimulares que pueden influir en la mirada.

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4. ANEXOS

De acuerdo con el Reglamento de Enseñanzas Oficiales de Doctorado de la Universidad de La Laguna sobre la Modalidad de Tesis Doctoral por Compendio de Publicaciones (Artículo 29, epígrafe b; BOULL Año II núm. 14, 28 de julio de 2017), la presentación de una tesis bajo esta modalidad debe incluir:

> *(b) Entre la introducción y el resumen mencionados, o bien como anexos, deberá figurar una copia completa de los trabajos donde consten necesariamente los datos personales de todos los autores y las autoras, así como la referencia completa de la revista en la que los trabajos han sido publicados o, en su caso, la carta de aceptación.*

Como anexos, presentamos a continuación una copia completa de cada trabajo publicado o en curso de publicación, derivados de la investigación realizada para esta tesis doctoral.

4.1. ANEXO I

- Gutiérrez-García, A., & Calvo, M.G. (2017). Social anxiety and threat-related interpretation of dynamic facial expressions: Sensitivity and response bias *Personality and Individual Differences, 107*, 10-16.

4.2. ANEXO II

- Gutiérrez-García, A., & Calvo, M.G. (2016a). Social anxiety and trustworthiness judgments of dynamic facial expressions of emotion. *Journal of Behavior Therapy and Experimental Psychiatry, 52*, 119-127.

4.3. ANEXO III

- Gutiérrez-García, A., & Calvo, M.G. (2016b). Social anxiety and perception of (un)trustworthiness in smiling faces. *Psychiatry Research, 244*, 28-36.

4.4. ANEXO IV

- Gutiérrez-García, A., Calvo, M.G., & Eysenck, M.W. (2018). Social anxiety and detection of facial untrustworthiness: Spatio-temporal oculomotor profiles. *Psychiatry Research, 262*, 55-62.

4.5. ANEXO V

- Gutiérrez-García, A., Eysenck, M. W., & Calvo, M. G. (enviada revisión). Social anxiety and coping with fear of negative evaluation: An eye-tracking study. *Anxiety, Stress, and Coping*.

ANEXO I

Gutiérrez-García, A., & Calvo, M. G. (2017). Social anxiety and threat-related interpretation of dynamic facial expressions: Sensitivity and response bias *Personality and Individual Differences, 107,* 10-16.

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Social anxiety and threat-related interpretation of dynamic facial expressions: Sensitivity and response bias

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ABSTRACT

Facial expressions can convey disapproval or rejection, which is highly relevant information for socially anxious observers. We investigated how social anxiety biases the interpretation of ambiguous expressions towards threat. Undergraduates with clinical levels of social anxiety and non-anxious controls were presented with 1-s video-clips displaying facial happiness, anger, fear, sadness, disgust, and surprise, at various levels of emotional intensity, or neutral expressions. Participants categorized the expressions. Social anxiety was associated with enhanced detection of anger and disgust at low intensity levels, relative to non-anxious controls. Also, social anxiety was related to a higher probability of interpreting emotionally "neutral" faces as angry. *A′* sensitivity was affected, with no effects on *B″* response criterion. Socially anxious individuals are likely to perceive hostility, disapproval, or dislike in ambiguous facial expressions (with low intensity signals of anger/disgust, or "neutrality"). The effect involves an interpretative bias that occurs during expression encoding and is not contaminated by response biases.

1. Introduction

The core feature of social anxiety and social phobia is a persistent and excessive fear of being evaluated by other people, and the avoidance of situations involving scrutiny and possible negative evaluation (American Psychiatric Association, 2013). Such symptoms have been attributed to biased threat-related interpretations of ambiguous social cues (Heimberg, Brozovich, & Rapee, 2014; Hofmann, 2007). Socially anxious individuals would be prone to judge social stimuli as threatening, which would maintain and increase social fear and avoidance. There is indeed evidence that descriptions of ambiguous social scenarios are interpreted by socially anxious individuals in a more negative, or a less positive, manner than by non-anxious ones (see Mobini, Reynolds, & Mackintosh, 2013; Morrison & Heimberg, 2013).

In social interaction, facial expressions are a major source of information about the feelings and intentions of other people, such as the liking and approval expressed by happy faces or the hostility and disapproval of angry faces. Accordingly, given the nature of social anxiety, and that facial expressions in social settings are frequently ambiguous (Calvo, Gutiérrez-García, Fernández-Martín, & Nummenmaa, 2014; Krumhuber & Scherer, 2011), we can predict—and aim to investigate—that (a) social anxiety will bias interpretative processes by facilitating the recognition of threat-related expressions that convey hostility and rejection, i.e., anger and disgust, (b) differences between socially anxious and non-anxious individuals will appear especially for low expressive intensities, when expressions become more ambiguous, and (c) social anxiety will be related to a higher probability of threat-related interpretations of "neutral" (not explicitly emotional) faces.

Prior research has, however, yielded inconsistent findings (see Morrison & Heimberg, 2013; Staugaard, 2010). Social anxiety is not generally associated with explicit recognition performance in/accuracy for basic and prototypical expressions (e.g., anger, sadness, etc.), and there is only limited evidence that socially anxious individuals tend to interpret ambiguous—morphed or blended—expressions in a more negative way (as angry: Bell et al., 2011; Yoon, Yang, Chong, & Oh, 2014; or contemptuous: Heuer, Lange, Isaac, Rinck, & Becker, 2010) or in a less benign fashion (as less happy: Gutiérrez-García & Calvo, 2014), relative to non-anxious individuals. But, even for ambiguous expressions, there have been failures to find any difference as a function of social anxiety (Button, Lewis, Penton-Voak, & Munafò, 2013) and social phobia (Jusyte & Schönenberg, 2014).

We aim to extend prior research by increasing the ecological validity of stimuli and sensitivity of measures. First, in most prior studies, photographic faces with static expressions were presented. Yet, facial behavior in daily life is typically dynamic. Two studies have used a task that approximates the dynamic nature of facial expressions in the real world, by displaying morphed faces that unfolded gradually from neutral to full emotion. Joormann and Gotlib (2006) reported that

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individuals with social phobia needed less expression unfolding to identify anger than depressed or healthy controls did. Heuer et al. (2010) found that socially anxious individuals misinterpreted disgust as contempt (an emotion related to social rejection). Dynamic displays may thus be appropriate for investigating interpretative bias. In line with this approach, we used dynamic morphing, but tried to mimic natural movement more closely (see Hoffmann, Traue, Bachmayr, & Kessler, 2010). Instead of morphing a face from neutral to emotional at a rate of 500 ms (Joormann & Gotlib, 2006) or 1 s (Heuer et al., 2010) per frame, we used a 30-frame per s unfolding rate.

Second, in prior studies, recognition performance was generally measured only in terms of "correct" responses. Instead, two recent studies (Langner, Becker, Rinck, & van Knippenberg, 2015; Yoon et al., 2014) applied Signal Detection Theory (SDT) to obtain discrimination measures, and separate perceptual sensitivity from response criterion. This serves to determine whether anxious individuals are better at detecting threat in truly threat-related expressions (high sensitivity to anger), or they are simply more likely to respond that all faces look threatening, regardless of the actual emotion (a more lenient response criterion for anger). Yoon et al. (2014) reported that social anxiety was related to both greater sensitivity to mild angry expressions and a response bias towards labelling other expressions as angry, but Langner et al. (2015) found no effects, thus results were discrepant. It must, nevertheless, be noted that a limited number of expressions were investigated (neutral, angry, and happy: Yoon et al., 2014; or neutral and angry: Langner et al., 2015), which were presented in static format. We extended this approach by applying SDT measures to all six basic emotions (angry, fearful, sad, disgusted, surprised, and fearful) in dynamic format.

Given that dynamic (relative to static) displays are beneficial for facial affect identification particularly for subtle expressions (Krumhuber, Kappas, & Manstead, 2013), we reduced their intensity (see Bell et al., 2011; Button et al., 2013). In addition to the 0% neutral face baseline, we generated dynamic morphs of facial emotions with intensities of 25%, 50%, and 75% (relative to each 100% full-blown emotion). In a categorization task, 1-s video-clips were presented, and participants selected one of six response options (the six basic emotions). In addition to hits and false alarms, indices of A' sensitivity and B'' response criterion were computed, as well as type of emotional confusions from neutral faces. If there is a threat-related interpretative bias in social anxiety during expression encoding, social anxiety should be associated with (a) high A' scores for expressions conveying hostility and rejection, i.e., anger and disgust, (b) low recognition thresholds, i.e., at low expressive intensities, and (c) a high probability of confusions of neutral faces as angry or disgusted. If the tendency to endorse negative interpretations occurs for all expressions or the B'' criterion is affected, then a response—rather than a genuine encoding—bias will be involved.

2. Methods

2.1. Participants and social anxiety measures

Forty-eight psychology undergraduates (mean age: 21.6 years; range: 19–25) took part in the experiment after informed consent. They were selected from a pool of 213 students on the basis of their convergent high or low scores on the Social Interaction Anxiety Scale (SIAS) and the Social Phobia Scale (SPS; Mattick & Clarke, 1998; see Gomez, 2016, for short forms of these scales). The used Spanish versions have been validated in large undergraduate samples (Olivares, García-López, & Hidalgo, 2001). Each questionnaire is a 20-item measure with a Likert-type scale ranging from 0 (not at all characteristic of me) to 4 (extremely characteristic). Sample items: "I have difficulty making eye-contact with others" (SIAS); or "I can get tense when I speak in front of other people" (SPS). These scales were administered in various classrooms to groups of students, with anonymous codes.

Twenty-four participants (16 female) with the highest (SIAS: $M = 47.79$; $SD = 8.56$; SPS: $M = 33.54$; $SD = 6.65$) scores, and another 24 (16 female) with the lowest scores (SIAS: $M = 13.67$; $SD = 3.41$; SPS: $M = 10.83$; $SD = 3.07$), were selected for the experiment. For the social anxiety group, we used the following clinical cut-off scores: ≥34 on the SIAS and ≥24 on the SPS (see Brown et al., 1997; Jusyte & Schönenberg, 2014; Weeks et al., 2005). The anxious and the non-anxious groups had the same female/male proportion and age. The study was approved by the local ethics committee and was conducted in accordance with the Declaration of Helsinki.

2.2. Facial expression stimuli

We used 1-s video-clips as stimuli (see Supplemental materials). To build them, we first selected digitized color photographs of prototypical neutral, happy, angry, fearful, sad, disgusted, and surprised faces of 24 posers (12 females; 12 males) from the Karolinska Directed Emotional Faces database (KDEF; Lundqvist, Flykt, & Öhman, 1998; Calvo & Lundqvist, 2008).

Second, these face stimuli were subjected to morphing by means of FantaMorph© software (Abrosoft). For each expression of each poser, we created a sequence of 100 frames progressively increasing emotional intensity, based on two images: a neutral face as the first frame, and a full-blown emotional face (happy, etc.) as the final frame. We then selected frames no. 1 (neutral), 25, 50, and 75, which represented, respectively, the 0, 25, 50, and 75% intensities. The full-blown, 100% intensity level was not used because prior research has generally shown no recognition differences as a function of social anxiety for prototypical expressions (Staugaard, 2010). Fig. 1 shows examples of the different intensity levels.

Third, dynamic versions of these expressions were created with FantaMorph©. Video-clips involved a smooth continuum between the neutral and each emotional expression at 30 frames per second. Facial expressions unfolded until the corresponding maximal target intensity (i.e., 25, 50, or 75%). The unfolding sequence developed for 900 ms after stimulus onset, and the last frame was frozen for 100 ms. This morphing rate was used to simulate natural average unfolding speed of emotional facial expressions (Hoffmann et al., 2010). In the 0% intensity condition, a still image of a neutral face was displayed for 1 s.

2.3. Procedure

Each participant was presented with 144 video-clips of emotional expressions (24 models × 6 emotions × 1 intensity level for each emotion) plus 24 photographs of neutral expressions (i.e., the 0% intensity condition). To avoid habituation, a participant was presented with each poser only once displaying each of the six emotions, each time with a different intensity. The face stimuli were shown on a computer screen in three blocks, by means of E-Prime 2.0. Trial order was randomized. Participants were asked to indicate which emotion was displayed on each trial by pressing one key out of six. The six basic emotional expressions were explicitly identified in advance. Participants were informed that some faces displayed low-intensity emotions, but not that some of them were neutral. This way, we forced observers to detect subtle expressions—which was particularly relevant for the low-intensity and the neutral conditions—and thus bias their interpretation.

The sequence of events on each trial is shown in Fig. 2. After an initial 500-ms fixation cross, a photograph of a neutral expression appeared for 1 s or a video-clip unfolded for 900 ms plus a 100-ms still final frame. The face subtended 10.5 (height) × 8.0 (width) cm. Following the face offset, there was a 300-ms blank interval before a response screen appeared, with six boxes shown horizontally. Each box was associated to a number and a verbal label (e.g., 4: disgust; 5: happiness, etc.). The assignment of emotions to numbers/locations was counterbalanced

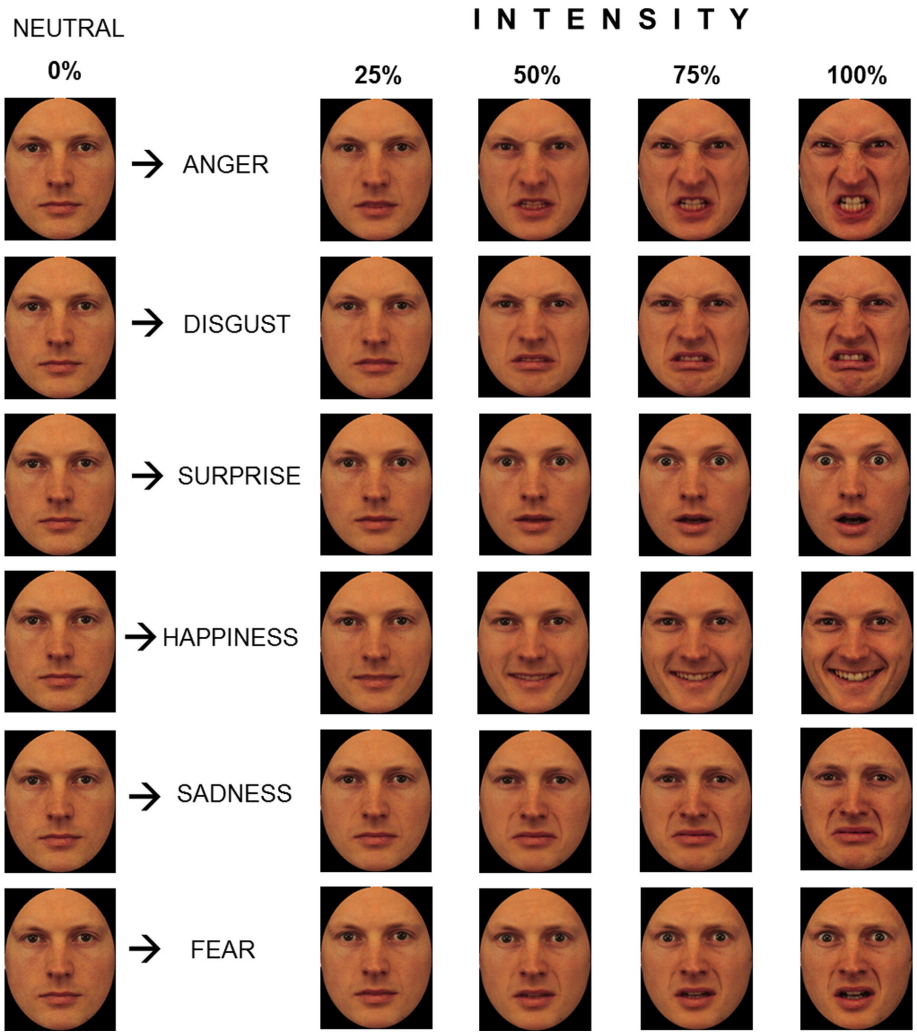


Fig. 1. Types of expressions and levels of intensity (the 100% intensity condition was not used, but is shown here for comparison).

across participants. The upper row of keys in a standard computer keyboard was used for responding.

2.4. Experimental design and dependent variables

The experiment involved a mixed factorial design with a between-subjects factor (social anxiety: low vs. high) and two within-subjects factors (expression: happy, surprised, fearful, sad, disgusted, and angry; and intensity: 25 vs. 50 vs. 75%), orthogonally combined.

We assessed (a) the probability of hits, i.e., responses that coincided with the displayed expression (e.g., responding "happy" when the face stimulus was intended to convey happiness), (b) false alarm rates (e.g., responding "happy" when the face stimulus conveyed sadness, fear, etc.), (c) sensitivity or discrimination, by computing the non-parametric A' index (which varies from low to high sensitivity in a 0–1 scale, where 0.5 represents the chance level; see Gardiner, Ramponi, & Richardson-Klavehn, 2002), (d) response bias or criterion, by computing the non-parametric B'' index (which varies from −1.0 to 1.0, where a positive value indicates a strict criterion and a negative value reflects a lenient criterion; see Gardiner et al., 2002)[1], (e) reaction times, and (f) type of confusions of neutral expressions, i.e. the probability that a neutral face was judged as each of the six emotional expressions. We intentionally excluded the possibility of responding "Neutral" to force selective confusions. This allowed us to examine interpretative biases; particularly, whether socially anxious, relative to non-anxious participants, were likely to judge neutral faces as angry.

[1] These SDT indices (A' and B'') measure the observers' ability to identify each emotion as different from the others (sensitivity), and the tendency to generalize a particular response label for categorizing any given expression (response bias).

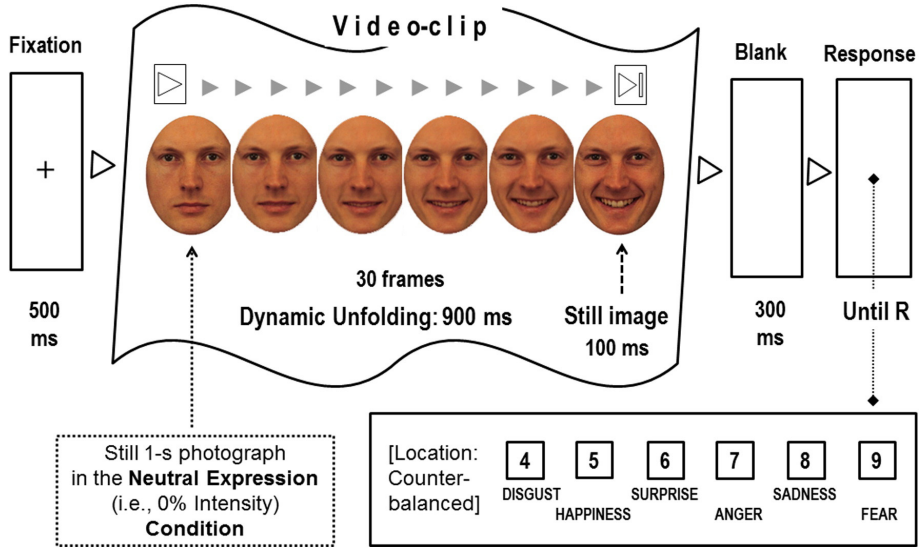


Fig. 2. Sequence of events on an experimental trial.

3. Results

3.1. Hits, false alarms, A′ sensitivity, B″ criterion, and reaction times

A 2 (social anxiety) × 6 (emotional expression) × 3 (expressive intensity) ANOVA was conducted, with Bonferroni corrections ($p < 0.05$) for a posteriori multiple contrasts involving the expression and intensity factors. With our sample size ($n = 48$) we had 0.80 power to detect an effect of $f = 0.31$ ($d = 0.62$) at $\alpha = 0.05$.

Main effects of expression and intensity (but not of anxiety; $Fs < 1$, $ps > 0.50$) emerged for (a) hit rate, $F(5, 230) = 58.90$, $p < 0.0001$, $\eta_p^2 = 0.56$ (expression), $F(2, 92) = 202.42$, $p < 0.0001$, $\eta_p^2 = 0.82$ (intensity), (b) false alarms (FAs), $F(5, 230) = 14.16$, $p < 0.0001$, $\eta_p^2 = 0.24$ (expression), $F(2, 92) = 124.05$, $p < 0.0001$, $\eta_p^2 = 0.73$ (intensity), (c) A' sensitivity, $F(5, 230) = 41.21$, $p < 0.0001$, $\eta_p^2 = 0.47$ (expression), $F(2, 92) = 198.94$, $p < 0.0001$, $\eta_p^2 = 0.81$ (intensity), and (d) B'' criterion, $F(5, 230) = 14.37$, $p < 0.0001$, $\eta_p^2 = 0.24$ (expression), $F(2, 92) = 21.34$, $p < 0.0001$, $\eta_p^2 = 0.32$ (intensity). Generally, hits and A' scores increased, FAs decreased, and B'' criterion became more liberal, with increasing expressive intensity (25 vs. 50 vs. 75%: hits = 0.443 vs. 0.675 vs. 0.803; FAs = 0.451 vs. 0.339 vs. 0.195; A' = 0.386 vs. 0.692 vs. 0.857; B'' = 0.113 vs. −0.039 vs. −0.091). Also, happy expressions were associated with more hits, higher A' scores, and fewer false alarms, than the rest, while fearful expressions were associated with the lowest A' scores (see Table 1).

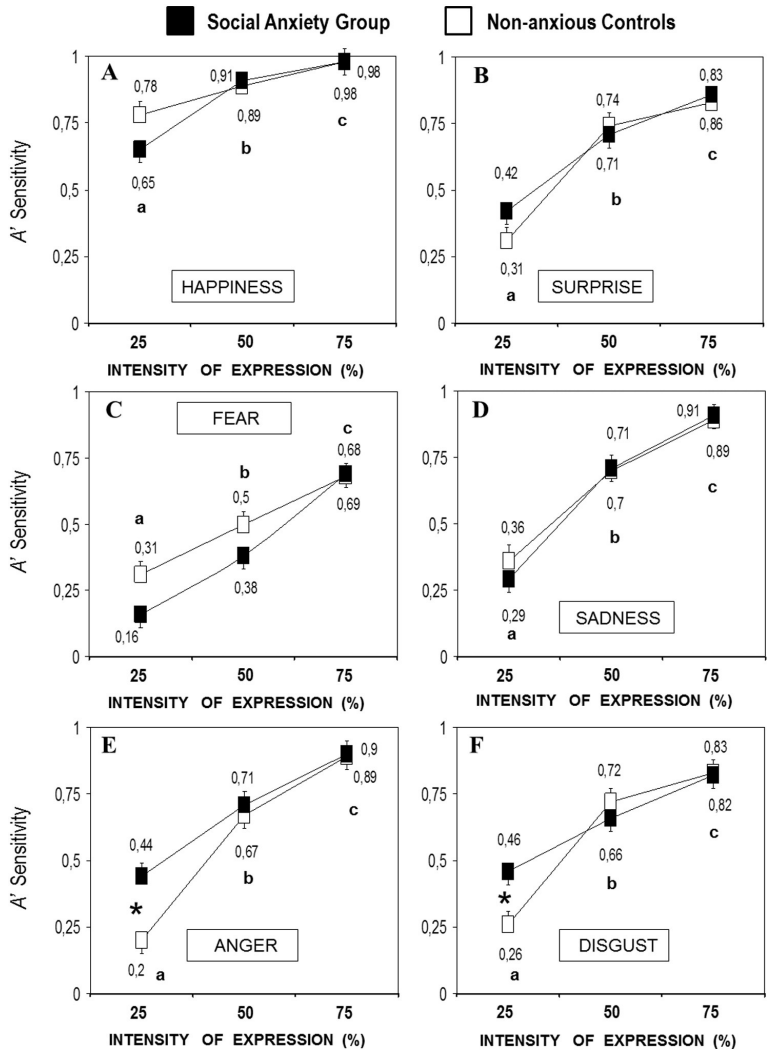
These main effects were qualified by interactions between emotional expression and expressive intensity for hit rate, $F(10, 460) = 2.76$, $p = 0.009$, $\eta_p^2 = 0.06$, false alarms, $F(10, 460) = 5.94$, $p < 0.0001$, $\eta_p^2 = 0.11$, and A' sensitivity, $F(10, 460) = 3.66$, $p = 0.001$, $\eta_p^2 = 0.07$. Importantly, the critical *A' sensitivity* measure was further influenced by a three-way interaction, $F(10, 460) = 2.22$, $p = 0.016$, $\eta_p^2 = 0.05$. In contrast, the B'' criterion was not affected by anxiety alone or in combination with any of the other factors ($Fs < 1$, $ps > 0.50$), thus implying that sensitivity was not contaminated by response biases. To decompose the three-way interaction, we conducted social anxiety (2) by intensity (3) ANOVAs for each expression separately. Fig. 3A to F show the mean A' scores, with differences as a function of intensity and anxiety. The intensity effect was significant for all the expressions ($Fs > 18.00$, $ps < 0.000$, $\eta_p^2 = 0.28$). In addition, there was an anxiety by intensity interaction for angry, $F(2, 92) = 4.33$, $p = 0.016$, $\eta_p^2 = 0.09$, and disgusted faces, $F(2, 92) = 4.31$, $p = 0.017$, $\eta_p^2 = 0.09$, but not for the others ($Fs < 1.85$, $ps \geq 0.18$). To decompose the anxiety by intensity interactions for anger and disgust, we conducted pairwise comparisons (t-tests for independent samples) between anxious and non-anxious groups at each intensity level. Socially anxious participants showed higher sensitivity than non-anxious controls at the 25% intensity condition for angry, $t(46) = 3.29$, $p = 0.002$, and disgusted, $t(46) = 2.62$, $p = 0.012$, expressions, with no significant differences at 50% and 75% intensities.

For reaction times, only main effects of emotional expression (see Table 1, for multiple contrasts), $F(5, 230) = 13.31$, $p < 0.0001$, $\eta_p^2 = 0.22$, and expressive intensity, $F(2, 92) = 49.28$, $p < 0.0001$, $\eta_p^2 = 0.52$, emerged. Judgments were significantly faster in the 75% intensity

Table 1
Mean (and standard error of the mean, in parenthesis) hit probability, false alarm rates (FAs), A' Sensitivity, B'' Response Criterion, and Reaction Times (RTs; ms) for each facial expression.

Measure	Emotional expression					
	Happiness	Surprise	Fear	Sadness	Anger	Disgust
Hits	0.855 (0.021)^{a}	0.712 (0.023)^{b}	0.361 (0.025)^{d}	0.682 (0.022)^{b}	0.666 (0.020)^{b}	0.566 (0.016)^{c}
FAs	0.176 (0.019)^{a}	0.449 (0.033)^{c}	0.314 (0.023)^{bc}	0.385 (0.029)^{c}	0.380 (0.025)^{c}	0.266 (0.020)^{b}
A'	0.865 (0.017)^{a}	0.645 (0.023)^{b}	0.453 (0.027)^{c}	0.644 (0.025)^{b}	0.637 (0.021)^{b}	0.627 (0.017)^{b}
B''	−0.210 (0.074)^{c}	−0.294 (0.080)^{c}	0.463 (0.057)^{a}	−0.100 (0.078)^{bc}	−0.110 (0.073)^{bc}	0.215 (0.059)^{ab}
RTs	911 (36)^{a}	1028 (36)^{b}	1222 (39)^{c}	1070 (37)^{b}	1140 (33)^{bc}	1138 (37)^{bc}

Note. Across expressions (horizontal rows), average scores with a different superscript are significantly different in multiple contrasts (Bonferroni-corrected, $p < 0.05$); scores sharing a letter are equivalent.



Figs. 3A to F. Mean *A′* sensitivity scores for each facial expression and intensity level. Asterisks indicate significant differences between the socially anxious and the non-anxious groups at a given intensity. For both groups, scores with a different letter across expressive intensities indicate significant differences in multiple post hoc contrasts (Bonferroni-corrected, $p < 0.05$).

condition (957 ms) than the others, and faster in the 50% intensity (1069 ms) than the 25% intensity (1228 ms) condition.

3.2. Confusions of neutral faces

The probability of confusion of neutral faces with each emotion was analyzed in a 2 (social anxiety) × 6 (expression) ANOVA. Main effects of expression, $F(5, 230) = 43.62$, $p < 0.0001$, $\eta_p^2 = 0.49$, were qualified by an interaction, $F(5, 230) = 22.16$, $p < 0.0001$, $\eta_p^2 = 0.33$. The main effect of anxiety was not significant ($F < 1$). To decompose the interaction, first, we compared the socially anxious and the control groups for each expression by means of *t*-tests for independent samples. No significant differences appeared for fearful and surprised expressions ($ps > 0.14$). In contrast, anxious participants were more likely than non-anxious controls to interpret neutral faces as angry, $t(46) = 8.80$, $p < 0.0001$, with the same trend for disgust, $t(46) = 1.95$, $p = 0.057$, but were less likely to interpret neutral faces as happy, $t(46) = 5.81$, $p < 0.0001$, and sad, $t(46) = 2.91$, $p = 0.006$ (see Fig. 4). Second, one-way (6: expression) ANOVAS revealed that, for the anxious group, $F(5, 115) = 40.44$, $p < 0.0001$, $\eta_p^2 = 0.64$, neutral faces were perceived as angry more likely than as any other expression, whereas the non-anxious group, $F(5, 115) = 23.21$, $p < 0.0001$, $\eta_p^2 = 0.50$, was more likely to perceive neutral faces as sad (see Fig. 4).

4. Discussion

Type of emotional expression and level of expressive intensity affected all the dependent variables (hits, false alarms, *A′* sensitivity, *B″* criterion, and reaction times) in a consistent manner, which validates the paradigm and measures. The specific findings revealed a threat-

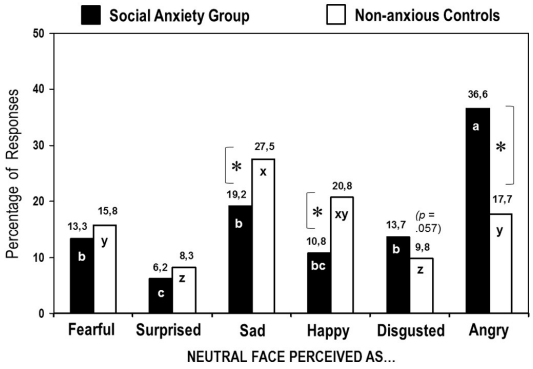


Fig. 4. Probability of "confusion" of neutral faces as emotional expressions by socially anxious and non-anxious groups. An asterisk indicates significant differences ($p < 0.05$) between groups. Across expressions, means with a different letter (a, b, c: for the socially anxious group; x, y, z: for the non-anxious controls) are significantly different. Means sharing a letter are equivalent. Note: Participants were "forced" to choose an emotional label (there was no "neutral" option) for all the face stimuli.

related interpretative bias in social anxiety, involving expression encoding rather than response biases. Essentially, the relevant evidence came, first, from a three-way interaction between social anxiety, type of emotional expression, and level of intensity, for A' sensitivity scores, in the absence of differences in B'' *response* criterion; and, second, from the interaction between social anxiety and type of expression for emotional confusions of neutral faces.

Social anxiety was associated with high A' sensitivity for expressions conveying hostility and rejection, i.e., anger and disgust, but not for other, non-threatening (even if negatively valenced, i.e., fearful and sad) or non-negative (surprise and happy) expressions. This is understandable, given the nature of social anxiety, with fear of negative evaluation as a hallmark: Negative evaluation is more likely to come from people showing anger and disgust, whereas the other expressions do not convey direct threat. The special sensitivity to anger and disgust is in line with prior research (anger: Bell et al., 2011; Yoon et al., 2014; disgust: Heuer et al., 2010). Nevertheless, such a facilitated detection of anger and disgust occurred at low levels of expressive intensity, when expressions became more ambiguous. This is consistent with the distrust towards angry and disgusted expressions at lower intensity thresholds shown by socially anxious observers (Gutiérrez-García & Calvo, 2016a). Altogether, this supports theory and research on interpretative bias: Relative to non-anxious people, socially anxious individuals are more likely to judge social stimuli as threatening when they are ambiguous regarding potential negative evaluation and rejection (Mobini et al., 2013; Morrison & Heimberg, 2013). In contrast, at higher expressive intensities (when ambiguity decreased), we found no differences in discrimination accuracy as a function of social anxiety. For prototypical expressions (either threat- or non-threat-related), socially anxious observers recognize them as accurately as non-anxious ones, even at intermediate levels of expressive intensity. This means that social anxiety is not affected by any expression encoding deficit (see Staugaard, 2010; Button et al., 2013; Jusyte & Schönenberg, 2014).

The tendency to judge "neutral" expressions as angry (and disgusted) in social anxiety is also consistent with the hypothesis that social anxiety biases the interpretation of ambiguous expressions towards hostility and rejection. Neutral faces are not like a blank slate devoid of any meaning, but rather they have some affective tone due to facial appearance cues resembling emotional expressions (Franklin & Zebrowitz, 2013). Thus neutral faces are inherently ambiguous, and therefore amenable to different interpretations. Interestingly, when neutral faces were interpreted negatively, socially anxious participants chose the threatening meaning (i.e., anger or disgust) while non-anxious participants chose a non-threatening (for the viewer) meaning (i.e., sadness). Furthermore, socially anxious participants were less likely to opt for a positive interpretation (i.e., happiness) than non-anxious participants. This is consistent with the finding that social anxiety inhibits a benign judgment of ambiguous expressions as happy, even if they exhibit a smiling mouth, unless the face also contains congruent happy eyes (Gutiérrez-García & Calvo, 2014, 2016b). According to the benign-bias hypothesis, social anxiety is characterized by a lack of a positive evaluation of moderately positive stimuli, unlike the normal tendency in non-anxious individuals (Huppert, Foa, Furr, Filip, & Mathews, 2003). Our findings also support this hypothesis.

The B'' response criterion was equivalent for socially anxious and non-anxious participants, in spite of the clear differences in the A' sensitivity index. In addition, as indicated above, the tendency to endorse negative interpretations of ambiguous expressions by the anxious group was highly selective: It did not occur for all the expressions, but only for those having subtle threat-related facial cues. Altogether, this implies that the bias engages genuine encoding processes rather than merely a response bias. Otherwise we should have found a general tendency in anxious participants towards labelling all types of expressions as threatening, at least at low intensities, which was not the case. Our findings extend those obtained by Langner et al. (2015) and Yoon et al. (2014), also using sensitivity and response criterion measures. While Yoon et al. (2014) found not only higher sensitivity in social anxiety but also a response bias for angry expressions, Langner et al. (2015) found no effects on either measure. Apart from other methodological differences between these studies and our own study, we used a wider range of expressions, thus involving greater discrimination demands, and we used dynamic instead of static expressions. It is possible that this (presumably, more ecologically valid) presentation has made our approach more sensitive, particularly for ambiguous and subtle expressions (see Krumhuber et al., 2013).

5. Conclusions

Social anxiety was associated with enhanced A' sensitivity towards perceiving anger and disgust at low levels of expressive intensity (high ambiguity). In contrast, there was no effect for other expressions (fear, sadness, surprise, and happiness), or for anger and disgust at higher intensities. The fact that effects were selective for particular expressions and intensity levels, and that the B'' criterion was not affected, rules out a response bias explanation, and suggests that there is a genuine cognitive (interpretative) bias during expression encoding. Relatedly, social anxiety was associated with enhanced evaluation of neutral expressions as angry (and disgusted), but reduced evaluation of them as happy or sad. These findings support the hypothesis of a threat-interpretation bias when processing ambiguous facial expressions.

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The authors declare no conflict of interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.paid.2016.11.025.

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ANEXO II

Gutiérrez-García, A., & Calvo, M. G. (2016a). Social anxiety and trustworthiness judgments of dynamic facial expressions of emotion. *Journal of Behavior Therapy and Experimental Psychiatry*, *52*, 119-127.

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Social anxiety and trustworthiness judgments of dynamic facial expressions of emotion

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ABSTRACT

Background and objectives: Perception of trustworthiness in other people is essential for successful social interaction. Facial expressions—as conveyers of feelings and intentions—are an important source of this information. We investigated how social anxiety is related to biases in the judgment of faces towards un/trustworthiness depending on type of emotional expression and expressive intensity.
Methods: Undergraduates with clinical levels of social anxiety and low-anxiety controls were presented with 1-s video-clips displaying facial happiness, anger, fear, sadness, disgust, surprise, or neutrality, at various levels of emotional intensity. Participants judged how trustworthy the expressers looked like.
Results: Social anxiety was associated with enhanced distrust towards angry and disgusted expressions, and this occurred at lower intensity thresholds, relative to non-anxious controls. There was no effect for other negative expressions (sadness and fear), basically ambiguous expressions (surprise and neutral), or happy faces.
Limitations: The social anxiety and the control groups consisted of more females than males, although this gender disproportion was the same in both groups. Also, the expressive speed rate was different for the various intensity conditions, although such differences were equated for all the expressions and for both groups.
Conclusions: Individuals with high social anxiety overestimate perceived social danger even from subtle facial cues, thus exhibiting a threat-related interpretative bias in the form of untrustworthiness judgments. Such a bias is, nevertheless, limited to facial expressions conveying direct threat such as hostility and rejection.

1. Introduction

Social anxiety and social phobia (or social anxiety disorder, SAD) are characterized by persistent and excessive fear and avoidance of situations involving scrutiny and possible negative evaluation by other people (American Psychiatric Association, 2013; Heimberg, Brozovich, & Rapee, 2014; Skocic, Jackson, & Hulbert, 2015). According to cognitive-behavioral models, such symptoms are due to biases towards threat-related interpretations of ambiguous social cues (Clark, 2001; Heimberg et al., 2014; Hofmann, 2007), and even of positive social events (e.g., Alden, Taylor, Mellings, & Laposa, 2008; Weeks & Howell, 2012). Prior research has found support for this proposal: When presented with descriptions of ambiguous social scenes, socially anxious individuals interpret them in a more negative or a less positive manner, relative to non-anxious individuals (for a review, see Mobini, Reynolds, & Mackintosh, 2013). During social interaction, facial expressions represent an important source of information about the feelings and intentions of other people, such as the liking and approval expressed by happy faces, the hostility of angry faces, and the rejection conveyed by disgusted faces. Accordingly, given the nature of social anxiety, and that facial expressions in social settings are frequently ambiguous (Calvo, Gutiérrez-García, Fernández-Martín, & Nummenmaa, 2014), we could predict that social anxiety is likely to bias the recognition of negatively valenced expressions.

Against this prediction, however, there is no clear empirical support for an interpretative bias in facial expression *categorization* (for a review, see Staugaard, 2010; also, Gilboa-Schechtman & Shachar-Lavie, 2013). Social anxiety is not generally associated

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with recognition in/accuracy for *basic* emotional expressions (e.g., anger, etc.). There is, nevertheless, some—albeit limited—evidence that socially anxious individuals tend to interpret *ambiguous*, morphed or blended, expressions in a more negative way (as angry: Bell et al., 2011; Yoon, Yang, Chong, & Oh, 2014; or as contemptuous: Heuer, Lange, Isaac, Rinck, & Becker, 2010) or in a less benign fashion (as less happy: Gutiérrez-García & Calvo, 2014), relative to non-anxious individuals. But, even for ambiguous expressions, there have been failures to find any differences as a function of social anxiety (e.g., Button, Lewis, Penton-Voak, & Munafò, 2013) and SAD (e.g., Jusyte & Schönenberg, 2014). Accordingly, it is possible that socially anxious and non-anxious individuals decode emotional facial expressions similarly in explicit recognition tasks.

Nonetheless, faces and facial expressions convey multiple information, and observers routinely make not only state inferences about transitory emotions of other people (e.g., angry), but also trait inferences about relatively stable personality characteristics (e.g., aggressive) upon meeting unfamiliar people (see Said, Haxby, & Todorov, 2011; Todorov, Said, Engell, & Oosterhof, 2008). Furthermore, trait inferences are influenced by expressive facial cues, according to the emotion overgeneralization hypothesis (Franklin & Zebrowitz, 2013). One of such trait judgments involves un/trustworthiness evaluation (i.e., how much someone seems trustworthy for a satisfactory or, rather, a potentially harmful personal or professional engagement), which is particularly relevant in practical terms for successful social behavior. Importantly for the aims of the current study, trustworthiness judgments presumably entail a directly relevant component of social anxiety, as it involves fear and avoidance of interaction with people from whom disapproval or negative evaluation is anticipated; and indeed trustworthiness judgments implicate approach or avoidance in social interaction (van't Wout & Sanfey, 2008). Accordingly, social anxiety might drive *un*trustworthiness judgments (or curtail trustworthiness) as a preventive, self-protecting mechanism: To avoid feared negative evaluation, anxious individuals could be alert to subtle facial cues indicative of untrustworthiness, or to over-interpret ambiguous cues as signs of untrustworthiness. Furthermore, this would be especially likely to occur for facial cues of anger and disgust—even if subtle—because they are associated with hostility and rejection.

Empirical evidence regarding the relationship between social anxiety and facial trustworthiness judgments is scarce. To our knowledge, only two studies have directly addressed this issue (Cooper et al., 2014; Meconi, Luria, & Sessa, 2014), and another one has considered trait anxiety (Willis, Dodd, & Palermo, 2013). In spite of the conceptual link that we have just proposed between trustworthiness and social anxiety, the results of these studies are not convergent. Willis et al. (2013) found a negative relationship between trait anxiety and trustworthiness judgments. Individuals with higher levels of trait anxiety perceived affectively neutral faces as less trustworthy than those with lower anxiety. Meconi et al. (2014) found that differences in SPCN (an electrocortical correlate of visual working memory processing) between trustworthy and untrustworthy—albeit not explicitly emotional—faces correlated with social anxiety. Untrustworthy faces enhanced SPCN amplitudes especially in anxious participants, who encoded untrustworthy faces in working memory better than non-anxious participants. In contrast, however, Cooper et al. (2014) reported that the magnitude of the relationship between social anxiety and trustworthiness judgments was not significant, also using non-emotional expressions. The limited evidence thus suggests that the influence of social anxiety on trustworthiness deserves further investigation with complementary approaches.[1]

To this end, we aimed to extend prior research in various respects. First, we used *emotional* (happiness, anger, fear, disgust, sadness, and surprise) rather than neutral facial expressions as stimuli. This allowed us to determine (a) whether social anxiety is related to biased trustworthiness judgments generally, regardless of positive or negative emotional expression, or (b) such a relationship involves all the negative expressions, or (c) it only involves those conveying direct threat (anger) or rejection (disgust). Second, assuming ambiguity is a critical condition for interpretative biases, we varied the *intensity* of each expression from a neutral to a full-blown emotion. As ambiguity increases at low intensities, we were particularly interested in those ranging from 10 to 50%. This manipulation has been performed in some studies on social anxiety and expression *recognition* (e.g., Bell et al., 2011; Button et al., 2013). We extended it to establish *trustworthiness* thresholds for each emotion relative to neutral expressions. Third, we used *dynamic* displays by means of video-clips. This was aimed at increasing ecological validity, given that facial behavior in real life is dynamic; and also at increasing sensitivity, as dynamic displays improve recognition, particularly for ambiguous and subtle expressions (see Krumhuber, Kappas, & Manstead, 2013). Fourth, beyond the prior studies on trustworthiness as a function of trait anxiety or pre-clinical social anxiety, we included participants reaching *clinical* cut-off scores in self-report scales (albeit not patients). Given the continuum between sub-clinical social anxiety and clinical levels of social phobia (García-López, Beidel, Muela-Martínez, & Espinosa-Fernández, in press; Rapee & Heimberg, 1997; see Morrison & Heimberg, 2013), our approach is presumably relevant to social anxiety disorder.

This approach was implemented in an experiment investigating whether and how social anxiety was related to trustworthiness evaluation of faces depending on type of emotional expression and expressive intensity. Undergraduates with high or low social anxiety were selected as participants. They were presented with 1-s video-clips displaying facial expressions at various levels of emotional intensity (from 0% or neutral to 100% or full-blown). The task involved judging how trustworthy the person showing each expression looked like. We predict that high social anxiety will be associated with (a) reduced trustworthiness (or increased untrustworthiness) evaluation of negative expressions related to hostility and disapproval (i.e., angry and disgusted), but (b) will *not* be related to trustworthiness processing of negative expressions not conveying any direct threat (sad and fearful), nor (c) those that are merely ambiguous (surprised and neutral), with no explicit positive or negative cue, or (d) positive (happy) expressions. These predictions are concerned, respectively, with what we label as the (a) threat, (b) negativity, (c) ambiguity, and (d) positivity hypotheses. In addition, we predict that trustworthiness *thresholds* will be especially affected for angry and disgusted expressions: Such expressions will be perceived as conveying greater *un*trustworthiness at *lower intensities* than the other expressions for socially anxious participants than for non-anxious controls.

2. Methods

2.1. Participants

Forty-eight undergraduates (32 female) took part in the experiment for course credit, after informed consent. The mean age of participants was 21.5 years (range 19–25 years). All of them were of the same ethnic background (white Caucasian of Spanish origin). They were selected from a pool of 349 students, on the basis of their

[1] As suggested by a reviewer, constructs such as "how evaluating" or "how disapproving" the faces seem to socially anxious individuals could help to specify the meaning and nature of un/trustworthiness judgments, and thus would be worthy of investigation.

high or low scores on the Social Interaction Anxiety Scale (SIAS; Mattick & Clarke, 1998), the Social Phobia Scale (SPS; Mattick & Clarke, 1998), the Liebowitz Social Anxiety Scale—Self-Report version (LSAS-SR; Liebowitz, 1987), and the Brief Fear of Negative Evaluation (BFNE) scale (Leary, 1983). Twenty-four participants (17 female) with the highest and another 24 (17 female) with the lowest scores were selected (see Table 1).

For the high-anxiety group, the following clinical cut-off scores were used as inclusion criteria: scores ≥34 on the SIAS and ≥24 on the SPS, which would indicate social phobia (Brown et al., 1997); and scores ≥ 60 on the LSAS-SR, which have been shown to provide the best balance between sensitivity and specificity of SAD (Rytwinski et al., 2009). All the participants in the social anxiety group reached or were above these cut-offs on the LSAS, SIAS, and SPS. The mean scores for these measures, as well as for the BFNE scale, reached levels obtained for SAD patients (Weeks et al., 2005) and generalized SAD (Jusyte & Schönenberg, 2014) and social phobia (Gallego, Botella, Quero, Baños, & García-Palacios, 2007) undergraduates. Nevertheless, participants in our social anxiety group (see also 2.2. Measures) had not received a diagnosis of SAD via a structured clinical interview.

About two weeks before the experiment, these scales were administered in various classrooms to groups of students. They were briefly informed that we were interested in social anxiety. Each participant used an anonymous code. The study was approved by the local ethics committee and was conducted in accordance with the Declaration of Helsinki.

2.2. Measures

The SIAS (α = .93, current study, henceforth) and the SPS (α = .92; Mattick & Clarke, 1998) assess fear of social interaction with other people and fear of being observed by others, respectively. The Spanish versions that we used have been validated in large undergraduate samples (Olivares, García-López, & Hidalgo, 2001). Each questionnaire is a 20-item measure that uses a Likert-type scale ranging from 0 (*not at all characteristic or true of me*) to 4 (*extremely characteristic or true of me*). Sample items include "I have difficulty making eye-contact with others" (SIAS) or "I can get tense when I speak in front of other people" (SPS). Researchers use scores greater than 33 on the SIAS or 23 on the SPS to indicate social phobia (Brown et al., 1997). Mean SIAS scores ranging from 49 (Weeks et al., 2005) to 51 (Brown et al., 1997), and mean SPS scores between 34 (Weeks et al., 2005) and 37 (Brown et al., 1997) have been reported for SAD (Weeks et al., 2005) and social phobia (Brown et al., 1997) patients. For generalized SAD undergraduates, the respective SIAS and SPS means are 48 and 32 (Jusyte & Schönenberg, 2014).

The LSAS-SR (Liebowitz, 1987) is comprised of 24-items that assess anxiety and avoidance in social interaction (11 items) or social performance (13 items) situations. Example items include, respectively, "Talking to people in authority" and "Entering a room when others are already seated." Items are rated on 4-point scales of fear and avoidance, which range from 0 (*none* and *never*, respectively) to 3 (*severe* and *usually*, respectively). We calculated a total score by summing the anxiety and avoidance ratings. The total score has demonstrated good internal consistency (α = .94), adequate convergent and discriminant validity, and high test–retest reliability (Baker, Heinrichs, Kim, & Hofmann, 2002; Heimberg et al., 1999). A score of 60 or more is considered to be suggestive of having generalized SAD (Rytwinski et al., 2009). Mean scores of 74 (Weeks et al., 2005) or 85 (Haker, Aderka, Marom, Hermesh, & Gilboa-Schechtman, 2014) have been reported for SAD patients, and of 79 for generalized SAD undergraduates (Jusyte & Schönenberg, 2014).

The BFNE scale (Leary, 1983; Spanish version by Gallego et al., 2007) is a 12-item scale used to assess fear of negative evaluation by others, as a hallmark of social anxiety and SAD. Responses range from 1 (*not at all characteristic of me*) to 5 (*extremely characteristic of me*) to representative items such as "I am afraid others will not approve of me". The BFNE is a well-validated scale, with high test-retest reliability (r = .75; Leary, 1983), and internal consistency (α = .93), factorial validity, and construct validity in undergraduate (Rodebaugh et al., 2004) and clinical samples (with mean scores of 47 for pre-treatment social phobia patients; Weeks et al., 2005). In Spanish undergraduate samples clinically diagnosed as individuals with social phobia, mean BFNE scores of 43 have been reported (Gallego et al., 2007).

Table 1
Participant characteristics.

	Non-anxious group		Social anxiety group		Statistics
	N = 24; female: 67%		N = 24; female: 67%		
	M	SD	M	SD	
Age	21.58	1.47	21.37	1.50	$t(46) = .49$, $p = .63$, *ns*
SIAS	13.87	3.21	47.21	8.81	$t(46) = 17.41$, $p < .0001$
SPS	11.04	3.38	32.92	6.48	$t(46) = 14.66$, $p < .0001$
LSAS	13.33	3.96	74.04	7.55	$t(46) = 34.86$, $p < .0001$
BFNE	22.17	4.05	47.46	5.49	$t(46) = 18.15$, $p < .0001$

Note. SIAS: Social Interaction Anxiety Scale. SPS: Social Phobia Scale. LSAS: Liebowitz Social Anxiety Scale. BFNE: Brief Fear of Negative Evaluation Scale.

2.3. Face stimuli

We used 1-s video-clips as stimuli. To build them, we followed three steps. First, we selected digitized color photographs of prototypical neutral, happy, angry, fearful, sad, disgusted, and surprised faces of 24 posers (12 females; 12 males) from the Karolinska Directed Emotional Faces database (KDEF; Lundqvist, Flykt, & Öhman, 1998; see Calvo & Lundqvist, 2008).

Second, these face stimuli were subjected to morphing by means of FantaMorph© software (Abrosoft). For each expression of each poser, we created a sequence of 100 frames with increasing emotional intensity, based on two images: a neutral face as the first frame, and a full-blown emotional face (happy, etc.) as the final frame. We then selected frames no. 0 (neutral; original KDEF), 10, 20, 30, 40, 50, and 100 (full-blown; original KDEF), which represented, respectively, the 0, 10, 20, 30, 40, 50, and 100% intensities across the unfolding of the emotional expression. As we aimed to determine recognition *thresholds* (i.e., the *lowest* stimulus intensity at which the perceived trustworthiness for an emotional expression changes relative to the neutral face), we omitted intensities above 50% (except the 100% intensity). Fig. 1 shows examples of the different intensity levels for each expression.

Third, dynamic versions were created with FantaMorph© software. One-second duration video-clips were generated involving a smooth continuum between the neutral and each emotional expression of the same poser at 30 frames per s. Facial expressions unfolded dynamically up to the corresponding maximal target intensity (i.e., 10%, 20%, etc.). For all expression and intensity conditions, the unfolding sequence lasted for 900 ms after stimulus onset, and the last frame was frozen for 100 ms. This morphing rate was used to simulate natural average unfolding speed, following prior research on the recognition of dynamic expressions (see Hoffmann, Traue, Bachmayr, & Kessler, 2010; Pollick, Hill, Calder, & Paterson, 2003; Recio, Schacht, & Sommer, 2013). In the 0% intensity condition, a 1-s still image of a neutral face was displayed. A

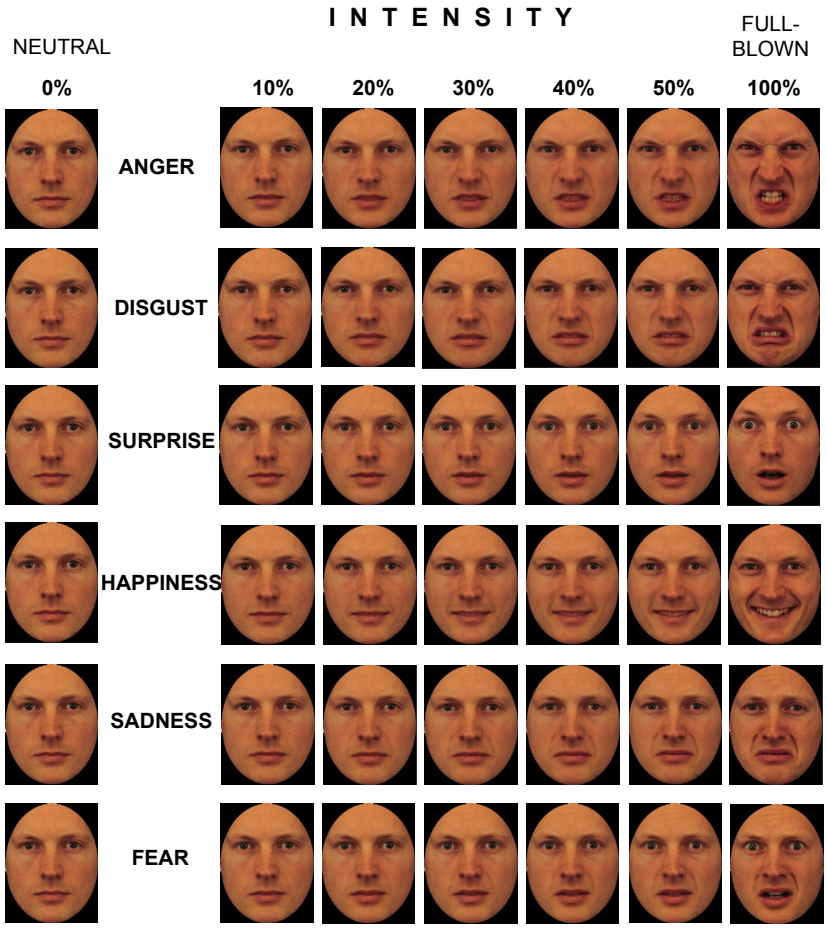

Fig. 1. Types of expressions and levels of intensity.

1-s display is sufficient for expression recognition (Calvo & Lundqvist, 2008) and trustworthiness impression formation (Todorov, Pakrashi, & Oosterhof, 2009).

2.4. Procedure, performance measures, and experimental design

In individual experimental sessions, participants were told that short video-clips of faces would be presented with different expressions and intensities, and were asked to indicate quickly how untrustworthy or trustworthy each expresser looked like. The sequence of events on each trial is illustrated in Fig. 2. After an initial 500-ms fixation screen, a central face unfolded for 1 s, subtending a visual angle of 9.5° (height) × 7.5° (width) at a 60-cm viewing distance. Following face offset, the question "un/trustworthy?" was displayed, along with a row of numbers from 1 to 9, where 1 was labelled as "Not at all trustworthy", and 9 as "Extremely trustworthy". Participants responded by using the number keys at the upper row of a computer keyboard. The selected response and reaction times (from face offset) were collected.

In 168 trials, each participant was presented with 144 video-clips (24 models × 6 emotional expressions × 1 intensity level for each expression), plus 24 photographs of neutral expressions in the 0% intensity condition. The face stimuli were shown on a computer monitor, in seven blocks, by means of E-Prime 2.0 software. To avoid potential habituation to each poser, each participant was presented with each poser only once displaying each of the six emotional expressions, each time in a different intensity condition, and in a different block of trials. In addition, all the participants were presented with all the neutral faces. Six different counterbalancings of poser expression and intensity were used and trial order was randomized.

The experiment involved a mixed factorial design, in which one between-subjects factor (Social anxiety: low vs. high) and two within-subjects factors (Expression: happy, surprised, fearful, sad, disgusted, and angry; and Intensity: 0, 10, 20, 30, 40, 50, and 100%) were orthogonally combined.

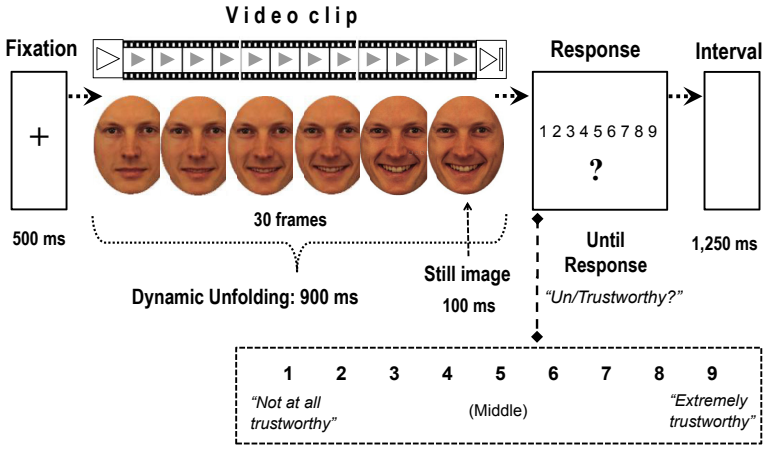

Fig. 2. Sequence of events on an experimental trial. A schematic example of a neutral-to-full-blown (100% target intensity) emotional expression is shown. For the other target intensities (e.g., 50%), the video-clip also unfolded at 30 frames per second and the total display duration was the same (900-ms unfolding until the corresponding target intensity + a final 100-ms still image of the respective target intensity).

3. Results

3.1. Participant characteristics

The socially anxious and the non-anxious groups did not differ with regard to gender (with the same 67/33% female/male proportion), age (see Table 1), and socio-cultural background (all were undergraduates at the University of La Laguna). Compared to the non-anxious group, the social anxiety group exhibited higher scores on all five anxiety measures (SIAS, SPS, LSAS, BFNE, and STAI; see Table 1).

3.2. Analysis of trustworthiness judgments

An overall 2 (Social Anxiety) × 6 (Expression) × 7 (Intensity) ANOVA was conducted on trustworthiness responses in the 9-point judgment scale and response latencies. Greenhouse-Geisser corrections for unequal variances were performed, as well as Bonferroni corrected (for a desired .05 alpha) a posteriori multiple contrasts regarding the intensity factor ($p < .0083$; for six comparisons, i.e., each intensity level against the neutral baseline, to establish the threshold). The multiple comparisons across expressions (as a main factor) were not of specific interest in this study, but rather the interaction with social anxiety. With our sample size ($n = 48$) we had .80 power to detect an effect of $f = .31$ ($d = .62$) at $\alpha = .05$.

3.2.1. Response judgments

Main effects of anxiety, $F(1, 46) = 21.42$, $p < .0001$, $\eta_p^2 = .32$, and expression, $F(5, 230) = 435.62$, $p < .0001$, $\eta_p^2 = .90$, were qualified by interactions between anxiety and expression, $F(5, 230) = 17.08$, $p < .0001$, $\eta_p^2 = .27$, expression and intensity, $F(30, 1380) = 85.99$, $p < .0001$, $\eta_p^2 = .65$, and a three-way interaction, $F(30, 1380) = 2.60$, $p = .006$, $\eta_p^2 = .053$. To decompose the interactions, first, anxiety by intensity ANOVAs were conducted for each expression. Fig. 3A–F shows the scores and multiple contrasts across intensity levels for each expression, separately for non-anxious and anxious participants. For *surprised*, *fearful*, and *sad* faces, no main effects or the interaction reached statistical significance (see Fig. 3B–D). Importantly, no significant differences appeared between anxious and non-anxious groups for *neutral* faces either, $t(46) = .038$, $p = .70$.

For *happy* faces, an intensity effect emerged, $F(6, 276) = 234.06$, $p < .0001$, $\eta_p^2 = .84$. As indicated in Fig. 3A, post hoc multiple comparisons revealed a gradual increase in trustworthiness as function of facial happiness intensity. We used such comparisons to determine the threshold, i.e., the lowest intensity level at which trustworthiness ratings for the emotional face became statistically different from those for the neutral face. The multiple contrasts indicated that happy faces started to be judged as conveying more trustworthiness already at 20% intensity.

For *angry* and *disgusted* faces, effects of anxiety, $F(1, 46) = 81.46$, $p < .0001$, $\eta_p^2 = .64$ (anger), $F(1, 46) = 56.04$, $p < .0001$, $\eta_p^2 = .55$ (disgust), and intensity, $F(6, 276) = 53.44$, $p < .0001$, $\eta_p^2 = .54$ (anger), $F(6, 276) = 60.74$, $p < .0001$, $\eta_p^2 = .57$ (disgust), were qualified by interactions, $F(6, 276) = 5.49$, $p < .001$, $\eta_p^2 = .11$ (anger), $F(6, 276) = 4.39$, $p < .001$, $\eta_p^2 = .09$ (disgust). The intensity effect was significant for both anxious, $F(6, 138) = 49.12$, $p < .0001$, $\eta_p^2 = .68$ (anger), $F(6, 138) = 49.68$, $p < .0001$, $\eta_p^2 = .68$ (disgust), and non-anxious individuals, $F(6, 138) = 12.04$, $p < .0001$, $\eta_p^2 = .34$ (anger), $F(6, 138) = 17.65$, $p < .0001$, $\eta_p^2 = .43$ (disgust). As indicated in Fig. 3E and F, trustworthiness declined gradually with decreasing intensity. The interactions reflected the different thresholds for each group. As shown by the multiple post hoc comparisons (see Fig. 3E and F), anxious participants started to detect *un*trustworthiness at 20% intensity of anger and disgust, relative to neutral faces, whereas non-anxious participants did not perceive such a difference until 40% intensity. This was confirmed by pairwise comparisons between the two groups at each intensity level: anxious participants judged angry faces as more untrustworthy than non-anxious participants at all intensities, all $ts(46) \geq 2.74$, $ps \geq .009$, except the 10% condition; and the same was the case for disgusted faces, all $ts(46) \geq 3.87$, $ps < .0001$.

3.2.2. Reaction times

Expression, $F(5, 230) = 11.92$, $p < .0001$, $\eta_p^2 = .21$, and intensity, $F(6, 276) = 28.05$, $p < .0001$, $\eta_p^2 = .38$, effects emerged, but those of social anxiety ($F < 1$) and the interactions were non-significant (all

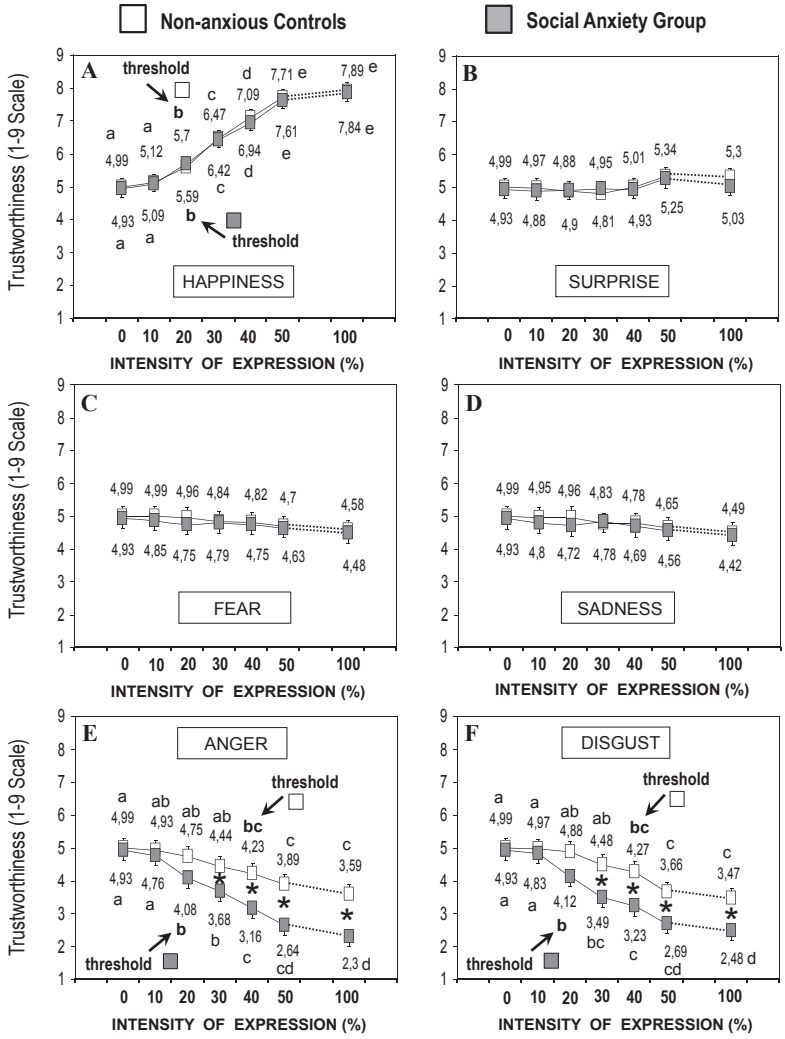

Fig. 3. A–F. Mean trustworthiness judgment scores for each type of facial expression and intensity level. Within each anxiety group, across expressive intensities, scores with a different letter indicate significant differences in multiple post hoc contrasts (Bonferroni corrected, $p < .0083$); scores with the same letter are equivalent. Asterisks indicate significant differences between the social anxiety and the non-anxious groups at a given intensity. "Threshold" indicates the intensity level at which significant differences between the neutral and the emotional face started.

Fs ≤ 1.08, *ps* ≥ .34). Table 2 shows the scores and multiple contrasts across intensity levels, similarly for anxious and non-anxious participants. Multiple post-hoc comparisons indicated that trustworthiness judgments were faster in the 100% intensity condition than the rest, and faster in the 50% intensity condition than for most of the other intensities.

4. Discussion

Two major findings involving interactions between social anxiety, expression, and intensity were relevant to the specific aims of the current study. First, participants with high social anxiety evaluated angry and disgusted faces as more untrustworthy than non-anxious participants did. In contrast, social anxiety was not related to trustworthiness judgments for sad, fearful, surprised, happy, and neutral faces. Second, thresholds for angry and disgusted expressions were lower (i.e., lower intensities were required to judge them as more untrustworthy than neutral expressions) for anxious than for non-anxious participants. These findings support our predictions, as detailed below.

Social anxiety was associated with enhanced *untrustworthiness* judgments of angry and disgusted faces. Given the nature of social anxiety—with fear of negative evaluation as a hallmark—it is understandable that untrustworthiness is endorsed to expressions

Table 2
Mean reaction times (ms) for each facial expression and intensity level, averaged for high- and low-anxiety groups.

Intensity	Type of emotional expression						Average	
	Happiness	Surprise	Fear	Sadness	Anger	Disgust	M	*SE*
Neutral	1606	1606	1606	1606	1606	1606	1606[c]	26
10%	1569	1629	1621	1615	1589	1589	1604[c]	24
20%	1519	1593	1580	1561	1546	1539	1556[c]	23
30%	1507	1563	1555	1560	1495	1522	1534[c]	20
40%	1474	1532	1520	1527	1459	1487	1500[bc]	20
50%	1407	1426	1447	1457	1430	1379	1428[b]	23
100%	1217	1299	1309	1299	1276	1272	1279[a]	26
Average	1471	1521	1520	1518	1487	1488		
SE	13	12	13	12	11	13		

Note. Across *intensities* (vertical rightmost rows), average scores with a different letter are significantly different from the Neutral baseline, in Bonferroni-corrected ($p < .0083$) multiple contrasts; scores sharing a letter are equivalent. *SE*: Standard error of the mean.

conveying hostility and rejection. In contrast, the other expressions (sad, fearful, happy, surprised, and neutral) do not convey direct threat, and therefore it is not relevant for a socially anxious person to judge them as especially untrustworthy. Particularly, the lack of any statistical effect regarding happy faces (e.g., due to their being potentially interpreted as mockery by socially anxious individuals) does not support the hypothesis of a threatening interpretation bias for positive cues (e.g., Weeks & Howell, 2012). The relationship between social anxiety and untrustworthiness for angry and disgusted expressions is consistent with prior research using other approaches. First, angry and disgusted faces are generally perceived as untrustworthy; happy faces, as trustworthy; and sadness, fear, and surprise are unrelated to trustworthiness (Oosterhof & Todorov, 2008, 2009; Said et al., 2011). It is thus reasonable that perception of untrustworthiness from signs of anger and disgust is especially susceptible to being related to social anxiety. Second, compared with healthy controls, individuals with social phobia are more likely to misclassify facial expressions as angry (Bell et al., 2011), and socially anxious individuals tend to interpret disgust as contempt (Heuer et al., 2010). Third, social anxiety is associated with overestimation of perceived social cost of an interaction with people expressing facial anger (Button et al., 2013; Douilliez, Yzerbyt, Gilboa-Schechtman, & Philippot, 2012) and disgust (Button et al., 2013; Schofield, Coles, & Gibb, 2007). Fourth, compared to non-anxious individuals, those with SAD rate dominant others more extremely (Haker et al., 2014). Accordingly, and given that anger and disgust are associated with perception of dominance (see Said et al., 2011), it is possible that socially anxious individuals judge angry and disgusted faces as most untrustworthy because they perceive and exaggerate perception of dominance.

Social anxiety was associated with enhanced *sensitivity* to *subtle* facial cues of disgust and anger when forming trustworthiness impressions. This was evidenced by the lower thresholds at which changes in trustworthiness appeared for such emotional faces, relative to neutral faces.[2] Prior studies on social anxiety and trustworthiness (Cooper et al., 2014; Meconi et al., 2014) used expressions with no explicit emotion, and level of intensity was not varied. Our findings add to them by showing that effects of social anxiety start for slightly emotional faces. This is consistent with several lines of research. First, some studies on expression recognition (rather than trustworthiness) have manipulated expressive intensity. Joormann and Gotlib (2006) reported that individuals with social phobia needed less intensity to identify anger than depressed or control groups did. Relatedly, Yoon et al. (2014) found that social anxiety was associated with greater sensitivity to mild facial anger. Intensity variations of disgust were not included. Second, in general (i.e., regardless of anxiety), the *active* search and detection of subtle cues of anger and disgust in "neutral" (not explicitly emotional) faces is negatively related to trustworthiness ratings, while detection of fear, sadness, and surprise is not related, and that of happiness is positively related (Oosterhof & Todorov, 2008; Said et al., 2011). This suggests that socially anxious individuals might have an active default search mechanism for threat cues. This would lead them to perceive untrustworthiness from minor signs of anger and disgust, by overgeneralization (i.e., attributing un/trustworthiness to people whose "neutral" facial configuration or physical features resemble an emotion; Franklin & Zebrowitz, 2013).

A special contribution of the current study is the use of dynamic expressions as stimuli, instead of static faces. Dynamic morphing provides a realistic experimental approach (but see below) to assess the on-line processing of real faces in social contexts, where expressions typically change. This approach has been widely used in prior behavioral and neurophysiological research (e.g., Harris, Young, & Andrews, 2014; Kessels, Montagne, Hendriks, Perrett, & de Haan, 2013). In social phobia or social anxiety research, Joormann and Gotlib (2006), and Heuer et al. (2010) used a paradigm that simulates dynamic expressions. Sequences of photographs of the same individual showed increasing degrees of morphed expressions changing from neutral into emotional at a rate of 500 ms (Joormann & Gotlib, 2006) or 1 s (Heuer et al., 2010) per photograph. Participants viewed the sequence and stopped it as soon as they could recognize the emotion. This procedure produced the impression of a movie and was suitable for assessing recognition thresholds. Nevertheless, the display rate was probably low for representing the way facial expressions naturally unfold. In the current study, dynamic expressions with more natural rates were used (Hoffmann et al., 2010; Pollick et al., 2003; Recio et al., 2013), thus increasing ecological validity. In addition, our dynamic stimuli may have increased sensitivity (relative to static faces; see Arsalidou, Morris, & Taylor, 2011; Krumhuber et al., 2013; Recio, Sommer, & Schacht, 2011). The reason is that kinetic information may boost expression recognition because motion captures and focuses attention on the relevant (i.e., diagnostic of emotion and trustworthiness), changing facial features.

Among the potential limitations of the current study, first, there were more socially anxious females than males, although such a disproportion remained in the control group. The larger representation of females actually reflects the higher prevalence of social anxiety and social phobia in women than men in the general population (APA, 2013; Xu et al., 2012); also in Spanish samples (García-López, Inglés, & García-Fernández, 2008; Inglés et al., 2010; Olivares, Piqueras, & Rosa, 2006). As a consequence, understandably, our use of a clinical cut-off criterion included more anxious females than males. This implies that generalization of the current findings can be made as a function of whether or not the clinical threshold is reached, regardless of sex of individuals. Second, we generated video-clips of morphed expressions. This procedure allows for controlling many aspects of face stimuli, and has been used often (see above). However, the rate of expressive change was different for the various intensity conditions (i.e., slower rates at

[2] The untrustworthiness judgments and the lowered expressive intensity thresholds for socially anxious vs. non-anxious participants, particularly for angry and disgusted faces, are unlikely to be due to differences in expression recognition speed. If emotional expression encoding differences had affected trustworthiness evaluation (as a potential confound), this should have been reflected in the speed of trustworthiness judgments as a function of anxiety. This was not the case, as there were no reaction time differences between anxious and non-anxious participants in trustworthiness judgments. Nevertheless, we had no direct evidence of emotion recognition per se.

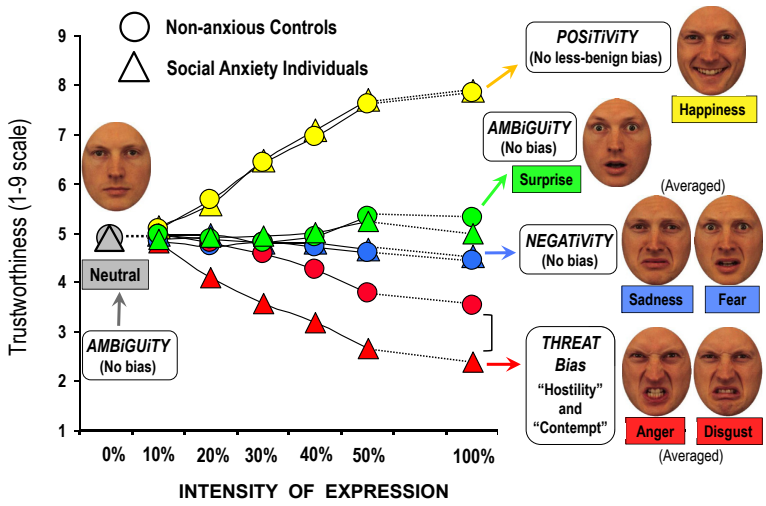

Fig. 4. Integration of results and their relevance to four hypotheses (threat bias, negativity bias, ambiguity bias, and positivity bias; see last paragraph of 1. Introduction). Given the similar effects of social anxiety for angry and disgusted faces, on one side, as well as for sad and fearful faces, on the other, data have been averaged for each pair of expressions in the graphical representation.

lower intensities). Such a speed variation was necessary to keep display time constant at 1 s for all the intensities (otherwise, the low-intensity displays would have been shorter). Against possible criticisms, such speed rates were equated for all the expressions and for anxious and control groups, yet interactions of intensity with expression and group appeared. Also, Recio et al. (2013) found that unfolding speed of morphed expressions did not generally influence the pattern of recognition differences across emotions.

5. Conclusions

Social anxiety was associated with enhanced sensitivity towards perceiving angry and disgusted expressions as untrustworthy, and this occurred from low levels of expressive intensity. In contrast, there was no relationship for other negative expressions (sadness and fear), ambiguous expressions (surprise and neutral), or happy expressions. The fact that the effects were selective rules out a response bias explanation, and suggests that they reflect genuine untrustworthiness encoding during impression formation. These findings support the threat-processing bias hypothesis, but not the negativity, the ambiguity, or the reduced positivity bias hypotheses, respectively, as outlined in the Introduction (see Fig. 4, for an integration of hypotheses and findings). Individuals with high levels of social anxiety thus seem to overestimate social danger specifically for expressions conveying hostility and rejection, even for subtle facial cues. The fact that threat-related emotions are generally exhibited at low intensities in everyday settings due to social constraints, and that this bias is concerned with a critical aspect for social interaction, such as personal trustworthiness, makes it particularly relevant in practical terms.

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ANEXO III

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Social anxiety and perception of (un)trustworthiness in smiling faces

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ABSTRACT

In social environments the smile can be driven by different motives and convey different emotions. This makes a smiling face ambiguous and amenable to alternative interpretations. We investigated how social anxiety is related to trustworthiness evaluation of morphed dynamic smiling faces depending on changes in the eye expression. Socially anxious and non-anxious participants judged the un/trustworthiness of people with different smiles. Social anxiety was related to reduced trustworthiness of (a) faces with a neutral mouth unfolding to a smile when the eyes were neutral at the beginning or end of the dynamic sequence, and (b) faces with a smiling mouth when happy eyes slightly changed towards neutrality, surprise, fear, sadness, disgust, or anger. In contrast, social anxiety was not related to trustworthiness judgments for non-ambiguous expressions unfolding from neutral (eyes and mouth) to happy (eyes and mouth) or from happy to neutral. Socially anxious individuals are characterized by an interpretation bias towards mistrusting any ambiguous smile due to the presence of non-happy eyes.

1. Introduction

Trusting other people is critical for successful social interaction. Judgments of un/trustworthiness (i.e., how much we can trust someone for a satisfactory or, rather, potentially harmful relationship) presumably entail a relevant component of social anxiety (Cooper et al., 2014), as they implicate social approach or avoidance (van't Wout and Sanfey, 2008). Social anxiety is characterized by persistent and intense fear and avoidance of negative evaluation from other people (American Psychiatric Association, 2013; Morrison and Heimberg, 2013). This means that socially anxious individuals are particularly sensitive to disapproval and rejection. Accordingly, social anxiety might drive *un*trustworthiness (or curtail trustworthiness) judgments as a preventive, self-protecting mechanism: To avoid negative social evaluation, socially anxious individuals could be biased to detect subtle facial cues indicative of untrustworthiness, or to interpret ambiguous cues as untrustworthy.

The predicted relationship between social anxiety and perception of untrustworthiness has been addressed in three prior studies, all of which used photographs of non-emotional expressions as stimuli. Meconi et al. (2014) found that untrustworthy faces elicited enhanced Sustained Posterior Contralateral Negativity (SPCN; a neural electrocortical correlate of visual working memory processing) amplitudes in socially anxious participants, who also encoded untrustworthy faces in working memory better than non-anxious participants. Willis et al. (2013) reported that individuals with high trait anxiety (which is related to social anxiety: see Section 2.1.2.) perceived faces as less trustworthy than low-anxiety individuals. In contrast, Cooper et al. (2014) found no significant relationship between social anxiety and trustworthiness judgments. Nevertheless, this might have been due to the use of a participant sample with normally distributed scores (i.e., relatively healthy undergraduates) instead of groups selected as a function of their extreme scores in social anxiety. In any case, such discrepancies suggest that this issue needs further investigation.

The three prior studies (Cooper et al., 2014; Meconi et al., 2014; Willis et al., 2013) are limited by the use of only neutral faces conveying no explicit emotion. We aimed to extend prior research by using *emotional*—yet *ambiguous*—expressions. More specifically, we focused on smiling faces with happy or non-happy (e.g., neutral, angry, etc.) eyes. The rationale for this approach is based on two major reasons that make the relationship between social anxiety and trustworthiness for smiling faces relevant. First, in spite of its appearance as a simple gesture in the mouth region, the smile is actually associated with very different emotions. Apart from enjoyment, a smile can be driven by motives such as

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dominance (i.e., a way of communicating and maintaining social status), sarcasm, and contempt, or nervousness, embarrassment, and appeasement, or it can convey mere politeness (Ambadar et al., 2009; Calvo et al., 2013a, 2013b; Niedenthal et al., 2010). This makes the smile amenable to multiple interpretations, which could be biased by social anxiety. As smiles can be seen negatively (e.g., arrogance, etc., or even mockery), it is possible that social anxiety preferentially activates such meanings, particularly those related to disapproval or negative evaluation. This would occur especially when information from other facial sources—mainly, the eyes—is not congruent with a smiling mouth. Given the ubiquity of the smile in social settings (Calvo et al., 2014; Somerville and Whalen, 2006), such an interpretative bias might have a profound influence on the development or maintenance of social anxiety, and thus have clinical implications because of the frequent exposure to this type of ambiguous stimuli.

Second, Gutiérrez-García and Calvo (2014) investigated whether social anxiety facilitates the discrimination between genuine and fake smiles. Socially anxious and non-anxious participants categorized as "happy" or "not happy" faces with either (a) a truly happy expression (i.e., congruent happy eyes and a smiling mouth), (b) truly non-happy expressions (e.g., congruent angry eyes and angry mouth), and (c) blended expressions with a smile but incongruent non-happy (e.g., angry, sad, etc.) eyes. No differences appeared for truly happy or non-happy faces, which reveals that social anxiety is not related to recognition sensitivity for prototypical expressions (see Staugaard, 2010; although effects depend on the type of evaluative judgment that is assessed: Lange et al., 2013). However, relative to non-anxious participants, those high in social anxiety were *more likely* to judge as "not happy" *all* the blended expressions with non-happy eyes, and were especially *faster* in judging as "not happy" the blended expressions with angry, fearful, or disgusted eyes (but not those with sad, surprised, or neutral eyes). These results suggest, respectively, that social anxiety inhibits a benign interpretation of *all* the ambiguous expressions with a smile, and speeds up the detection of those with *threatening* eyes (but see Jusyte and Schönenberg, 2014). The current study investigates whether such effects are associated with perception of *untrustworthiness* from ambiguous—due to non-happy eyes—expressions with a smile.

Accordingly, variations in cues of facial happiness (e.g., a smiling mouth but non-happy eyes) leading to ambiguity constitute a reasonable ground for investigating the role of social anxiety in judging trustworthiness. In two experiments, we presented 2-s video-clips displaying dynamic facial expressions to high or low socially anxious participants, who judged how trustworthy the person showing each expression was. As stimuli, we used morphed faces in motion, to mimic real-life expressions and to increase sensitivity of measures (Krumhuber et al., 2013; Recio et al., 2013). Experiment 1 investigated the relationship between social anxiety and trustworthiness evaluation of faces in which the eyes *and* the mouth unfolded—together or independently—from neutral to happy or vice versa. Experiment 2 investigated such a relationship for faces in which changes occurred *only*—and subtly—in the eye expression (unfolding from happy to angry, sad, fearful, disgusted, surprised, or neutral) while the mouth remained smiling. Whereas Experiment 1 was focused on changes in the smiling mouth and happy eyes in relation to a neutral face, Experiment 2 was concerned with changes in non-happy eyes in the presence of a static smiling mouth. Thus a wide range of types of smiling faces were examined.[2]

We predicted that individuals with social anxiety, relative to non-anxious controls, would be likely to judge as less trustworthy smiling faces with non-happy eyes, and that this would occur especially when the eyes convey anger or disgust. As socially anxious individuals are particularly sensitive to critical or disapproving attitudes from other people, such ambiguous or incongruent smiles would be interpreted as untrustworthy by virtue of their association with dominance, mockery, or contempt. In contrast, for genuinely happy faces with congruent eyes and mouth, no differences in trustworthiness will appear as a function of social anxiety, thus showing no deficit in expression identification or a general interpretative bias.

2. Experiment 1: faces with neutral or happy eyes and neutral or smiling mouth

2.1. 1. Methods

2.1.1. Participants

A pool of 354 psychology undergraduates initially responded to various social anxiety questionnaires (see below). We selected 48 participants with high scores and 48 participants with low scores on the Brief Fear of Negative Evaluation (BFNE) scale (Leary, 1983). Next, within each high or low BFNE group, we formed two subgroups of 24 students each by matching (in pairs) them in sex (15 females and 9 males in each subgroup) and BFNE scores. Finally, we randomly assigned each subgroup either to Experiment 1 or 2, so that the samples were comparable. The participants' age ranged between 20 and 25 years.

In Experiment 1, 24 participants in the social anxiety group were selected if their BFNE scores were ≥ 40; and another 24 in the non-socially-anxious group, if their BFNE scores were < 30 (see Table 1). About two weeks before the experiment, the BFNE scale, the trait scale of the State-Trait Anxiety Inventory (STAI-T; Spielberger et al., 1983), the Social Interaction Anxiety Scale (SIAS), and the Social Phobia Scale (SPS; Mattick and Clarke, 1998) were administered to the 354 students in various classrooms. Each participant used an anonymous code. The study was approved by the local ethics committee and conducted in accordance with the Declaration of Helsinki.

2.1.2. Measures

The BFNE scale (Leary, 1983) was the primary measure of social anxiety. This 12-item scale assesses fear of negative evaluation by others, as a major component of social anxiety. Responses range from 1 (*not at all characteristic of me*) to 5 (*extremely characteristic of me*) for representative items such as "I am afraid others will not approve of me". The BFNE is a well-validated scale (Spanish version by Gallego et al., 2007), with high test-retest reliability (r=.75; Leary, 1983), factorial and construct validity in undergraduate (Rodebaugh et al., 2004) and clinical samples (with mean scores for social phobia patients of M=47, Weeks et al., 2005; and M=43 in Spanish clinically-diagnosed social phobic undergraduates, Gallego et al., 2007).

The SIAS and the SPS (Mattick and Clarke, 1998) are companion scales designed to measure fear of social interaction and fear of being observed, respectively. Each questionnaire is a 20-item measure that uses a scale ranging from 0 (*not at all characteristic of me*) to 4 (*extremely characteristic of me*), with participants indicating the extent to which the statement applies to them (e.g.,

[2] Among the multiple possible combinations (type of eye and mouth expression, type of change, etc.), we had to select a manageable number of them that were theoretically relevant as well as plausible in real life. Although the ecological validity of some of the resulting expressions (see Sections 2.1.3. and 3.1.2. *Stimuli*) (*footnote continued*) may be uncertain (see Section 4), such combinations were necessary for systematically examining the role of the eyes and the mouth.

Table 1
Participant characteristics in Experiment 1.

	Low social anxiety		High social anxiety		Differences
	M	*SD*	*M*	*SD*	*Statistics*
Age	21.79	1.25	21.62	1.34	$t(46) = .44$, $p=.66$, *ns*
BFNE (α=.91)	22.45	4.02	47.04	3.90	$t(46)=17.73$, $p<.0001$
STAI-T (α=.93)	34.20	5.97	48.79	9.92	$t(46)=6.17$, $p<.0001$
SIAS (α=.92)	14.17	3.62	35.58	9.63	$t(46)=10.20$, $p<.0001$
SPS (α=.90)	11.50	3.41	30.67	8.83	$t(46)=9.91$, $p<.0001$

Note. BFNE: Brief Fear of Negative Evaluation Scale. STAI-T: State Trait Anxiety Inventory-Trait version. SIAS: Social Interaction Anxiety Scale. SPS: Social Phobia Scale. α: Cronbach alphas in the current study.

SIAS; "I have difficulty making eye-contact with others"; e.g., SPS; "I can get tense when I speak in front of other people"). Spanish versions have been validated in large undergraduate samples (Olivares et al., 2001). Researchers use scores greater than 33 on the SIAS or 23 on the SPS to indicate social phobia (Brown et al., 1997).

The trait scale of the STAI (Spielberger et al., 1983) is a 20-item questionnaire used to assess a relatively enduring disposition to feel stress, worry, and discomfort in a wide range of situations. Trait anxiety items include: "I worry too much over something that really doesn't matter". Items are rated on a 4-point scale from 1 (*almost never*) to 4 (*almost always*). In our experimental sample, the STAI scores were correlated with BFNE ($r=.73$), SIAS ($r=.69$), and SPS ($r=.63$) scores (all $ps < .0001$; $N=48$).

2.1.3. Stimuli

We used 2,000-ms video-clips. To build them, we first selected photographs of *prototypical* neutral (i.e., neutral eyes and mouth; henceforth, Neutral) and happy (i.e., happy eyes and a smiling mouth; henceforth, Happy) expressions of 24 posers (12 females; 12 males) from the Karolinska Directed Emotional Faces database (KDEF; Lundqvist et al., 1998). Second, we constructed composite faces for each poser (see Calvo et al., 2012), by combining the upper half of each happy face and the lower half of the neutral face, and vice versa. This produced two types of *blended* expressions: (a) neutral eyes and a smiling mouth (henceforth, Ne+Sm), and (b) happy eyes and neutral mouth (henceforth, He+Nm). Fig. 1 shows an example of these expressions.

Third, the resulting photographic versions (Neutral, Happy, He+Nm, Ne+Sm) were converted into 30-frame per second dynamic expressions by means of FantaMorph© (version 5.4.2 Deluxe; Abrosoft) software. To this end, one photograph of each version was placed as the first frame of the sequence (e.g., Neutral) and another photograph of a different version (e.g., Happy) as the last frame of the sequence. FantaMorph generated a continuum that smoothly unfolded from one expression to the other. This yielded eight experimental conditions (see Table 2). A total of 192 video-clips were used (24 posers by eight expression conditions).

Within each video, the initial expression (e.g., Neutral) lasted for 500 ms, followed by a 1,000-ms unfolding from the initial to the final expression (e.g., Happy), which remained still for 500 ms. The 1,000-ms unfolding was established to approximate the typical and natural average speed in prior research on recognition of dynamic expressions (Hoffmann et al., 2010; Kamachi et al., 2001; Pollick et al., 2003; Recio et al., 2013). Each face subtended a visual angle of 10.6° (height) × 8.0° (width) at a 70-cm viewing distance. This approximates the size of a real face (18.5 × 13.8 cm) viewed from a 1-m distance.

2.1.4. Procedure

Each participant was presented with the 192 video-clips (24 of each expression) in 6 blocks of 32 trials by means of E-Prime 2.0 software. Block order was counterbalanced, the number of trials of each expression was balanced for each block, and trial order was randomized. Participants were told that short videos would be presented, with different facial expressions. They were asked to respond quickly how much trustworthy each expresser looked like in a 9-point scale, where 1 and 2 indicated "very untrustworthy"; 3 and 4 indicated "rather untrustworthy"; 5, "neither trustworthy nor untrustworthy"; 6 and 7, "rather trustworthy"; and 8 and 9, "very trustworthy", by pressing a key (upper row of a computer keyboard).

The sequence of events on each trial is shown in Fig. 2. After an

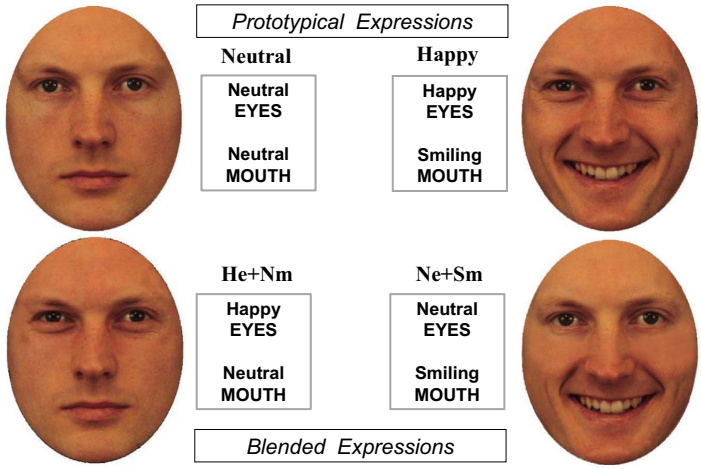

Fig. 1. Types of prototypical (Neutral: neutral eyes and mouth; or Happy: happy eyes and mouth) and blended expressions (Ne+Sm: neutral eyes and a smiling mouth; He+Nm: happy eyes and a neutral mouth) in Experiment 1.

Table 2
Experimental conditions as a function of combinations of eye and mouth expressions at the beginning and end of the dynamic sequence, in Experiment 1.

Condition	Initial expression EYES	Initial expression MOUTH	Unfolding towards	Final expression EYES	Final expression MOUTH	Acronym
1	Neutral	Neutral	→	Happy	Smile	Neutral→Happy
2	Happy	Neutral	→	Happy	Smile	He+Nm→Happy
3	Neutral	Neutral	→	Neutral	Smile	Neutral→Ne+Sm
4	Neutral	Smile	→	Happy	Smile	Ne+Sm→Happy
5	Happy	Smile	→	Happy	Neutral	Happy→He+Nm
6	Neutral	Smile	→	Neutral	Neutral	Ne+Sm→Neutral
7	Neutral	Neutral	→	Happy	Neutral	Neutral→He+Nm
8	Happy	Smile	→	Neutral	Neutral	Happy→Neutral

Note. **Neutral**: congruent neutral eyes and neutral mouth. **Happy**: congruent happy eyes and happy (smiling) mouth. **He+Nm**: Happy eyes (He) and Neutral mouth (Nm). **Ne+Sm**: Neutral eyes (Ne) and Smiling mouth (Sm).

initial 500-ms fixation cross in the center of a screen, a video-clip appeared: a still photograph of the initial expression (500 ms), followed by unfolding of the initial towards the final expression (1,000 ms), and a still photograph of the final expression (500 ms). Following face offset, a screen appeared with the question "how much trustworthy"? The selected response and reaction times (from face offset) were collected. A 1,250-ms blank screen served as an intertrial interval.

2.2. Results and discussion

2.2.1. Participant characteristics

The social anxiety and the non-socially-anxious (henceforth, non-anxious controls) groups did not differ in gender (both, 62.5% females), age (see Table 1), and background (all were psychology undergraduates at La Laguna University). The social anxiety group exhibited higher scores on all four anxiety measures (BFNE, SIAS, SPS, and STAI; see Table 1). The mean BFNE scores in this group are equivalent to those reported for clinical social phobia (Gallego et al., 2007; Weeks et al., 2005). SIAS and SPS scores also indicated that the social anxiety group was highly symptomatic with 13 (54%) and 18 (75%) individuals, respectively, exceeding previously reported thresholds for identifying clinical social phobia (Brown et al., 1997).

2.2.2. Analysis of trustworthiness judgments

An overall 2 (Social Anxiety: high vs. non-anxious controls) × 8 (Facial Expression: see Table 2) ANOVA was conducted on trustworthiness responses in the 1–9 judgment scale and response latencies. Facial expression was a repeated-measures factor. For this and all the following analyses in both experiments, Greenhouse-Geisser corrections for unequal variances were performed, as well as Bonferroni corrections ($p < .05$) for a posteriori multiple contrasts. With our sample size ($n = 48$) we had .80 power to detect an effect of $f = .31$ ($d = 0.62$) at $\alpha = .05$.

For *response judgments*, main effects of social anxiety, $F(1, 46) = 12.97$, $p < .001$, $\eta_p^2 = .22$, and expression, $F(7, 322) = 298.55$, $p < .0001$, $\eta_p^2 = .87$, were qualified by an interaction, $F(7, 322) = 10.30$, $p < .0001$, $\eta_p^2 = .18$. Separate ANOVAs revealed expression effects for the non-anxious, $F(7, 161) = 221.84$, $p < .0001$, $\eta_p^2 = .91$, and the socially anxious, $F(7, 161) = 109.17$, $p < .0001$, $\eta_p^2 = .83$, groups. The interaction reflects the fact that trustworthiness ratings were higher for non-anxious than for socially anxious participants for the Neutral→Ne+Sm, $t(46) = 5.18$, $p < .0001$, and the Ne+Sm→Happy, $t(46) = 6.77$, $p < .0001$, expressions, whereas there were no differences as a function of social anxiety for the other expressions. Fig. 3 shows the scores and multiple contrasts across expression categories.

For *reaction times*, only a main expression effect emerged, $F(7, 322) = 4.62$, $p = .002$, $\eta_p^2 = .09$, with no more statistically significant effects ($Fs < 1$). Table 3 shows the scores and multiple contrasts across expression categories, similarly for non-anxious and socially anxious participants.

The paradigm and measures were sensitive to expression manipulations, with genuinely happy expressions (i.e., Neutral→Happy) being judged as trustworthy to a greater extent and faster than all the non-genuinely happy—yet smiling—faces, and as more trustworthy than faces with no final smile, for all the participants. In addition, relative to non-anxious, socially anxious participants judged as less trustworthy smiling faces with neutral eyes at the beginning (Ne+Sm→Happy) or end (Neutral→Ne+Sm) of the dynamic sequence. This form of ambiguity caused by neutral eyes in an otherwise smiling face (but not by happy eyes in the presence of a neutral mouth; He+Nm→Happy)

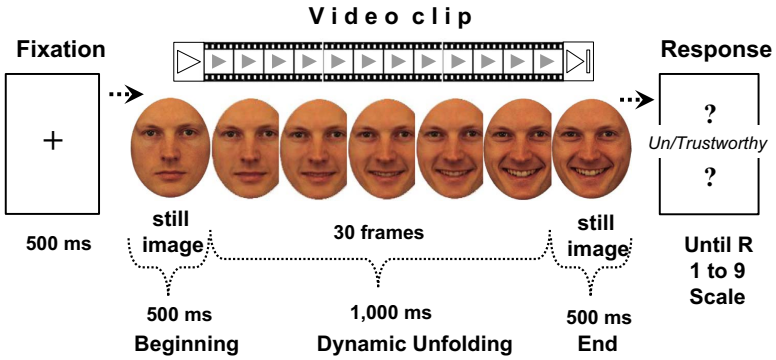

Fig. 2. Sequence of events on each trial in Experiment 1.

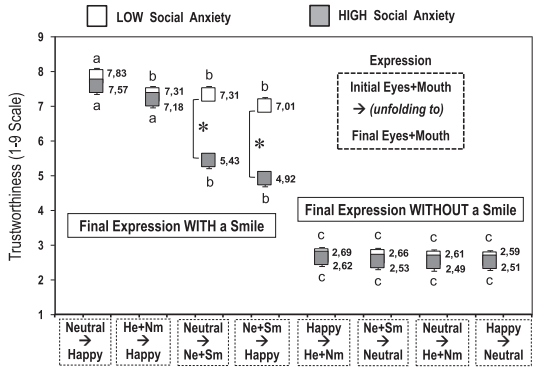

Fig. 3. Mean trustworthiness judgment scores for each type of facial expression, in Experiment 1. Within each anxiety group, across expression categories, scores with a different letter indicate significant differences in multiple post hoc contrasts; scores with the same letter are equivalent. Neutral: congruent neutral eyes and neutral mouth. Happy: congruent happy eyes and happy (smiling) mouth. He+Nm: Happy eyes (He) and Neutral mouth (Nm). Ne+Sm: Neutral eyes (Ne) and Smiling mouth (Sm).

aroused untrustworthiness especially for socially anxious individuals. In contrast, social anxiety did not modulate trustworthiness judgments of prototypical happy (Neutral→Happy) or non-happy (all those lacking a final smile) expressions.

3. Experiment 2: faces with a smiling mouth but "leaking" non-happy eyes

Experiment 2 investigated the role of social anxiety in trustworthiness judgments of smiling faces when *slight* changes (50% of intensity) appear in the *eye* expression (neutral, surprised, fearful, sad, disgusted, or angry). Such blended expressions may, in fact, represent fake smiles in social encounters where the smiler is not genuinely happy, but rather may have internal negative feelings (e.g., arrogance, sarcasm, or contempt, for angry or disgusted eyes; or nervousness, embarrassment, or appeasement, for fearful or sad eyes; or merely politeness, for surprised or neutral eyes; see Calvo et al., 2013a, 2013b). These feelings may involuntarily "leak" (e.g., as micro-expressions) through the eye region, even though a smiling mouth is intentionally exhibited. Although the smiling mouth makes a critical contribution to the *categorization* of faces as happy, the eyes become important for the *affective* processing of a smile and for judging genuine happiness (Calvo et al., 2012; Johnston et al., 2010; McLellan et al., 2010). Accordingly, the perception of non-happy changes in the eyes may be important for judging (un)trustworthiness. To examine this effect, we used faces in which the eyes unfolded from happy towards neutral, angry, etc., while maintaining a smiling mouth.

Table 4
Participant characteristics in Experiment 2.

	Low social anxiety		High social anxiety		Differences
	M	*SD*	*M*	*SD*	*Statistics*
Age	22.00	1.25	21.83	1.31	$t(46) = .45$, $p=.65$, *ns*
BFNE	22.08	4.55	46.67	5.58	$t(46)=16.73$, $p<.0001$
STAI-T	33.79	6.32	48.25	10.25	$t(46)=5.88$, $p<.0001$
SIAS	13.92	3.83	35.29	9.78	$t(46)=9.97$, $p<.0001$
SPS	11.29	3.59	30.33	8.93	$t(46)=9.69$, $p<.0001$

Note. BFNE: Brief Fear of Negative Evaluation Scale. STAI-T: State Trait Anxiety Inventory-Trait version. SIAS: Social Interaction Anxiety Scale. SPS: Social Phobia Scale.

3.1. Methods

3.1.1. Participants and measures

For Experiment 2, 48 undergraduates who did not participate in Experiment 1 were extracted from the same pool of 354 students (see 2.1.1., above). Twenty-four high (≥ 40) BFNE scorers (15 female) and 24 low (<30) scorers (15 female) were selected (see Table 4). The STAI, SIAS, and SPS measures were also used.

3.1.2. Stimuli

With the same photographs of 24 KDEF posers as in Experiment 1, we built 2,000-ms video-clips for six new experimental conditions. First, we constructed six composite face versions by replacing the upper half of each happy face with the neutral, surprised, fearful, sad, disgusted, or angry upper face half of the same individual, while the smiling mouth remained unchanged (see Calvo et al., 2013a, 2013b). This produced the following *blended* expressions: neutral eyes and a smiling mouth (henceforth, Ne+Sm); surprised eyes and a smile (SUe+Sm); fearful eyes and a smile (Fe+Sm); sad eyes and a smile (SAe+Sm); disgusted eyes and a smile (De+Sm); and angry eyes and a smile (Ae+Sm). Fig. 4 (lower row of faces) shows samples of the blended expressions (with non-happy eyes at 50% intensity). In addition, as *prototypical* expressions, we included Neutral (i.e., neutral eyes and mouth) and Happy (i.e., happy eyes and a smiling mouth) faces.

Table 3
Mean reaction times (ms) for each facial expression as a function of social anxiety in Experiment 1.

	Type of expression							
	Final expression WITH a smile				*Final expression WITHOUT a smile*			
Anxiety	Neutral to happy	He+Nm to happy	Neutral to Ne+Sm	Ne+Sm to happy	Happy to He+Nm	Ne+Sm to neutral	Neutral to He+Nm	Happy to neutral
Low								
Mean	788	926	922	961	894	946	908	917
SD	171	223	205	187	227	246	210	227
High								
Mean	881	984	1,008	1,018	936	912	944	922
SD	220	242	249	218	227	230	219	210
Average and contrasts for multiple comparisons								
	835^{a}	955^{b}	965^{b}	989^{b}	915^{ab}	929^{ab}	926^{ab}	920^{ab}

Note. Average scores with a different letter are significantly different across type of expression; scores sharing a letter are equivalent. **Neutral**: congruent neutral eyes and neutral mouth. **Happy**: congruent happy eyes and happy (smiling) mouth. **He+Nm**: Happy eyes (He) and Neutral mouth (Nm). **Ne+Sm**: Neutral eyes (Ne) and Smiling mouth (Sm).

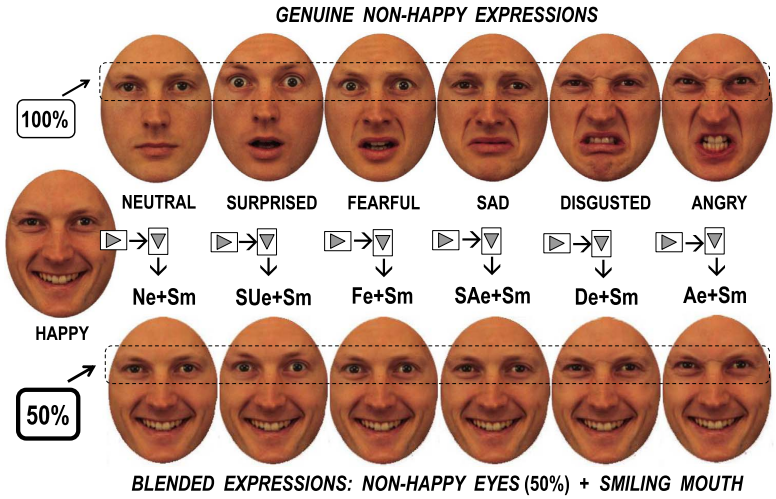

Fig. 4. Types of blended expressions (lower row: Ne+Sm; SUe+Sm; Fe+Sm; SAe+Sm; De+Sm; Ae+Sm) with non-happy eyes (neutral, surprised, fearful, sad, disgusted, and angry, respectively, and a smile, Sm) unfolding to 50% (of the respective full-blown non-happy expressions; upper row) from a happy face, in Experiment 2.

Second, the photographic versions were converted into video format with FantaMorph© software. The Neutral (i.e., Neutral→Happy) and Happy (i.e., Happy→Neutral) conditions remained as in Experiment 1. For the new blended expressions, a photograph of a happy face (happy eyes and a smiling mouth) was displayed for 1,000 ms, and then the eyes unfolded for 1,000 ms towards one of the six non-happy expressions at 30 frames per second: (a) Happy→Ae+Sm, which evolved from happy eyes and a smiling mouth towards angry eyes (up to 50% of anger intensity), but maintained the smile; (b) Happy→SAe+Sm, from happy to sad eyes (50%) and a smile; (c) Happy→Fe+Sm: from happy to fearful eyes (50%) and a smile; (d) Happy→De+Sm: from happy to disgusted eyes (50%) and a smile; (e) Happy→SUe+Sm: from happy to surprised eyes (50%) and a smile; and (f) Happy→Ne+Sm: from happy to neutral eyes (50%) and a smile. A total of 192 video-clips were produced (24 posers by eight conditions).

3.1.3. Procedure

Each participant was presented with all 192 video-clips in 6 blocks by means of E-Prime 2.0. The instructions and task were the same as in Experiment 1. The sequence of events on each trial were also the same, except that, after a 1,000-ms still photograph with a happy face (eyes and mouth), the expression unfolded towards non-happy eyes from second 1 to second 2, with no static expression at the end (see Fig. 5).

3.2. Results and discussion

3.2.1. Participant characteristics

The socially anxious and the non-anxious groups did not differ in gender (both, 62.5% females), age, and background. The social anxiety group exhibited higher scores on all four anxiety measures (Table 4). The mean BFNE scores in this group are consistent with those reported for clinical social phobia (Gallego et al., 2007; Weeks et al., 2005). SIAS and SPS scores indicated that the social anxiety group was highly symptomatic with 12 (50%) and 18 (75%) individuals, respectively, exceeding thresholds for social phobia (Brown et al., 1997).

3.2.2. Analysis of trustworthiness

A 2 (Anxiety) × 8 (Expression; repeated-measures) ANOVA was conducted on trustworthiness judgments and response latencies. For *response judgments*, main effects of social anxiety, $F(1, 46)=61.41$, $p<.0001$, $\eta_p^2=.57$, and expression, $F(7, 322)=291.48$,

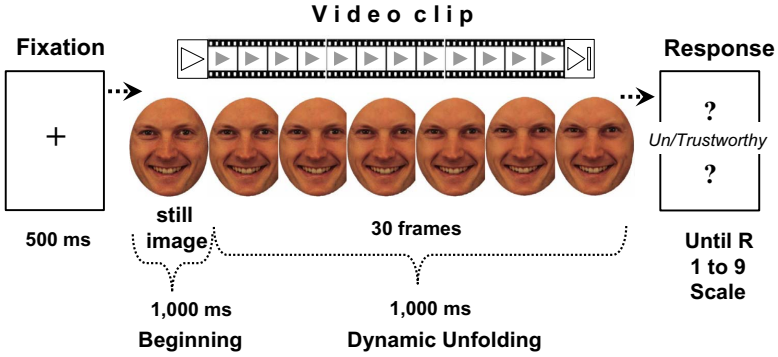

Fig. 5. Sequence of events on each trial in Experiment 2.

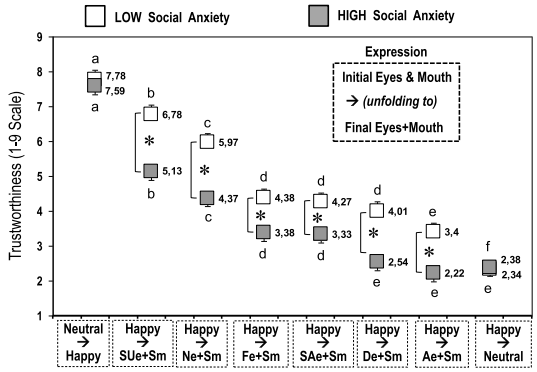

Fig. 6. Mean trustworthiness judgment scores for each type of facial expression, in Experiment 2. Within each anxiety group, across expression categories, scores with a different letter indicate significant differences in multiple post hoc contrasts; scores with the same letter are equivalent. Neutral: congruent neutral eyes and neutral mouth. Happy: congruent happy eyes and happy (smiling) mouth. SUe: Surprised eyes. Ne+Sm: Neutral eyes. Fe+Sm: Fearful eyes. SAe+Sm: Sad eyes. De+Sm: Disgusted eyes. Ae+Sm: Angry eyes. Sm: Smiling mouth.

$p < .0001$, $\eta_p^2 = .86$, were qualified by an interaction, $F(7, 322) = 9.06$, $p < .0001$, $\eta_p^2 = .17$. Separate ANOVAs revealed effects of expression for the non-anxious group, $F(7, 161) = 139.97$, $p < .0001$, $\eta_p^2 = .86$, and the socially anxious group, $F(7, 161) = 162.38$, $p < .0001$, $\eta_p^2 = .88$. The interaction reveals that trustworthiness ratings were higher for non-anxious than for socially anxious participants for the Happy→SUe+Sm, $t(46) = 5.88$, $p < .0001$, Happy→Ne+Sm, $t(46) = 5.72$, $p < .0001$, Happy→Fe+Sm, $t(46) = 3.94$, $p < .0001$, Happy→SAe+Sm, $t(46) = 4.62$, $p < .0001$, Happy→De+Sm, $t(46) = 7.59$, $p < .0001$, and Happy→Ae+Sm, $t(46) = 5.66$, $p < .0001$, expressions, whereas there were no differences as a function of social anxiety for the Neutral→Happy ($p = .37$) and the Happy→Neutral ($p = .19$) expressions. Fig. 6 shows the scores and multiple contrasts across expression categories.

For *reaction times*, a reliable expression effect emerged, $F(7, 322) = 39.52$, $p < .0001$, $\eta_p^2 = .46$, with no more statistically significant effects ($Fs < 1$). Table 5 shows the scores and multiple contrasts across the different expression categories, similarly for non-anxious and socially anxious participants.

The paradigm and measures were sensitive to expression manipulations, as genuinely happy expressions (Neutral→Happy) were judged as trustworthy to a greater extent and faster than non-genuinely happy—yet smiling—faces. In the same vein, significant trustworthiness differences appeared across most of the blended expressions sharing the same smiling mouth but different non-happy eyes. There was, nevertheless, a strong moderating role of social anxiety. For all the expressions with unfolding non-happy eyes in the presence of a smile, socially anxious participants either judged them as less trustworthy (Happy→SUe+Sm) or more untrustworthy (rest of expressions) than non-anxious participants. The prediction that social anxiety would lead to untrustworthiness evaluation especially for smiling faces with angry or disgusted eyes was not confirmed.

4. General discussion

Socially anxious and non-socially-anxious participants judged as *similarly* trustworthy expressions unfolding from a neutral mouth to a congruent happy face (with happy eyes and a smiling mouth), and as similarly *un*trustworthy expressions unfolding towards a neutral mouth (regardless of the eyes). In contrast, socially anxious participants judged as *less* trustworthy (or *more* untrustworthy) smiling faces involving *ambiguity* (a) due to the presence of incongruent neutral eyes at some point (beginning or the end) of the dynamic sequence (Experiment 1), or (b) due to happy eyes in a smiling face changing slightly (50%) towards neutral, surprised, angry, disgusted, sad, or fearful eyes (Experiment 2). These results support the hypothesis that reduced perception of happiness in ambiguous smiling faces by socially anxious individuals (Gutiérrez-García and Calvo, 2014; see also Maoz et al., 2016) is related to enhanced perception of untrustworthiness; and that this applies to all non-happy eyes, regardless of their affective valence. Socially anxious individuals would be especially prone to negatively interpret a smile with non-congruent eyes because it arouses untrustworthiness.

These findings have clinical implications regarding the conceptualization of social anxiety. First, according to cognitive models (Clark, 2001; Heimberg et al., 2014), social anxiety is characterized by a negative interpretative bias for ambiguous social stimuli. Our results have shown this in the form of untrustworthiness evaluation of ambiguous smiling faces. A smile can be seen as a signal of warmth and approval, but it can also be appraised in a less benign manner, even as a sign of dominance, contempt, or mockery, etc., which is particularly relevant to fear of negative evaluation, disapproval, and rejection, as the hallmark of social anxiety. Given that the smile is ubiquitous in social

Table 5
Mean reaction times (ms) for each facial expression as a function of social anxiety in Experiment 2.

	Type of Expression							
	Happy eye expression unfolding to 50% of non-happy							
Anxiety	Neutral to happy	Happy to SUe+Sm	Happy to Ne+Sm	Happy to Fe+Sm	Happy to SAe+Sm	Happy to De+Sm	Happy to Ae+Sm	Happy to Neutral
Low								
Mean	801	1,237	1,304	1,216	1,219	1,265	1,142	921
SD	160	298	260	269	281	270	239	267
High								
Mean	877	1,208	1,258	1,206	1,194	1,217	1,045	910
SD	245	243	266	204	213	299	285	262
Average and contrasts for multiple comparisons								
	839[a]	1,222[c]	1,281[c]	1,211[c]	1,207[c]	1,241[c]	1,093[b]	916[a]

Note. Average scores with a different letter are significantly different across type of expression; scores sharing a letter are equivalent. **Neutral**: congruent neutral eyes and neutral mouth. **Happy**: congruent happy eyes and happy (smiling) mouth. **SUe+Sm**: Surprised eyes (SUe) and Smiling mouth (Sm). **Ne+Sm**: Neutral eyes (Ne) and Smiling mouth (Sm). **Fe+Sm**: Fearful eyes (Fe) and Smiling mouth (Sm). **SAe+Sm**: Sad eyes (SAe) and Smiling mouth (Sm). **De+Sm**: Disgusted eyes (De) and Smiling mouth (Sm). **Ae+Sm**: Angry eyes (Ae) and Smiling mouth (Sm).

environments and frequently amenable to different interpretations, such a bias would often put socially anxious individuals at risk of enhancing their fears and subsequent social avoidance, in a vicious circle. Second, however, the lack of a bias for genuine happy faces—with a smile and congruent eyes—reveals that social anxiety is not characterized by any deficit or disfunction in expression identification (see Staugaard, 2010). This suggests that social anxiety would be essentially adaptive in the recognition and trustworthiness evaluation of faces with a smile: Social anxiety facilitates detection of incongruent (possibly fake) smiles, while not impairing an accurate evaluation of genuine smiles. As a self-protecting mechanism against disapproval and rejection, the socially anxious person would be biased to detect actual, subtle facial cues indicative of untrustworthiness. This would serve a major goal in social anxiety (i.e., to avoid negative evaluation) at the otherwise unlikely cost of judging a genuine smile as fake (and thus miss social reward).

The current study adds to previous ones on social anxiety and trustworthiness in that we used emotional instead of neutral face stimuli (Cooper et al., 2014; Meconi et al., 2014; Willis et al., 2013), and dynamic instead of static displays. Our approach also extends the scope to an important expression—due to its ubiquity and multifaceted significance in social environments—such as smiling. Social anxiety was related to untrustworthy evaluation of ambiguous smiling expressions, thus in line with the Willis et al. (2013) and Meconi et al. (2014) results. Our findings can also be integrated with those obtained in studies of perceived *cost* of social interaction (Button et al., 2013; Douilliez et al., 2012; Schofield et al., 2007), as perceived high cost of interaction with a person implies reduced trust in that person. Elevated social anxiety is associated with overestimation of social cost with people expressing facial disgust (Schofield et al., 2007), anger, disgust, fear, and sadness (Button et al., 2013), or anger and neutrality (Douilliez et al., 2012), but not with happy faces (Button et al., 2013; Schofield et al., 2007). Interestingly, first, the happy faces in these studies lacked any non-happy facial cue, which is consistent with our findings concerning the prototypical, non-ambiguous Neutral→Happy expressions. Second, in such studies, the enhanced perceived cost generalized to all non-happy expressions, which is consistent with our own findings regarding untrustworthiness for all smiling-mouth faces with non-happy eyes.

One potential limitation of the current study is the use of participants with high social anxiety rather than patients. Nevertheless, over half of the group met clinical thresholds for BFNE, SIAS, and SPS measures (Brown et al., 1997; Gallego et al., 2007; Weeks et al., 2005; see also Button et al., 2014). This suggests that our results have relevance to clinical populations, given the continuum between sub-clinical social anxiety and social anxiety disorder, and the fact that cognitive biases in patients have also been found in non-clinical samples (García-López et al., in press; see Morrison and Heimberg, 2013). Another possible limitation is concerned with the ecological validity of our stimuli. As in many prior studies (e.g., Harris et al., 2014; Kessels et al., 2013), we used morphed facial expressions, which, nevertheless, differ from natural expressions. Morphing involves linear changes between two faces where all the features change at the same time and with uniform speed. In contrast, natural expressions may unfold in a rather asynchronous and asymmetrical manner. Thus future research should extend these findings to natural expressions. A related issue is the unusualness of some expressions (e.g., happy eyes combined with a neutral mouth). While such combinations were necessary (see Footnote 1), it is possible that social anxiety may be more related to face 'strangeness' than to perception of ambiguity or threat cues. Against this hypothesis, however, there were no differences as a function of social anxiety for some unusual faces (e.g., happy eyes with a neutral mouth unfolding to a happy face, and many others). Finally, trustworthiness was assessed by means of subjective judgments rather than by actual trust behavior. It would be useful to investigate whether similar results would be found when some form of approach or avoidance behavior is assessed. Dijk et al. (2011) demonstrated that trustworthiness judgments in fact paralleled actual trust-related behavior (lending money in a morally framed task).

In sum, social anxiety is related to untrustworthiness evaluation (a) of faces unfolding from neutral to happy, if a smiling mouth develops in the presence of neutral eyes; and (b) of smiling faces, if happy eyes slightly change towards neutrality, surprise, fear, sadness, disgust, or anger. In contrast, social anxiety is unrelated to trustworthiness judgments of prototypical, non-ambiguous expressions dynamically unfolding from neutral to happy, or happy faces unfolding to a neutral expression. Socially anxious individuals are thus characterized by a bias towards mistrusting any (ambiguous) smile in the presence of non-happy eyes. Non-socially-anxious individuals are indeed sensitive to non-happy eyes, too, but their trustworthiness evaluation is much less affected.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.psychres.2016.07.004.

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ANEXO IV

Gutiérrez-García, A., Calvo, M. G., & Eysenck, M. W. (2018). Social anxiety and detection of facial untrustworthiness: Spatio-temporal oculomotor profiles. *Psychiatry Research, 262*, 55-62.

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Social anxiety and detection of facial untrustworthiness: Spatio-temporal oculomotor profiles

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ABSTRACT

Cognitive models posit that social anxiety is associated with biased attention to and interpretation of ambiguous social cues as threatening. We investigated attentional bias (selective early fixation on the eye region) to account for the tendency to distrust ambiguous smiling faces with non-happy eyes (interpretative bias). Eye movements and fixations were recorded while observers viewed video-clips displaying dynamic facial expressions. Low (LSA) and high (HSA) socially anxious undergraduates with clinical levels of anxiety judged expressers' trustworthiness. Social anxiety was unrelated to trustworthiness ratings for faces with congruent happy eyes and a smile, and for neutral expressions. However, social anxiety was associated with reduced trustworthiness rating for faces with an ambiguous smile, when the eyes slightly changed to neutrality, surprise, fear, or anger. Importantly, HSA observers looked earlier and longer at the eye region, whereas LSA observers preferentially looked at the smiling mouth region. This attentional bias in social anxiety generalizes to all the facial expressions, while the interpretative bias is specific for ambiguous faces. Such biases are adaptive, as they facilitate an early detection of expressive incongruences and the recognition of untrustworthy expressers (e.g., with fake smiles), with no false alarms when judging truly happy or neutral faces.

1. Introduction

Socially anxious individuals are particularly sensitive to negative evaluation, which makes them experience persistent and intense fear of social situations in which they may be scrutinized (American Psychiatric Association, 2013). Interpretation biases (i.e., judging ambiguous stimuli and situations as threatening) have been proposed to underlie the development and maintenance of social anxiety (see Amir and Bomyea, 2010; Steinman et al., 2014). There is evidence that ambiguous social stimuli are interpreted in a more negative (or less positive) manner by socially anxious than by non-anxious individuals (see Mobini et al., 2013; Morrison and Heimberg, 2013). Facial expressions are relevant social cues as they convey approval and liking, or disapproval and hostility, and they are often ambiguous (for example, due to low or subtle intensity, or co-occurrence with non-congruent cues, blends, etc.). Thus, they are amenable to different interpretations. It is therefore likely that the socially anxious person uses observed facial cues to infer potential negative evaluation or intentions from others.

Prior research on the explicit *recognition* (in expression categorization tasks) of *prototypical* facial expressions (e.g., anger, sadness, etc.) has generally found no differences as a function of social anxiety (see Staugaard, 2010). In contrast, there is some evidence that socially anxious individuals interpret *ambiguous* expressions in a more negative way (as angry: Bell et al., 2011; Gutiérrez-García and Calvo, 2017; Yoon et al., 2014; or disgusted or contemptuous: Gutiérrez-García and Calvo, 2017; Heuer et al., 2010), or in a less benign fashion (as less happy: Gutiérrez-García and Calvo, 2014, 2017), relative to non-anxious individuals (but see Button et al., 2013; Jusyte and Schönenberg, 2014). Further, for basic facial emotions, social anxiety is associated with enhanced sensitivity toward perceiving anger and disgust at *low intensities* (i.e., under high ambiguity), with no effect for other expressions (fear, sadness, surprise, and happiness), or for anger and disgust at higher intensities (i.e., low ambiguity; Gutiérrez-García and Calvo, 2017). The facilitated detection of anger and disgust, and the biased interpretation of ambiguous expressions as anger, disgust, or contempt, are understandable, as these expressions are related to negative evaluation and rejection, and fear of it constitutes a hallmark of social anxiety.

An implication is that, to avoid feared negative social evaluation or rejection, social anxiety might drive *untrustworthiness* judgments (as an interpretative process) of other people as soon as signs—even if

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ambiguous—of those expressions are detected. However, prior research on the relationship between social anxiety and un/trustworthiness judgments has obtained discrepant findings when *neutral* faces were used as stimuli. Meconi et al. (2014) found enhanced encoding of untrustworthy faces in social anxiety, but Cooper et al. (2014) reported non-significant effects. In contrast, with *emotional* faces as stimuli, social anxiety is related to (a) heightened distrust toward angry and disgusted expressions even at low intensities (Gutiérrez-García and Calvo, 2016a), and (b) reduced trustworthiness for smiling faces with neutral eyes, or when happy eyes subtly change toward non-happy (e.g., neutral, angry, etc.) (Gutiérrez-García and Calvo, 2016b).

The aim of the current study was to examine whether an attentional bias (i.e., selective and early gaze allocation to particular face regions) can account for such interpretative bias (i.e., untrustworthiness judgments of ambiguous expressions). We hypothesize that the tendency to distrust blended expressions with a smile but non-happy eyes by socially anxious individuals develops through a gaze bias toward looking earlier at non-happy eyes. In contrast, the visual attention of non-anxious individuals would be attracted more by the salient smiling mouth, thus making them judge such expressions as happy, given the diagnostic value of the smile for happiness categorization (Calder et al., 2000; Calvo et al., 2014); and, hence, as trustworthy, given the consistent relationship between perceived facial happiness and trustworthiness (Krumhuber et al., 2007; Quadflieg et al., 2013). We focused on smiling faces because of the inherent ambiguity of the smile, which can actually be associated with very different emotions apart from enjoyment and warmth, such as arrogance, dominance, sarcasm, contempt, nervousness, embarrassment, appeasement, or mere politeness (Ambadar et al., 2009; Niedenthal et al., 2010). Accordingly, faces with a smile are suitable to investigate interpretative bias in the form of reduced trustworthiness, since happy faces are generally rated as trustworthy but smiles can have multiple meanings (including negative ones, e.g., mockery).

A secondary aim focused on the role of different types of non-happy eyes. More specifically, we were interested in how different non-happy eye expressions (angry, fearful, surprised, and neutral) in faces with a smile modulate the proposed attentional bias. Although the smile makes a critical contribution to the *semantic categorization* of faces as happy, the eyes become important for the *affective processing* of a smile as genuine (Calvo et al., 2012; Johnston et al., 2010; McLellan et al., 2010). Presumably, the eyes can finely express more affective nuances than the straight smiling mouth (which otherwise can be voluntarily controlled to a greater extent), and the eyes can thus convey the expresser's current feelings and intentions better than the mouth. These feelings may involuntarily "leak" as micro-expressions through the eye region, even though a smiling mouth is intentionally exhibited. Further, the perceived authenticity of facial happiness and the genuineness of a smile are related to perceived trustworthiness (Krumhuber et al., 2007; Quadflieg et al., 2013) and predict trust behavior (Centorrino et al., 2015). Accordingly, perceived trustworthiness should be particularly sensitive to expressive changes in the eyes. We thus explored whether a bias toward selective early gazing at the eyes is modulated by type of non-happy eyes (or, rather, generalizes to all expressions) in social anxiety.

To investigate the above issues, we presented 2-s video-clips displaying dynamic facial expressions to high social anxiety (HSA) and low social anxiety (LSA) participants, who judged the expressers' trustworthiness while their eye fixations were recorded. Eye-tracking measures assessed the face region to which gaze was selectively directed and the gaze time course. The face stimuli involved (a) *prototypical* expressions (happy: neutral eyes and mouth unfolding to happy eyes and a smile; or non-happy: happy eyes and a smile unfolding to neutral) and (b) *blended* expressions with a constant smiling mouth but eyes changing from happy to non-happy (angry, fearful, surprised, or neutral). For blended expressions, *slight* changes (50% of intensity) appeared in the *eyes*. Such expressions represent fake smiles in social encounters where the smiler is not genuinely happy, but rather may have internal negative feelings, motives, or intentions (e.g., arrogance, sarcasm, or contempt, for angry eyes; or nervousness, embarrassment, or appeasement, for fearful eyes; or merely politeness, for surprised or neutral eyes; Calvo et al., 2013). A 50% intensity of non-happy eye expressions was chosen to make the change realistic in a face with a smiling mouth. Higher intensities are unlikely to occur in social interaction, and would thus seem odd or unnatural.

2. Method

2.1. Participants

The Brief Fear of Negative Evaluation (BFNE) scale (Leary, 1983), the Social Interaction Anxiety Scale (SIAS) and Social Phobia Scales (SPS; Mattick and Clarke, 1998) were administered to the 236 students in classrooms, using anonymous codes. Twenty-four psychology undergraduates with high scores (HSA; $\geq$ 40) and 24 with low scores (LSA; $<$ 30) on the BFNE scale were selected, with 15 females and 9 males in each group, aged 20–25 years. The HSA group had significantly higher scores than the LSA group on all three anxiety measures (BFNE, SIAS, and SPS; Table 1). With this sample size, the power for detecting medium effect sizes (f = 0.25) in interactions between group (two groups) and within-subject (six measurements) factors is larger than 0.90, at α = 0.05, with a .5 correlation, and non-sphericity correction *épsilon* = 1. Written informed consent was obtained from the participants. The study was approved by the local ethics committee and conducted in accordance with the WMA Declaration of Helsinki 2008.

2.2. Social anxiety assessment

The 12-item BFNE scale assessing fear of negative evaluation by others (Leary, 1983) was the primary measure of social anxiety. Responses range from 1 (*not at all characteristic of me*) to 5 (*extremely characteristic of me*). The BFNE is well-validated (Spanish version by Gallego et al., 2007), with high factorial and construct validity in undergraduate (Rodebaugh et al., 2004) and clinical samples (M scores = 47 in social phobia patients, Weeks et al., 2005; and M = 43 in clinically-diagnosed social phobic undergraduates, Gallego et al., 2007). The mean HSA BFNE scores (M = 46.33) in the current study are thus comparable to those of clinical social phobia.

The SIAS and the SPS (Mattick and Clarke, 1998) assess fear of social interaction and fear of being observed, respectively. Each questionnaire is a 20-item measure using a scale ranging from 0 (*not at all characteristic of me*) to 4 (*extremely characteristic of me*), with participants indicating the extent to which the statement applies to them. Spanish versions have been validated in large undergraduate samples (Olivares et al., 2001). Researchers use scores greater than 33 on the SIAS or 23 on the SPS to indicate social phobia (Brown et al., 1997). The mean SIAS (M = 35.33) and SPS (M = 30.33) scores in the current study thus indicated the HSA group was highly symptomatic.

Table 1
Participant characteristics.

	Low social anxiety		High social anxiety		Differences
	M	*SD*	*M*	*SD*	*Statistics*
Age	22.12	1.26	21.71	1.33	$t(46) = 1.09$, $p = 0.28$, *ns*
BFNE	22.25	4.58	46.33	5.02	$t(46) = 17.36$, $p < 0.0001$
SIAS	13.92	3.83	35.33	9.77	$t(46) = 9.99$, $p < 0.0001$
SPS	11.62	3.45	30.33	8.93	$t(46) = 9.57$, $p < 0.0001$

Note. BFNE: Brief Fear of Negative Evaluation Scale. SIAS: Social Interaction Anxiety Scale. SPS: Social Phobia Scale.

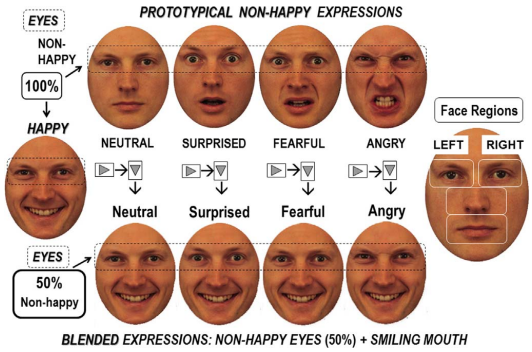

Fig. 1. Types of blended expressions (lower row) with a smile and 50% non-happy eyes (neutral, surprised, fearful, and angry), between the respective prototypical, full-blown non-happy expressions (upper row) and a prototypical happy face (middle left). Face regions: Left and right, from the viewer's perspective.

2.3. Stimuli

We used 144, 2-s video-clips of facial expressions (24 video-clips for each of six categories). To construct them, we first selected photographs of *prototypical* neutral expressions (i.e., neutral eyes and mouth; henceforth, Neutral) and happy expressions (i.e., happy eyes and a smiling mouth; Happy) of 24 posers (12 female; 12 male) from the Karolinska Directed Emotional Faces database (KDEF; Lundqvist et al., 1998). Second, we created *blended* expressions (see Fig. 1; lower row of faces): Composite faces were formed by replacing the upper half of each happy face with the neutral, surprised, fearful, or angry upper face half of the same individual, while the lower face half with the smile remained unchanged. This produced four blends: neutral eyes and a smile; surprised eyes and a smile; fearful eyes and a smile; and angry eyes and a smile. Third, for blends, we established a 50% intensity level of the eye expression. To this end, by means of FantaMorph© software (Abrosoft), we created a sequence of frames between the eyes of a prototypical happy face (100% intensity; Fig. 1, middle row, left) and the eyes of a prototypical non-happy face (either, neutral, surprised, fearful, or angry; 100% intensity; Fig. 1, upper row). Then, we extracted exactly the intermediate frame of the sequence, which represented the middle point between both ends (i.e., 50% happy-nonhappy; Fig. 1, lower row). Fourth, the resulting photographic versions were converted into *dynamic* versions using FantaMorph. One photograph was placed as the first frame of the sequence (e.g., Neutral; or Happy, etc.) and another (e.g., Happy; or neutral, surprised, etc. eyes and a smiling mouth) as the last frame. FantaMorph generated a continuum that smoothly unfolded from one expression to the other at 30 frames per second.

This yielded four experimental conditions of *dynamic blended* expressions (see samples of video-clips in the Supplemental Materials): (a) a happy face (i.e., happy eyes and a smiling mouth) unfolding toward *neutral eyes* (up to 50%) while keeping the *smile*; (b) a happy face unfolding from happy to *surprised eyes* (50%) while keeping the *smile*; (c) a happy face unfolding from happy to *fearful eyes* (50%) while keeping the *smile*; and (d) a happy face unfolding to *angry eyes* (50%) while keeping the *smile*. Within each video-clip, a photograph of a happy face (happy eyes and a smiling mouth) was initially displayed for 1000 ms, and then the eyes evolved for 1000 ms toward one of the four non-happy eye expressions.

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Two more conditions involved *dynamic prototypical* expressions: (a) Neutral (i.e., Neutral→Happy), in which both the eyes and the mouth evolved from neutral to happy; and (b) Happy (i.e., Happy→Neutral), in which both the eyes and the mouth evolved from happy to neutral. Within each video-clip, the initial expression (Neutral or Happy) lasted for 500 ms, followed by a 1000-ms unfolding to the final expression (e.g., Happy), which remained still for 500 ms.

2.4. Procedure

Each participant was presented with the 144 video-clips. Participants were told short videos would be shown, with different facial expressions (otherwise unspecified). On each trial, upon video offset, participants had to judge and respond quickly *"how trustworthy each expresser looked like"* on a 9-point scale, by pressing a key on the top row of a standard computer keyboard: 1 indicated "very untrustworthy"; 5, "neither trustworthy nor untrustworthy"; and 9, "very trustworthy"). The selected response and reaction times were collected. Faces subtended an angle of 10.6° (height) × 8.0° (width) at a 70-cm viewing distance, approximating the size of a real face viewed from 1 m.

2.5. Eye-movement measures

Gaze behavior was recorded via a 500-Hz (binocular; spatial resolution: 0.03°; gaze position accuracy: 0.4°) RED system eyetracker (SensoMotoric Instruments GmbH; Teltow, Germany). Four face regions of interest (see Fig. 1) were defined: left eye, right eye, nose/cheek, and mouth. *Left* and *right* eye are considered from the *viewer's perspective*, i.e., left-eye fixations refer to fixations made by viewers toward their left (the right eye of the videoed person).

Gaze duration for each expression, face region, and display period (i.e., 0–1000 ms [static] and 1001–2000 ms [dynamic], for *blended* expressions; or 0–500 ms [static], 501–1500 ms [dynamic], and 1501–2000 ms [static], for *prototypical* expressions) assessed *amount of attention*. Gaze duration represents the total dwell time (all fixations) viewing each region per period. *Net* gaze duration was obtained, after saccades, blinks, and fixations shorter than 80 ms were removed.

Fixation density, i.e., the number of fixations (across all viewers; mean per expression category) on each region during each of 60 consecutive 33-ms time bins across the 2-s face display was computed. This provides a fine-grained analysis of the scanpath of fixations over time, and reveals the processing *time course*. As an additional measure of the fixation time course, *entry times* (i.e., the time elapsed from face onset until first fixation on each region) were also examined.

3. Results

For all the following analyses, Greenhouse-Geisser corrections for unequal variances were performed to deal with potential violations of the sphericity assumption. Also, Bonferroni corrections ($p < 0.05$ threshold) were used for all post hoc multiple comparisons, to correct for potential Type I errors.

3.1. Trustworthiness judgments

A 2 (Social Anxiety: HSA vs. LSA) × 6 (Facial Expression: see 2.3.) ANOVA was performed on trustworthiness judgments (1–9 scale) and latencies. For *response ratings*, effects of social anxiety, $F(1, 46) = 11.66$, $p < 0.001$, $\eta_p^2 = 0.20$, and expression, $F(5, 230) = 273.09$, $p < 0.0001$, $\eta_p^2 = 0.86$, were extended with an interaction, $F(5, 230) = 4.26$, $p = 0.002$, $\eta_p^2 = 0.09$. HSA participants endorsed lower scores than LSA ones to happy expressions unfolding to *blended* expressions with (a) *neutral eyes* and a smile, $t(46) = 3.72$, $p < 0.001$, $d = 1.07$, (b) *surprised eyes* and a smile, $t(46) = 3.07$, $p = 0.004$, $d = 0.89$, (c) *fearful eyes* and a smile, $t(46) = 2.63$, $p = 0.012$, $d = 0.76$, and angry eyes and a smile, $t(46) = 3.11$, $p = 0.004$, $d = 0.90$. There were no anxiety group differences for prototypical expressions unfolding from neutral to happy ($p = 0.40$) or happy to neutral ($p = 0.87$). For *reaction times*, an expression effect emerged (see Fig. 2, for mean scores and multiple

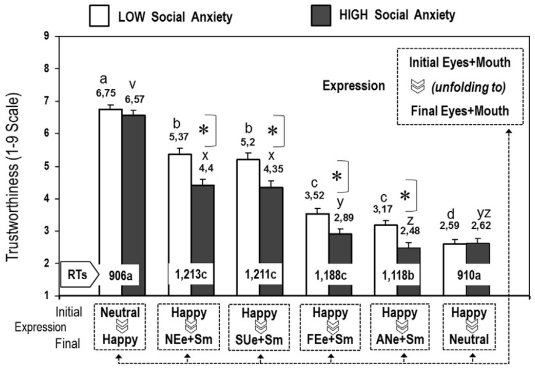

Fig. 2. Mean trustworthiness judgment scores and reaction times (RTs, ms) for each expression. Within each anxiety group, across expression categories, scores with a different letter (a, b, c, d: socially anxious group; v, x, y, z: non-anxious group) indicate significant differences; scores with the same letter are equivalent. For RTs, the scores for both groups are averaged. Vertical lines in bars indicate standard errors of the mean. **Neutral**: neutral eyes and neutral mouth. **Happy**: happy eyes and happy (smiling) mouth. **NEe + Sm**: Neutral eyes and Smile; **SUe + Sm**: Surprised eyes and Smile; **FEe + Sm**: Fearful eyes and Smile; **ANe + Sm**: Angry eyes and Smile.

contrasts), $F(5, 230) = 64.69$, $p < 0.0001$, $\eta_p^2 = 0.58$, with no effects of social anxiety ($p = 0.17$) or the interaction ($F < 1$).

3.2. Gaze duration

Net gaze duration on each face region of *blended* expressions was analyzed using a repeated-measures ANOVA involving Social Anxiety (2) × Expression (4; see 2.3) × Region (4; see 2.5) × Interval (2: 0–1000 ms vs. 1001–2000 ms), with expression, region, and interval as within-subjects factors. The *prototypical* expressions were analyzed separately because their display intervals were different (see 2.3), in a Social Anxiety (2) × Expression (2) × Region (4) × Interval (3: 0–500 ms vs. 501–1500 ms vs. 1501–2000 ms). We will focus on the statistically significant effects involving anxiety (other significant effects will be reported in footnotes 1–5, and non-significant effects will not be reported).

3.2.1. Blended expressions

An interaction of anxiety by region, $F(3, 138) = 4.71$, $p = 0.006$, $\eta_p^2 = 0.09$, emerged. As shown in Fig. 3, pairwise comparisons showed that LSA participants fixated on the *mouth* longer than HSA ones in both the 0-to-1000-ms period, $t(46) = 3.16$, $p = 0.004$, $d = 0.91$, and the 1001–2000-ms period, $t(46) = 2.83$, $p = 0.008$, $d = 0.82$. The reverse occurred for the *left eye* region, which was fixated longer by HSA participants, $t(46) = 2.95$, $p = 0.005$, $d = 0.85$, and, $t(46) = 2.42$, $p = 0.03$, $d = 0.70$, respectively. These group differences remained significant across all four blended expressions (all $ts > 2.15$, $ps \leq 0.037$, $ds \geq 0.62$).[1]

3.2.2. Prototypical expressions

An anxiety by interval by region interaction, $F(6, 276) = 8.53$, $p < 0.0001$, $\eta_p^2 = 0.16$, emerged. The anxiety by region interaction was significant in the 501-to-1500-ms, $F(3, 138) = 9.35$, $p < 0.0001$, $\eta_p^2 = 0.17$, and the 1501-to-2000-ms, $F(3, 138) = 5.22$, $p = 0.003$, $\eta_p^2 = 0.10$, periods, but not in the 0–500-ms period. For both expressions, LSA participants fixated on the mouth longer than HSA ones, $ts(46) \geq 3.00$, $ps \leq 0.004$, $ds \geq 0.87$, whereas the reversed occurred on the left, $ts(46) \geq 2.76$, $ps \leq 0.008$, $ds \geq 0.80$, and the right, $ts(46) \geq 2.03$, $ps \leq 0.048$, $ds \geq 0.59$, eyes (see Fig. 3).[2]

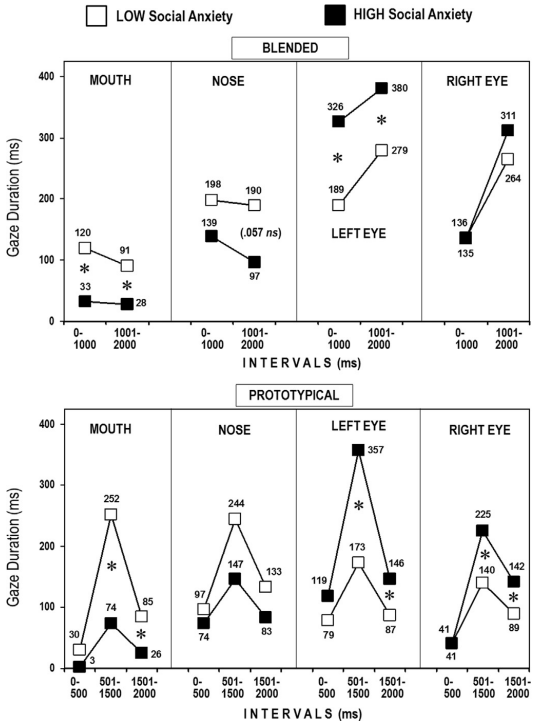

Fig. 3. Mean gaze duration on each face region across successive intervals, for *blended* facial expressions (averaged) and *prototypical* expressions (averaged), as a function of social anxiety. Asterisks indicate significant differences between socially anxious (HSA) and non-anxious (LSA) groups. Left and right eye, from the viewer's perspective.

3.3. Fixation density over the 2-s stimulus display

To assess the time course of gaze over time (60 consecutive 33-ms bins), a Social Anxiety (2) × Expression (4) × Region (4) × Interval (60) ANOVA on fixation density scores was conducted for *blended* expressions; and a Social Anxiety (2) × Expression (2) × Region (4) × Interval (60) ANOVA, for *prototypical* expressions.

3.3.1. Blended expressions

Interactions of anxiety by region, $F(3, 184) = 202.13$, $p < 0.0001$, $\eta_p^2 = 0.77$, and anxiety by region by interval, $F(177, 10856) = 21.26$, $p < 0.0001$, $\eta_p^2 = 0.26$, appeared.[3] To decompose them, we first

[1] Additional significant effects of region, $F(3, 138) = 19.40$, $p < 0.0001$, $\eta_p^2 = 0.30$, interval, $F(1, 46) = 107.55$, $p < 0.0001$, $\eta_p^2 = 0.70$, and region by interval, $F(3, 138) = 45.38$, $p < 0.0001$, $\eta_p^2 = 0.50$, revealed that gaze duration on the *mouth* decreased from the first (0–1000 ms) to the second (1000–2000 ms) period, $F(1, 47) = 9.38$, $p = 0.004$, $\eta_p^2 = 0.17$, whereas it increased in the second period for the *left eye*, $F(1, 47) = 32.59$, $p < 0.0001$, $\eta_p^2 = 0.41$, and the *right eye*, $F(1, 47) = 137.20$, $p < 0.0001$, $\eta_p^2 = 0.74$, with no significant difference for the *nose* region ($p = 0.09$).

[2] Effects of region, $F(3, 138) = 4.81$, $p = 0.005$, $\eta_p^2 = 0.09$, interval, $F(2, 92) = 531.37$, $p < 0.0001$, $\eta_p^2 = 0.92$, and a region by interval by expression interaction, $F(6, 276) = 6.93$, $p < 0.0001$, $\eta_p^2 = 0.13$, revealed that gaze duration on the *mouth* was longer for the Neutral-to-Happy than for the Happy-to-Neutral expression in the second period (500–1500 ms), $t(47) = 4.25$, $p < 0.001$, and the third period (1500–2000 ms), $t(47) = 2.34$, $p = 0.024$, whereas gaze duration on the *left eye* region was longer for the Happy-to-Neutral than for the Neutral-to-Happy expression in the third period, $t(47) = 2.97$, $p = 0.005$, with no more significant differences.

[3] For blended expressions, additional effects of region, $F(3, 184) = 882.64$,

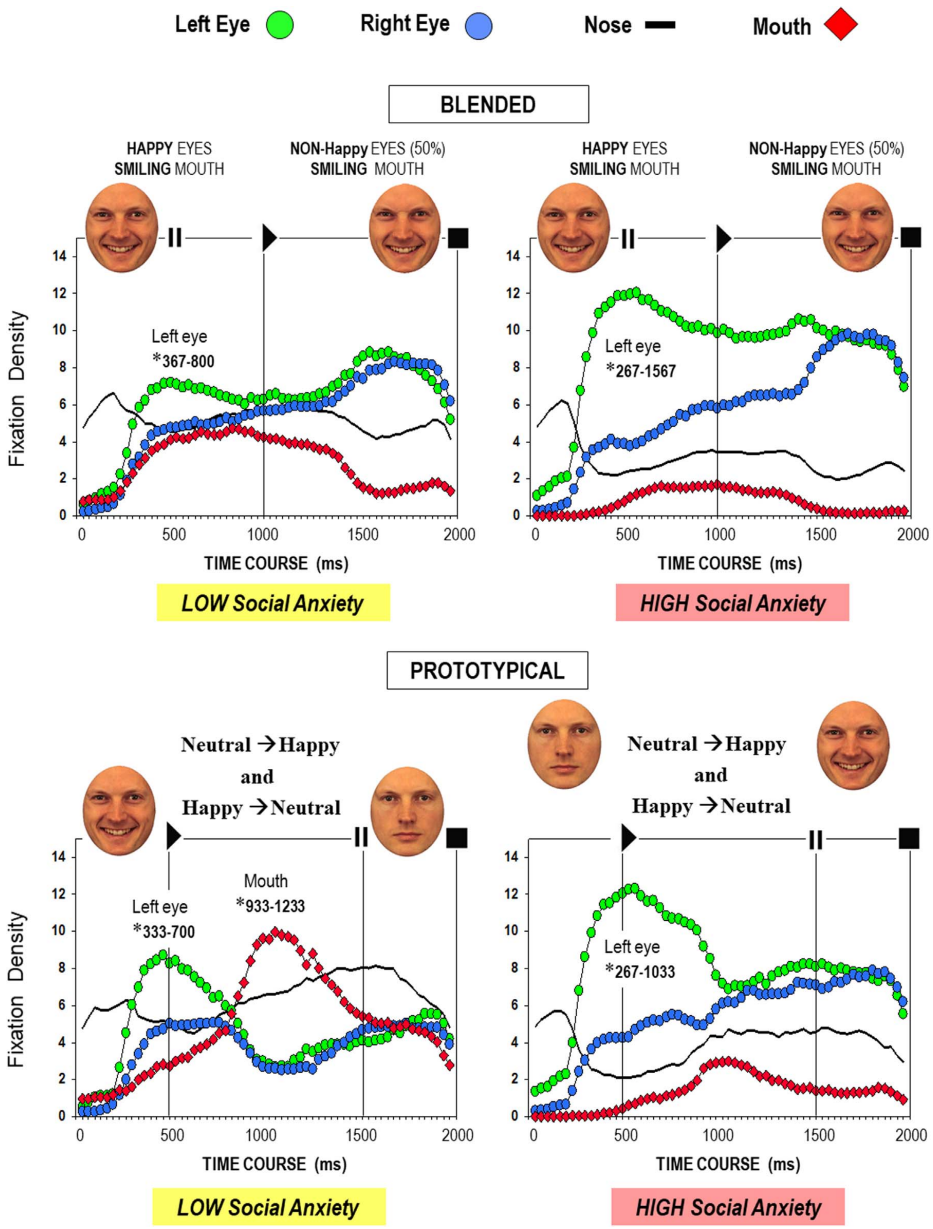

Fig. 4. Fixation density across 60 33-ms consecutive bins over the 2-s face display for each region of blended expressions (averaged; upper half) and prototypical expressions (averaged; lower half). For each pair of numbers preceded by an asterisk (e.g., *367–800, for the left eye; upper left panel; non-anxious group), the first number (e.g., 367) indicates the *threshold* for that region, i.e., the earliest time bin (onset) at which a region (e.g., left eye) had more fixation density than all the other regions. The range between the first and the second number (e.g., 800) indicates the *amplitude*, i.e., the latest time bin (offset) until which a region continued to have more fixation density than all the others. Left and right eye, from the viewer's perspective.

(*footnote continued*)
$p < 0.0001$, $\eta_p^2 = 0.94$, *interval*, $F(59, 10856) = 335.45$, $p < 0.0001$, $\eta_p^2 = 0.65$, *and an interval by region interaction*, $F(177, 10856) = 203.83$, $p < 0.0001$, $\eta_p^2 = 0.77$, *showed the different time course of fixations on each region, with an earlier, greater fixation density for the left eye region.*

conducted one-way (Region: 4) ANOVAs for each anxiety group and time bin (with Bonferroni corrections for multiple post hoc comparisons across regions). This served to indicate (a) the *threshold* (i.e., the earliest 33-ms time bin) at which each region was fixated *first* significantly *more* than *all* the other regions, and (b) the time *amplitude* (i.e., how many

consecutive 33-ms intervals) each region *continued* to be fixated *more* than *all* the others. Second, pairwise comparisons (*t* tests) between the LSA and the HSA groups examined differences for each time bin. Fig. 4 illustrates the thresholds and amplitudes for each region and group. Scores were averaged across expressions as there was no expression by region by anxiety interaction ($F < 1$).

The one-way (Region) ANOVA indicated that, following fixation on the nose (initial fixation point), the *left eye* region *threshold* started at 267 ms for the HSA group, $F(3, 92) = 403.96$, $p < 0.0001$, $\eta_p^2 = 0.93$, but at 367 ms for the LSA group, $F(3, 92) = 36.87$, $p < 0.0001$, $\eta_p^2 = 0.55$. The *amplitude* of the left eye region advantage over all the other regions remained significant from 267 to 1567 ms for the HSA group, but only from 367 to 800 ms for the LSA group. Differences between groups were significant at all these time points (i.e., from 267 to 1567 ms; all $ts(46) \geq 3.22$, $ps \leq 0.002$, $ds \geq 0.93$). For the *mouth* region and the *right eye* region, there was no threshold, as they never received significantly more fixations than the other regions.

3.3.2. Prototypical expressions

Interactions of anxiety by region, $F(3, 184) = 296.48$, $p < 0.0001$, $\eta_p^2 = 0.83$, and anxiety by region by interval, $F(177, 10856) = 25.75$, $p < 0.0001$, $\eta_p^2 = 0.30$, emerged.[4] Given the lack of an interaction between expression and anxiety ($F < 1$), the data of both expressions were averaged (Fig. 4). The *left eye* region *threshold* started at 267 ms for the HSA group, $F(3, 92) = 164.97$, $p < 0.0001$, $\eta_p^2 = 0.84$, but at 333 ms for the LSA group, $F(3, 92) = 53.42$, $p < 0.0001$, $\eta_p^2 = 0.63$. The *amplitude* of the left eye region advantage over all the other regions remained significant from 267 to 1033 ms for the HSA group, but only from 333 to 700 ms for the LSA group, and group differences were significant at each of these time points; all $ts(46) \geq 6.47$, $ps < 0.0001$, $ds \geq 1.87$. The *mouth* region *threshold* started at 933 ms for the LSA group, $F(3, 92) = 63.65$, $p < 0.0001$, $\eta_p^2 = 0.67$, and the *amplitude* advantage remained until 1233 ms, with significant differences across all these intervals between groups; all $ts \geq 12.10$, $ps < 0.0001$, $ds \geq 3.49$.

3.4. Entry times

Mean entry times were analyzed via a Social Anxiety (2) × Expression (4: blended; or 2: prototypical) × Region (3; the nose was excluded because its location coincided with the *initial* central fixation point) ANOVA across the whole 2-s display. For *blended* expressions, an anxiety by region interaction, $F(2, 92) = 3.74$, $p = 0.028$, $\eta_p^2 = 0.08$, revealed that the *left eye* was fixated earlier on average by HSA ($M = 546$ ms) than by LSA ($M = 772$) participants, $t(46) = 2.85$, $p = 0.007$, $d = 0.82$, but entry times for the *mouth* (882 vs. 771), and the *right eye* (965 vs. 936) were equivalent ($p \geq 0.42$, *ns*) for HSA and LSA groups. For *prototypical* expressions, an anxiety by region interaction, $F(2, 92) = 5.92$, $p = 0.004$, $\eta_p^2 = 0.11$, revealed that the *left eye* was fixated earlier by HSA ($M = 486$ ms) than LSA ($M = 674$) participants, $t(46) = 2.58$, $p = 0.013$, $d = 0.74$, and the reverse occurred for the *mouth* (1070 vs. 864, respectively), $t(46) = 2.98$, $p = 0.005$, $d = 0.86$, with no significant differences for the *right eye* (834 vs. 877).[5]

[4] For prototypical expressions, effects of region, $F(3, 184) = 194.82$, $p < 0.0001$, $\eta_p^2 = 0.76$, interval, $F(59, 10856) = 177.10$, $p < 0.0001$, $\eta_p^2 = 0.49$, and interval by region, $F(177, 10856) = 101.54$, $p < 0.0001$, $\eta_p^2 = 0.62$, showed the different time course of fixations on each region, with an earlier, greater fixation density for the left eye region.

[5] Additional effects involved region, for blended, $F(2, 92) = 13.32$, $p < 0.0001$, $\eta_p^2 = 0.23$, and prototypical, $F(2, 92) = 24.00$, $p < 0.0001$, $\eta_p^2 = 0.34$, expressions. Post hoc contrasts indicated that, for blended expressions, the left eye was fixated earlier ($M = 659$ ms) than the mouth (797 ms), which was fixated earlier than the right eye (950 ms). For prototypical expressions, the left eye was fixated earlier ($M = 580$ ms) than the mouth (967 ms) and the right eye (855 ms), which did not differ from each other.

4. Discussion

HSA participants rated blended expressions with ambiguous smiles as less trustworthy than did LSA participants, but no group differences appeared for prototypical expressions with congruent eyes and mouth. In addition, for both blended and prototypical expressions, HSA observers looked earlier and longer at the (left) eye region,[6] whereas LSA viewers looked earlier and longer at the mouth. These differences indicate enhanced selective attention to the eyes in social anxiety. Such an attentional bias presumably facilitates detection of incongruence between the eye expression and the smile (i.e., blended expressions), thus leading to perceived *un*trustworthiness, with no effect when there is congruence.

The proposed attentional mechanism (gaze bias toward the eye region) may seem counterintuitive, given that social anxiety is typically conceptualized as avoidance of social contact. In fact, in eyetracking research, some studies have shown avoidance of eye contact in socially anxious individuals (Horley et al., 2003; Moukheiber et al., 2010), and also gaze avoidance of faces (Chen et al., 2015; Weeks et al., 2013). In contrast, our findings converge with those reported by Boll et al. (2016; also Wieser et al., 2009), in which social phobia patients oriented overt attention (initial saccades) more frequently toward the eyes of happy, fearful, angry, and neutral faces, and they continued to fixate the eye region longer (dwell times), and the mouth region shorter, than healthy controls did. With brain measures (ERPs; event related potentials), Felmingham et al. (2016) also obtained convergent findings in favor of early attentional bias (rather than avoidance) and enhanced cortical processing of faces in high social anxiety, as indexed by greater N1, P2, and P3 amplitudes (from 100 to 350 ms from stimulus onset) in a HSA compared to an LSA group. Nevertheless, it is likely that prolonged eye contact raises feelings of being threatened, and therefore gaze avoidance should eventually occur. Consistently, the studies reporting gaze avoidance (Horley et al., 2003; Moukheiber et al., 2010; Weeks et al., 2013) used long stimulus display times (10 –12 s), whereas these were much shorter (≤ 3 s) in the Boll et al. (2016), Felmingham et al. (2016), and the current study.

It is thus possible to reconcile both types of findings regarding initial attention (short periods) and later gaze avoidance (longer periods). These findings can be discussed in relation to the vigilance-avoidance hypothesis (Mogg et al., 1997). According to this hypothesis, social anxiety induces initial hypervigilance to potential social threat cues (e.g., eyes) by enhancing sensitivity and orienting to them, followed by attentional avoidance and reduced cognitive processing. Both mechanisms would fulfill important—and complementary—adaptive functions: A hypervigilant, early gaze direction toward the eyes facilitates early threat detection, and thus prepares for subsequent behavioral avoidance; avoidant gaze behavior would be useful for averting signs of facial threat and preventing excessive fear of evaluation. The evidence supporting this hypothesis is more consistent regarding hypervigilance than avoidance (for reviews, see Armstrong and Olatunji, 2012 and Staugaard, 2010). Our own results corroborate the early vigilance mechanism involving initial orienting to potentially threatening eyes. We found no evidence of the avoidance mechanism, probably due to the short stimulus displays in the current study.

Our findings of interpretative and attentional biases are consistent with cognitive models of social anxiety (see Heimberg et al., 2014; Hofmann, 2007), and add substantial and nuanced information with clinical implications. First, while selective attention toward the eyes generalized to all facial expressions, the reduced trustworthiness bias was specific for ambiguous ones. The attentional bias is useful for the early detection of expressive incongruence, as a first potential sign of

[6] Interestingly, both HSA and LSA groups looked earlier and longer at the left than the right visual field. This reflects the natural leftward gaze bias in free-viewing tasks (e.g., Guo et al., 2009). As social anxiety did not interact with visual field, we will not discuss this effect.

untrustworthiness. To the extent that eye expression is relevant for affective processing (Calvo et al., 2012; Johnston et al., 2010; McLellan et al., 2010), and may convey information about the expresser's motives and intentions, attention to the eye region must be important for assessing trustworthiness. It is thus possible that socially anxious persons might be prone to orient early towards the *eye* region *specifically* (as the most informative region for potential inconsistencies). However, there is the alternative interpretation that socially anxious persons can be generally more skeptical regarding their conspecifics, and therefore quickly scan for inconsistencies in their facial expressions to *all* face regions (not only the eyes). To weigh up between these possibilities, further research could use face stimuli that show identical eye regions with varying mouth regions.

Second, it has generally been assumed that cognitive biases in social anxiety are typically maladaptive. Against this view, the observed early vigilance and recognition of untrustworthy expressers (e.g., with fake smiles) is adaptive. Possibly, the early vigilance toward the eyes is strategically driven for detecting what socially anxious individuals fear most, i.e., signs of disapproval and rejection. It thus makes sense for them to early orient their gaze to the expressers' eyes, and then decide about behavioral approach or avoidance. Importantly, this adaptive benefit occurs without apparent cost, as such an attentional mechanism does not impair trustworthiness judgments for prototypical facial expressions (happy or neutral, with congruent eyes and mouth). Clinical intervention should thus be selective when dealing with cognitive biases in social anxiety, as adaptive aspects (e.g., hypervigilance to facial expression inconsistencies) and maladaptive aspects (e.g., generalized social fear and withdrawal) may coexist.

We used a non-patient sample of socially anxious participants. However, the BNFE *mean* scores of the HSA group were equivalent to those of clinical social phobia (Gallego et al., 2007; Weeks et al., 2005), and the SIAS, and SPS *mean* scores (albeit not some individual scores) were clearly above clinical cut-offs (Brown et al., 1997). This suggests that our findings have relevance for clinical populations, given the continuum between sub-clinical social anxiety and social anxiety disorder or social phobia, as well as the shared cognitive biases (Morrison and Heimberg, 2013). In addition, some of our critical effects with high social anxiety participants (i.e., initial gaze orienting to the expresser's eyes) were comparable to those obtained by Boll et al. (2016) with patients having a primary diagnosis of social phobia. Our findings with a non-patient sample also allow us to generalize them to a wider population, i.e., young people with high levels of social anxiety who can, nevertheless, cope with daily life demands (including higher education). Progress can, nevertheless, be made by obtaining eyetracking measures during real social interaction (Chen et al., 2015), when trustworthiness judgments would have obvious adaptive importance, beyond the mere observation of video-clips of expressers who posed no real threat (e.g., negative evaluation or disapproval).

In sum, we hypothesized that the tendency to distrust blended expressions with a smile but non-happy eyes (interpretative bias) by socially anxious individuals may develop through a gaze bias towards looking earlier at non-happy eyes (attentional bias). Consistent with this hypothesis, participants with clinical levels of social anxiety judged smiling faces with incongruent eyes as less trustworthy than non-anxious participants did. Further, the former were more likely than the latter to selectively look earlier and longer at the eye region, whereas the reverse occurred for the mouth region. Thus the tendency to distrust ambiguous smiling expressions might be attributed to an attentional bias involving early overt attention to the eye region. In contrast, preferential attention to the smile would bias judgments towards enhanced trustworthiness.

Acknowledgment

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ANEXO V

Gutiérrez-García, A., Eysenck, M. W., & Calvo, M. G. (revised). Social anxiety and coping with fear of negative evaluation: An eye-tracking study. *Anxiety, Stress, and Coping*.

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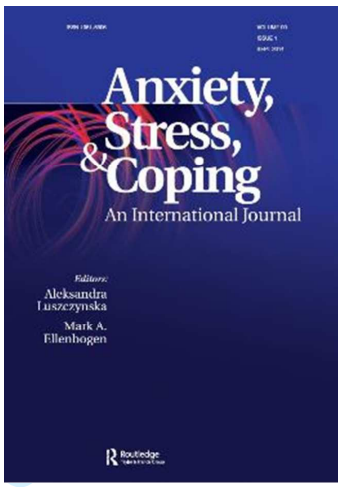

Social anxiety and coping with fear of negative evaluation: An eye-tracking study

Journal:	*Anxiety, Stress, & Coping*
Manuscript ID	GASC-2018-0010.R1
Manuscript Type:	Research Article
Keywords:	social anxiety, facial expression, smile, trustworthiness, eye movements

Manuscript ID GASC-2018-0010
Gutiérrez-García, A., Eysenck, M. W., & Calvo, M. G. (Revised). Social anxiety and coping with fear of negative evaluation: An eye-tracking study. *Anxiety, Stress, and Coping*.

Dear Dr. Yiend,

Thank you and the reviewers for your comments on our manuscript. For the current resubmission, we have considered all the points that were raised. Below we indicate (RESPONSEs) how we have addressed each of them. In the manuscript, we have coloured the changes in blue. When a whole sub/section has undergone major or multiple changes, only the corresponding title is blue-coloured.

Please note that, given the ASC norms on length constraints, it was necessary to be selective regarding the new information that could be added within the manuscript. We, nevertheless, think all the relevant issues have been included.

No closely related manuscripts (overlapping in terms of data or research aims) have been submitted for consideration to the same or to any other journal.

Sincerely,
Manuel G. Calvo
mgcalvo@ull.edu.es

09-Apr-2018

Editorial decision: Revise and resubmit
Dear Prof. Calvo:

I have now received three independent reviews on your manuscript entitled "Social anxiety and coping with fear of negative evaluation: An eye-tracking study" that you submitted to Anxiety, Stress, & Coping (ASC).

Based on the reviews and my own careful reading of the manuscript, my editorial decision is "Revise and resubmit (major revision)," meaning that I would like to invite you to revise the manuscript and then resubmit it to ASC to be reviewed again by one or two reviewers.

As you will see from the reviews (that you find at the bottom of this email), the reviewers made some positive comments about your manuscripts, but also had a number of concerns.

Despite the reviewers' concerns, I feel that--after a thorough revision--the manuscript may have the potential to make a significant contribution to the literature.

Therefore, I would like to invite you to revise the manuscript and then resubmit it to ASC within the next three months.

However, please note that this opportunity does not guarantee that your work will ultimately be accepted for publication in ASC, only that I see potential in your work and am willing to examine the manuscript again after you have attempted to address the questions and concerns raised in this decision letter.

When you submit your manuscript, please provide a response to the comments made by the reviewers and myself and include an itemized list detailing how you have addressed each of the points the reviewers and I raised (a) explaining the amendments that you made to address the points and (b) justifying the points that you do not agree with and consequently did not change/include. Please be as specific as possible in your response.

Please do not include any details in your response that will give away your identity (e.g., your letter head), because your response with the itemized list will be forwarded to the reviewers along with your revised manuscript in a second round of reviews.

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Your manuscript number has been appended to denote a revision. Please enter your responses to the comments made by the reviewers and myself in the space provided.

IMPORTANT: Your original files are available to you when you upload your revised manuscript. Please delete any redundant files before completing the submission.

We are trying to facilitate timely publication of manuscripts submitted to ASC. Therefore, if it is not possible for you to submit your revision by 08-Jul-2018, we may have to consider your revised manuscript as a new submission.

Looking forward to receiving your resubmission, With best wishes,

-- Jenny Yiend

Jenny Yiend, PhD
Associate Editor
Anxiety, Stress, & Coping

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Reviewer(s)' Comments to Author:

Reviewer: 1

Comments to the Author
The present manuscript examined the hypothesis that social anxiety involves an early selective attention toward people's eyes when expressing ambiguous positive expressions, in order to

facilitate the detection of potential negative evaluation signals. This question is timely relevant both for the clarification of potential mechanisms maintaining social anxiety and for the identification of potential targets for fine-grained intervention. The study has a number of strengths. First, the study used dynamic instead of static faces (video-clip stimuli of realistic morphing animation) that may better represent the nature of social signals during real-life social interactions. Second, eye-tracking was used to derive precise estimations of gaze behavior toward the different features of dynamically changing social signals. Third, the role of the physical visual saliency of the facial expressions on gaze behavior was analyzed, allowing to estimate to what extent social anxiety-related gaze patterns would reflect top-down controlled strategies, rather than attentional capture driven by low-level perceptual factors. All these aspects make the study undoubtedly interesting. Furthermore, the experimental design is rigorous, and the article is well-written and clearly organized. Yet, there are some issues that would be worth considering in order to gain a better understanding of the findings presented.

1) The main claim of authors is that cognitive biases (attention, interpretation) in socially anxious individuals are typically framed as maladaptive, whereas they could fulfil an adaptive function. Specifically, authors propose that, since socially anxious individuals are characterized by fear to others' negative evaluation and are highly motivated to avoid negative evaluators, they would display an early vigilance to ambiguously positive facial cues because they would be suggestive of negative social evaluation, and therefore such attention bias would lead them to interpret ambiguous positive cues in a more negative or less trustworthy manner. Although the reasoning is elegant, I am not sure how can we assume that such biased interpretation might indeed serve for an adaptive function. Social interactions in real-life commonly convey receiving feedback from low-intensity or ambiguous rather than prototypical high-intensity facial signals of emotion, particularly ambiguous or mixed positive states. Given this, a specialization in interpreting ambiguous or low-intensity positive expressions as signals of potential negative evaluation might, rather than being adaptive, facilitate an overgeneralization in the perception of negative evaluation, in turn, leading to an overgeneralized avoidance of this sort of social contexts (i.e., before disconfirming whether the low-intensity context reflected a real negative evaluation or not). Therefore, it seems difficult framing such phenomenon as "adaptive". Recent research has tested interpretation biases in the perception of emotions when participants viewed mixed morphed happy and disgusted expressions (Sanchez, Romero, Maurage & De Raedt, 2017;). Disgusted expressions are particularly interesting here since they convey clear signals of negative emotions projected toward the viewer (whereas for angry expressions, e.g., as tested by Maoz et al., 2017, the "recipient" of the expresser's negative emotion might be less clear). Sanchez et al (2017) showed that healthy individuals (with lower depression scores) are characterized by a biased perception of mixed happy-disgusted signals (i.e., mixed acceptance-rejection signals projected toward the viewer) as predominately positive, suggesting that, in absence of clear signaling, an adaptive coping strategy might comprise preferentially perceiving ambiguous mixed social signals as positive. This conflicts with authors view that the "tendency to negatively interpret such facial expressions is understandable … as an anticipatory self-protecting vigilance mechanism against negative evaluation by other people" (p. 5).

RESPONSE 1:
The excellent analysis made by the reviewer has convinced us that labelling the proposed coping mechanism as generally "adaptive" may be excessive. Accordingly, we no longer refer to "adaptive" in the manuscript. Rather, first, we mention that the coping mechanism (i.e., distrusting faces with a smile but non-happy eyes; and early selective gazing at the eyes, to detect expressive inconsistencies) in social anxiety is functional or useful to identify potential negative evaluators (e.g., with fake smiles). Second, with the

following distinction (last sentence of the 1st paragraph of p. 4), we have acknowledged some important points raised by the reviewer: "Such a mechanism would serve to reduce the *actual occurrence* of negative evaluations from other people, because negative evaluators could be detected and avoided in advance. Nevertheless, this could happen at the cost of increasing anxiety, because of the higher probability of *perceiving potential* threats (including false alarms; and possibly missing some positive signals in ambiguous expressions)." So this implies both adaptive and maladaptive effects of social anxiety, but the major goal, i.e., an avoidance or a decrease of negative evaluations from others, would be fulfilled.

We have not referred to the Sanchez et al. (2017) study because—although very enlightening regarding this issue—it was concerned with depressed, rather than socially anxious, individuals. Also, the reviewer argues that, "in absence of clear signaling, an adaptive coping strategy might comprise preferentially perceiving ambiguous mixed social signals as positive." In our view, this is probably adaptive in terms of reducing possible false alarms (i.e., interpretation of an ambiguous expression as negative when it could actually be positive) and the experience of negative emotions. But it would not be adaptive if actual threats are missed, due to an unrealistically benign interpretation of ambiguous expressions. So there are two sides of the coin, as we have tried to acknowledge in the above paragraph.

Regarding the Maoz et al. (2017?) article, we wonder whether the reviewer refers to Maoz et al. (2016), which we have already cited.

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2) Nonetheless, it could be arguable that an early attention vigilance and interpretation bias to perceive untrustworthiness in the specific ambiguity feature tested in this study (ambiguity as a function of the incongruence between the eyes and mouth signals from the same expresser) is adaptive because such specific incongruence potentially reflects negative evaluation. Authors state this reasoning at several points in the manuscript (e.g., "a bias has been shown for ambiguous smiling faces with non-happy eyes, possibly due to perception of negative aspects", p. 6). Yet, how we can be sure that this is the case? In other words, is there any empirical evidence supporting that this specific sort of fake-incongruent facial expressions are perceived by general population as reflecting not only untrustworthy but actual negative evaluation signals (i.e., mockery, arrogance, sarcasm, etc.). If this is not the case, how can we be sure that such specialization in social anxiety serves for an adaptive function?

RESPONSE 2:
In prior research, first, it has been found that, for observers unselected as a function of anxiety, this type of smiling faces with neutral eyes are judged as "happy" by 49% (Calvo, Fernández-Martín, & Nummenmaa, 2012) or 58% (Calvo, Marrero, & Beltrán, 2013), albeit always as significantly "less happy" than the prototypical happy faces with a smile and happy eyes (96 to 98%). Second, the smiling faces with neutral eyes are judged as "merely polite" (but "non-happy") or plainly "fake" by 25% or 13% of viewers, respectively (Calvo et al., 2013). Third, the prototypical happy faces produce positive affective priming on the processing of pleasant scenes, whereas faces with the same smile but neutral eyes do not (Calvo et al. 2012). This allows us to say that our current face stimuli with ambiguous smiling expressions (with neutral eyes) do not convey positive affect. Nevertheless, they are unlikely to be perceived as "actual

negative evaluation signals" by the general population. The important point is, however, that such faces can be seen (they are, in fact) as non-genuinely happy expressions by about half of "normal" observers. This opens the possibility for negative interpretations by viewers who are vigilant for signs of untrustworthiness (i.e., socially anxious individuals). Please note we have not referred to this issue in the manuscript.

References:

Calvo, M.G., Fernández-Martín, A., & Nummenmaa, L. (2012). Perceptual, categorical, and affective processing of ambiguous smiling facial expressions. *Cognition, 125*, 373-393.

Calvo, M.G., Marrero, H., & Beltrán, D. (2013). When does the brain distinguish between genuine and ambiguous smiles? An ERP study. *Brain and Cognition, 81*, 237-246.

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3) I also wonder to what extent the specific task goal might have influenced the results. Participants' task was to judge trustworthiness of dynamic expressions in each trial. This means that participants had the specific goal of "being vigilant to detect signals of untrustworthiness", a rule that might be easier to follow by socially anxious individuals. I wonder what would have happened if participants had been asked, for instance, to naturally scan faces without any clear goal and then randomly rate faces in different dimensions (e.g., trustworthiness, acceptance, attractiveness). In absence of a clear top-down rule of scanning, would have results looked the same (e.g., would have socially anxious still top-down regulated attention to preferentially look toward eyes rather than mouth signals)?

RESPONSE 3:

To deal with this issue, we have added the following sentences at the end of the first paragraph of the *"Conclusions and extensions"* section (p. 20): "An issue for further research is whether this pattern of selective orienting in social anxiety is task-goal specific (i.e., it depends on using the task of trustworthiness evaluation). Alternatively, it may reflect a very general scanning pattern also under more natural conditions in the absence of such an explicit goal (this possibility could, in fact, occur if socially anxious individuals are *generally* and *intrinsically* concerned with trustworthiness evaluation)."

Please note our more extensive comments:

We chose trustworthiness evaluation as a specific task goal because such an evaluation is generally important in social interaction (see, for example, Bonnefon, Hopfensitz, & De Neys, 2017; Todorov, Olivola, Dotsch, & Mende-Siedlecki, 2015), and therefore it should be relevant for social anxiety as a major factor in social interaction. In fact, prior research has indicated that social anxiety is related to perception of untrustworthiness (see our manuscript, Introduction). In a further step, we wanted to uncover some specificities of this relationship (a) in connection with interpretative bias, by distinguishing between prototypical (or genuine) and blended (ambiguous) expressions; and (b) in connection with attentional bias, by exploring selective fixations on the eye and the mouth regions.

In this context, the issue raised by the reviewer is timely. Will the patterns of results we have discovered on interpretative bias (i.e., distrusting ambiguous smiling faces, but not prototypical happy expressions) and attentional bias (i.e., selective early orienting of gaze to the eye region of both ambiguous and prototypical faces) remain in the absence of an explicit trustworthiness evaluation task-goal?

Regarding the interpretative bias, such task goal (and the corresponding performance measure) would obviously be necessary if we want to assess trustworthiness. Regarding attentional bias, however, it is difficult to guess. It is likely that the selective orienting pattern is activated by the specific task-goal of trustworthiness evaluation. But it is also possible that socially anxious individuals are generally concerned with trustworthiness evaluation in social encounters, and therefore, the top-down rule might be activated for them without an explicit trustworthiness evaluation task goal.

In the absence of relevant evidence, however, we can only speculate. For example, it is unlikely that the observed selective attention pattern would occur if we simply presented face stimuli on a screen—with which viewers did not need to interact—and leave them to freely scan the faces with no task goal. Further, in such conditions, with a different specific task-goal (e.g., attractiveness, etc.), it is likely that new top-down (task-relevant) strategies would be activated, which could inhibit the trustworthiness strategy. To address the issue raised by the reviewer, eye movements should be assessed in a situation involving a real interaction, with different tasks or no specific task. But this is beyond the aims of the current study.

References:

Bonnefon, J.F., Hopfensitz, A., & De Neys, W. (2017). Can we detect cooperators by looking at their face? *Current Directions in Psychological Science, 26,* 276-281.

Todorov, A.T., Olivola, C.Y., Dotsch, R., & Mende-Siedlecki, P. (2015). Social attributions from faces: Determinants, consequences, accuracy, and functional significance. *Annual Review of Psychology, 66,* 519–545.

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4) Please, clarify the reasons to analyze the left and right eyes as separate areas of interest, instead of as a unique area of interest.

RESPONSE 4:

The left/right eye distinction was just an exploratory approach. As this issue was raised also by Reviewer 3, we have now combined both eyes as a unique area for all the measures, and no longer distinguish between left and right.

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5) Also clarify the main hypotheses: it is stated that “HSA participants are expected to look earlier at the eye region, whereas LSA participants will look earlier at the smiling mouth” (p. 7). In the theoretical background this potential bias is framed referred to conditions of ambiguity (i.e., non-happy eyes combined with happy smile). Yet, the hypotheses read as authors expected to find this difference for any type of social signal (either incongruent or prototypical happy and neutral expressions). Please, clarify this.

RESPONSE 5:
Yes, in our predictions regarding attentional bias (see 2nd para. of p. 7), we indicate that selective early gazing at the eyes would be a general strategy in high social anxiety (as was empirically corroborated) for all types of expressions (i.e., "…regardless of eye expression"); at least, under the current task-goal conditions. If social anxiety drives detection of expressive inconsistencies, it is understandable that such an attentional strategy is initially generalized for all the expressions. Subsequently, if inconsistencies are actually detected, untrustworthiness evaluation would occur; and, if there are no inconsistencies, trustworthiness judgments would not be affected. In sum, the earlier attentional bias would be general while the later interpretative bias would be specific to incongruent expressions.

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6) Relatedly, note that results indeed indicate that HSA displayed an early detection and preferential (longer) processing of eyes in general (i.e., irrespectively of whether the faces were ambiguous, prototypically happy or prototypically neutral) rather than specifically for ambiguous (non-happy eyes smiling) expressions. Authors state that "enhanced early selective attention to the eye region presumably facilitates detection of expressive ambiguities or inconsistencies, thus leading to untrustworthiness judgments" (p. 15). How can we be sure that these general biases are (sub)serving to the specific detection of untrustworthiness in ambiguous expressions? It might be worth that authors directly tested such assumption (e.g., modelling the relation between fixation durations toward eye regions during non-happy eyes smiling expressions and subsequent probability of rating those expressions as untrustworthy).

RESPONSE 6:
To discriminate between truly happy faces with a congruent eye/mouth expression and ambiguous smiling faces with non-congruent eye/mouth expressions, it is reasonable that the selective gazing bias is activated for all the faces. Attention to the face (and facial features) must precede trustworthiness assessment. In other words, in order to judge a face as un/trustworthy, it must be looked at first, and congruence or incongruence should be detected. So the attentional selection strategy must be general, irrespective of facial expression.

We assume that "selective attention to the eye region facilitates detection of expressive ambiguities or inconsistencies, thus leading to untrustworthiness judgments" because the observers who used such an attentional strategy (i.e., the socially anxious participants) were also *the same* who produced significantly more untrustworthiness judgments of faces with expressive ambiguities. The current methodological approach does not allow us to perform a more direct test of the assumption.

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7) Also note that Net Gaze Duration index, a anxiety x expression x region three-way interaction was supported both for the 501-to-1,500-ms period and for the 1,501-to-2,000-ms period. However, follow-up pairwise comparisons showed two-way anxiety x region effects in general (differential eye-mouth processing for HSA and LSA occurring for all types of

expressions, either ambiguous or prototypical). I wonder how such three-way interaction (suggesting differential effects depending on the expression type) can be then interpreted.

RESPONSE 7:
In the 1st paragraph of p. 14, we have indicated that "The above three-way interaction came from the fact that the eye and the mouth region differences between LSA and HSA participants were larger in the 501-to-1,500-ms period for some expressions than for others (e.g., $t = 4.80$, $p < .0001$, $d = 1.39$, vs. $t = 2.58$, $p = .013$, $d = .074$; albeit all of them were statistically significant); and, in the 1,501-to-2,000-ms period, differences were significant for all the expressions (all ts > 2.85, ps ≤ .006, ds ≥ 0.82) except for one of them (i.e., Neutral→HeNm; $p = .23$)."

Consistently, it must also be noted that the effect sizes of the anxiety by region interactions ($\eta_p^2 = .22$ and $\eta_p^2 = .12$, for the 501-to-1,500-ms period and the 1,501-to-2,000-ms period, respectively) were larger (twice the size) than those for the three-way interactions ($\eta_p^2 = .11$ and $\eta_p^2 = .06$, respectively). This implies that the effects of anxiety on selective (i.e., depending on face region) gaze duration generalized (albeit with some differences) across expressions. So this is compatible with both the two-way and the three-way interactions.

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8) Please, report the reliability (e.g., internal consistencies) of the measures in the current study. This applies not only to the questionnaires but also to the attention and interpretation indices: It would be highly valuable proving that cognitive indices are actually consistent across the trials for each condition. Note that this is a common practice in recent eye-tracking research (e.g., Lazarov, Abend & Bar-Haim, 2016; Sanchez, Romero & De Raedt, 2017; Waechter, Nelson, Wright, Hyatt & Oakman, 2014), which is allowing to support the relevance of using these indices in contrast to reaction-time based proxy measures with rather poor psychometric properties (e.g., Waechter et al., 2014).

RESPONSE 8:
The internal consistencies (Cronbach's alpha values) for the self-report measures are shown in Table 1. The consistencies for trustworthiness ratings, reaction times, gaze durations, and entry times, are reported in the respective Results sections.

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Reviewer: 2

Comments to the Author
The authors investigated fixation patterns and trustworthiness ratings of of individuals high or low in social anxiety. The results add further support for attentional and interpretative biases in social anxiety. Notably, the authors should be applauded for seemingly providing their raw data in supplemental datasets. Unfortunately, I was unable to access these files.

This being said, I must admit that I had pronounced difficulties to follow the introduction and its prime focus on an "anticipatory coping strategy in social anxiety". In addition, I failed to understand the relation between the introduction and the chosen experimental design with a wealth of experimental conditions and a worrisome inflation of potentially false positive findings.

Main points:

- As already stated above, the authors discuss in length that attentional and interpretative biases of facial expressions in social anxiety "reflect anticipatory coping mechanisms, in the service of adaptive early detection (and eventual avoidance) of negative evaluators" or that "a socially anxious person is thought to be motivated to specifically avoid people who can be negative evaluators". In other words, ""while it has typically been assumed cognitive biases in socially anxious individuals are maladaptive, we explored the hypothesis that the fulfil an adaptive function and may be driven strategically". The authors even go so far to continuously describe causal relations either at a theoretical level or in the description of their results "early attention to the eyes by HAS individuals enhances detection of expressive incongruences, thus leading to untrustworthiness judgements".
After reading the introduction, I still fail to see the rationale behind this new "model" and why this would be considered "adaptive". Based on my knowledge as well as the literature discussed in this manuscript there is no support for these claims. And strikingly, this model was not even investigated in their complex experimental design. Results of their own study as well as of previous studies are still more easily reconcilable with negative interpretation biases as done in the literature. I fail to understand the need for a new model.

Thus, I would propose the authors focus on attentional and interpretative biases in social anxiety and try to relate these aspects to the chosen experimental design.

And please provide clear hypotheses that relate the introduction and prior evidence to the experimental design.

RESPONSE 9:
The reviewer is right. As indicated in our RESPONSE 1 to Reviewer 1, we no longer refer to "adaptive" in the manuscript. Rather, we mention that the proposed coping mechanism (i.e., distrusting faces with a smile but non-happy eyes; and early selective gazing at the eyes, to detect inconsistencies) in social anxiety is functional or useful to identify potential negative evaluators (e.g., with fake smiles). Further, we make the following distinction (last sentence of the 1st paragraph of p. 4): "Such a mechanism would serve to reduce the *actual occurrence* of negative evaluations from other people, because negative evaluators could be detected and avoided in advance. Nevertheless, this could happen at the cost of increasing anxiety, because of the higher probability of *perceiving potential* threats (including false alarms; and possibly missing some positive signals in ambiguous expressions)." So this implies both adaptive and maladaptive effects of social anxiety, but the major goal, i.e., an avoidance or a decrease of negative evaluations from others, would be fulfilled.

Also, we have reformulated the hypotheses in connection with prior research (see *"Interpretative and attentional coping with ambiguous smiles: Hypotheses"* section, pp. 5-6); and the predictions in connection with our experimental design (see "*Overview of the study and predictions"* section, pp. 6-8).

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• The experimental design is presented in Figure 1. The author manipulated the initial stimulus valence (presented for 500ms), followed by a morphing phase (1000ms), and an additional presentation of the final stimulus for 500ms. The particular relevance of the chosen experimental stimuli remains unclear. Importantly, the crucial condition (based on my reading of the manuscript) is only part of one of the 6 different conditions. It remains unclear, as to why the authors include all the "unnecessary" conditions in the experiment. I do not assume that all these stimuli should be considered control conditions. It is necessary to provide the authors a much more detailed background how they designed this experiment. And again, please provide clear hypotheses. It might be that this was a rather exploratory study, but this should be stated more clearly.

RESPONSE 10:
We used three periods (1: static, 2: dynamic, 3: static) for various reasons. In general, the static periods made the display more natural. Thus, we avoided an abrupt beginning and end of the dynamic expression (i.e., at the same time as the onset and offset of the stimulus), which otherwise could have artificially affected eye fixations and movements in undesirable ways. In addition, the initial static period served as a baseline with which to compare the dynamic—critical—period; and the final static period served to assess possible carryover effects of the dynamic expression.

We agree that the neutral-to-happy expression constitutes the pivotal condition. Nevertheless, we also included other expressions for theoretical, methodological, and practical reasons. First, we aimed to investigate the role of expressive changes in the eyes and the mouth in overt attention deployment, and this required comparisons between prototypical (neutral-to-happy, and happy-to-neutral) blended expressions (the rest) where the eyes and the mouth expression were combined in different ways. This was important to examine the role of in/congruence. Second, additional conditions were necessary to introduce enough variability of expressions as stimuli, with changes in the eyes and/or the mouths, to avoid guiding the viewers to use uniform processing strategies across trials. Third, this approach contributes to external validity, as expressions (including smiling faces) are highly variable in social contexts, and blended expressions are indeed very frequent (Calvo, Fernández-Martín, & Nummenmaa, 2014) in real life.

Reference:
Calvo, M.G., Gutiérrez-García, A., Fernández-Martín, A., & Nummenmaa, L. (2014). Recognition of facial expressions of emotion is related to their frequency in everyday life. *Journal of Nonverbal Behavior*, *38*, 549-567.

As indicated in our preceding response (RESPONSE 9), we have now made the hypothesis and predictions more explicit, including its connection with the design manipulations and measures.

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• Most importantly, the authors analyze their eye-tracking findings in a 4-way ANOVA. The inclusion of 15 terms in this analysis (4 main effects, six 2-way interaction, four 3-way interactions, and one four-way interactions) substantially increases the probability for a Type-I

error. More specifically, the probability for a Type-I error in the presented analysis is .54 rather than .05. Please see Cramer et al., 2016, Psychonomic Bulletin & Review, for a discussion of this issue. Thus, the sheer number of experimental factors and the perceived lack of specific hypotheses has me worry about the replicability of the presented findings. In my opinion, they need to consider a correction procedure.

RESPONSE 11:
We are aware of the need for correction of Type I error when multiple post hoc comparisons are performed for factors with more than two levels. As indicated in the 2nd paragraph of the Results section ("A 2 (Social Anxiety) × 6 (Facial Expression) ANOVA…"; p. 12), we routinely performed Bonferroni corrections, by setting a $p < .05$ threshold in the SPSS analyses, which was adjusted depending on the number of factor levels.

Further, we never carried out comparisons across levels *within* factors with more than two levels (i.e., expression, region, and period—except for visual saliency). Rather, we were concerned with the interactions involving anxiety, which we analyzed by comparing low vs. high anxiety groups, hence *only two* levels. Thus, no multiple—but, rather, pairwise—comparisons were performed for the findings of relevance to the hypotheses. In fact, our hypotheses and predictions were concerned with such pairwise comparisons.

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Minor points:

- Please provide a rationale as well as prior evidence for the visual saliency analysis.

RESPONSE 12:
We have modified the "*Computational modelling of visual saliency*" section (pp. 11-12) for providing the rationale. We have added some relevant references regarding the relationship between visual saliency and visual attention in general (see a review by Borji & Itti, 2013). We have also referred to studies using face stimuli specifically, in which overt eye movements (Calvo & Nummenmaa, 2008) and covert attentional capture (Calvo, Beltrán, & Fernández-Martín, 2014) were related to visual saliency (with the same modelling algorithm as in the current study).

References:

Borji, A., & Itti, L. (2013). State-of-the-art in visual attention modeling. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 35*, 185-207.

Calvo, M.G., Beltrán, D., & Fernández-Martín, A. (2014). Early processing of happy facial expressions in peripheral vision: Neurophysiological evidence. *Biological Psychology, 100*, 60-70.

Calvo, M.G., & Nummenmaa, L. (2008). Detection of emotional faces: Salient physical features guide effective visual search. *Journal of Experimental Psychology: General, 137*, 471-494.

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- In addition, the introduction focuses seemingly on the specific effects of anger and disgust. The more surprising it was for me to realize that the authors did not include these emotions in their experimental design.

RESPONSE 13:
In the 2nd paragraph of the p. 4 ("Some previous research..."), we set out the necessary background for our theoretical proposal, by reviewing four groups of prior relevant studies, of which only one of them ("First…") focuses on anger and disgust. Further, we refer to anger and disgust in a way that is relevant to our approach regarding perception of untrustworthiness in ambiguous expressions with a smile but non-happy eyes (it must be noted angry and disgusted faces are typically representative of untrustworthiness perception: e.g., Oosterhof & Todorov, 2009; Sutherland, Young, & Rhodes, 2017).

References:
Oosterhof, N.N., & Todorov, A. (2009). Shared perceptual basis of emotional expressions and trustworthiness impressions from faces. *Emotion, 9,* 128–133.
Sutherland, C.A.M., Young, A.W., & Rhodes, G. (2017). Facial first impressions from another angle: How social judgements are influenced by changeable and invariant facial properties. *British Journal of Psychology*, *108*, 397–415.

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- Please do not only include power for interaction of within-by-between-variables, but also for the more critical post-hoc comparisons between groups.

RESPONSE 14:
We computed power for the within-by-between interactions because such interactions (i.e., anxiety by region, and anxiety by region by expression) were the ones critically predicted by our hypotheses. For power regarding direct comparisons between anxiety groups, we computed Cohen's *d* values. The main effects of expression or period were not relevant to our hypotheses, and post-hoc multiple comparisons were not performed (nevertheless, we included Bonferroni corrections in the overall ANOVAs).

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Reviewer: 3

Comments to the Author
Thank you for inviting me to review the manuscript entitled 'Social anxiety and coping with fear of negative evaluation: An eye-tracking study'. The manuscript reports a study intended to test the hypothesis that preferential processing of threat information in elevated social anxiety is an adaptive coping mechanism. I quite liked the experimental task the authors developed, in that it involved the presentation of dynamic facial expressions. The field has probably been overly reliant on the use of static images for too long, and the use of dynamic images is a neat step forward. However, as expanded upon below, the authors did not provide strong justification for the hypothesis under test, and also did not clearly communicate the

predictions generated by this hypothesis, which together significantly detracted from the sense of a tightly designed study.

RESPONSE 15:
We have justified the hypotheses (see *"Interpretative and attentional coping with ambiguous smiles: Hypotheses"* section, pp. 5-6), and generated specific predictions linking the hypotheses with our experimental design (see "*Overview of the study and predictions"* section, pp. 6-8).

The proposed coping mechanism was rather a general assumption. The hypotheses were specifically concerned with interpretative bias and attentional bias.

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As the authors correctly point out, in order to explain why some individuals tend to experience higher levels of social anxiety than others, it has been hypothesised that socially anxious individuals display biases in the processing of threatening socially-relevant information, whereby they attend more to such threat information, and have an inflated tendency to impose threat interpretations on ambiguous social information. It is argued that these biases are maladaptive, as they result in a cognitive representation of the social environment that is overly threatening, and so drives vulnerability to social anxiety. In the present paper, the authors suggest that such biases are not in fact maladaptive, but are instead adaptive. However, this key argument is not sufficiently elaborated upon within the paper, and much of the research the authors review, supposedly to demonstrate support for the hypothesis that selective processing of threatening socially-relevant information in social anxiety is adaptive, would seem equally to support the hypothesis that such processing is maladaptive. Indeed, I found it a bit difficult to see how such biased processing of socially threatening information could be adaptive (i.e. rather than making someone more vulnerable to social anxiety, it would instead make someone less vulnerable to social anxiety). The authors suggest that these biases may enable socially anxious individuals to better behaviourally avoid people who may evaluate them in a negative manner. But if a person were to preferentially process the threatening elements of their social environment, in an proactive effort to avoid negative evaluation, then as mentioned, this would increase the prospects of them actually detecting threatening social information, which would in turn drive anxiety. I suppose this anxiety could be offset by the short-term emotional benefits that may accompany the improved capacity to avoid negative evaluation. However, not every person we encounter with an angry or disgusted expression has that expression because they are negatively evaluating with us, and so preferentially processing threatening social information may lead an individual, at least some of the time, to needlessly experience social anxiety. Further, if that preferential processing led to increased behavioural avoidance, especially in circumstances where the negative evaluation was perceived rather than real, then it would result in needless behavioural avoidance, with this avoidance bringing, as the authors themselves suggest, missed opportunities to enjoy the emotional and social benefits that can be obtained from interaction with others. Thus, I was not convinced by the suggestion that social anxiety-linked biases in the processing of negative socially-relevant information are adaptive.

RESPONSE 16:
We essentially agree with the reviewer, and no longer refer to "adaptive" in the manuscript. Rather, as indicated in our RESPONSEs 1 and 9, the proposed coping mechanism (i.e., distrusting faces with a smile but non-happy eyes; and early selective

gazing at the eyes, to detect inconsistencies) in social anxiety is useful to identify potential negative evaluators (e.g., with fake smiles), but it also involves some (non-adaptive) limitations. In this regard, we make the following distinction (last sentence of the 1st paragraph of p. 4): "Such a mechanism would serve to reduce the *actual occurrence* of negative evaluations from other people, because negative evaluators could be detected and avoided in advance. Nevertheless, this could happen at the cost of increasing anxiety, because of the higher probability of *perceiving potential* threats (including false alarms; and possibly missing some positive signals in ambiguous expressions)." So this implies both adaptive and maladaptive effects of social anxiety, albeit the major goal, i.e., an avoidance or a decrease of negative evaluations from others, would be fulfilled.

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In addition to the lack of strong justification for hypothesis under test, the different predictions generated by this hypothesis were not clearly communicated anywhere in the manuscript. Not only did this make it difficult to determine what pattern of results would support the hypothesis under test (I had a sense of a rather exploratory approach to data analysis), it also made it difficult to judge whether the experimental methodology employed was fit for purpose. For example, the authors use eye-tracking to assess selective attentional processing of facial features, and compute three indices of attention reflecting bias in: i. which facial features are attended to; ii. when these different facial features are attended to; and iii. how long these different facial features are attended to. It was not clear whether the hypothesis under test would implicate social anxiety-linked attentional differences in one, a subset, or all of these different facets of attention. Further, the methodology employed involved exposing participants to a number of different types of emotional facial expression, which initially were presented in a static manner, followed by the dynamic change in expression, and a final static presentation. It was not clear whether the particular patterns of attention that differentiate the high vs. low socially anxious participants would be evident across some or all of the different expressions presented, raising the question of which facial expression are critical to present (the same kinds of issues apply when considering the trustworthiness ratings, which purportedly provide an index of interpretive bias), or whether these patterns of attention would be evident only when the face was displaying a static expression, a dynamic expression, or both.

RESPONSE 17:
As indicated in our RESPONSE 15, we have rewritten the hypotheses and predictions sections (pp. 5-8). The reviewer asks about the connection of our hypotheses/predictions with four methodological aspects: type of eye-movement measures, type of expression, type of region, and type of display period. We have now made these issues clearer.

For interpretative bias, and regarding type of expression, we indicate that only blended expressions with a smile but non-happy eyes—but not prototypical expressions with a smile and happy eyes—will be affected (i.e., reduced trustworthiness). The other aspects (i.e., eye-movement measure, face region, and display period) are not concerned with interpretative bias, but rather with attentional bias.

For attentional bias, we indicate that (a) all types of expressions will be affected, as well as (b) both types of eye-movement measures (entry times—i.e., "when"—and gaze duration—i.e., "how long"), and that (c) the eye and the mouth region (i.e., "which" one

was preferentially—earlier and longer—fixated) will be selectively affected by high and low social anxiety. Regarding (d) display period, we have predicted that such effects will occur mainly during the dynamic expression display (albeit carryover effects could extend to a following static period).

Regarding display period and type of expression, please see also our RESPONSE 10 to Reviewer 2.

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I also found the analysis sections a bit difficult to follow in places. For example, consider the section that reports the gaze duration and mean fixation duration data. In this section, analyses are carried out on a measure of 'net gaze duration' (it was not exactly clear what this measure reflects, as it was not properly defined in the manuscript). The authors report the presence of lower-order interactions, and an overall four-way interaction. They then decompose the four-way interaction, reporting simple three-way interaction(s), which is fine, but then jump to simple main effects, skipping the component simple two-way interaction(s). Next, analysis of the mean fixation duration is reported, but the analysis carried out is not communicated (e.g. was it a 2 x 6 x 4 ANOVA like the analysis of the net gaze duration?). And throughout these analyses, the authors distinguish the left vs. right eye. It was difficult to see why this would be necessary given that I could not imagine any prediction which would implicate one or other eye as being more likely to be attended to.

RESPONSE 18:
We meant that net gaze duration involved gaze duration after saccades and blinks were removed. The sentence has now been slightly reworded to make it clearer: "*Net* gaze duration (i.e., mean total dwell time after saccades and blinks were removed) for each expression…" (2nd paragraph of p. 11).

We have rewritten the last paragraph of the gaze duration results ("As shown in Figure 3, pairwise comparisons…"; 4th paragraph of p. 13). See also our RESPONSE 7 to Reviewer 1 (above). With the planned pairwise comparisons, we directly addressed the critical points in our hypotheses regarding the selective attention to face regions as a function of anxiety.

The mean fixation duration measure has now been removed; it was a bit redundant with gaze duration, as an index of attentional engagement. Further, mean gaze duration could not (by its very nature) be split into different periods, unlike gaze duration. This removal has allowed us to save some space for new issues raised by the reviewers.

Doubts about the left vs. right eye distinction were also expressed by Reviewer 1 in his/her point 4 (our RESPONSE 4, above). We have now combined both eyes as a unique area for all the measures, and no longer distinguish between left and right. The major findings without the left/right eye distinction remain essentially the same.

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Thus, in summary, while I thought the experimental task is novel, and I would certainly like to see the approach of dynamic images being used more in the attentional bias literature, the

aforementioned issues, particularly associated with the hypothesis and predictions, I believe significantly undermine the potential impact and contribution of the present paper.

RESPONSE 19:
Thank you for underlining the positive aspects. In our previous responses, we have tried to address the issues raised by the reviewer.

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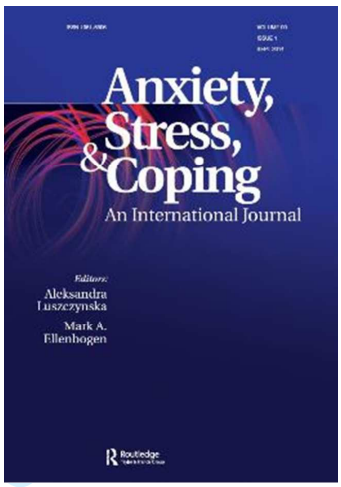

Social anxiety and coping with fear of negative evaluation: An eye-tracking study

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Social anxiety and coping with fear of negative evaluation:

An eye-tracking study

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Abstract

Background and objectives: Fear of negative evaluation by other people is the hallmark of social anxiety. We examined the hypothesis that, to facilitate detection of negative evaluators, an anticipatory coping strategy in social anxiety involves selective early gazing at the eyes of other people.

Methods: Eye fixations were assessed while participants watched video-clips displaying dynamic facial expressions with prototypical (happy eyes and a smile) or ambiguous (a smile but non-happy eyes) smiling faces. High socially anxious (HSA) undergraduates with clinical levels of anxiety on questionnaire measures and low-anxious controls (LSA) judged expressers' trustworthiness.

Results: Social anxiety was especially associated with reduced trustworthiness (*interpretative bias*) of ambiguous smiling faces. Importantly, HSA viewers selectively looked earlier at the eye region (*attentional bias*), whereas LSA viewers preferentially looked at the smiling mouth. The attention of HSA observers was captured less than that of LSA observers by the physical visual saliency of the smile.

Conclusions: Early attention to the eyes by HSA individuals enhances detection of expressive incongruences, thus leading to untrustworthiness judgments. These biases are functional because they facilitate recognition of untrustworthy expressers (e.g., with fake smiles). Social anxiety drives an active coping mechanism designed to detect negative evaluators (i.e., criticism, mockery, etc.).

Word count: 200

Keywords: social anxiety; facial expression; smile; trustworthiness; eye movements

Introduction

Social anxiety is characterized by persistent and intense fear of negative evaluation (American Psychiatric Association, 2013), with a sense of dread or apprehension concerning being judged unfavorably by other people. Cognitive biases have been implicated as factors maintaining social anxiety (for reviews, see Morrison & Heimberg, 2013; Steinman, Teachman, & Gorlin, 2014). Socially anxious individuals exhibit (a) *attentional bias*, i.e., selective attention to threat-related stimuli (see Armstrong & Olatunji, 2012; and also reduced attention to positive social feedback, e.g., facial signs of approval: Lin, Hofmann, Qian, Kind, & Yu, 2016), as well as (b) *interpretative bias*, i.e., interpreting ambiguous stimuli and situations in a negative way (see Mobini, Reynolds, & Mackintosh, 2013; or lacking a positive interpretation bias: Weeks & Howell, 2012), when processing threat-related social cues. The present study is concerned with attentional and interpretative biases for faces in social anxiety (see Staugaard, 2010). We aim to address the issue of whether such biases are mechanisms of anticipatory coping, in the service of early detection of potential negative evaluators, to avoid actual negative evaluation.

Social anxiety and detection of negative evaluators

Facial expressions are highly relevant cues in social interaction, as they often reflect emotional states, attitudes, motives, and intentions. Further, they can convey approval and liking, but also disapproval and hostility, which is crucial given that fear of negative evaluation is the hallmark of social anxiety. More specifically, socially anxious individuals' critical fear—which they are especially motivated to escape from or to avoid—is negative evaluation (criticism, rejection, mockery, etc.). Nevertheless, as individuals living in a social environment, we have to interact with other people. If interaction is generally avoided, we will miss opportunities for obtaining necessary

benefits and will suffer ostracism. Accordingly, rather than generally avoiding social contact, a socially anxious person is thought to be motivated to specifically avoid people who can be negative evaluators. To this end, as a coping mechanism against the feared *consequences* (disapproval, rejection, etc.), social anxiety would drive early vigilance to facial cues suggestive of negative evaluation, and would lead individuals to interpret ambiguous facial cues in a negative way. Such a mechanism would serve to reduce the *actual occurrence* of negative evaluations from other people, because negative evaluators could be detected and avoided in advance. Nevertheless, this could happen at the cost of increasing anxiety, because of the higher probability of *perceiving potential* threats (including false alarms; and possibly missing some positive signals in ambiguous expressions).

Some previous research constitutes the basis of our previous conceptualization. First, social anxiety facilitates detection of anger and disgust from low expressive intensities (Gutiérrez-García & Calvo, 2017), and is associated with heightened distrust towards angry and disgusted faces from low intensities (Gutiérrez-García & Calvo, 2016a) and with a tendency to misattribute anger to ambiguous or neutral expressions (Gutiérrez-García & Calvo, 2017; Peschard & Philippot, 2017). This is understandable, given that anger and disgust convey hostility, disapproval, or rejection. Second, participants with social anxiety disorder judge ambiguous morphed (between happy and angry) faces as angrier than non-anxious ones, and are slower when making happy, compared to angry interpretations, thus reflecting cautiousness towards happy-looking faces (Maoz et al., 2016). Relatedly, socially anxious individuals are more likely than non-anxious ones to categorize as "non-happy" ambiguous expressions with a smile but non-happy eyes (Gutiérrez-García & Calvo, 2014). Third, socially anxious individuals mistrust any ambiguous smile in a face with non-happy eyes, whereas social anxiety is

unrelated to trustworthiness judgments for non-ambiguous expressions unfolding from neutral (eyes *and* mouth) to happy (eyes *and* mouth) or vice versa (Gutiérrez-García & Calvo, 2016b). Fourth, with *neutral* (non-emotional) faces (i.e., eyes and mouth) as stimuli, Meconi, Luria, and Sessa (2014) noticed enhanced encoding of untrustworthy-looking faces in social anxiety, although Cooper et al. (2014) reported non-significant effects. Altogether, the above findings reveal heightened sensitivity to facial signs of hostility and untrustworthiness in social anxiety. This makes sense within our conceptualization of a self-protecting vigilance mechanism against negative evaluation, which is particularly likely to come from hostile and untrustworthy expressers.

Interpretative and attentional coping with ambiguous smiles: Hypotheses

In the current study, we examined two hypotheses regarding the proposed coping mechanism leading to anticipatory detection of negative evaluation and evaluators in social anxiety. One hypothesis is related to interpretative bias and the other to attentional bias. Regarding *interpretative* bias, we focused on *trustworthiness* judgments, given that social anxiety is related to a tendency to distrust people with ambiguous expressions (Gutiérrez-García & Calvo, 2016a, 2016b). In this context, smiles represent a suitable stimulus to investigate interpretative bias in the form of reduced trustworthiness judgments. The reason is that, apart from reflecting enjoyment or friendliness, smiling faces are amenable to multiple interpretations (Ambadar, Cohn, & Reed, 2009; Niedenthal, Mermillod, Maringer, & Hess, 2010), including negative ones, particularly depending on the accompanying eye expression. Accordingly, for ambiguous smiling faces with non-happy eyes, we hypothesize that social anxiety facilitates perception of negative aspects (e.g., mockery, arrogance, dominance, contempt, sarcasm, etc.; hence related to feared negative evaluation), and therefore socially anxious individuals should specially distrust such faces, relative to non-anxious

individuals; in contrast, trustworthiness judgments of non-ambiguous smiling faces (i.e., with happy eyes) woul not be affected by social anxiety.

Regarding *attentional* bias, we will focus on *selective orienting,* i.e., *which* facial regions attract *how much* visual attention and *when*. The eye expression makes a critical contribution to perception of (non)genuineness or (in)authenticity of facial happiness (McLellan, Johnston, Dalrymple-Alford, & Porter, 2010), and perceived (non)genuine happiness is related to (un)trustworthiness (Krumhuber et al., 2007). Accordingly, a useful coping mechanism for anticipatory detection of potential negative evaluation must involve early gaze direction to the eyes of expressers. This attentional strategy would serve for detecting incongruences between non-happy eyes and a smiling mouth (Calvo, Gutiérrez-García, Avero, & Lundqvist, 2013). We therefore hypothesize that social anxiety drives selective early gazing at the eyes, regardless of expression, which would then facilitate untrustworthiness judgments of smiling faces with incongruent non-happy eyes. In contrast, the visual attention of non-anxious individuals is hypothesised to be attracted more by the smiling mouth, regardless of eye expression, thus leading them to judge such expressions as happy (given the diagnostic value of the smile: Calvo, Gutiérrez-García, & Del Líbano, 2018) and, hence, as trustworthy (given the relationship between smiling faces and trustworthiness judgments; Sutherland, Young, & Rhodes, 2017).

Overview of the study and predictions

To address the above interpretative and the attentional bias hypotheses, we designed the following task and experimental conditions and generated specific predictions. High socially anxious (HSA) and low anxious (LSA) participants were presented with 2-s video-clips displaying dynamic facial expressions in which the eyes and/or the mouth unfolded from neutral to happy or vice versa. An initial static

expression period (500 ms) was followed by a dynamic period (1,000 ms) and a final static period (500 ms). We used such dynamic expressions to increase ecological validity and enhance expression recognition (Calvo, Avero, Fernández-Martín, & Recio, 2016; see Krumhuber, Kappas, & Manstead, 2013). The face stimuli represented either (a) *prototypical,* non-ambiguous happy (happy eyes *and* a smiling mouth) or non-happy (neutral eyes and mouth) expressions, or (b) *blended,* ambiguous expressions with a smiling mouth *but* neutral eyes (or a neutral mouth but happy eyes). The HSA and LSA observers judged the expressers' trustworthiness, which served to assess interpretative bias in social anxiety.

Regarding interpretative bias, we predicted reduced trustworthiness evaluation (i.e., lower trustworthiness scores in HSA relative to LSA participants) for blended, but not for prototypical, expressions. We were particularly interested in attentional bias, with two complementary approaches. First, we examined three aspects of the viewers' eye movements and fixations: *Where* (i.e., the *face region* to which gaze is selectively directed), *when* (i.e., the gaze time course, as assessed by *entry times*), and *how much* (i.e., *gaze duration*). We predicted that HSA participants would be more likely than LSA ones to look selectively at the eye region earlier and longer (i.e., earlier entry times and longer gaze duration), regardless of eye expression; in contrast, LSA participants should look earlier and longer at the smiling mouth. Second, we assessed visual saliency (i.e., physical properties) of the eye and the mouth regions via computational modelling, and then saliency was correlated with fixations. This served to determine the extent to which gaze was driven by low-level perceptual factors in a bottom-up manner. We predicted a lower correlation between visual saliency and fixation on the smiling mouth in HSA relative to LSA participants, with no differences for faces with a neutral mouth. This would reveal strategic coping by HSA individuals, i.e., opposing the automatic

capture by the smile saliency. The predicted attentional bias effects are expected to occur mainly during dynamic display period of the facial expressions (albeit carryover effects could extend to a following static period).

Method

Participants and social anxiety assessment

From a pool of 251 psychology undergraduates, 24 participants with high scores (HSA; ≥ 40) and 24 with low (LSA; < 30) scores on the Brief Fear of Negative Evaluation (BFNE) scale (Leary, 1983) were selected, with 15 females and 9 males in each group, aged 20 to 25 years (see Table 1). The BFNE scale, and also the Social Interaction Anxiety Scale (SIAS) and Social Phobia Scale (SPS; Mattick & Clarke, 1998), were administered in various classrooms, using anonymous codes. The HSA group had significantly higher scores than the LSA group on all three anxiety measures (see Table 1). Written informed consent was obtained from participants. The study was approved by the University of XXXX ethics committee (CEIBA2016-0222) and conducted in accordance with the WMA Declaration of Helsinki 2008. With this sample size, the power for detecting medium effect sizes ($f = 0.25$) in interactions between group and within-subject factors is larger than 0.90, at alpha = 0.05.

(Insert Table 1 about here)

The 12-item BFNE scale assessing fear of negative evaluation (Leary, 1983; see Carleton, Collimore, McCabe, & Antony, 2011) was the primary measure of social anxiety. Responses range from 1 (*not at all characteristic of me*) to 5 (*extremely characteristic of me*). The BFNE scale is well-validated (Spanish version by Gallego, Botella, Quero, Baños, & García-Palacios, 2007), with high test-retest reliability (r = .75; Leary, 1983), factorial and construct validity in undergraduate (Rodebaugh et al., 2004) and clinical social phobia samples (with mean scores of $M = 47$: Weeks et al.,

2005; and *M* = 43: Gallego et al., 2007). The mean HSA BFNE scores (*M* = 47.71) in the current study are thus comparable to those of clinical social phobia.

The SIAS and the SPS (Mattick & Clarke, 1998; see Heidenreich, Schermelleh-Engel, Schramm, Hofmann, & Stangier, 2011) assess fear of social interaction and fear of being observed, respectively. Each questionnaire is a 20-item measure using a scale ranging from 0 (*not at all characteristic of me*) to 4 (*extremely characteristic of me*). Spanish versions have been validated in large undergraduate samples (Olivares, García-López, & Hidalgo, 2001). Researchers use scores greater than 33 on the SIAS or 23 on the SPS to indicate social phobia (Brown et al., 1997). The mean SIAS and SPS scores in the current study (*M* = 37.75 and 31.29, respectively) thus indicated the HSA group was highly symptomatic.

Stimuli

We used 2-s video-clips. First, we selected photographs of *prototypical* neutral (i.e., neutral eyes and mouth; henceforth, Neutral) and happy (i.e., happy eyes and a smiling mouth; henceforth, Happy) expressions of 24 posers (12 females; 12 males) from the Karolinska Directed Emotional Faces database (KDEF; Lundqvist, Flykt, & Öhman, 1998). Second, composite faces were constructed for each poser by combining the upper half of each happy face and the lower half of the neutral face, and vice versa, which produced two types of *blended* expressions: (a) neutral eyes and a smiling mouth (henceforth, Ne+Sm), and (b) happy eyes and neutral mouth (henceforth, He+Nm). Figure 1 shows an example of these expressions.

Third, the resulting photographic versions (Neutral, Happy, He+Nm, Ne+Sm) were converted into 30-frame per second dynamic expressions using FantaMorph© (Abrosoft) software. To this end, one photograph was placed as the first frame of the sequence (e.g., Neutral) and another (e.g., Happy) as the last frame. FantaMorph

generated a continuum that smoothly unfolded from one expression to the other. This yielded six experimental conditions (see Figure 1). Samples of video-clips for each condition are shown in the ESM_1.mpeg (Supplemental Materials: Sample Video Stimuli) electronic file. For example, Neutral→ Happy refers to a condition in which an initial expression with neutral eyes and mouth unfolded to a final expression with happy eyes and a smile; and He+Nm→Happy indicates an initial expression with happy eyes and a neutral mouth unfolding to a final expression with happy eyes and a smile.

(Insert Figure 1 about here)

A total of 144 video-clips were used (24 posers by six expressions). Within each video-clip, the initial expression (e.g., Neutral) lasted (static period) for 500 ms, followed by a 1,000-ms unfolding (dynamic period) from the initial to the final expression (e.g., Happy), which remained still (static period) for 500 ms. The 1-s dynamic unfolding approximates the typical and natural average speed of expression development (see Hoffmann, Traue, Bachmayr, & Kessler, 2010). The same dynamic display duration was used by Johnston, Mayes, Hughes, and Young (2013). Each face was 10.6° (height) × 8.0° (width) at a 70-cm viewing distance, approximating the size of a real face (18.5 × 13.8 cm) viewed from 1-m.

Procedure

Each participant was presented with all the 144 video-clips in 4 blocks of 36 trials, randomly ordered. Experiment Center software (SensoMotoric Instruments GmbH, Teltow, Germany) was used. Participants were told short videos would be presented, with different facial expressions (otherwise unspecified), and were asked to judge and respond quickly *"how trustworthy each expresser appeared"* on a 9-point scale, by pressing a key on the top row of a computer keyboard: 1 indicated "very untrustworthy"; 5, "neither trustworthy nor untrustworthy"; and 9, "very trustworthy").

The sequence of events on each trial was as follows: After a 500-ms central fixation cross, a video-clip started with a still initial expression (500 ms), followed by unfolding towards the final expression (1,000 ms), and a still final expression (500 ms). Following face offset, the question "how trustworthy"? appeared.

Eye-movement measures

Gaze behavior was recorded via a 500-Hz (spatial resolution: 0.03°; gaze position accuracy: 0.4°) RED system eyetracker (SensoMotoric Instruments GmbH; Teltow, Germany). Three face regions of interest (see Figure 1) were defined: eye/eyebrow (henceforth, eyes), nose/cheek (nose), and mouth. About 97% of total fixations occurred within these four regions. Net *gaze duration* (i.e., mean total dwell time after saccades and blinks were removed) for each expression, face region, and display period (0-to-500 ms; 501-to-1,500 ms; 1,501-to-2,000 ms), assessed amount of *attentional engagement*. *Entry times* (i.e., the time elapsed from face onset until first fixation on each region) measured the *time course* of selective *attentional orienting* to each facial region. An additional *fixation density* measure (i.e., the number of fixations on each region) was computed on a stimulus base, to correlate gaze behavior with stimulus visual saliency (see Results, Visual saliency, below).

Computational modelling of visual saliency

Visual saliency is a computationally derived index of the perceptual prominence of an image region in relation to its surroundings, as a function of physical stimulus properties such as luminance, contrast, and spatial orientation. In prior research, saliency has proved to guide covert and overt attention (see Borji & Itti, 2013). We assessed visual saliency of the face regions of interest, relative to the whole face image, by means of the iLab Neuromorphic Vision C++ Toolkit algorithm (iNVT; http://ilab.usc.edu/toolkit/; Itti & Koch, 2000). This algorithm simulates which physical

features in an image attract attention, by mimicking the response properties of retinal neurons, lateral geniculate nucleus, thalamus, and V1. The iNVT has been used previously to assess face visual saliency and (a) overt attention (as assessed by eye movements; Calvo & Nummenmaa, 2008) and (b) covert attentional capture (as assessed by brain activity; Calvo, Beltrán, & Fernández-Martín, 2014). As our stimuli involved dynamic change, we computed saliency values over time for each of the three periods (i.e., 500-ms still initial expression, 1,000-ms expression unfolding, and 500-ms still final expression) across the 2 s of each video-clip. To the extent that some face cues or regions are (or become, with movement) more salient than others, they will attract eye fixations selectively. As a consequence, saliency will bias attention towards the facial information on which trustworthiness judgments are based. The relevant issue here is whether attention will be affected by visual saliency differently for HSA and for LSA viewers, as predicted (see Introduction).

Results

Analysis of trustworthiness judgments

A 2 (Social Anxiety) × 6 (Facial Expression) ANOVA was conducted on trustworthiness responses. Expression was a repeated-measures factor. For this and all the following analyses, we performed Bonferroni corrections (with a $p < .05$ threshold) whenever *a posteriori* multiple contrasts were involved. For *response judgments* (internal consistency was .72, as assessed by Cronbach's α), main effects of anxiety, $F(1, 46) = 5.43$, $p = .024$, $\eta_p^2 = .11$, and expression, $F(5, 230) = 253.92$, $p < .0001$, $\eta_p^2 = .85$, and an interaction, $F(5, 230) = 12.22$, $p < .0001$, $\eta_p^2 = .21$, were statistically significant. Trustworthiness ratings of HSA participants were lower than those of LSA participants for Neutral→Ne+Sm expressions, $t(46) = 5.10$, $p < .0001$, $d = 1.47$, and He+Nm→Happy expressions, $t(46) = 4.13$, $p < .0001$, $d = 1.19$, with no differences for

the others. For *reaction times* (α = .95), only a main expression effect emerged, $F(5, 230) = 4.63$, $p = .002$, $\eta_p^2 = .09$, with Neutral→Happy faces being responded to faster than the others. Figure 2 shows the scores and contrasts across expressions.

(Insert Figure 2 about here)

Gaze duration

Gaze duration (α = .64) on each face region was analyzed via a Social Anxiety (2) × Expression (6) × Region (3: eyes, mouth, nose) × Interval (3: 0-to-500 ms [static] vs. 501-to-1,500 ms [dynamic] vs. 1,501-to-2,000 ms [static]) ANOVA, with social anxiety as a between-subjects factor, and expression, region, and interval as within-subjects factors. There were interactions of anxiety by region, $F(2, 92) = 9.96$, $p < .0001$, $\eta_p^2 = .18$, anxiety by interval by region, $F(4, 184) = 12.08$, $p < .0001$, $\eta_p^2 = .21$, and a four-way interaction, $F(20, 920) = 3.96$, $p < .001$, $\eta_p^2 = .08$.

To decompose the interactions, Social Anxiety (2) × Expression (6) × Region (3) ANOVAs were conducted for each interval. In the 0-to-500-ms period, the anxiety by region interaction, and the anxiety by expression by region interaction, did not reach statistical significance ($ps \geq .09$). In contrast, in the 501-to-1,500-ms period, the anxiety by region interaction, $F(2, 92) = 12.87$, $p < .0001$, $\eta_p^2 = .22$, and the anxiety by expression by region interaction, $F(10, 460) = 5.61$, $p < .0001$, $\eta_p^2 = .11$, were significant. This was also the case in the 1,501-to-2,000-ms period, $F(2, 92) = 6.40$, $p = .005$, $\eta_p^2 = .12$, and, $F(10, 460) = 3.08$, $p = .012$, $\eta_p^2 = .06$, respectively.

As shown in Figure 3, pairwise comparisons for independent samples revealed that LSA participants fixated on the *mouth* longer than HSA participants in the 501-to-1,500-ms period, $t(46) = 4.17$, $p < .0001$, $d = 1.20$, and the 1,501-to-2,000-ms period, $t(46) = 2.90$, $p = .007$, $d = 0.84$. In contrast, HSA participants fixated on the *eyes* longer than HSA participants in the 501-to-1,500-ms period, $t(46) = 4.27$, $p < .0001$, $d = 1.23$,

and the 1,501-to-2,000-ms period, $t(46) = 3.03$, $p = .004$, $d = 0.87$. No significant differences emerged for the nose region ($ps \leq .10$). The above three-way interaction came from the fact that the eye and the mouth region differences between LSA and HSA participants were larger in the 501-to-1,500-ms period for some expressions than for others (e.g., $t = 4.80$, $p < .0001$, $d = 1.39$, vs. $t = 2.58$, $p = .013$, $d = 0.74$; albeit all of them were statistically significant); and, in the 1,501-to-2,000-ms period, differences were significant for all the expressions (all $ts > 2.85$, $ps \leq .006$, $ds \geq 0.82$) except for one of them (i.e., Neutral→HeNm; $p = .23$).

(Insert Figure 3 about here)

Entry times

The analysis of entry times ($\alpha = .83$) via a Social Anxiety (2) × Expression (6) × Region (2; the nose was excluded because its location coincided with the *initial* central fixation point, and hence entry time was generally equal to 0 ms) ANOVA across the 2-s display yielded an anxiety by region interaction, $F(1, 46) = 12.74$, $p = .001$, $\eta_p^2 = .22$, with no three-way interaction ($F < 1$). Pairwise contrasts between HSA and LSA groups revealed that the *eyes* were fixated earlier by HSA ($M = 444$ ms) than LSA ($M = 588$) participants, $t(46) = 2.70$, $p = .010$, $d = 0.78$, whereas the *mouth* was fixated first earlier by LSA ($M = 862$) than HSA ($M = 1,069$) participants, $t(46) = 3.43$, $p = .001$, $d = 0.99$.

Visual saliency

First, we computed visual *saliency difference scores* between the 0-to-500-ms (static) and the 501-to-1,500-ms (dynamic) periods (i.e., second minus first) for each face region. Such scores reflect how much expressive change contributes to saliency. An Expression (6) × Region (3: eyes vs. nose vs. mouth) ANOVA showed an interaction, $F(10, 345) = 13.25$, $p < .0001$, $\eta_p^2 = .28$. One-way (3: Region) ANOVAs revealed differences for all the expressions unfolding from a neutral to a *smiling mouth*

(i.e., Neutral→Happy, Neutral→Ne+Sm, and He+Nm→Happy), $F(2, 69) = 73.49$, $p < .0001$, $\eta_p^2 = .59$, with the mouth being more salient ($M = 2.17$) than all the other regions (nose: -0.47; eyes: -1.15). However, differences between the mouth and the other regions were non-significant for expressions displaying a final *neutral mouth* (Neutral→He+Nm, Happy→He+Nm, Happy→Neutral; mouth: -0.69; nose: -0.28; eyes: -0.94; all *p*s > .18).

(Insert Table 2 about here)

Second, importantly for the aims of this study, we correlated visual saliency scores with the observers' fixation density scores to determine how much saliency guided oculomotor behavior. Table 2 shows the relevant Pearson correlations and the differences as a function of social anxiety. For expressions ending with a *smiling mouth*, that is, when the smiling mouth was especially salient (see above), the positive correlations between saliency and fixations were significantly greater for LSA than for HSA participants, using the Fisher *r*-to-*z* transformation. In contrast, the analysis of expressions ending with a *neutral mouth* showed no significant positive correlations and non-significant differences between groups.

Discussion

Three major findings jointly provided a characterization of key cognitive aspects of social anxiety. First, there was an *interpretative bias*, such that HSA participants distrusted blended expressions with ambiguous smiles (due to eye-mouth incongruence) more than LSA ones did. In contrast, judgments of prototypical expressions with congruent eyes and mouth did not differ as a function of social anxiety. Second, social anxiety was associated with an *attentional bias*, as HSA participants consistently fixated on the eye region earlier and longer than LSA ones, who fixated on the smiling mouth region earlier and longer. The enhanced early selective attention to the eye region

presumably facilitates detection of expressive ambiguities or inconsistencies, thus leading to untrustworthiness judgments. Third, selective attention was captured by the *visual saliency* of the facial stimulus to a greater extent for LSA than for HSA groups when a neutral mouth unfolded to a smiling mouth. This suggests HSA viewers' attention is guided in a way that opposes the 'automatic' effects of physical stimulus saliency. Altogether, these findings provide robust support for our hypotheses.

Eye-fixation patterns and visual saliency

Why were HSA observers more likely than LSA ones to fixate on the eye region? There is controversy concerning whether high social anxiety is associated with enhanced (Boll, Bartholomaeus, Peter, Lupke, & Gamer, 2016; Gutiérrez-García, Calvo, & Eysenck, 2018; Wieser, Pauli, Alpers, & Mühlberger, 2009; current study) or reduced (Horley, Williams, Gonsalvez, & Gordon, 2003; Howell, Zibulsky, Srivastav, & Weeks, 2016; Moukheiber et al., 2010; Weeks, Howell, & Goldin, 2013) eye contact. Mogg, Bradley, de Bono, and Painter (1997) proposed an influential vigilance-avoidance hypothesis according to which social anxiety induces initial hypervigilance to potential social threat cues (e.g., non-happy eyes) by enhancing sensitivity and orienting to them, followed by rapid attentional avoidance and reduced subsequent cognitive processing of such stimuli. There is empirical support for the above hypothesis (e.g., Garner, Mogg, & Bradley, 2006; Wieser et al., 2009), with more evidence for hypervigilance than for avoidance (see Armstrong & Olatunji, 2012). If we extrapolate from this hypothesis, it is possible that an early selective fixation on the eyes by socially anxious observers could be followed by avoidance, thus making the apparent empirical inconsistencies regarding eye contact compatible.

Prior eye-tracking studies have not specifically addressed the hypothesis regarding the *time course* of gaze contact (early) and avoidance (later). Nevertheless,

the findings can be considered in relation to this hypothesis. Interestingly, studies in which socially anxious individuals focused more than non-anxious ones on the eyes (i.e., enhanced gaze contact, with no avoidance) used relatively short presentation times (150 or 3,000 ms: Boll et al., 2016; 2 s: Gutiérrez-García et al., 2018; current study; or 6.33 s: Wieser et al., 2009), thus, the effects occurred early. Relatedly, with a different approach using brain measures (ERPs; event-related potentials), Felmingham, Stewart, Kemp, and Carr (2016) presented faces for 1,500 ms and also obtained evidence of sustained (rather than avoidant) early cortical processing in high social anxiety. In contrast, studies finding social anxiety is associated with avoidance of eye contact (Horley et al., 2003; Howell et al., 2016; Moukheiber et al., 2010; Weeks et al., 2013) used longer presentation times (10 to 12 s; or a live 4-min conversation, in Howell et al., 2016). It is thus possible that short stimulus presentations are more sensitive to early vigilance effects, while longer presentations are more suitable to assess avoidance. Accordingly, attentional focusing on the eyes (earlier and short periods) or gaze avoidance (later and longer periods) is probably time-dependent.

An additional finding involving *visual saliency* suggests this attentional bias in social anxiety engages top-down coping processes. The tendency of HSA observers to look early at the eye—rather than the mouth—region occurred even though the smiling mouth was more visually salient than any other face region. Importantly, gaze allocation was related to visual saliency to a greater extent for LSA than HSA participants when high saliency changes appeared in the face, i.e., when a neutral mouth unfolded to a smiling mouth. Thus, the eye fixations of LSA viewers were more influenced by stimulus saliency than those of HSA ones. This suggests the early attentional focus of LSA observers is driven in a bottom-up fashion by physical stimulus properties (i.e., captured by perceptual saliency), which otherwise represents the typical pattern in

"normal"—unselected as a function of anxiety—observers (Calvo & Nummenmaa, 2008; Calvo et al., 2013). Indeed, the smile saliency is associated with early attentional capture, as assessed by the N1 ERP component (Calvo et al., 2014). In contrast, the attentional focus of HSA viewers is guided more strategically (presumably, intentional search of the eye expression that might reveal un/trustworthiness), thus counteracting automatic attentional capture by the smiling mouth physical saliency.

Trustworthiness judgments and eye fixations

Both high and low social anxiety groups judged dynamic expressions with a final smile as less trustworthy when there was eye-mouth incongruence (i.e., He+Nm→Happy; and Neutral→Ne+Sm), compared to congruent, genuinely happy faces (i.e., Neutral→Happy). However, the critical finding was that such reductions in trustworthiness ratings were significantly greater for HSA than LSA participants. In contrast, trustworthiness ratings were comparable for HSA and LSA participants when the face stimuli involved truly happy expressions (i.e., happy eyes and a smile) or clearly non-happy expressions (i.e., those concluding with a neutral mouth). These findings disprove the hypothesis that social anxiety is associated with an across-the-board interpretative bias producing generalized low trustworthiness ratings, or a mere response bias. Instead, HSA individuals have an interpretative bias specifically for ambiguous (but not for unambiguous) smiles.

According to cognitive models of social anxiety and phobia, persistent and excessive fear and avoidance of social situations are due in part to biases towards threat-related interpretations of ambiguous social cues (e.g., Heimberg, Brozovich, & Rapee, 2014). There is, indeed, evidence that socially anxious individuals often interpret such cues more negatively or less positively than non-anxious ones (Mobini et al., 2013), and this bias can even extend to positive cues (Weeks & Howell, 2012). It therefore makes

sense that ambiguous smiling faces may be interpreted as expressing disapproval or rejection, as they could signal social threat (e.g., being laughed at). Thus, by assessing trustworthiness judgments, we examined a significant aspect of threat-related interpretative biases pertinent to cognitive models. Further, our measurement of observers' gaze behavior served to detail the associated underpinnings regarding *where* (face region) *when* (time course) and *how much* (amount of processing) attention is selectively allocated. This is relevant for exploring the cognitive mechanisms proposed by models of social anxiety.

Presumably, the socially anxious individuals' interpretative bias (i.e., enhanced distrusting of smiling faces with non-congruent eyes) is due to an attentional bias (i.e., early selective allocation of overt attention to the eye region). That is, HSA viewers might be more likely than LSA ones to detect expressive ambiguities or incongruences in smiling faces (leading them to distrust such faces more than LSA individuals) because HSA observers fixate earlier and longer on the eye region. In ambiguous smiling faces, incongruence probably depends mainly on the eyes (e.g., McLellan et al., 2010; see Niedenthal et al., 2010). Accordingly, observers (HSA) who preferentially attend to the eyes are at an advantage for detecting any incongruence and thus distrusting the expresser. In contrast, non-anxious (LSA) individuals preferentially attend to the smiling mouth probably because their gaze is more 'automatically' attracted by visual saliency. As a result, LSA observers would be less likely to process fully the eye-mouth incongruence, basing their trustworthiness judgments mostly on smile information. In sum, early selective attention to the eyes by HSA individuals enhances detection of expressive incongruences, which would lead to facial untrustworthiness judgments.

Conclusions and extensions

Participants with high levels of social anxiety (HSA) judged ambiguous smiling faces with non-congruent eyes as less trustworthy than non-anxious (LSA) ones. Further, the former (HSA) were more likely than the latter (LSA) to selectively look earlier and longer at the eye region, whereas the reverse occurred for the mouth region. This attentional bias is probably strategically driven (i.e., opposing the 'automatic' capture by the salient smile), as high social anxiety was associated with gazing towards the eye region even though the smiling mouth was more physically salient, and visual saliency was more related to gaze behavior for LSA than HSA participants. An issue for further research is whether this pattern of selective orienting in social anxiety is task-goal specific (i.e., it depends on using the task of trustworthiness evaluation). Alternatively, it may reflect a very general scanning pattern also under more natural conditions in the absence of such an explicit goal (this possibility could, in fact, occur if socially anxious individuals are *generally* and *intrinsically* concerned with trustworthiness evaluation).

The specific biases we have identified in social anxiety are functional, in that they facilitate the detection of fake smiles indicative of untrustworthiness (and possibly negative evaluation). This benefit occurs without apparent cost because trustworthiness judgments for genuinely happy faces are unimpaired. Importantly for the conceptualization of social anxiety (with clinical levels, in people who can, nevertheless, deal with daily life demands, including higher education), these biases can be seen as a coping mechanism for the early detection of potential negative evaluators. Thus, treatment approaches should fine-tune (but not remove) such a mechanism, to prevent generalized hypervigilance and hyper-reactivity.

The current study used dynamic face, video-clip stimuli of realistic morphing

animation. Such stimuli have proved valid in both behavioral (e.g., Calvo et al., 2016) and neurophysiological (e.g., Johnston et al., 2013) research. However, such stimuli do not involve any interaction with the observers (e.g., the expressers provide no feedback and pose no real threat—negative evaluation—to observers). Accordingly, the investigation of cognitive biases in social anxiety could usefully be extended by assessing gaze behavior during simulated interaction (e.g., with a pre-recorded audience; see Lin et al., 2016) or live interaction (see Howell et al., 2016), while maintaining rigorous experimental control of stimulus properties in spite of using complex conditions.

Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's website: (a) ESM_1.mpeg (Supplemental Materials: Sample Video Stimuli); (b) ESM_2A.xlsx (Supplemental Data_Dataset Trustworthiness and Eye Movements); and (c) ESM_2B.xlsx (Supplemental Data_Dataset Fixation Density and Visual Saliency). This supplementary information provides examples of the stimuli, as well as the raw data.

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Table 1

Participant Characteristics

	Low Social Anxiety		High Social Anxiety		Differences
	M	*SD*	*M*	*SD*	*Statistics*
Age	21.96	1.33	21.79	1.38	$t(46) = 0.42$, $p = .67$, *ns*
BFNE (α = .91)	21.75	4.64	47.71	5.63	$t(46) = 17.44$, $p < .0001$
SIAS (α = .92)	14.42	5.01	37.75	8.46	$t(46) = 11.63$, $p < .0001$
SPS (α = .90)	11.29	3.00	31.29	8.05	$t(46) = 11.41$, $p < .0001$

Note. BFNE: Brief Fear of Negative Evaluation Scale. SIAS: Social Interaction Anxiety Scale. SPS: Social Phobia Scale.

Table 2

Pearson Correlations between Visual Saliency and Fixation Density Difference Scores in the Dynamic Period (501-to-1,500 ms) minus the Static Period (0-to-500 ms), for Socially Anxious and Non-anxious Groups, and Differences (z and p; two-tailed) between Groups, as a function of Expression.

Expression	Low Anxiety *r*	High Social Anxiety *r*	Fisher's *z*	Difference Low vs. High Anxiety *p*
Final *Smiling* Mouth	.79***	.36**	4.08	.0001
Neutral→Happy	.62***	.24*	2.82	.005
He+Nm→Happy	.63***	.26*	2.79	.005
Neutral→Ne+Sm	.61***	.26*	2.60	.009
Final *Neutral* Mouth	-.18 *ns*	-.36**	1.14	*ns*
Happy→He+Nm	-.07 *ns*	-.23 *ns*	0.96	*ns*
Neutral→He+Nm	.03 *ns*	.01 *ns*	0.12	*ns*
Happy→Neutral	-.06 *ns*	-.29*	1.40	*ns*

$N = 96$; *$p < .05$; **$p < .01$; ***$p < .0001$

Note. Neutral: neutral eyes and neutral mouth. Happy: happy eyes and happy (smiling) mouth. He+Nm: Happy eyes (He) and Neutral mouth (Nm). Ne+Sm: Neutral eyes (Ne) and Smiling mouth (Sm). → Unfolding to.

Figure Captions

Figure 1. Types of prototypical (Neutral: neutral eyes and mouth; or Happy: happy eyes and mouth) and blended expressions (Ne+Sm: neutral eyes and a smiling mouth; He+Nm: happy eyes and a neutral mouth), regions of interest, and resulting dynamic expression conditions (as a function of combinations of initial and final eye and mouth expression).

Figure 2. Mean trustworthiness judgment scores and reaction times (RTs, ms) for each expression. Within each anxiety group, across expression categories, scores with a different letter indicate significant differences. Vertical lines in bars indicate standard errors of the mean. Neutral: neutral eyes and neutral mouth. Happy: happy eyes and happy (smiling) mouth. He+Nm: Happy eyes (He) and Neutral mouth (Nm). Ne+Sm: Neutral eyes (Ne) and Smiling mouth (Sm).

Figure 3. Mean gaze duration on each face region across successive intervals as a function of social anxiety. Asterisks indicate significant differences between socially anxious and non-anxious groups.

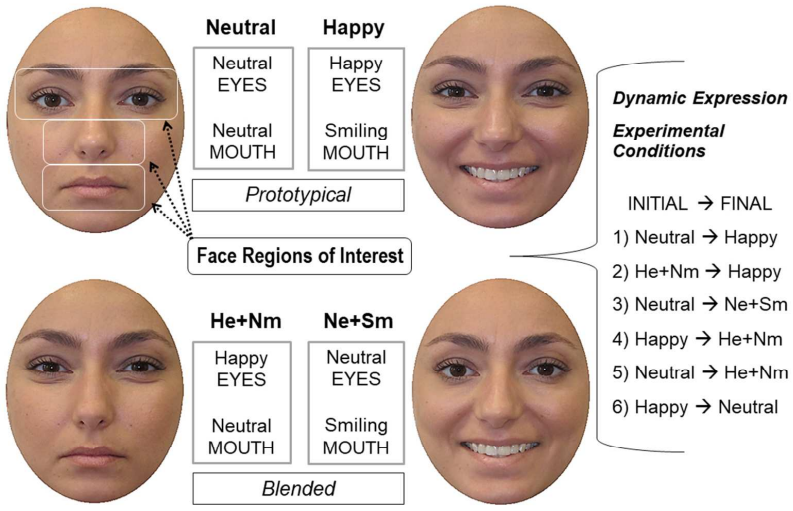

Figure 1

285x190mm (96 x 96 DPI)

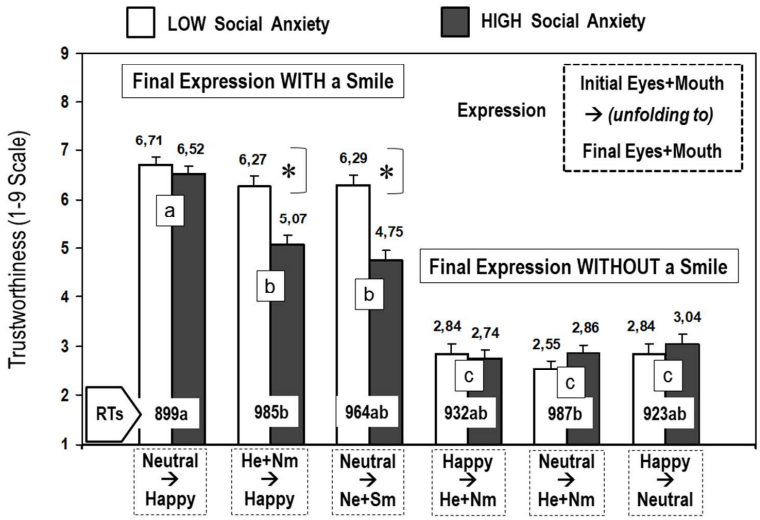

Figure 2

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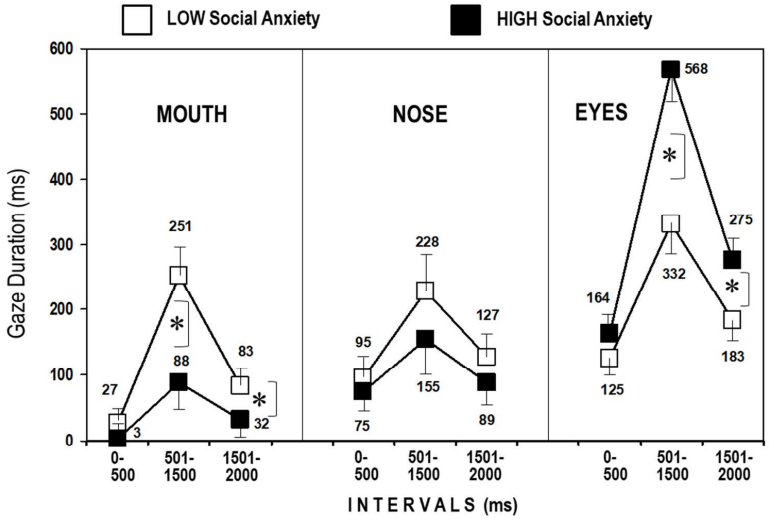

Figure 3

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