REALIDAD VIRTUAL COMO UN ENTORNO DE LABORATORIO EN LA INVESTIGACIÓN EN PSICOLOGÍA:

CONDUCTA ALIMENTARIA Y ANSIEDAD ESCÉNICA

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Presumes que eres la ciencia
yo no lo he entendío así
porque siendo tú la ciencia
no me has comprendío a mí.

(Soleares, letra popular)

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RESUMEN

El uso de la Realidad Virtual (RV) en psicología cuenta con una amplia trayectoria desde los años 90, bifurcándose en dos campos bien diferenciados: por un lado, el campo de los trastornos de la ansiedad, y por otro, el campo de la alimentación. Dentro de los trastornos de ansiedad, es reciente el uso de RV en el estudio de los trastornos de ansiedad social relacionados con la "ansiedad de desempeño" o "ansiedad de solo actuación" (DSM V), como el hablar o actuar en público, de interés en los últimos años. En este campo, recientemente se ha comenzado a investigar la conocida como ansiedad escénica musical (en inglés music performance anxiety, MPA). En el campo de los trastornos de la alimentación, principalmente se ha aplicado el uso de la RV a la evaluación y tratamiento de la distorsión de la imagen corporal y las respuestas emocionales de los pacientes de anorexia, bulimia y trastorno por atracón. El estudio de la conducta alimentaria temprana en población adolescente comienza a tomar importancia como una forma de predecir estos trastornos alimentarios en el futuro. No obstante, siguen siendo necesarios estudios que muestren la validez empírica y ecológica de la RV en estos campos, así como su aplicación dentro de la investigación psicológica junto a otras metodologías de uso tradicional.

El objetivo de esta tesis doctoral es evaluar la aplicación de la RV como un entorno de laboratorio válido en la investigación en psicología, aportando nuevas evidencias en áreas relativamente novedosas y de incipiente investigación como son

la ansiedad escénica musical y la conducta alimentaria temprana. Se eligen estos dos campos de estudio en concreto al ser los menos investigados dentro de sus respectivas áreas. Se espera que los resultados de los estudios sean similares a los registrados en experimentos en vivo, confirmando la validez externa de la técnica de RV.

La presente tesis doctoral se estructura en tres estudios. Con el primer estudio nos planteamos conocer la distribución y características de la MPA en población española y su relación con distintos grupos de variables: sociodemográficas, musicales, de aprendizaje y psicológicas. La MPA es uno de los mayores problemas a los que se enfrenta un músico en el desarrollo de su carrera profesional, siendo causante un gran número de abandonos durante las enseñanzas superiores (Dalia, 2004). Este trastorno de ansiedad se manifiesta a través de sintomatología cognitiva, conductual y sobre todo física (Kenny, 2011), lo que hace que se produzca un detrimento en las habilidades interpretativas del intérprete musical. Para este estudio, una muestra de estudiantes de conservatorios andaluces fueron evaluados buscando obtener información sobre su nivel de MPA, así como recoger información relevante sobre variables socio demográficas, entrenamiento musical, procesos de aprendizaje musical y otras variables relacionadas con la salud física y psicológica de los músicos. Los resultados mostraron que las variables con mayor peso para predecir MPA son mayormente variables psicológicas y de salud, entre las que se encuentran la depresión, miedo a la evaluación negativa, fobia social, el uso de sustancias y una pobre motivación de logro musical. Las variables sociodemográficas y las relacionadas con el aprendizaje musical mostraron poca relevancia. La edad de la primera actuación en público se mostró como la única variable de entrenamiento musical con suficiente poder para predecir MPA. Los datos relativos a la distribución del MPA entre los músicos facilitaron la muestra adecuada para llevar a cabo el estudio 2, así como la elaboración del paradigma experimental y de un entorno virtual ad hoc acorde a las características de esta población.

El objetivo del estudio 2 fue emplear la RV para comprender las bases fisiológicas implicadas en la MPA. Para ello se requirió la participación de 30 músicos previamente clasificados en el estudio 1 como altos o bajos en MPA, cuya tarea consistía en interpretar una obra musical dentro de un entorno virtual consistente en un auditorio con público y diseñado ad hoc para la ocasión. Se realizó un registro de las respuestas fisiológicas (electrocardiograma, conductancia eléctrica de la piel y electromiografía facial), antes, durante y después de la interpretación musical.

Mientras que los estudios previos en esta área de investigación se habían limitado a registrar el arousal (Studer, Danuser, Wild, Hildebrandt, y Gomez, 2014; Williamon, Auffeger y Eiholzer, 2013; Yoshie, Kudo, Murakoshi y Ohtsuki, 2009), en este caso se optó por realizar además una evaluación afectiva a través del registro de la electromiografía facial. El objetivo de eta última técnica fue conocer la evaluación emocional que hacen los músicos en relación a la interpretación en público. Los resultados muestran que la RV funciona como un entorno de laboratorio válido para el estudio del MPA, ya que valida resultados obtenidos en vivo en el estudio de las respuestas psicofisiológicas en MPA. Al igual que se concluye en estudios realizados en vivo, no se encontraron diferencias en arousal fisiológico (manifestado en la frecuencia cardiaca y conductancia eléctrica de la piel) en relación con la interpretación entre los músicos con alta y baja MPA, mostrando que no hay una relación entre la ansiedad autopercibida y la activación psicofisiológica. Sí que se encontraron diferencias entre grupos en la actividad del músculo corrugador, donde los músicos con alta MPA mostraron mayor activación, respondiendo al patrón clásico de activación ante los estímulos distractores desagradables (Bradley, Codispoti, Sabatinelli, y Lang, 2001; Larsen, Norris y Cacioppo, 2003). Respecto a las diferentes partes de la interpretación en público, se replican resultados de estudios llevados a cabo en vivo (Studer et al., 2014), donde se produce un mayor nivel de activación durante la fase de interpretación en relación con la fase de preparación y post actuación, manifestada en un incremento de la frecuencia cardiaca en todos los participantes

Se propone un último estudio sobre el uso de RV en laboratorio, donde se evalúa la eficacia de esta técnica para el estudio de la conducta alimentaria de riesgo en la alimentación en adolescentes. Los elevados niveles de obesidad en niños y adolescentes, así como el elevado número de estos que realizan conductas poco saludables dejan en evidencia los importantes problemas de salud pública que supone una inadecuada conducta alimentaria (Melendez, Cañez de la Fuente y Frías, 2012). Además, estos problemas de alimentación suponen la antesala a futuros trastornos alimentarios en el futuro, como la anorexia, bulimia o trastornos por atracón. El objetivo de este estudio es realizar la validación empírica de la aplicación de RV en conducta alimentaria adolescente no clínica, a fín de compararlos con resultados previos en la literatura en situaciones de laboratorio y naturales. Para ello se creó un entorno de bufé virtual, dónde 60 alumnos y alumnas de 4º de la ESO podían elegir todo los que quisieran para su consumo virtual de entre una gran variedad (salados, dulces, vegetales y frutas). Con los datos obtenidos se construyó un modelo de regresión

hierática que ayudó a predecir las variables que favorecían la elección de cierta cantidad y tipos de alimentos.

Los resultados mostraron el entorno de RV elaborado ad hoc para este estudio funciona como un entorno de laboratorio válido en el campo de la conducta alimentaria en adolescentes sanos, pues replica resultados obtenidos previamente en entornos reales con esta población. Los adolescentes presentaban una relación inversa entre la puntuación de conducta restrictiva y la selección de alimentos ricos en calorías, con independencia de si realizan dieta o no. Esto parece mostrar que aquellos cuyo comportamiento restrictivo es alto ingieren menor cantidad de comida y comen menos calorías de las necesarias para mantener su peso corporal actual, como menos contenido de grasas y azúcar (Van Strien, Frijters, van Staveren, Defares y Deurenberg, 1986). Los datos también mostraron una relación directa entre los niveles de hambre previos y la selección de alimentos ricos en calorías, independientemente de si realizan dieta o no. Esto mostraría como las señales fisiológicas naturales del hambre siguen siendo relevantes en el control de la alimentación en los adolescentes.

Los resultados obtenidos en los diferentes estudios muestran como la RV funciona como un entorno de laboratorio válido en la investigación en psicología, especialmente en las áreas relativamente novedosas que se tratan en esta tesis doctoral: la ansiedad escénica musical y la conducta alimentaria temprana.

INTRODUCCIÓN

1. REALIDAD VIRTUAL

1.1. Introducción

Se han ofrecido diferentes definiciones de realidad virtual (RV) a lo largo de su desarrollo (Burdea, 1993; Hill, 1996; Perpiñá, Botella y Baños, 1997; Sherman y Craig, 2018), de hecho, en el libro *The dawn of the new everything* de Lanier (2018) podemos encontrar hasta 50 definiciones de este término. Todas tienen en común que hacen referencia a un conjunto de escenarios generados por ordenador, con los que se puede interactuar en tiempo real y donde existe la sensación de inmersión y presencia. Así, podemos definir a la RV como una tecnología que genera un mundo artificial con el que se puede interactuar y que estimula distintos canales sensoriales para generar la experiencia subjetiva de estar en dicho lugar (Botella, Perpiñá y Baños, 2000; Botella, Baños, Perpiñá y Ballester, 1998; Botella, García-Palacios, Baños y Quero 2007; Lanier, 2018). La RV se diferencia de otros sistemas como el de realidad aumentada (RA) en que esta última combina la visión del mundo real con objetos virtuales de forma interactiva y en tres dimensiones (Van Krevelen y Poelman, 2010).

El mundo virtual se refiere al espacio artificial donde se desarrolla la actividad de la RV en el que la información sensorial es suficiente para crear la ilusión de estar físicamente en él (Ryan, Cornick, Blascovich y Bailenson, 2019). Este mundo tiene que generarse de manera tridimensional, con las características propias del mundo real. Sin embargo, en algunos casos, es manipulado para obtener resultados improbables o imposibles en vivo. El objetivo principal de la RV es la generación del sentido de presencia en el entorno virtual. Se entiende la presencia como un estado de estar mentalmente sumergido en el entorno que se presenta, de manera que el usuario se comporta y siente como si realmente estuviera en el mundo virtual (Botella, García - Palacios, Baños y Quero, 2009; Diemer, Alpers, Peperkorn, Shiban y Mühlberger, 2015; Slater, 2018). Resulta necesario diferenciar entre presencia e inmersión, ya que con frecuencia se usan como sinónimos, pero no lo son. La inmersión sería una propiedad objetiva proporcionada por la visualización y los sistemas interactivos en relación a la realidad física, mientras que la presencia es un estado subjetivo que se produce mediante la manipulación de la inmersión (North y North, 2016; Slater, 2018). La inmersión comprende la desconexión del mundo real y el tiempo real, así como la participación completa en la tarea (Shu, Huang, Chang y Chen, 2019). Puede ser más alta o más baja en la medida en que el sistema de RV reproduzca las características sensoriomotoras naturales para la percepción (Sanchez-Vives y Slater, 2005; Slater,

2018), por lo que aspectos como el tipo de dispositivo visual y el sonido están estrechamente relacionados con la inmersión.

Entre los dispositivos visuales más inmersivos se encuentran las gafas de RV (en inglés, *Head Mounted Displays*, HMD). Son dispositivos móviles oclusivos que utilizan un sistema óptico para presentar las escenas virtuales y producir una fuerte sensación de inmersión (Wang et al., 2016). Otra categoría de dispositivos virtuales menos inmersivos son los sistemas de pantalla. Son sistemas fijos no oclusivos, entre los que se encuentran las pantallas semiesféricas 3D con forma cóncava, que combinan la pantalla panorámica y semiesférica con un proyector (Sherman y Craig, 2018). Gracias a su gran tamaño y a la proyección estereoscópica, el usuario se ve fácilmente envuelto en la experiencia virtual. Otro sistema de proyección es la conocida como *CAVE* (acrónimo de Automated Virtual Environment) que son habitaciones donde el entorno virtual se proyecta en las paredes frontales y laterales (Gutiérrez-Maldonado, Ferrer-García, Dakanalis y Riva, 2018). Favorece experiencias colectivas de RV al permitir que diferentes personas compartan la misma experiencia al mismo tiempo. Al comparar estos sistemas inmersivos, en general no se encuentran diferencias significativas en el rendimiento de los participantes o en la sensación de inmersión (Bowman, Datey, Farooq, Ryu y Vasnaik, 2001), participación, interacción, *embodyement* (Philpot, Glancy, Passmore, Wood, Fields, 2017), ni en la efectividad de los dispositivos (Meyerbröker, Morina, Kerkhof y Emmelkamp, 2011). Cuando el sistema de proyección se trata de una pantalla simple, se encuentra que los dispositivos HMD producen una mayor sensación de presencia e inmersión (Shu, Huang, Chang y Chen, 2019). Sin embargo, cuando el sistema de proyección se trata de una pantalla semiesférica, se ha encontrado evidencia de que el sentido de presencia de los participantes era mayor que con gafas HMD (North y North, 2016). Igual ocurre cuando se comparan con HMD de baja calidad o con las CAVE, donde estas últimas muestran mejor rendimiento (Kim, Rosenthal, Zielinski y Brady, 2012).

La elección de un dispositivo u otro se basa en las necesidades requeridas dentro del mundo virtual. Por ejemplo, se optará por un dispositivo de salida visual oclusivo si el objetivo de la tarea es aumentar la inmersión en la misma. Sin embargo, cuando no es conveniente aislar a los participantes del mundo real por completo, porque tienen que usar las manos u otra parte de su cuerpo, se optará por un sistema de pantalla semiesférica con proyección en tres dimensiones y 180º grados, o una CAVE.

1.2. Uso de la realidad virtual con fines experimentales

Las aplicaciones de la RV en contextos experimentales se hallan presentes en la actualidad en gran cantidad de campos, como la medicina, la enseñanza, marketing, arquitectura, el entretenimiento y la psicología (Ryan et al., 2019). La experimentación ayudada de la técnica de RV difiere de los procedimientos clásicos (como la exposición en imaginación, o la presentación de imágenes o fotografías) en que la RV proporciona un mejor equilibrio entre la validez interna y ecológica, pues las simulaciones de RV pueden controlarse completamente con fines experimentales (Riva, Gutiérrez-Maldonado, Dakanalis y Ferrer-García, 2019).

De entre las ventajas que ofrece en la experimentación, la RV mejora la capacidad de replicar experimentos psicológicos realizados en vivo, abriendo la ventana a nuevas preguntas de investigación (De la Rosa y Breidt, 2018). Por ejemplo, es el caso de los estudios donde se ha demostrado que la RV es una herramienta eficaz para inducir estados emocionales en contextos experimentales, permitiendo graduar la intensidad del impacto emocional mediante el realismo o el nivel de interacción (Rodríguez-Árbol, Ciria, Delgado-Rodríguez, Muñoz, Calvillo-Mesa y Vila, 2013). Estos resultados fueron replicados en una investigación sobre el craving por el tabaco (Muñoz, Idrissi, Sánchez-Barrera, Fernández-Santaella y Vila, 2013) donde los participantes observaban imágenes agradables, desagradables y relacionadas con el tabaco dentro de un entorno de RV. Los resultados confirmaron que los estímulos relacionados con el tabaco elicitaban en los participantes una respuesta de sobresalto similar a los estímulos desagradables, pero subjetivamente se evaluaban como positivos, lo que sugiere que el mecanismo subyacente del craving activa las tendencias motivacionales tanto aversivas como apetitivas.

La RV permite manejar con precisión diferentes características del ambiente, pudiendo manipular fácilmente y de manera aislada las variables independientes del estudio (Maples-Keller, Bunnell, Kim y Rothbaum, 2017). Es el caso del estudio para evaluar la viabilidad de un proyecto de elaboración de calzadas compartidas para el uso de vehículos y peatones (Lee y Kim, 2021). De entre varias opciones diseñadas, se evaluó la seguridad percibida, así como de la conveniencia de caminar por cada una de esas opciones mediante un entorno de RV por el cual los participantes pueden caminar como si de un entorno real se tratase. Los resultados muestran como los peatones muestran mayor seguridad en las calzadas compartidas que tienen prioridad peatonal, moviéndose de forma más libre en las calzadas que tienen un diseño

integrado para vehículos y peatones. De esta forma la viabilidad del proyecto de elaboración de calzadas compartidas pudo evaluarse antes de su construcción. La RV también ha contribuido a evaluar la viabilidad de diferentes entornos sociales para elicitar ansiedad en jóvenes con y sin diagnóstico de fobia social según las características del ambiente (Parrish, Oxhandler, Duron, Swank y Bordnick, 2016). Los escenarios virtuales consistían en una fiesta y un entorno donde hablar en público ante una audiencia. Se concluyó que ambos entornos generaban más ansiedad que dos entornos neutrales en todos los jóvenes, especialmente en los diagnosticados con fobia social.

La RV permite a los sujetos realizar tareas idénticas a las realizadas en la vida real o incluso situaciones complejas imposibles de recrear en el contexto de laboratorio (Botella, Baños y Quero, 2017). Es el caso del estudio que, mediante RV, investigó el efecto que la música ambiente de las tiendas tiene en las emociones y el comportamiento de los compradores (Dad, Rehman, Kear y Davies, 2018). El estudio sometía a participantes a navegar por una tienda virtual inmersiva durante unos minutos mientras se evaluaron parámetros como emoción, placer y arousal pre y post experimento, así como el efecto de la música en su comportamiento de compra. La RV ayudó a mostrar que la música ambiental aumenta significativamente los niveles de excitación de los compradores, lo que aumenta los niveles de placer y su comportamiento de acercamiento positivo a los productos.

En conclusión, la RV parece ofrecer lo mejor de ambos mundos: control experimental total requerido para el razonamiento científico y el comportamiento natural dentro de entornos realistas para impulsar la validez ecológica de los resultados (De la Rosa y Breidt, 2018).

1.3. Aplicaciones de la realidad virtual en psicología clínica

Lo que hace tan atractiva a la RV para su uso en psicología clínica es su capacidad para recrear situaciones relevantes desde el punto de vista terapéutico (Botella et al., 2007). Es por ello que su uso se ha extendido en diferentes áreas dentro de la evaluación y tratamiento psicológico, como el estrés postraumático (Rothbaum, 2014), el trastorno obsesivo compulsivo (van Bennekom, Kasanm oentalib, de Koning y Denys, 2017), la evaluación neuropsicológica (Patton, Dawe, Scharver, Mussa-Ivaldi y Kenyon, 2006), la evaluación y tratamiento en discapacidad

del desarrollo y del aprendizaje (Herrero y Lorenzo, 2020), así como en el abuso sustancias (Worley, 2019), o los desórdenes psicóticos (Pot-Kolder et al., 2018). Pero principalmente, su uso se ha consolidado mayoritariamente en dos ámbitos bien diferenciados: por un lado, los trastornos de la ansiedad, y por otro los trastornos de la alimentación.

La literatura ha demostrado que la exposición mediante RV reduce los síntomas de ansiedad a corto, medio y largo plazo y producen una mejora similar a la exposición en vivo o en imaginación (Chesham, Malouff y Schutte, 2018; Kothgassner, Goreis, Kafka, Van Eickels, Plener y Felnhofer, 2019). La RV ha sido especialmente útil en el tratamiento de las fobias, como miedo a volar (Gottlieb, Doniger, Hussein, Noy y Plotnik, 2020), agorafobia (Botella et al., 2007), trastorno de estrés postraumático (Rothbaum et al., 2014), acrofobia (Suyanto, Angkasa, Turaga y Sutoyo, 2017) y aracnofobia (Minns et al., 2019). Los resultados de estos estudios muestran que la exposición mediante RV disminuye la ansiedad de los pacientes con respecto al estímulo fóbico, es más eficaz que la exposición en imaginación, y tan eficaz como la exposición en vivo. En el trastorno de ansiedad social, los resultados muestran que la RV es igual de efectiva que la exposición en vivo, y que produce mejoras en el comportamiento ansioso, estado de ánimo depresivo, y el miedo a las interacciones sociales y a la evaluación negativa (Anderson, Edwards y Goodnight, 2017; Bouchard et al., 2017). Las intervenciones usando la RV en el miedo a hablar en público, han consistido en escenas con audiencia frente a la cual los participantes tienen que realizar un discurso. Los resultados muestran que no hay diferencias entre la reacción de los participantes ante una audiencia virtual frente a una real, y que reduce los niveles de ansiedad relacionados con la exposición en público, disminuye las creencias catastróficas y aumenta la autoeficacia percibida. (Lindner et al., 2021; Nazligul, Yilmaz, Gulec, Gozcu, O'Connor y Clarke, 2017; Takac, Collett, Blom, Conduit, Rehm y De Foe, 2019).

La RV ha sido usada también en la modificación del esquema corporal en los trastornos de la alimentación como la anorexia nerviosa, bulimia nerviosa y trastorno por atracón (Haynos, Watts, Loth, Pearson y Neumark-Stzainer, 2016). Cuando el paciente puede ver una representación virtual de un cuerpo distinto al suyo, se producen cambios en la representación negativa del propio cuerpo (Serino et al., 2016). Además, se produce una disminución de la sobreestimación del mismo (Keizer, van Elburg, Helms y Dijkerman, 2016), un incremento de la satisfacción corporal (Serino et al., 2016), así como una mejora en la sintomatología depresiva y ansiosa

(Perpiñá, Botella, Baños, Marco, Alcañiz y Quero, 1999). Cuando se compara una intervención cognitivo-conductual usando RV con una clásica, se observa mayor eficacia en la primera, manteniéndose esta mejoría al año de seguimiento (Marco, Perpiñá y Botella, 2014). Otros estudios demuestran la eficacia de la RV para el control del deseo intenso *(craving)* por consumir determinados alimentos (Ferrer-García, Gutiérrez-Maldonado, Agliaro-López, Lobera-Espi, Pla y Vilalta-Abella, 2014; Ferrer-García, Gutiérrez-Maldonado, Treasure y Vilalta-Abella, 2015). Al comparar la exposición a estímulos de comida a través de RV frente a exposición en vivo, se encuentra que la exposición virtual provoca respuestas emocionales comparables a las producidas por la exposición real a alimentos (Gutiérrez-Maldonado, Pla-Sanjuanelo y Ferrer-García, 2016; Mikkelsen, Bucher, Hieke, Verain y van den Puttelaar, 2016; Ung, Menozzi, Hartmann y Siegrist, 2017).

2. NUEVOS CAMPOS DE APLICACIÓN DE LA REALIDAD VIRTUAL EN PSICOLOGÍA

Como hemos visto con anterioridad, la RV ha sido ampliamente aplicada en la investigación en psicología, así como en la evaluación y tratamiento de trastornos de ansiedad y trastornos de la alimentación. Dentro de estos dos campos, consideramos que aún quedan áreas relativamente nuevas por explorar. En relación a los trastornos de ansiedad, en la quinta actualización del Manual diagnóstico y estadístico de los trastornos mentales (en inglés *Diagnostic and Statistical Manual of Mental Disorders*, DSM-5) se incluye dentro de los trastornos de ansiedad social los relacionados con la "ansiedad de desempeño" o "ansiedad de solo actuación" como el hablar o actuar en público. Son recientes los estudios que incorporan la RV a este campo, con preguntas aún abiertas que requieren respuesta. Respecto a los trastornos de la alimentación, aunque el uso de la RV está ampliamente extendido a la evaluación y tratamiento de la anorexia, la bulimia o el trastorno por atracón, consideramos que aún queda por conocer la influencia que tiene el comportamiento alimentario como factor predisponente de estos trastornos a través del estudio de población adolescente no clínica. Dados estos dos ámbitos, de los trastornos de ansiedad y la conducta alimentaria, en este trabajo hemos profundizado en dos aspectos: la ansiedad escénica musical y la conducta alimentaria temprana. A continuación, se revisará el estado de la cuestión para ambas.

2.1. Ansiedad escénica musical

2.1.1. Definición y características

La ansiedad escénica musical (en inglés *music performance anxiety,* MPA) es uno de los mayores problemas a los que se enfrenta un músico en su carrea profesional, manifestándose con síntomas afectivos, cognitivos, somáticos y comportamentales que ocurren con independencia de la calidad del músico (Kenny, 2011). Además, este estado se experimenta antes, durante y después de la actuación, viviéndose de manera subjetiva con mayor intensidad que las respuestas fisiológicamente evocadas (Papageorgi, Hallam y Welch, 2007). La Asociación Americana de Psiquiatría (en inglés *American Psychiatric Association*, APA), la clasifica como un trastorno de ansiedad social, y la describe como el miedo o ansiedad intensos que aparecen en relación a una o más situaciones sociales, añadiendo la clasificación "relacionada solo con la ejecución" cuando el miedo fóbico se limite a hablar o actuar en público (APA, 2013). Se estima que la prevalencia de la MPA entre los músicos se encuentra entre un 16,5% y un 60% (Fernholz et al., 2019), siendo la causante del 20% de los abandonos en las enseñanzas superiores de música (Dalia, 2004).

Entre los factores que predisponen al desarrollo de la MPA, destacan los factores sociodemográficos como el sexo o la edad. Así, las mujeres muestran más ansiedad que los hombres (Iusca y Dafinoiu, 2012; Thomas y Nettelbeck, 2014; Vaag, Bjørngaard y Bjerkeset, 2016; Fernholz et al., 2019), independientemente de la edad (Ryan, 2006). En relación con la edad, se encuentra que, dentro del grupo de músicos adolescentes, se muestran niveles de MPA más altos en los más mayores (de 14 a 19 años) (Osborne, Kenny y Holsomback, 2005) y que los niños de corta edad raramente sufren ansiedad escénica de manera significativa, mostrándose desinhibidos y poco preocupados por la exposición pública (Kenny, 2006). Otro factor predisponente es sufrir otros trastornos psicológicos como la ansiedad, depresión o fobia social (Kenny, Driscoll y Ackermann, 2014; Barbar, De Souza Crippa y De Lima Osório, 2014; Mason y Daniels, 2018). Algunos estudios estiman que entre el 20% y el 32% de los músicos con MPA cumplen los criterios de un trastorno depresivo (Kenny et al., 2014), y entre el 19% y el 33%, de fobia social (Kenny, Fortune y Ackermann, 2013; Barbar et al., 2014). También se han observado una alta comorbilidad entre la ansiedad rasgo y la MPA independientemente del género musical (Martin-Gagnon y Creech, 2019), del género de los músicos o de las condiciones de aprendizaje (Kenny, 2011).

Sobre los factores precipitantes, destacan los relacionados con el entrenamiento musical. Así, por ejemplo, aquellos músicos que tocan instrumentos de cuerda manifiestan niveles de MPA más altos que los de viento (Iusca y Dafinoiu, 2011; Umuzdas, Tök y Umuzdas, 2019). Cuando se diferencia entre músicos solistas y orquestales, los solistas muestran mayores niveles de MPA (Casanova, Zarza-Alzugaray y Orejudo, 2018). Respecto al género musical, se encuentra que los músicos clásicos generalmente tienen mayor nivel de MPA que los músicos de otros géneros (Papageorgi, Creech y Welch, 2011). La experiencia de tocar en público se ha considerado un factor relevante, donde los músicos que tienen más experiencia realizando conciertos o actuaciones, o bien aquellos que se exponen más a la interpretación en público, son los que tienen menores niveles de MPA (González, Blanco-Piñeiro y Díaz-Pereira, 2017; Biasutti y Concina, 2014; Ryan y Andrews, 2009). Finalmente, los estudiantes de cursos más avanzados son los que experimentan más MPA en comparación con los principiantes (Casanova et al., 2018; Guven, 2017).

2.1.2. Metodología: Respuestas psicofisiológicas y realidad virtual

El estudio de la MPA en músicos se ha llevado a cabo de forma tradicional a través de la recogida de datos subjetivos como los autoinformes (Ortiz-Brugués, 2011; Fernholz et al., 2019; Mason y Daniels, 2018; Kenny et al., 2013). Estos tienen lugar antes y/o después de la interpretación en público, así como de forma independiente a la misma, aportando información valiosa sobre la sintomatología subjetiva y sobre los factores predictores o precipitantes del trastorno. No obstante, se torna necesario completar esta información con datos objetivos a través de técnicas psicofisiológicas, con el objetivo de conocer las respuestas emocionales de los músicos durante la interpretación en público.

Los estudios sobre las respuestas fisiológicas relacionadas con la MPA han sido escasos, en parte por la dificultad del análisis de las respuestas fisiológicas evocadas, y en parte por la dificultad de realizar su captación en condiciones de interpretación en público. Tres han sido las respuestas fisiológicas más estudiadas en relación con la MPA: frecuencia cardiaca, conductancia eléctrica de la piel (en inglés *Skin Conductance Response*, SCR) y la electromiografía (EMG).

En líneas generales, los estudios que han registrado la actividad cardíaca señalan que las interpretaciones con público producen un aumento de la misma en comparación con interpretaciones privadas o ensayos (Studer, Danuser, Wild, Hildebrandt, y Gomez, 2014; Williamon, Auffeger y Eiholzer, 2013; Yoshie, Kudo, Murakoshi y Ohtsuki, 2009). Más aún, cuando se registra la frecuencia cardíaca antes, durante y después de la interpretación en público, los resultados señalan que esta se incrementa en la fase de actuación con respecto a las otras dos fases (Studer et al., 2014). Sin embargo, cuando se ha intentado relacionar la frecuencia cardiaca y el nivel de ansiedad escénica autopercibida, no se han encontrado relaciones claras, señalando la importancia de variables cognitivas en la ansiedad subjetiva y la falta de coherencia en los tres sistemas de respuesta: fisiológico, cognitivo y conductual (Spahn, Echternach, Zander, Voltmer y Richter, 2010).

Hay poca investigación en relación a las respuestas de SCR y la MPA durante la interpretación en público. En un estudio realizado por Yoshie y colaboradores (2009), se recogió la SCR durante la interpretación en público y en los ensayos. Los resultados muestran mayor nivel de conductancia en las interpretaciones con público en relación a los ensayos, lo que refleja la activación de la rama simpática del sistema nervioso autónomo durante la interpretación. Sin embargo, no hay estudios que comparen el nivel de conductancia entre sujetos con alta o baja MPA autopercibida, o durante las diferentes fases de la interpretación (antes, durante y después). Finalmente, la medida de EMG en el estudio de la MPA se reduce al registro de los músculos de las extremidades superiores como el músculo trapecio superior izquierdo (Kenny et al., 2013), el bíceps braquial, el extensor de los dedos común y el flexor de los dedos superficial (Yoshie et al., 2009) como forma de estudiar la musculatura con más probabilidad de tensarse durante la actividad interpretativa. Sorprendentemente, no existen estudios que registren la actividad electromiográfíca de los músculos faciales para evaluar las expresiones emocionales que están asociadas al MPA. El registro de las respuestas faciales durante la interpretación podría permitir conocer el componente emocional de MPA, pues diferentes estímulos relacionados con las condiciones de actuación (condiciones físicas, ruido, temperatura, el público presente o los propios pensamientos) pueden modular la respuesta emocional en músicos con MPA (Kaleńska-Rodzaj, 2020).

Tal y como señalábamos más arriba, la investigación sobre la MPA presenta una serie de limitaciones para poder llevarla a cabo en un escenario en vivo. El recrear situaciones de actuación con público real, introducir variables distractoras que afecten

a la actuación de manera sistemática o incluso poder controlar las condiciones experimentales para el registro de respuestas fisiológicas resulta inviable. Es por esta razón que numerosos estudios incluyen escenarios en RV para superar algunas de las limitaciones que presenta la exposición en vivo. Por ejemplo, Williamon y colaboradores (2013) estudiaron la capacidad de la RV para recrear situaciones de interpretación en público. Para ello, se registró la actividad cardíaca en un concierto con público real y en otro concierto con público virtual. El análisis de la variabilidad cardíaca mientras realizaban la actuación señaló que la situación real no difería significativamente de la respuesta cardíaca en situación virtual. En aquellas intervenciones en las que se emplea la RV para desensibilizar las respuestas de ansiedad, los resultados señalan que el uso de situaciones virtuales es eficaz para reducir las respuestas fisiológicas ansiógenas (Orman, 2003, 2004). En un estudio realizado por Conklin (2011) el objetivo era comparar la MPA experimentada en una actuación en vivo con la actuación virtual. Los resultados mostraron que la actuación virtual provocó niveles significativamente más bajos de MPA que la actuación en vivo, y que los participantes que participaron en el entrenamiento con RV redujeron sus niveles de MPA transfiriendo esta reducción a las actuaciones en vivo posteriores. Resultados similares mostraron una reducción significativa en la MPA para los músicos con un alto nivel de ansiedad estado, para aquellos con un alto nivel de ansiedad rasgo, y para mujeres en particular, tras un entrenamiento con RV (Bissonnette, Dubé, Provencher y Sala, 2015, 2016).

El uso de la RV aún por explorar es el de replicar los resultados obtenidos previamente en estudios en vivo en relación a las respuestas psicofisiológicas experimentadas durante la interpretación en público, pero desde la seguridad del entorno controlable de laboratorio. De esta forma, también se podría realizar una visión integradora jamás hecha hasta ahora, donde se evalúe no solo la frecuencia cardiaca como medidor del arousal, sino la SCR y la relación entre ambas. Otro parámetro por explorar es la evaluación del factor emocional a través de la electromiografía facial, que puede aportar un importante valor a la hora de evaluar el componente emocional de la interpretación en público.

2.2. Comportamiento alimentario temprano

2.2.1. Definición y características

El comportamiento alimentario temprano, especialmente en jóvenes adolescentes, se ha postulado como un factor predictor del desarrollo de trastornos de la conducta alimentaria (TCA) en el futuro (Melendez, Cañez de la Fuente y Frías, 2012). Según el enfoque multidimensional de Garner (1993), durante la adolescencia se dan una serie de factores biológicos, psicológicos, familiares y socio-culturales que pueden originar comportamientos alimentarios poco saludables y predisponentes para el desarrollo de un TCA. A nivel biológico, la adolescencia supone una etapa trascendental en la ontogenia del ser humano, en la que destaca un intenso crecimiento y mayores necesidades energéticas (Rufino-Rivas, Figuero, Ubierna, Amigo-Lanza, Gonzalez-Lamuño y García-Fuentes, 2007). Es por ello que en esta etapa pueden surgir enfermedades con base nutricional que favorezcan un TCA a largo plazo. Dentro de los factores individuales o psicológicos destacan determinadas características de personalidad que se forjan en la adolescencia, como el perfeccionismo, la introversión, la baja autoestima o el miedo a la evaluación negativa (Garner, 1993). El ambiente familiar predispone a padecer un TCA cuando se convive con otro familiar con este trastorno, se vive en un ambiente de sobre protección o existe una preocupación excesiva por la apariencia (Garner, 1993). Respecto a los factores socio culturales, la etapa de la adolescencia es en la que se producen mayores cambios psicológicos y fisiológicos (Melendez, Cañez de la Fuente y Frías, 2012) como es el aumento de peso. Esto produce una disonancia entre los cánones de belleza ensalzados por los medios y las redes sociales, y el propio cuerpo, rechazando los cambios corporales y produciendo la insatisfacción corporal y las conductas desadaptativas para cambiarlo.

Los comportamientos alimentarios poco saludables o de riesgo se relacionan con el miedo a engordar, el deseo de adelgazar o una actitud alterada respecto al peso (Pamies-Aubalat, Marcos y Castaño, 2010). De hecho, se estima que el 41% de los adolescentes españoles presenta preocupación por engordar, el 50% deseo de adelgazar y un 55,6% presenta una percepción de la imagen corporal errónea o distorsionada (Ferreruela, Ruíz, Piqueres, Forés, Sebastiá y Perelló, 2017). Dentro de estos comportamientos poco saludables se encuentran el hacer dieta, la restricción de la ingesta, las conductas purgativas o anómalas y el comer emocional (Unikel, Bojórquez y Carreño, 2004; Pamies-Aubalat et al., 2010; Ferreruela et al., 2017).

Respecto al concepto de “hacer dieta” se entiende como el intento de restringir la ingesta calórica con el objetivo de cambiar la forma del cuerpo y bajar de peso (Haynos, Field, Wilfley y Tanofsky-Kraff, 2015). Esta conducta está relacionada con mayor riesgo de desarrollar deficiencias nutricionales en el futuro, desaceleración del crecimiento así como sobrepeso (Lowe, Doshi, Katterman y Feig, 2013). Un concepto fácilmente confundible con el de hacer dieta, es el de la restricción de alimentos. La conducta restrictiva se caracteriza por la preocupación por la ingesta de ciertos alimentos y la limitación de la misma, y se diferencia del concepto de dieta en que esta última tiene como objetivo una restricción de la ingesta calórica suficiente como para perder peso (Lowe et al., 2013). Diferentes estudios sugieren que la restricción excesiva en los adolescentes puede tener un efecto contraproducente y, finalmente, ir seguida de un aumento de peso (Field et al., 2003; Lluch, Herbeth, Mejean y Siest, 2000; Stice, Cameron, Killen, Hayward y Taylor, 1999) aunque otros postulan que la restricción alimentaria es condición indispensable para la pérdida de peso y disminución del índice de masa corporal (IMC) y que no necesariamente ha de conllevar un aumento de peso o considerarse una conducta de riesgo para los adolescentes (Johnson, Pratt y Wardle, 2012). El hambre es otro de los factores que puede afectar a la ingesta de los adolescentes. Esta es definida como la sensación fisiológica experimentada por la privación de alimentos, donde la persona se encuentra en un estado agudo de necesidad calórica (Hernández et al., 2018; Espel-Huynh, Muratore y Lowe, 2018). Sin embargo, el entorno actual en el que se desenvuelven los adolescentes proporciona grandes cantidades de alimentos económicos y muy apetitosos, lo que activa lo que se conoce como impulso hedónico de comer (Ely, Howard y Lowe, 2015). Este impulso consiste en consumir alimentos aun cuando no se tiene hambre fisiológica (Finlayson, King y Blundell, 2007; Lowe y Levine, 2005), lo que tiene un impacto muy diferente en la ingesta de los adolescentes. Por ejemplo, el hambre hedónica ha sido asociada con la frecuencia e intensidad del deseo por la comida y con el desarrollo y la gravedad de los atracones en las poblaciones obesas (Forman et al., 2007; Ochner, Green, van Steenburgh, Kounios y Lowe, 2009; Witt y Lowe, 2014).

Se estima que un número importante de la población adolescente española lleva a cabo conductas alimentarias de riesgo (entre un 4,9% y un 11,2%; Ferreruela et al., 2017; Pamies-Aubalat et al., 2010). Ambos estudios coinciden en que son los adolescentes más jóvenes los que presentan mayor riesgo de llevar a cabo estas conductas, especialmente las chicas (Boutelle, Neumark-Sztainer, Story y Resnick, 2002). También son peligrosas conductas actuales entre los adolescentes como comer

con un horario desorganizado o comer grandes cantidades de comida ultraprocesada (Aranceta, Serra, Pérez, Ribas y Delgado, 2012).

2.2.2. Metodología: elección de alimentos y realidad virtual

Con el objetivo de estudiar el comportamiento alimentario en el laboratorio, se ha llevado a cabo paradigmas muy variados. Entre ellos se encuentra el seguimiento del tiempo de fijación a los estímulos alimentarios (Stockburger, Schmalzle, Flaisch, Bublatzky y Schupp, 2009), la atención a señales visuales relacionadas con la comida (Papies y Veling, 2013) o las tareas de elección de alimentos, ya sea mediante la presentación de fotografías, presentados en tres dimensiones o alimentos reales en tipo bufé libre.

El objetivo de las tareas de elección de alimentos es conocer qué variables afectan a la forma de alimentarse de los adolescentes, los alimentos que se eligen con mayor frecuencia y qué variables afectan a esta elección**.** Dentro de las tareas de elección de alimentos, las imágenes de alimentos han sido un recurso eficaz para evaluar variables como el comportamiento de la mirada ante estímulos alimenticios (Graham, Hoover, Ceballos y Komogortsev, 2011). En el caso de mujeres obesas, se encuentra que los niveles de hambre están relacionados con una mayor atención a los alimentos dulces y fritos, pero un menor tiempo de permanencia de la mirada en ellos. (Gearhardt, Treat ,Hollingworth y Corbin 2012). Otra variable evaluada a través de las imágenes de alimentos es el deseo. A través de esta tarea, se encuentra que, al igual que ocurre con los alimentos reales, las personas que activan el mecanismo de restricción de alimentos muestran menos deseo por los alimentos más calóricos (Ouwehand y Papies, 2010).

Para las tareas de predicción de elección de alimentos también se ha recurrido al uso de comida real dentro de entornos naturales de elección y consumo de alimentos, como pueden ser tiendas de comestibles (Luomala, Hellén y Jokitalo, 2017) o restaurantes (Papies y Veling, 2013). Dentro de los entornos naturales de elección y consumo de alimentos, uno de los paradigmas más empleado es el de **bufé libre**, dónde los participantes pueden elegir para consumir entre una variedad de alimentos. En general, el paradigma utiliza alimentos reales (Wang, Cakmak y Peng, 2018) pero también se ha optado por sustituir la comida real por alimentos falsos (Mikkelsenet al., 2016; Ung et al., 2017). Los resultados de estos estudios muestran que, cuando se compara un bufé con comida falsa y otro de comida real, se produce una correlación

positiva entre la cantidad de comida que se elige en ambos (Bucher, Van der Horst y Siegrist, 2012). Se deduce que el paradigma del bufé libre es eficaz a la hora de predecir la conducta alimentaria, pues la exposición a alimentos (reales o falsos) dentro del laboratorio provoca respuestas emocionales comparables a las producidas en una situación de bufé real.

La RV se ha utilizado ampliamente en el estudio del comportamiento alimentario y los trastornos relacionados con la alimentación (Riva, Gutiérrez-Maldonado, Dakanalis y Ferrer-García, 2019), ya que ha demostrado que en los entornos virtuales los individuos se comportan y toman decisiones de manera similar a como lo hacen en la vida real (Siegrist, Ung y Zank, 2018). En este campo, la RV tiene la ventaja de poder equilibrar la validez interna y ecológica, pues las simulaciones en entornos virtuales pueden controlarse completamente con fines experimentales mientras que los participantes realizan tareas idénticas a las realizadas en la vida real (Riva et al., 2019). Además, permite a los investigadores incluir señales importantes para el participante dentro de los entornos virtuales específicos (como cafeterías, bufés o tiendas de comestibles) con el fin de estudiar comportamientos relacionados con los alimentos. Es por ello que la RV aporta una potente herramienta para mejorar la validez ecológica en el paradigma del bufé libre sin los costes que implican el uso de alimentos reales (Schroeder, Lohmann, Butz y Plewnia, 2016; Ferrer-García et al., 2015; Celikcan et al., 2018; Siegrist et al., 2018).

Algunos estudios han comparado la validez de los estímulos alimentarios según su tipología, incluyendo entre ellos alimentos virtuales. Con el objetivo de probar si los estímulos virtuales son tan efectivos como los estímulos reales, y más efectivos que las fotografías, Gorini, Griez, Petrova y Riva (2010) evaluaron las reacciones emocionales a la comida real, comida virtual y fotografías de comida en dos muestras de pacientes afectados por anorexia y bulimia nerviosa en comparación con un grupo de sujetos sanos. Los resultados mostraron que la exposición virtual de alimentos provocaba respuestas emocionales comparables a las producidas por la exposición real de alimentos. En el estudio de Ung y colaboradores (2017) se encuentra una correlación positiva entre la cantidad de alimentos elegidos en una condición de bufé virtual y una condición de bufé de comida falsa. Cuando se evalúan las respuestas psicológicas y fisiológicas a comida virtual se encuentra que, reflejando el efecto de la vida real, la exposición a alimentos virtuales provoca respuestas psicológicas más fuertes que la exposición a estímulos no alimentarios virtuales (Van der Waal, Janssen, Antheunis, Culleton y van der Laan, 2021). Esto muestra que el uso de

comida virtual es un método de investigación útil y que la RV es un método prometedor para examinar el impacto de las señales ambientales en el comportamiento nutricional humano.

OBJETIVOS

OBJETIVO DE LA TESIS DOCTORAL

El objetivo principal de esta tesis es estudiar el uso de la RV como un instrumento válido en la investigación psicológica del MPA y del comportamiento alimentario temprano. Aunque la RV comienza a ser empleada en estos dos ámbitos, consideramos que existen aún cuestiones en las que profundizar en ambos campos en los que la RV puede aportar importantes beneficios, como lo viene haciendo hasta ahora.

En el campo de la MPA, la RV ha sido empleada como técnica para evaluar la ansiedad autoinformada en músicos. Si bien la información sobre la ansiedad subjetiva es una valiosa herramienta para la evaluación, no nos permite conocer si los niveles reportados son debidos a la expectativa sobre la RV que el músico posee o a la capacidad del entorno virtual para evocarlas. El estudio de las respuestas fisiológicas en situaciones de concierto virtual permitiría obtener un índice objetivo de la capacidad de la RV para inducir ansiedad. Por otro lado, este estudio daría soporte a la eficacia de la RV como instrumento experimental con una alta validez ecológica para el estudio del MPA.

Respecto a la conducta alimentaria temprana, la RV se ha empleado como una forma de evaluación y tratamiento de trastornos de la alimentación en población adulta y mayoritariamente clínica. Sin embargo, la RV aún no ha sido probada como una herramienta de evaluación de conductas alimentarias poco saludables en población adolescente y no clínica. El estudio de la conducta alimentaria en situaciones de elección de alimentos permitiría obtener un índice de las conductas alimentarias de riesgo que podrían ser causantes de un trastorno de la alimentación en el futuro. De igual forma, se refutaría la eficacia de la RV como un instrumento altamente válido en el campo de la conducta alimentaria.

Objetivos del Estudio 1:

- Conocer las características del trastorno de MPA.
  - Objetivo Específico 1.- Determinar las variables que predicen el MPA en estudiantes de conservatorio.

- Objetivo Específico 2.- Seleccionar una muestra de estudiantes de conservatorio para participar en el segundo estudio, así como información útil para la realización del paradigma experimental de dicho estudio.

Objetivos del Estudio 2:

- Estudiar las respuestas psicofisiológicas del MPA durante la interpretación en un entorno virtual.
- Conocer la eficacia de la RV para inducir ansiedad en músicos.
  - Objetivo Específico 1.- Conocer la respuesta en conductancia, tasa cardíaca y electromiografía facial de los músicos con alta y baja MPA.
  - Objetivo Específico 2.- Conocer la respuesta en conductancia, tasa cardíaca y electromiografía facial de los músicos antes, durante y después de la interpretación musical.
  - Objetivo Específico 3.- Establecer la relación entre respuestas fisiológicas y los autoinformes de MPA.

Objetivos del Estudio 3:

- Estudiar las características implicadas en la selección de alimentos y su relación con la conducta alimentaria temprana.
- Explorar el uso del paradigma del bufé virtual para el estudio de la conducta alimentaria temprana.
  - Objetivo Específico 1.-Determinar la influencia del hacer dieta en el IMC, y en la evaluación afectiva y de características organolépticas de los alimentos de un buffé virtual en población adolescente.
  - Objetivo Específico 2.- Determinar el papel del hambre, el estilo restrictivo y la dieta para predecir la selección de alimentos en un bufé virtual en población adolescente.

ESTUDIO 1

Predictors of music performance anxiety in conservatory students.

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PREDICTORS OF MUSIC PERFORMANCE ANXIETY IN CONSERVATORY STUDENTS

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ABSTRACT

Music performance anxiety (MPA) is one of the main problems experienced by music students. It manifests in affective, cognitive, somatic and behavioural symptoms that can occur regardless of the quality of the musical performance. The aim of this study was to perform a regression analysis to determine the variables that contribute to the prediction of MPA in conservatory students. A total of 295 Spanish music students aged 15 to 68 years enrolled in Spanish conservatories completed a battery of questionnaires selected to collect information about demographic characteristics, musical training, learning processes and health and psychological variables. Pearson's correlations and ANOVA were calculated, and a regression analysis was done to predict the development of MPA. The results showed that MPA is largely predicted by health and psychological variables, including depression, fear of negative evaluation, social avoidance, poor achievement motivation and use of substances to alleviate MPA. Age at first musical performance with an audience was the only musical training variable with sufficient strength to predict MPA (the older the participant, the greater the MPA). The article concludes with a discussion of the need to implement psychological and educational counselling in music education centres as well as specific training to increase the quality of the musical career and personal wellbeing of the students.

Keywords: Musicians, Performance anxiety, Social phobia, Psychological disorders

1. INTRODUCTION

Music performance anxiety (MPA) is a state of "marked and persistent anxious apprehension related to musical performance" manifested through affective, cognitive, somatic and behavioural symptoms that can occur in different music performance settings regardless of the quality of the musical performance (Kenny, 2011). The prevalence rate of MPA in musicians (students and professionals) is between approximately 24% and 80% (Ortiz-Brugués, 2009, 2011; Middlestadt & Fishbein, 1988); it is estimated that MPA causes approximately 20% of student abandonment at superior conservatories (Dalia, 2004), while 40% of students who continue are moderately anxious, and 20% are highly anxious about performance experiences (Wilson, 2002). From a theoretical perspective, the triple vulnerability model (Barlow, 2000) is one of the most consistent and reliable integrative models that can be applied to MPA (Kenny 2004, 2009; Papageorgi, Creech, & Welch, 2011; Orejudo-Hernández, Zarza-Alzugaray & Casanova, 2018). The model incorporates three levels of interacting vulnerabilities: a generalized biological vulnerability; a specific psychological vulnerability associated with learning and a global perception of helplessness; and a generalized psychological vulnerability stemming from experiences associated with music performance.

Based on this triple vulnerability model, Kenny developed the Kenny Music Performance Anxiety Inventory (KMPAI) to assess the underlying symptoms of MPA based on three factors: concerns specifically related to proximal performance, psychological vulnerability or helplessness and the context of early interactions and relationships (Kenny, Davis & Oates, 2004). Several versions of this inventory have been validated in different cultures (Barbar et al., 2014; Chang-Arana, 2018) among adolescents and children (Zarza-Alzugaray et al., 2018) and for numerous musical genres (Martin-Gagnon & Creech, 2019; Iusca & Dafinoiu, 2012), showing good psychometric properties.

Considering the high prevalence of MPA among musicians and its devastating effects, it is not surprising that numerous studies have examined the influence of specific variables on the development of MPA. Four categories of variables have been examined: demographic characteristics, musical training, learning processes and psychological comorbidity. Two demographic characteristics have been investigated, gender and age. Several studies have reported higher cognitive and somatic anxiety in female than male performers (Iusca & Dafinoiu, 2012; Thomas & Nettelbeck, 2014; Vaag, Bjørngaard, & Bjerkeset, 2016; Fernholz et al., 2019), a finding that has also been documented in elementary school children (Ryan, 2006). Osborne et al. (2005) compared MPA between different age groups (range 11–19 years) and found the highest MPA scores in the older group (14–19 years). At ages older than approximately 45–50 years, Fernholz observed a tendency towards lower MPA with increasing age (Fernholz et al., 2019). However, some studies have suggested that the start of musical training is more relevant than age for the development of MPA (Zarza-Alzugaray, Casanova & Orejudo, 2017; Boucher & Ryan, 2011).

Among the musical training variables investigated, the instrument played seems to influence MPA (Casanova, Zarza-Alzugaray & Orejudo, 2018). In one study, string players and singers reported significantly more MPA than did piano, brass or woodwind players (Iusca & Dafinoiu, 2012). Zarza-Alzugaray et al. (2017, 2016) found that piano and brass students experienced higher levels of MPA in comparison to other music students. However, these results may be associated with differences between primarily solo instruments and those generally played in an orchestra (Casanova et al., 2018). With regard to the musical genre, classical musicians generally have higher levels of MPA than other musicians (Papageorgi et al., 2011). In a study of students, a higher level of MPA was reported by jazz players than by other types of musician (Martin-Gagnon & Creech, 2019). Other previous studies found that the improvisational ability of jazz musicians is related to a low level of MPA during performances (Kaspersen & Götestam, 2002). Regarding experiences of public performance, no significant relationship was found by some studies between MPA and the number of years since the first performance with an audience (Fehm & Schmidt, 2006; González,

Blanco-Piñeiro & Díaz-Pereira, 2017). However, other studies reported that the number of years performing in front of an audience and the number of gigs correlated negatively with MPA development (González et al., 2017; Ryan & Andrews, 2009) and that students spending less time practicing had higher MPA levels (González et al., 2017; Biasutti & Concina, 2014).

Four learning process variables have been studied in relation to MPA: musical grade, age at the start of musical studies, musical lessons in a regulated context, and auditions. Higher-grade music students usually experience greater MPA in comparison to novices (Casanova et al., 2018; Guven, 2017). A study of school-age children indicated that MPA increases with more years of experience between 10 and 17 years of age (Patston & Osborne, 2016). Although the importance of age at the start of musical studies for MPA has not been investigated, a significant relationship has been found between age at the start of musical training and individuals' perceived MPA (Zarza-Alzugaray, Orejudo, Casanova & Aparicio-Moreno, 2018). Age at the start of musical studies could feasibly be related to MPA because younger students develop musical skills more easily in comparison to older adult students, who need individualised educational programmes that can generate anxiety and helplessness in relation to musical performance (Bowles, 2010; Perkins, Aufegger & Williamon, 2015). The audition experience is an important part of life for music students and is characterized by a specific setting; therefore, it markedly differs from other performance situations, such as gigs (Spahn, Walther & Nusseck, 2016). Previous research indicated that anxiety is higher when students are being evaluated (Taborsky, 2007). In addition, a positive relationship has been described between anxiety experienced in auditions and MPA development (Guven, 2017).

Finally, the comorbidity of MPA with other psychological and health disorders also provides evidence of consistent associations (Kenny, Driscoll & Ackermann, 2014; Barbar, De Souza Crippa & De Lima Osório, 2014; Mason & Daniels, 2018). It has been reported that 32% of Australian musicians with MPA have depression disorder and 33% social phobia (Kenny et al., 2014; Kenny, Fortune & Ackermann, 2013) and that 19% of Brazilian musicians with MPA have

social anxiety and 20% depression (Barbar et al., 2014). High comorbidity rates have also been observed between trait anxiety and MPA, regardless of the musical genre (Martin-Gagnon & Creech, 2019), gender of the musician or learning conditions (Kenny, 2011). The use of legal and illegal substances is frequent among musicians (Spracklen, 2018). In the context of MPA, there is a high prevalence of substance use to alleviate MPA (33.9%) among Spanish music students, most frequently with legal products such as prescription drugs or herbal remedies (Orejudo-Hernández et al., 2018). Other studies have shown that between 15 and 20% of American orchestra musicians use substances to alleviate MPA (Fishbein et al., 1988). Other strategies used by students to reduce MPA symptoms include music practice, deep breathing, relaxation and redirection of their attention to the achievement (Juncos & Markman, 2017; Kenny et al., 2014).

Previous investigations have provided relevant information on the individual contribution of specific variables to MPA. However, no studies have examined the combined influence of all of these variables in a single regression model to predict MPA. The correlational nature of the reported data leaves unanswered not only the causal direction of the relationship but also the weight of variables explaining the correlations observed. Regression analysis has the advantage of examining the combined effect of all variables on the dependent variable (MPA) and estimating the magnitude and importance of their contributions. Two previous studies (Nusseck, Zander, & Spahn, 2015; Dobos, Piko, & Kenny, 2018) used regression models to predict MPA. However, they measured only a few variables and did not cover the whole range of categories mentioned above. The present study was designed to investigate the predictors of MPA in music students by constructing a multiple regression model for the KMPAI (Kenny et al., 2004), including 26 variables corresponding to four categories: demographic characteristics, musical training, learning processes and health and psychological variables.

2. METHODS

2.1. Participants

The study included 295 Spanish music students aged 15 to 68 years (M = 21.76 years; SD = 7.09). The sample was composed of 141 males (M = 22.79 years; SD = 8.111) and 154 females (M = 20.82 years; SD = 5.881) who spoke Spanish as their first language. Most (68.2%) of the participants had finished secondary education (advanced), 16.2% had finished ordinary secondary education, 11.9% had completed university studies and 3.7% had only elementary education (see Table 1).

- Insert Table 1 about here-

In Spain, musical education in conservatories is divided into three levels: elementary degree (typically from 8 to 12 years old), professional degree (typically from 12 to 18 years old) and higher degree (typically from 18 to 22 years old), resulting in a total of 14 years of musical education. In the present study, 1.7% of participants were enrolled in an elementary degree course, 52.2% in a professional degree course, and 45% in a higher degree course (see table 3).

2.2. Measurements

An interview and a battery of questionnaires were used to gather information on demographic characteristics, musical training, learning processes and health and psychological variables (a full description is given in Appendix 1.). The questions about musical training concerned the participant's musical genre, age at first musical performance with an audience, number of concerts in the past year, motivation to begin musical studies, motivation to choose the musical instrument played, interest in music, individual practice (hours/week), age when first playing the instrument independently and musical instrument played (Table 2).

- Insert Table 2 about here-

In relation to the learning process, four questions addressed the participant's musical level: age at the start of musical studies, musical lessons in a regulated context (hours per week) and number of auditions (number of assessments of playing ability in past year) (Table 3). Finally, six standardised questionnaires (Table 4) were used to collect information on health and psychological measures:

- *Kenny Music Performance Anxiety Inventory (KMPAI).* The 26-item version of the inventory is specifically designed to measure performance anxiety in musicians (Kenny, Davis and Oates, 2004) and was validated in the Spanish population by Zarza-Alzugaray (2014). This inventory explains anxiety in terms of three factors that can cause a greater or lesser degree of anxiety response: concerns specifically related to a proximal performance (specific cognitions), psychological vulnerability (helplessness) and the context of early interactions and relationships (context). The questionnaire yields an overall MPA score from the three factors. The Spanish version of the KMPAI has an internal reliability of 0.86 according to Cronbach's alpha, with adequate predictive validity (Zarza-Alzugaray, 2014).

- *State-Trait Anxiety Inventory-Trait Form (STAI-T).* The STAI-T consists of 20 items rated on a 4-point scale to measure a general level of anxiety that persists beyond the present state (Spielberg, Gorsuch & Lushene, 1970). The questionnaire is designed to assess more stable individual characteristics that fluctuate little over time as well as the tendency to perceive stressful situations as dangerous and aversive.

- *Musical Achievement Motivation Questionnaire (MAMQ).* This questionnaire is a version of the achievement motivation scale of Manassero and Vázquez (1998) adapted to the musical context. It consists of 26 items rated on a nine-point Likert scale and includes five factors: interest (importance of the results of the performance, satisfaction with study time and desire to learn), task (expectations about success in auditions in the future and the frequency of successful task

completion), effort (persistence in tasks, self-imposed demands and perseverance in facing challenges), exams (evaluation of exams, assessment of the ability of the teacher and self-fulfilling expectations) and perfectionism (the need to perform perfectly in each performance).

- *Beck Depression Inventory (BDI-II)*. The BDI-II includes 21 items rated on a four-point scale and is one of the most widely used self-report measures for the severity of depression (Beck, Steer, & Brown, 1996).

- *Fear of Negative Evaluation (FNE*) *scale and the Social Avoidance and Distress Scale (SADS)*. These scales include 30 and 28 true/false items, respectively. They were developed by Watson and Friend (1969) to assess social anxiety and associated concerns related to social-evaluative threats.

Further information was also collected on strategies for handling MPA, treatment for anxiety and the use of substances to alleviate MPA (table 4).

- Insert Table 3 and Table 4 about here-

2.3. Procedure

The study was conducted between March 2017 and March 2018. Participants were recruited from 10 music conservatories in southern Spain. First, the researchers contacted each conservatory principal by telephone to inform them that investigators from the University of Granada sought volunteers for a study about musical habits**.** Out of the 11 conservatory principals contacted, 10 agreed to participate and scheduled a date for data collection. The data were collected during regular classes of 5 - 10 students. The researchers explained their interest in information about musical habits and obtained the informed consent of participants before starting the study. Parental authorisation was requested when participants were underage. One of the researchers was always present during the study, guaranteeing the homogeneity of the procedure and avoiding an experimenter effect. To guarantee the confidentiality of the participants, questionnaires were linked

to the participants by numerical codes to which only the main researchers had access. The study was conducted in accordance with the Declaration of Helsinki (1991) and was approved by the local ethics committee of the University of Granada.

2.4. Analytical strategy

Sequential stages were followed to build a regression model to predict MPA (dependent variable) from a set of variables (independent variables or predictors). The first stage was to estimate the strength of the association between each predictor and the dependent variable. Variables showing no evidence of association did not pass to the second stage. Two methods were used to estimate the strength of the association, depending on the continuous or discontinuous nature of the variable. When predictors were continuous variables, such as age or anxiety scores, the strength of the association was estimated using Pearson's bivariate correlation. For discrete variables, such as gender or type of musical instrument played, the strength of the association was estimated by one-way analysis of variance (ANOVA), dividing the participants into groups (i.e., male and female; string, wind, percussion and voice) and testing whether the groups significantly differed in the dependent variable (total KMPAI score).

In the first stage, Pearson bivariate correlations were applied to the following continuous variables: (a) Sociodemographic characteristics: age and education; (b) Musical training: age at first musical performance with an audience, number of concerts performed in the past year, individual practice at home, and age when first playing the instrument independently; (c) Learning process: current musical level, age at start of musical studies, musical lessons in a regulated context and number of auditions in the past year; and (d) Health and psychological variables, including all questionnaire items (trait anxiety, musical achievement motivation, depression, fear of negative evaluation and social avoidance and distress), number of behaviours to manage MPA, and number of substances taken to alleviate MPA. Between-group ANOVAs were used to analyse the remaining variables: gender, musical genre, motivation to begin musical studies, motivation to choose the

musical instrument played, interest in music, musical instrument played, treatment for anxiety, use of substances to mitigate MPA, and strategies to manage MPA.

In the second stage, variables showing a significant correlation with total KMPAI score or significant between-group difference were selected as predictor variables for the regression analyses. When the dependent variable is a continuous variable, as in the present study, stepwise multiple linear regression method is usually applied. In this method, predictors are entered or removed (backward elimination), sequentially evaluating in each run the combination of predictors that best explain the variance in the dependent variable. The method provides a statistic (R^2) that measures the fit of the model to the data (scale of 0-100%). Our regression analysis applied the backward elimination approach, in which all predictors were initially included in the model, and the predictor with the weakest and non-significant p-value was then removed. A new model was then created with the remaining predictors, and the process was repeated until no predictors remained in the model or no more predictors were removed. SPSS version 23 was used for all statistical analyses. A p-value of $\leqslant .05$ was considered statistically significant. The significant results are reported with degrees of freedom and effect size measures.

3. RESULTS

3.1. Stage 1a: Correlations between the continuous variables and KMPAI

Figure 1 depicts the significant correlations found between continuous variables and total KMPAI score. Significant correlations appeared for all health and psychological variables measured by questionnaires (STAI-T, MAMQ, BDI-II, FNE and SADS), for the number of substances used to alleviate MPA, for one musical training variable (age at first musical performance with an audience) and for one learning process variable (number of auditions in past year). The remaining continuous variables showed no significant correlation.

- Insert Figure 1 about here-

Figure 1. Significant correlation coefficients (Pearson's r, p<.05) between the KMPAI total scores and musical training, learning process and health and psychological variables

All significant correlations except two were positive, i.e., a higher value for the variable was associated with a higher total KMPAI score. Positive correlations were found for trait anxiety (STAI-T), depression (BDI-II), fear of negative evaluation (FNE), social avoidance and distress (SADS), number of substances used to alleviate MPA, and age at first musical performance with an audience (the older at first performance, the greater the MPA). Significant negative correlations were observed for musical achievement motivation (MAMQ) and number of auditions in the past year, i.e., a lower score for achievement motivation and a smaller number of auditions were associated with a higher total KMPAI score.

3.2. Stage 1b: Differences in KMPAI between subgroups of discrete variables

ANOVA results yielded significant differences in the following discrete variables: gender, receipt of treatment for anxiety, and use of substances to mitigate MPA. Men and women significantly differed in total KMPAI score ($F[1,293]=4.18$; $p<.05$; $\eta p^2=.014$), with a global mean score of 56.3 (SD=20.2) and a significantly higher mean score for females (M=58.6; SD=20.5) than males (M=53.8; SD=19.6). Significant differences were also found between participants who had received psychological treatment to reduce anxiety and those who had not ($F[1,292]= 6.63$; $p<.01$, $\eta p^2=.02$), observing a higher score for participants who had received this treatment [M=67.2; SD=16.7] than for those who had not [M=55.5; SD=20.2]. Likewise, significant differences were observed between the participants who had taken substances to alleviate MPA and those who had not ($F [1,293]=24.33$; $p<0.01$, $\eta p^2=.077$), observing a higher score in the former [M=64.7;

SD=18.9] than in the latter [M=52.6; SD=19.7]. No significant between-group differences in total KMPAI score were observed for the other discrete variables.

3.3. Stage 2: Multiple linear regression

According to the results of stage 1, the following variables were entered in the multiple backward linear regression analysis: number of auditions in the past year, age at first musical performance with an audience, gender, use of substances to alleviate MPA, number of substances used, treatment for anxiety, STAI-T score, MAMQ score, BDI-II score, FNE score and SADS score. The results yielded an optimum model ($F[6,286]=70.68$; $p<.01$) that included six variables (see table 5), one corresponding to the musical training category (older at first musical performance with an audience) and five corresponding to the health and psychological category (use of substances to alleviate MPA, fear of negative evaluation, social avoidance, depression and poor musical achievement motivation).

- Insert Table 5 about here-

These six variables were the best predictors of MPA (all $p<.001$). The corrected R^2 values increased as non-significant variables were removed from the model (from 1.5% to 58.9%). Accordingly, the final model explains 58.9% of the variance in KMPAI scores. The number of auditions in the past year, gender, number of substances taken to alleviate MPA, trait anxiety, and treatment for anxiety were not significant.

4. DISCUSSION

Despite its relevance in musical studies, MPA is a largely underexplored field in psychopathology. It is estimated to affect a substantial proportion of musicians, frequently

contributing to the abandonment of their musical training and/or professional career. The aim of this study was to assess the degree to which MPA in music students is predicted by demographic characteristics, musical training, learning processes and health and psychological variables. Data were collected on 26 variables to evaluate their relationship with MPA. The initial analysis, based on Pearson's correlation and ANOVA, revealed that 11 of these variables were significantly associated with higher MPA scores . The final regression model, based on multiple linear regression, showed that total KMPAI scores were significantly predicted by a combination of six of these variables, five corresponding to the health and psychological category (poor musical achievement motivation, fear of negative evaluation, depression, social avoidance and use of substances to alleviate MPA) and one corresponding to the musical training category (older age at first musical performance with an audience). No variable in the sociodemographic and learning process categories entered the prediction model. The model explained 58.9% of the variance in total KMPAI score. Previous MPA models were found to explain between 14% and 71% of the variance (Nusseck, Zander, & Spahn, 2015; Dobos, Piko, & Kenny, 2018), although they considered fewer variables than in the present study, focussing on a single category.

The present results confirm previous findings and expand the range of health and psychological predictors of MPA. Musical achievement motivation has been described as a good predictor of MPA (Zarza-Alzugaray, 2014), and low motivation levels have been related to thoughts of quitting and to the use of substances to alleviate MPA (Zarza-Alzugaray et al., 2018). Motivation to engage in musical activities is determined by complex interactions between the context in which students find themselves (Hallam, 2002) and their cognitions (concerns about performance, helplessness, self-concepts and goals). Regarding motivation to continue musical learning, it is important to consider how this can be influenced by family and teachers (O'Neill & McPherson, 2002). The family environment can positively or negatively influence thoughts and beliefs about musical skills in childhood. In addition, the positive impact of coaching by parents or teachers on

the psychological strength of individuals may reduce their vulnerability to MPA and the inevitable stress of playing in public.

With regard to cognitions related to low music achievement motivation, the self-perception of individuals appears to differ between those with high *versus* low MPA levels (Nicholson, Cody, & Beck, 2015). According to Kenny (2005), a marked concern with the consequences of a poor performance, a strong negative bias in the self-evaluation of previous performances and a strong expectation that a performance will be negatively evaluated by examiners /audiences are among the most common preoccupations of individuals with high levels of MPA. These observations were confirmed in the present study, in which the FNE scale score was included in the MPA model. It has been reported that the fear of negative evaluation is a common thread linking MPA to social phobia, which is frequently observed in musicians who are anxious about their performance (Nicholson, Cody, & Beck, 2015; Bobos et al., 2018). In addition, a body of research has proposed that social avoidance is an important component of MPA (Cirakoglu et al., 2013). Social avoidance is conceptualized as negative behaviours and cognitions that emerge in anxiety-inducing situations, preventing confrontation with these situations. Our model suggests that increased avoidance thoughts and MPA may result from specific cognitions related to the prospect of a performance, the fear of negative evaluation and low achievement motivation.

Depression and the use of substances to alleviate MPA were found to be relevant variables for predicting MPA in our regression model. International studies (Ackermann, Kenny, O'Brien, & Driscoll, 2014; Dobos et al., 2018; Barbar et al., 2014; Vaag, Bjørngaard & Bjerkeset 2016) have found that health and psychological problems are frequently reported by musicians and performing artists. Studies have also suggested that creativity, which is a prerequisite for many forms of artistic and musical performances, is associated with an increased risk of affective disorders (Kyaga et al., 2013). A study on the prevalence of performance anxiety among Brazilian musicians reported a high rate of psychiatric indicators (Barbar et al., 2014), while symptoms of depression were observed in 32% of a sample of Australian professional orchestral musicians (Ackermann et al.,

2014). Moreover, previous studies have discussed the use of substances to mitigate depression, trait anxiety and social phobia (Orejudo-Hernández et al., 2018).

The age at first musical performance with an audience was the only musical training variable with sufficient strength to predict MPA. Some studies found no significant relationship between MPA and the number of years since first performance with an audience (Fehm & Schmidt, 2006; González et al., 2017), whereas others described less anxiety in children with previous experience of performance than in those without this exposure (Bucher & Ryan, 2011). According to the present results, higher age at the first performance in front of an audience is associated with an increased likelihood of developing MPA. The negative correlation between KMPAI total score and number of auditions in the past year is consistent with this finding, indicating that exposure to evaluation situations helps to regulate psychophysiological responses and negative thoughts and to improve self-efficacy (González, Blanco-Piñeiro & Díaz-Pereira, 2018). In this way, exposure to playing in public has similar effects to those achieved by exposure therapy and is crucial for the reduction of phobic and anxiety symptoms (Antony & Swinson, 2000; Davey, 1997).

Although gender did not have sufficient strength to predict MPA in the regression model, the ANOVA showed a significant between-gender difference in total KMPAI, with women having higher rates of MPA than men. Numerous studies have confirmed this difference (Iusca & Dafinoiu, 2012; Thomas & Nettelbeck, 2014; Vaag, Bjørngaard, & Bjerkeset, 2016; Fernholz et al., 2019). However, gender differences are manifested not only in the level of anxiety but also in the expression of anxiety or in the synchronization of different responses to anxiety (behaviours, physiological responses, performance quality and self-report measures), with girls showing higher synchrony than boys (Ryan, 2006). The significant difference between genders may be related to specific cognitions. In general, female respondents report more worries and disturbing thoughts during performances in comparison to males (Robichaud, Dugas, & Conway, 2003; Oudejans, Spitse, Kralt, & Bakker, 2017). Moreover, Eccles et al. (1983) observed that parents who sustain gender stereotypes have less confidence in the abilities of their daughters. This lack of confidence

may have a stronger impact on academic outcomes and negative thoughts about musical performance among female than male students (Wentzel, K. R., Russell, S., & Baker, S, 2016). Thus, female students may be more likely to develop anxiety disorders due to low achievement motivation and negative cognition (Fishbein et al., 1988; Kenny et al., 2014; Papageorgi et al., 2011; Kenny & Ackermann, 2015)

The theoretical and practical implications of our findings should be evaluated, considering the limitations of our research and its future direction. First, this study is a multivariate correlational investigation and therefore does not allow causality between predictor and dependent variables to be inferred. However, the strength of multiple regression analysis is that an outcome can be predicted from the combination of several predictors, controlling for the influence of third variables. The causality of MPA is an important research issue that should be addressed in future studies using alternative multivariate methodologies (e.g., longitudinal design, path analysis or structural equation modelling). Second, the present study was carried out in music students alone and did not include professional musicians or music teachers, who also suffer from MPA. These are distinct populations with entirely different characteristics to whom the present results cannot be extrapolated. Finally, our study was entirely based on self-reported and retrospective data. MPA experienced in real or virtual reality situations could provide behavioural and psychophysiological data needed to elucidate the mechanisms underlying MPA and its eliciting contexts.

Taking these considerations into account, the present results indicate that the most relevant variables to predict whether a musician will experience MPA in the future are health and psychological factors, possibly the most difficult factors for music students, music teachers and conservatories to manage. The academic curriculum, at least in Spanish conservatories, focuses the student's efforts on achieving the performing skills of a professional musician. However, it is well documented that MPA affects numerous musicians, regardless of their professionality, musical talent or performance skills. The student's efforts to acquire technical and practical knowledge are

not sufficient to complete a music career or become a successful musician. It may be equally important to control MPA and its psychological predictors, such as fear of negative evaluation, social avoidance, depression, poor achievement motivation, and the use of substances. Hence, there appears to be a need for psychological counselling in music education centres such as conservatories or music schools. In addition, the age at first musical performance with an audience also appears in our study as an important MPA predictor, with musicians who started performing at an older age showing higher levels of MPA. During musical studies, opportunities for audition are only available two or three times per year and are generally not obligatory. Our data demonstrate the importance of exposure to musical performance at an early age in order to manage MPA, including performances for family members, teachers or general audiences.

In summary, the results of this study point to a set of health and psychological variables as important predictors of music performance anxiety in conservatory students, including fear of negative evaluation, social avoidance, depression, poor achievement motivation and the use of substances, together with being older at their first musical performance in public. Most of these variables are susceptible to prevention or modification by the implementation of appropriate educational and psychological counselling measures and interventions. Consequently, these findings can be considered a call to researchers and conservatory authorities to design and evaluate active policies aimed at mitigating MPA among students and addressing its main psychological predictors.

5. FUNDING

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TABLE 1: Socio-demographic characteristics

Age	$\bar{x}$	SD
Males	22.79	8.11
Females	20.82	5.88
Total	21.76	7.092
Gender	**N**	**%**
Males	141	47.8
Females	154	52.2
Education	**N**	**%**
Elementary	3	1.0
Secondary ordinary	48	16.2
Secondary advanced	201	68.2
University	35	11.9
Other	8	2.7

TABLE 2: Musical training variables

Musical genre	N	%
Classical	279	94.6
Flamenco	16	5.4
Age at the first musical performance with an audience	**N**	**%**
Before 8 years old	78	26.4
From 8 to 12 years old	174	59
From 13 to 18 years old	34	11.5
After 18 years old	8	2.7
Number of gigs	**N**	**%**
0	19	6.4
From 1 to 3	97	32.9
From 4 to 10	90	30.5
More than 10	88	29.8
Motivation to begin musical studies	**N**	**%**
Personal choice	222	75.3
Activity organized by the school	22	7.5
Choice of the parents	40	13.6
Other reason	11	3.7
Motivation to choose the musical instrument played	**N**	**%**
Personal choice	220	74.6
Instrument was provided by my professor/conservatory/school	29	9.8
Choice of the parents	25	8.5
Other reason	18	6.1
Interest in music	**N**	**%**
It's a hobby	51	17.3
I would like to be professional	192	65.1
I'm a professional	49	16.6
Family or academic imposition	2	0.7
Individual practice (hours per week)	**N**	**%**
From 0 to 5 hours per week	84	28.5
From 6 to 10 hours per week	80	27.1
From 11 to 20 hours per week	73	24.7

From 21 to 30 hours per week	43	14.6
More than 30 hours per week	15	5.1
Age at the first time playing the instrument independently	N	%
Before 8 years od	111	37.6
From 8 to 12 years old	153	51.9
From 13 to 18 years old	25	8.5
From 19 to 25 years old	4	1.4
From 26 to 40 years old	0	0
After 41 years old	2	0.7
Musical instrument played	N	%
String		
Bowed String	65	22
Struck String	55	18.6
Plucked String	47	15.9
Wind		
Woodwind	67	22.7
Brass	39	13.2
Percussion	7	2.4
Voice	15	5.1

TABLE 3: Learning process variables

Musical level	N	%
Elementary Degree	5	1.7
Professional Degree	154	52.2
Superior Degree	134	45.4
Age at the start of musical studies	**N**	**%**
Before 8 years od	61	20.7
From 8 to 12 years old	152	51.5
From 13 to 18 years old	47	15.9
From 19 to 25 years old	17	5.8
From 26 to 40 years old	13	4.4
After 41 years old	5	1.7
Musical lessons in a regulated context (hours per week)	**N**	**%**
5 or less	21	7.1
From 6 to 10	88	29.8
From 10 to 15	117	39.7
More than 16	69	23.4
Number of auditions	**N**	**%**
0	33	11.2
From 1 to 3	138	46.8
More than 3	124	42

TABLE 4: **Health and psychological variables**

QUESTIONNAIRES	$\bar{x}$	SD
KMPAI (Kenny Music Performance Anxiety Inventory)	56.38	20.241
STAI-T (State-Trait Anxiety Inventory-Trait Form)	27.23	4.976
MAMQ (Musical Achievement Motivation Questionnaire)	158.07	14.617
BDI-II (Beck Depression Inventory)	7.15	5.982
FNE (Fear of Negative Evaluation) scale	14.81	6.982
SADS (Social Avoidance and Distress Scale)	5.84	5.041
STRATEGIES TO MANAGE MPA		
Do you carry out behaviours to manage MPA before a musical performance?	N	%
No	99	33.6
Yes	196	66.4
Kind of behaviours carried out before a musical performance	N	%
Relaxation and breathing exercises	167	56.6
Superstitious behaviour	25	8.5
Quiet activity	35	11.9
Prayer	16	5.4
Number of behaviours carried out	N	%
1	141	47.8
2	45	15.3
3	10	3.4
TREATMENT (CURRENT OR PREVIOUS) FOR ANXIETY		
Are you receiving or have you received any treatment for anxiety?	N	%
No	274	92.9
Yes	21	7.1
USE OF SUBSTANCES TO ALLIVIATE MPA		
Have you ever take any substance to palliate MPA?	N	%
No	204	69.2
Yes	91	30.8
Kind of substances taken	N	%
Illegal substances	4	1.4
Tobacco	11	3.7

Pharmacy	22	7.5
Alcohol	4	1.4
Natural relaxing substances	52	17.6
Number of substances taken	N	%
1	59	20
2	14	4.7
3	2	0.7

TABLE 5. Linear regression results with the KMPAI total score as the dependent variable

Model 1	No standardized B	P	F Change	R2	R2 Corrected
			5,585	.019	.015
(Constant)	48.683	.000			
Age at first musical performance with an audience	4.016	.019			

Model 2	No standardized B	P	F Change	R2	R2 Corrected
			24,812	.096	.090
(Constant)	32.784	.000			
Age at first musical performance with an audience	3.983	.015			
Use of substances	12.179	.000			

Model 3	No standardized B	P	F Change	R2	R2 Corrected
			88.949	.597	.589
(Constant)	107,578	.000			
Age at first musical performance with an audience	3.825	.001			
Use of substances	5.504	.001			
FNE	.643	.000			
SADS	.576	.001			
BDI-II	.932	.000			
MAMQ	-.539	.000			

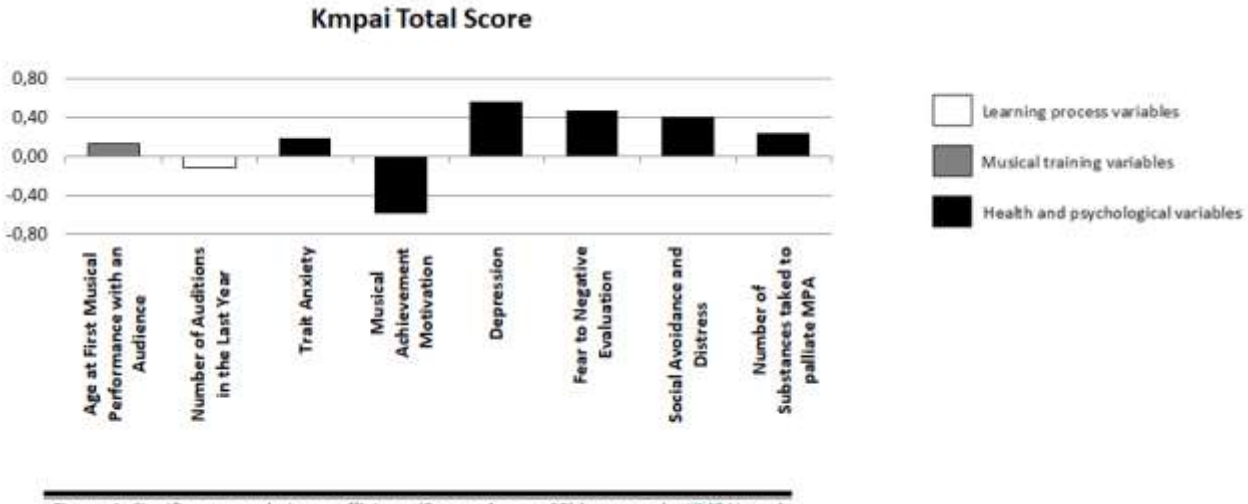

Figure 1. Significant correlation coefficients (Pearson's r, p<.05) between the KMPAI total scores and musical training, learning process and health and psychological variables

APPENDIX 1	
Socio-demographic characteristics	
Gender	Male or female
Education	Education level completed by the participant.
Musical training variables	
Musical genre	Musical genre studied and played most of the time.
Age at the first musical performance with an audience	Years of age when de participant performed with audience for the first time.
Number of gigs	Gig is a performance outside the formal musical education system. It is a voluntary activity, as a paid work.
Motivation to begin musical studies	The reason why the student started to play an instrument. Could be a personal, parental or scholar election.
Motivation to choose the musical instrument	The reason why the student choose an specific instrument. Could be a personal, parental or scholar election.
Interest in music	This is the importance of the musical studies in the life of the musician.
Individual practice (hours per week)	Hours per week of individual practice at home, outside the formal musical education.
Age at the first time playing the instrument independently	Years of age when student started to play an instrument, regardless the formal musical education.
Musical instrument	Main instrument played by the student.
Learning process variables	
Musical level	Actual year of training in the formal musical education.
Age at the start of musical studies	Years of age when student started to study in the formal musical education.
Musical lessons in a regulated context (hours per week)	Hours per week spent in the formal musical education.
Number of auditions	Exam in the formal musical education system. The aim is to evaluate the acquired skills in every trimester.
Health and psychological variables	
Strategies to manage MPA	Do you carry out behaviours before a musical performance? Yes/no
Number of behaviours carried out	The sum of the different behaviours carried out. • Relax and breathe exercises • Superstitious behaviour • Quite activity • Pray
Treatment (current or previous) for anxiety	Are you receiving or have you received any treatment for anxiety? Yes/no
Use of substances to alliviate MPA	Have you ever take any substance to palliate MPA? Yes/no
Number of substances	The sum of the different substances taken.

taken	• Ilegal substances • Smoke • Pharmacy • Alcohol • Natural relaxing substances

ESTUDIO 2

Affective responses in high- and low-anxiety musicians: Physiological responses during virtual musical performances.

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Affective responses in high- and low-anxiety musicians: Physiological responses during virtual musical performances

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ABSTRAC

Music performance anxiety (MPA) is one of the main problems that musicians suffer in their professional careers. The relationship between physiological arousal and MPA it is far from clear because general increases in self-reported state anxiety indicators are not predictive of general physiological arousal during performance. We hypothesize with the idea that, while high- and low-MPA populations show high psychophysiological arousal, the differences could be related to the appraisal of the situation that musicians make, but no study has evaluated the affective response during musical performance in musicians. The aim of the present study was to evaluate the emotional responses of musicians with high MPA compared with those with low MPA before, during and after musical performance. HR, SCR and the EMG activity of facial muscles were recorded, while 30 guitarists performed a solo piece on a virtual stage. No differences in physiological arousal were found between high- and low-MPA musicians. However, musicians with high MPA showed higher corrugator activity in the during performance phase than musicians with low MPA. It suggest that performance situations are perceived as potentially threatening and frightening by high MPA musicians, supporting the idea that greater defensive activation is related to MPA. The interaction between MPA and the degree of realism of the virtual environment is discussed.

1- INTRODUCTION

Music performance anxiety (MPA) is one of the main problems that musicians face in their professional careers. It is described as a state of marked and persistent anxious apprehension related to musical performance and is manifested by affective, cognitive, somatic and behavioural symptoms in different musical performance settings regardless of the quality of the musical performance (Kenny, 2011).

The relationship between physiological arousal and MPA has been seen as equivocal. Although an increase in arousal seems to enhance performance, overarousal of the autonomic nervous system seems to be related to MPA and maladaptive behaviour (Papageorgi, Hallam & Welch, 2007; Kwan, 2016; Yoshie et al. 2009). Several studies report a significant increase in musicians' heart rate (HR), skin conductance response (SCR) and self-reported arousal in public/evaluative performances compared with practice conditions (Williamon, Auffeger & Eiholzer, 2014; Studer, Danuser, Wild, Hildebrandt, & Gomez, 2014). Self-reported symptoms of exacerbated physiological arousal, such as palpitations, perspiration, dry mouth, trembling, and disturbances in breathing patterns, have been reported in musicians with MPA during public performances (Steptoe, 2001; Studer, Danuser, Hildebrandt, Arial & Gomez, 2011; Wesner, Noyes & Davis, 1990). However, general increases in self-reported state anxiety indicators are not predictive of general physiological arousal during performance (Kenny, Fortune & Ackermann, 2013). Fredrikson and Gunnarsson (1992) reported that musicians' HR is higher during performances than before or after performances. With respect to MPA, they found that high-anxiety musicians have a higher HR than low-anxiety musicians during public performances compared to private performances. Studer and colleagues (2014) reported changes in HR between performance situations (private performance, evaluated public performance, and after a

public performance), but higher levels of MPA were associated with an increase only in self-reported anxiety, not in physiological responses. Other studies have reached similar conclusions, reporting no significant differences in physiological arousal between high and low MPA (Dimberg & Thunberg, 2007). Although HR is more frequently used in performance anxiety studies (Iñesta, Terrados, García & Pérez, 2008; Fredrikson & Gunnarson, 1992), SCR changes have also been used as a physiological index. Yoshie, Kudo, Murakoshi and Ohtsuki (2009) found an increase in SCR from rehearsal to evaluation, reflecting the activation of the sympathetic division of the autonomic nervous system. To the best of our knowledge, no studies have compared the level of SCR between subjects with and without MPA during different phases of performance to confirm overactivation in MPA patients.

The absence of differences between high and low MPA could be related to the activation necessary to realise good performance in both populations rather than to MPA (Perdomo-Guevara, 2017). In other words, it is possible that high- and low-MPA populations show high psychophysiological arousal, but the differences could be related to musicians' appraisal of the situation. In general, musicians who suffer from MPA perceive a performance as potentially threatening and frightening (Kenny, 2010; Kaspersen & Gotesdam, 2002; Wesner, Noyes, & Davis, 1990). Thus, it is not the activation of the sympathetic nervous system per se (which occurs in anxious and nonanxious musicians alike) that causes MPA but musicians' negative evaluation of physiological arousal (Brooks, 2014; Kenny, 2010; Hanin, 2010; Steptoe 2001; Kaleńska-Rodzaj, 2018, 2019). Osborne and Kenny (2008) investigated the presence of positive and negative emotions in musical performance in musicians with MPA. Their findings suggest that the prevalence of negative emotions is positively correlated with anxiety and renders the experience of musicians with MPA less rewarding. No study

has evaluated the affective response during musical performance in musicians with MPA. Facial expressions have been studied through electromyography (EMG) during performance, allowing us to understand the affective component of MPA and the emotions linked to a performance. In a laboratory context, facial expressions of emotions can be measured using the EMG activity of the zygomaticus major muscle, which becomes active during expressions of happiness, such as smiling (Larsen, Norris & Cacioppo, 2003; Lang, Greenwald, Bradley & Hamm, 1993), as well as stress induction (Nitschke, 2020). The corrugator supercilii muscle is related to particularly angry facial expressions (Dimberg, 1982; Tan et al., 2012). Therefore, EMG is an established method that is widely used to study emotion in response to musical tracks (i.e., Merrill, Omigie & Wald-Fuhrmann, 2020; Bullack, Büdenbender, Roden & Kreutz, 2018), pictures (i.e., Lang, Greenwald, Bradley, & Hamm, 1993; Kulke, Feyerabend & Schacht, 2020) and anxiety (Smith, Bradley & Lang, 2005; Kret et al., 2013).

The aim of the present study was to understand emotional responses in musicians with high and low MPA before, during and after musical performance. To maintain ecological validity and high experimental control, virtual reality (VR) technology was used. Previous studies have shown that simulated environments offer realistic experiences of performance contexts and show patterns of physiological responses, self-reports and behaviour comparable to those of a real performance (Williamon, Auffeger & Eiholder, 2014; van Zyl, 2020; Bisonete & Dube 2016). Moreover, VR facilitates psychophysiological recordings without the difficulty of accessing musical performance environments or renting concert halls (Bissonnette & Dube 2016). In line with previous studies (Studer 2014; Spahn, Echternach, Zander, Voltmer & Richter, 2010; Kenny, Fortune & Ackermann, 2013), we anticipate no

significant differences in physiological arousal between high and low MPA assessed by means of HR and SCR. In addition, we expect that physiological arousal (HR and SCR) will be higher in the performance phase than before and after performance, but there will be no significant differences between groups. In relation to affective responses, we expect that musicians with high MPA will show more facial expressions of unpleasantness (high corrugator activity and lower zygomatic activity) during performance than musicians with low MPA.

2- METHOD

2.1.- Participants

The study was conducted from March 2018 to February 2020 and involved a sample of Spanish musicians (N=295) recruited from a database of musicians with and without MPA (Lupiáñez, Ortiz, Vila & Muñoz, 2021). From this pool, 64 Spanish guitarists with high and low scores on the Kenny Music Performance Anxiety Inventory (KMPAI) were contacted by telephone to participate. The inclusion criterion was that the participants had musical activities that involved performing regularly in front of an audience. The exclusion criteria were taking medication or having hearing, vision, cardiovascular or psychological problems as well as the use of drugs and alcohol. Of all the musicians who were contacted, 35 agreed to participate and scheduled a date for the experiment. However, 5 of the participants and their data were excluded because they were under pharmacological treatment (n=3) or due to problems in the experimental session (n=2). The confidentiality of the participants was maintained throughout the study using unique codes for participant identification. The participants were volunteers, and none of them received compensation for taking part in the experiment.

The study was conducted in accordance with the Declaration of Helsinki (1991) and was approved by the local ethics committee of the University of Granada.

The final sample was composed of 30 guitarists with high (n=15) and low (n=15) scores on the KMPAI. Their ages ranged from 18 to 59 years (M = 29.77 years; SD = 11.26), and the sample was composed of 20 men (M = 33.05 years; SD = 11.96) and 10 women (M = 23.20 years; SD = 5.88).

2.3. The virtual reality setup

The experimental setup consisted of VR scenarios created ad hoc with *World Vizard 5.0* software (*https://www.worldviz.com/vizard-virtual-reality-software*). The scenarios were presented on a *Visionstation VS1024-XL2*0 immersion system (Elumens ETC) with a 3D Epson projector full HD 1080p concave hemispherical screen used by the authors of this study in previous work (Muñoz, Idrissi, Sanchez-Barrera. Fernandez-Santaella & Vila, 2013). The participants moved freely in virtual environments using a joystick (Logitech Extreme 3D Pro S). To familiarize themselves with the VR technique, the participants trained in the use of the hardware for 15 minutes before the experimental session in a VR square with people, fountains and cafes. The experimental session consisted of a music gig in a virtual environment with three phases of 240 seconds each (Figure 1).

A).- Before performance. This phase takes place backstage, where the participant waits alone for his or her turn to perform while other musicians can be heard playing. Inside this room are typical backstage elements, such as a chair for resting, music stands with musical scores, musical instruments, and billboards of previous concerts.

B).- During performance. This phase takes place in a theatre with an audience and a stage where the participant performs a musical piece of his or her choice. While the participant is performing, some events can be heard: a chair scraping (Events 2 and 5; 7 seconds each), people coughing (Events 1 and 3; 3 seconds each), and a mobile phone ringing loudly (Event 4; 12 seconds). The aim of these events is to recreate real situations that musicians experience while they are playing a musical piece.

C).- After performance. This phase takes place in the same backstage area as the first phase, where the participant can rest for a few minutes while other musicians can be heard playing.

- Insert Figure 1 here -

2.2- Measurement

Subjective measurements

When the participants arrived at the laboratory, they completed the State-Trait Anxiety Inventory (STAI-T; Spielberg, 1970) to evaluate their level of anxiety in general. This instrument consists of 40 items rated on a 4-point scale to measure trait-level anxiety. High scores indicate higher levels of anxiety.

The immersion ability of participants was measured with the Immersive Tendencies Questionnaire (ITQ; Witmer & Singer, 1998; Bouchard, Robillard & Renaud, 2002) before beginning the virtual experience. The questionnaire contains 18 items with 7-point Likert scale response options (i.e., 1 = never, 4 = sometimes, 7 = very often). It is composed of four subscales: involvement (the propensity to become involved passively in some activities, such as reading books), focus (the tendency to maintain focus on current activities), emotion (the tendency to be emotionally involved

in activities) and games (the frequency with which the subject plays games and the level of involvement in these games). The sum of the points corresponds to an individual's immersive tendency. Thus, the range of possible scores was 18–126, and the sample mean score was 76.66 in the original study.

When the task was over, the participants evaluated their VR experience and enjoyment and their sense of presence in the virtual environment using the iGroup Presence Questionnaire (IPQ; Schubert, Friedmann, & Regenbrecht, 2001). This instrument is a 14-item self-report questionnaire that consists of four subscales: spatial presence, involvement, experienced realism and the general "sense of being there". Items are scored on a 7-point Likert scale where higher scores indicate a greater sense of presence.

Finally, the participants completed a ten-point visual analogue scale (VAS) of perceived anxiety during performance. The scale consisted of the following sentence: "Estimate on a scale of 0 to 10 your level of anxiety during the performance".

Psychophysiological measurements

HR, SCR and the facial EMG activity of the zygomaticus major and corrugator supercilii were recorded using a BIOPAC MP150 polygraph (BIOPAC Systems, Inc., Goleta, CA) set at a sample rate of 1000 Hz and with a notch filter set at 50 Hz. Acquisition was controlled by BIOPAC's AcqKnowledge 4.2 software.

HR was obtained from electrocardiographic (ECG) signals recorded with 8 mm diameter Ag-AgCl electrodes with electrolytic gel conductivity. ECG signals were recorded by using a lead I configuration (positive electrode on the left collarbone, negative electrode on the right collarbone and ground electrode on the left ankle) and a 5- to 35-Hz bandpass filter. HR was analysed using the MATLAB R2014a ECGLAB tool and KARDIA software (Perakakis, Joffily, Taylor, Guerra & Vila, 2010). Interbeat

intervals (IBIs) were detected for 240 seconds in each phase with ECGLAB, and the results were visually inspected and corrected through the manual addition or removal of individual beats for missed or extra beats, respectively (Allen, Chambers & Towers, 2007). Then, IBIs were transformed into weighted averages every second and expressed as differential scores with respect to a ten-second prephase period with KARDIA. Finally, every 240-second phase was divided into four intervals of 60 seconds and the mean HR was obtained, resulting in 12 intervals: before performance intervals (BP1, BP2, BP3 and BP4), during performance intervals (DP1, DP2, DP3 and DP4) and after performance intervals (AP1, AP2, AP3 and AP4).

SCR was recorded from two 8 mm diameter Ag-AgCl electrodes with isotonic gel placed on the neck (Van Dooren & Janssen, 2012) to avoid interfering with the performance of the musician. The SCR was determined by subtracting the activity in the 3 seconds of the prephase starting from the activity that occurred every 0.5 seconds during the 240 seconds of each phase. Finally, every phase was divided into four intervals of 60 seconds, and the SCR mean was obtained: before performance intervals (BP1, BP2, BP3 and BP4), during performance intervals (DP1, DP2, DP3 and DP4) and after performance intervals (AP1, AP2, AP3 and AP4).

The EMG activity of the zygomaticus and corrugator muscles was measured using miniature 4 mm diameter Ag-AgCl electrodes filled with conductive gel, which were placed based on the recommendations of Cacioppo, Tassinary and Berntson (2007) and bandpass filtered (30–300 Hz). The changes in zygomaticus and corrugator activity were analysed only during the performance phase when the five events took place. Data were analysed offline using a MATLAB program that rectified and integrated the signal in a baseline interval from 50 ms before the event to the event duration (Fridlund & Cacioppo, 1986). Facial EMG activity over the zygomaticus major

and corrugator supercilii was defined as the mean amplitude of the integrated EMG response for event duration. Events with a maximum peak in the window that did not reach above the mean of the baseline were computed as zero.

2.4.- Procedure

First, the researchers contacted the participants by telephone and informed them that investigators from the University of Granada were seeking volunteers to participate in a study about musical performance**.** The potential research participants were appropriately informed about the nature and purpose of the study, and instructions were provided by email. Of all the musicians contacted, 30 participated in the study (see above).

When the participants arrived at the laboratory on the scheduled day, the experimenters explained the aim of the experiment, and informed consent was obtained from the participants before starting the study. They completed the first part of the questionnaires (initial interview, STAI-T, KMPAI and ITQ) and then were guided to an acoustically and electrically isolated chamber. Once the electrodes were correctly placed, the participants explored the VR scenario called "Square". They familiarized themselves with VR technology and improved their abilities in a virtual environment. Later, they could spend 15 minutes repeating the routine that they usually practised in a real gig, such as warm-up exercises. Once this time was completed, a researcher explained the instructions of the experimental task, and the task began.

First, the participants were exposed to a black screen for seven minutes (adaptation period). After the experimental task started, the participants went through three phases: before performance, during performance and after performance. in the before-performance phase, the participants received voice-over instructions to wait for their turn to perform. They could walk through the VR backstage while other musicians

could be heard playing. Four minutes later, the voice-over called the participants and invited them by name to enter the stage and play a musical piece. During the performance phase, the participants played a musical piece that they selected. While they played, they heard five event sounds at 30 or 60 seconds. When the performance was over, the audience applauded, and the participants returned to the backstage area. During the after performance phase, the participants waited for four minutes in the backstage area, where they could hear other musicians playing on the stage. Finally, the participants left the experimental room and completed the IPQ and VAS of perceived anxiety during the gig.

2.5. Statistical analysis

To identify differences between low and high MPA in the STAI-T, ITQ, IPQ and VAS of perceived anxiety during performance, we used a simple ANOVA.

HR analysis and SCR analysis consisted of a 2x3x4 repeated-measures ANOVA with the following factors: group (high and low MPA), phase (before performance/during performance/after performance) and interval (4 intervals per phase). To analyse zygomaticus and corrugator activity, a 2x5 repeated-measures ANOVA was performed with group (high and low MPA) as the between-groups factor and event (Event 1/Event 2/Event 3/Event 4/Event 5) as the repeated-measures factor.

Finally, to link MPA with physiological responses and subjective measurements, we correlated the KMPAI scores with HR, SCR, and EMG as well as the STAI-T, IPQ, ITQ and VAS of perceived anxiety using Spearman's correlation with a level of significance at .05. For psychophysiological measures, we computed the average HR and SCR during the experimental session (from the onset of the before performance

phase to the end of the after performance phase). For the EMG of the zygomaticus and corrugator, we calculated the average magnitude of the whole set of events.

Greenhouse–Geisser adjustments were applied to control for violation of sphericity in repeated-measures designs. The results are reported with the F values, the original degrees of freedom, and the epsilon-corrected p score. The level of significance was set at $p < .05$. All analyses were performed using IBM SPSS Statistics v23.

3. Results

3.1. Comparative analysis: Subjective measurements

The sample was composed of 56.7% flamenco guitarists (n=17) and 43.3% (n=13) classical guitarists. Forty percent of the sample consisted of professional musicians (n=12), while 60% of the sample consisted of music students (n=18).

Table 1 shows the results of the comparative analysis between high and low MPA in subjective measurements. The ANOVA results yielded significant differences in the STAI-T questionnaire [$F_{(1,29)} = 6.39$; $p<.05$; $\mu 2=.18$] and significant differences in the VAS of perceived anxiety [$F_{(1,29)} = 4.66$; $p<.05$; $\mu 2=.14$], where high-MPA musicians scored higher than low-MPA musicians. On the ITQ emotion subscale, high-MPA musicians scored higher than low-MPA musicians [$F_{(1,29)} = 5.12$; $p<.05$; $\mu 2=.15$]. No significant differences between groups were observed in the IPQ factors or the rest of the factors in the ITQ.

- Insert Table 1 here -

3.2. Psychophysiological measurements

3.2.1. Heart rate

The 2x3x4 (group x phase x interval) ANOVA yielded a significant phase effect [$F_{(2,56)} = 85.89, p < .001$, μ2=.754] and interaction of phase × interval [$F_{(6,168)} = 3.83, p < .05$, μ2=.120]. No significant differences between groups or their interactions were found. Bonferroni tests comparing the HR changes between the three phases showed significant differences between the before-performance and during-performance phases (p<.01) and between the during-performance and after-performance phases (p<.001). No significant differences were found between the before- and after-performance phases (Figure 2).

- Insert Figure 2 here -

3.2.2. Skin conductance response (SCR)

The 2x3x4 (group x phase x interval) ANOVA yielded only a significant phase effect [$F_{(2,56)} = 4.86, p < .05$, μ2=,148]. No significant differences between groups or their interactions were found (all p>.05). Bonferroni tests comparing the SCR changes between the three phases showed a significant trend between the during-performance and after-performance phases (p=.058). No significant differences were found between the before- and during-performance phases or between the before- and after-performance phases.

- Insert Figure 3 here -

3.2.3. Zygomaticus and corrugator electromyography (EMG)

The 2x5 (group x event) ANOVA of EMG corrugator activity yielded a main effect of *group* [$F_{(1, 27)}$ =19.699, $p < 0.01$, μ2=.42]. High-MPA musicians showed higher facial expressions of unpleasantness (high corrugator activity) during events compared with low-MPA musicians (Figure 4). No significant differences in other factors or their interactions were found. Furthermore, there were no significant differences in the 2x5 ANOVA of zygomaticus activity in the *group* factor, the event factor or their interactions (p>.05).

- Insert Figure 4 here -

3.3. Correlations between subjective and psychophysiological measures

Table 2 shows the correlations between subjective and psychophysiological responses. Significant correlations between the KMPAI and STAI-T (p<.05) and between the KMPAI and VAS of perceived anxiety (p<.001) were observed. The correlation analysis between subjective and psychophysiological measures showed significant positive correlations between the STAI-T and HR (p=.05) and between the KMPAI and corrugator activity in the expected direction; high corrugator activity was related to higher scores on the KMPAI (p<.001). The remaining variables showed no significant correlations.

- Insert Table 2 here -

4. Discussion

The aim of the present study was to evaluate the emotional responses of musicians with high MPA compared with those with low MPA before, during and after musical performance. HR, SCR and the EMG activity of facial muscles were recorded while 30 guitarists performed a solo piece on a virtual stage. As expected, participants with MPA reported more anxiety after the performance (VAS) and anxiety in general (STAI-T) as well as a greater tendency to be emotionally involved in activities (ITQ-Emotion). No significant differences were found in their sense of being in the virtual environment (IPQ) or its subscales. No differences in physiological arousal (HR and SCR activity) were found between high- and low-MPA musicians. However, musicians with high MPA showed higher corrugator activity during the performance phase than musicians with low MPA, expressing a higher level of unpleasantness. In relation to the gig phases, the musicians demonstrated an increase in HR during the performance phase compared to the before- and after-performance phases. Finally, higher scores on the KMPAI correlated with a high level of trait anxiety (STAI-T) and perceived anxiety during performance (VAS) and higher corrugator activity, and higher STAI-T scores correlated with higher HR activity.

In our study, all participants reported high-medium levels of presence in the virtual environment, supporting the ability of the virtual environment to simulate a realistic performance context that evokes physiological and emotional responses (Rodriguez-Árbol, et al., 2013; Williamon, Auffeger & Eiholder, 2014; van Zyl, 2020; Bissonnette & Dube 2016). Likewise, musicians with high MPA scored higher on the ITQ emotion subscale than those with low MPA, showing a high tendency to be emotionally involved in the virtual environment. Some mental health conditions, such

as depression or anxiety, have a clear effect on how people experience the world (Huang and Alessi, 1999). The same is true for VR, where specific states of participants can influence their involvement in the virtual environment (Baños, Botella, García - Palacios, Villa, Perpiñá & Gallardo, 1999). Participants with high levels of anxiety have shown a greater feeling of presence and involvement in VR environments (Bissonette 2016; Baños et al., 1999; Renaud, Bouchard & Proulx 2002; Alsina-Jurnet & Gutiérrez-Maldonado, 2010) and are more sensitive to anxiety cues (Diemer, Alpers, Peperkorn, Shiban & Mühlberger, 2015).

High-MPA musicians reported a high level of perceived anxiety after the virtual performance compared with low-MPA musicians, as shown by previous studies (Steptoe, 2001; Studer, Danuser, Hildebrandt, Arial, & Gomez, 2011; Wesner, Noyes, & Davis, 1990). MPA is characterised by self-reports of anxiety, tension and thoughts about poor performance in performance situations (Kenny, 2011). Paradoxically, there were no significant differences in physiological arousal between the groups. Although it is thought that self-reports of anxiety should be related to high physiological activation, several studies have reported no significant differences in HR activity between musicians in relation to MPA levels (Kenny, Fortune & Ackermann, 2013; Studer et al., 2014; Dimberg & Thunberg, 2007; Smith, Bradley & Lang, 2005; Spahn, Echternach, Zander, Voltmer & Richter, 2010). In our study, no significant differences were found between the MPA levels of groups. This finding was confirmed by the lack of significant differences in SCR between groups. These results may be related to the level of arousal necessary for readiness to play and the capacity to sustain attention for performance in both groups of musicians. Playing an instrument involves a high level of activation to attend to multiple attentional demands, such as considering several stimuli at the same time (e.g., the score, body movements, events in the audience) or detecting

and appropriately responding to them over long periods of time (Rodrigues, Loureiro, & Caramelli, 2013). This state of overexcitation is higher during public performance, when the attention and cognitive effort to realise good performance are the highest (Perdomo-Guevara, 2017). Thus, musicians with low MPA show high levels of physiological arousal because they need to be activated to deal with performance challenges, such as high MPA.

To the best of our knowledge, this research is the first study of MPA in which affective response was measured during performance. As expected, significant differences between participants with MPA were found in corrugator activity, revealing an unpleasant state during the virtual performance. Corrugator activity is an index of unpleasantness in which activation increases during negative events (Bradley et al., 2001; Larsen, Norris, and Cacioppo, 2003). EMG activation during performance in musicians with high MPA suggests that performance situations are perceived as potentially threatening and frightening, supporting the idea that greater defensive activation is related to MPA (Kenny, 2010; Kaspersen & Gotesdam, 2002; Wesner, Noyes, & Davis, 1990). These results are supported by the high correlations between the KMPAI and the STAI-T and corrugator activity. Previous studies have shown that trait anxiety and MPA are closely associated (McCoy, 1999; Kenny, Davis & Oates, 2004; Martin-Gagnon & Creech, 2019; Kenny, Fortune, and Ackermann 2013; Lupiáñez, Ortiz, Vila & Muñoz, 2021). Trait anxiety is a relatively stable predisposition to perceive stressful situations as dangerous (Spielberg, 1970). This could be the reason why musicians with higher trait anxiety experience intense anxiety in public performance situations and appraise such situations as threatening and unpleasant. In contrast, no significant differences in zygomaticus major activity were found. Nitschke et al. (2020) previously found that stress induction showed a negative association with

zygomatic activity. Thus, with regard to the former findings, the lack of significant differences in zygomaticus activity between high-MPA and low-MPA musicians confirms the high level of arousal during virtual performance necessary for realising good performance by both groups of musicians (Perdomo-Guevara, 2017). Together, these findings highlight that the differences between musicians with high MPA and low MPA are related to musicians' appraisal of their physiological arousal in the situation.

In relation to gig phases, both groups of musicians demonstrated an increase in HR in the performance phase compared to the before- and after-performance phases and a trend towards reduced SCR during the performance phase compared with the after-performance phase. Previous studies have compared physiological responses before/during/after performance (Fredickson & Gunnarsson, 1992; Studer, Danuser, Wild, Hildebrandt, & Gomez, 2014) and physiological arousal in public or evaluative situations compared with practice conditions (Studer, Danuser, Wild, Hildebrandt, & Gomez, 2014; Larrouy-Maestri y Morsomme, 2014; Williamon, Auffeger & Eiholzer, 2014; Yoshie, Kudo, Murakoshi & Ohtsuki, 2009). These studies show stronger HR activation during public performance than during private performance, such as during the performance phase compared with during or after the performance phase. Our results are in line with these results: in the performance context, HR increased from the before-performance phase to the during-performance phase and decreased from the during-performance phase to the after-performance phase, corroborating previous findings (Fredrikson and Gunnarsson 1992; Studer, Danuser, Wild, Hildebrandt, & Gomez, 2014). The trend towards reduced SCR during the performance phase compared with the after-performance phase is difficult to explain. One tentative explanation is that the reduced SCR during the performance phase could be due to a rejection of external stimuli to redirect attentional resources to feedback related to playing an instrument

(Lacey & Lacey, 1967). According to one early, influential view, cardiac deceleration plays an instrumental role in aiding "both the organism's receptivity to afferent stimulation and the organism's readiness to make effective responses to such stimulation" (Lacey, 1972, p. 183). We could expect a large amplitude of response in the SCR to be indicative of a high level of attention to the stimulus presented (Dawson, Schell & Filion, 2007). However, if musicians attempt to avoid responding to external stimuli while directing attention to afferent feedback from their performance, they will have a decrease in SCR while cardiac activation is occurring.

Although this study reveals a coherent pattern of results suggesting the importance of emotional reappraisal in MPA, the lack of differences in physiological arousal between groups could be related to the degree of realism of the virtual environment. For the MPA-evoking scenario, the degree of realism is a decisive criterion for immersion, and effectiveness is directly associated with it. Both MPA groups reported high-moderate levels of immersion, which could influence the arousal response evoked. Future investigations should include real gig situations and other VR immersive technologies and should compare them with actual results. Given the positive results in VR research, it is interesting to consider VR for music teaching and skills learning for public performances and evaluative situations.

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Conflict of Interest The authors declare that the research was conducted in the absence of any professional, commercial or financial relationships that could be construed as a potential conflict of interest.

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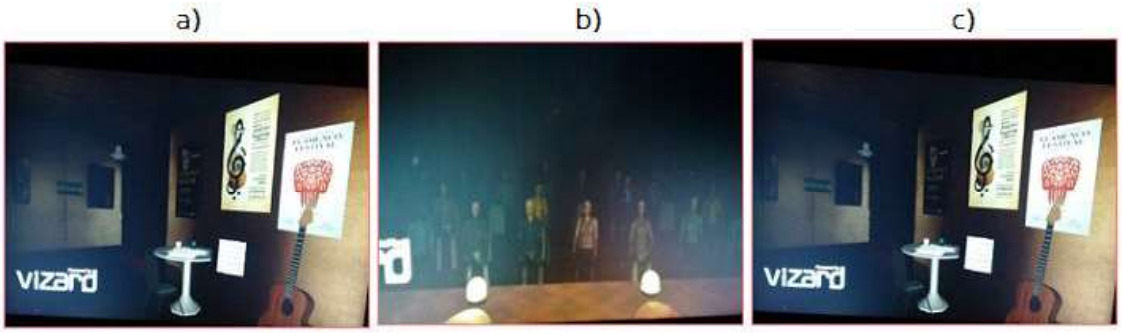

Figure 1. Experimental session in three virtual environments: a) Before performance. c) During performance, and c) After performance.

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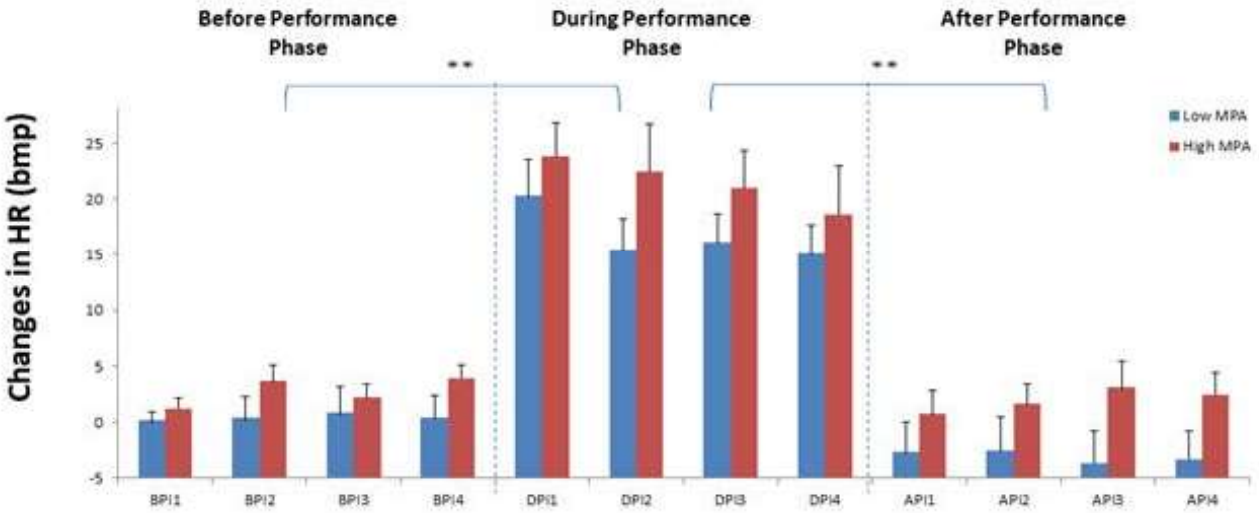

Figure 2. Changes in HR across the phases and intervals..

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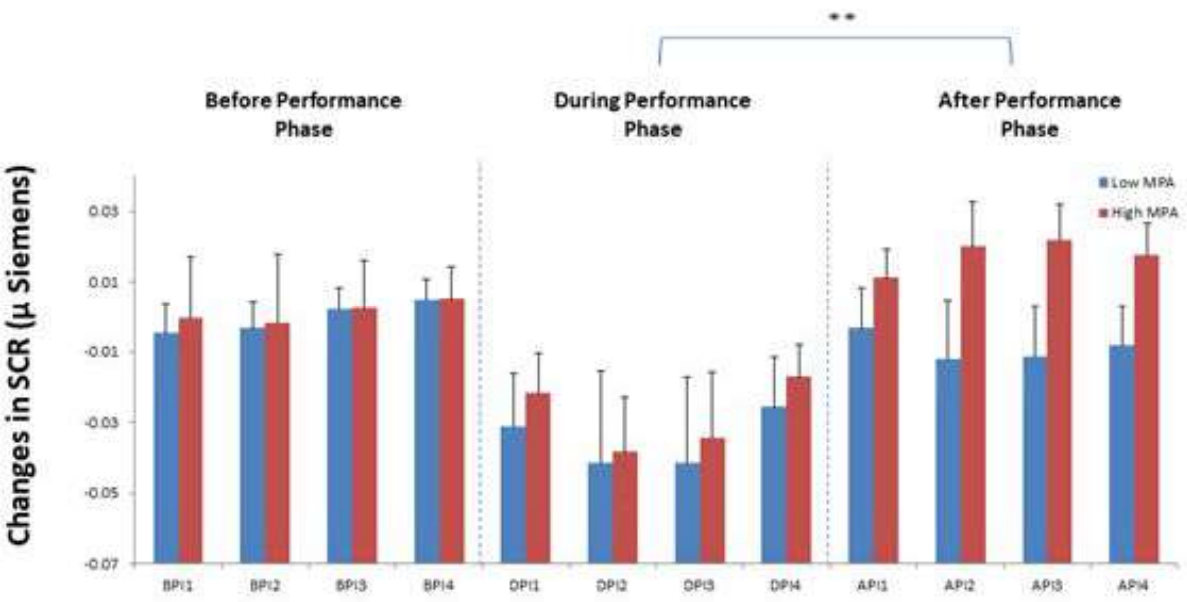

Figure 3. Changes in SCR across the phases and intervals.

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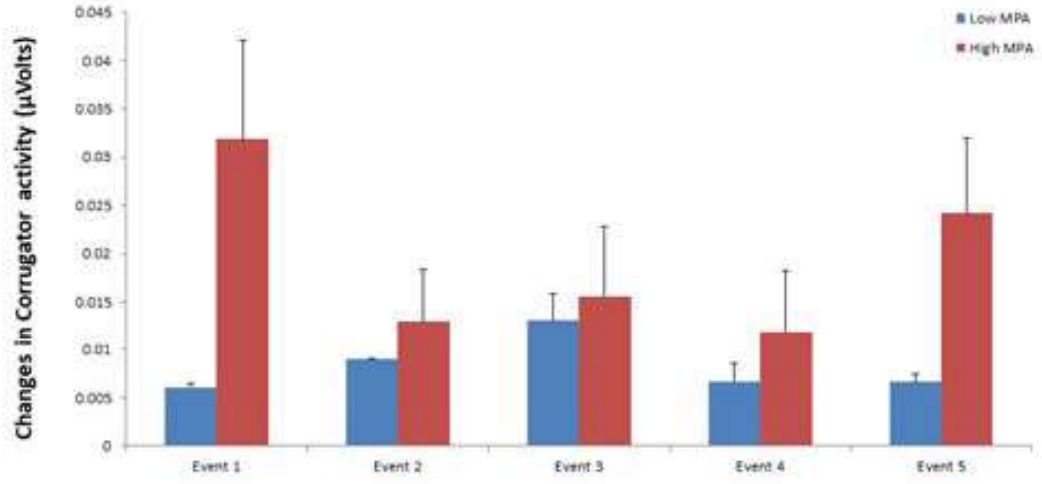

Figure 4. Changes in corrugator activity for every event.

Table 1. Comparative analysis between High and Medium MPA musicians in Subjective measurements. *p < 0.05

		MEAN	SD	F	μ^2
STAI – Trait	High MPA	28.00	4.375	F(1, 29) = 6.39*	.186
	Low MPA	24.25	4.535		
STAI – State	High MPA	22.60	3.019	F(1, 29) = .847	.029
	Low MPA	22.58	4.522		
ITQ Total Scores	High MPA	17.27	5.203	F(1, 29) = 1.16	.040
	Low MPA	16.67	5.565		
ITQ subscale Focus	High MPA	5.53	1.552	F(1, 29) = .013	.00
	Low MPA	5.17	1.031		
ITQ subscale Involvement	High MPA	4.87	2.232	F(1, 29) = 2.23	.074
	Low MPA	4.75	1.712		
ITQ subscale Emotion	High MPA	4.73	1.907	F(1, 29) = 5.12*	.155
	Low MPA	3.75	1.357		
ITQ subscale Games	High MPA	1.13	1.187	F(1, 29) = .436	.015
	Low MPA	1.92	1.929		
IPQ Total Scores	High MPA	6.07	7.842	F(1, 28) = .615	.022
	Low MPA	6.58	6.908		
IPQ subscale Spatial presence	High MPA	2.93	2.987	F(1, 29) = .924	.032
	Low MPA	2.67	3.676		
IPQ subscale Involvement	High MPA	5.93	4.431	F(1, 28) = .804	.029
	Low MPA	4.00	3.593		
IPQ subscale Experienced realism	High MPA	-3.87	2.264	F(1, 28) = .406	.015
	Low MPA	-3.25	2.340		
VAS of perceived anxiety	High MPA	4.60	2.53	F(1, 29) = 4.66*	.143
	Low MPA	3.17	2.125		

Table 2. Correlations between subjective and psychophysiological responses. *p < 0.05, **p < 0.01

	KMPAI	STAI_ Trait	STAI_ State	ITQ	IPQ	VAS of perceived anxiety	SCR Mean	HR Mean	ZYGOMATICUS Mean
STAI-Trait	.356*								
STAI-State	-.163	.173							
ITQ	.188	.185	.215						
IPQ	.240	.124	-.144	-.134					
VAS of perceived anxiety	.427**	.274	.032	.182	.009				
SCR Mean	.116	.190	.125	-.004	.124	.114			
HR Mean	.238	.332*	.152	-.026	.250	.194	.125		
ZYGOMATICUS Mean	.180	.015	-.080	.031	.188	-.009	.183	.088	
CORRUGATOR Mean	.502**	.175	-.020	.232	.181	.255	-.117	.354	-.064

ESTUDIO 3

Dieting and food choice during early adolescence: a virtual reality study.

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Running head: Adolescence, food choice and virtual reality

Title: Dieting and food choice during early adolescence: a virtual reality study

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Abstract

Attempts to lose weight by dieting often result in weight gain. Among the proposed mechanisms, it has been suggested that overeating usually follows dieting due to a failure of supplanting physiological with cognitive regulatory controls of eating. Nevertheless, such interaction between physiological and psychological processes remains unexplored during early stages of dieting. To start filling this gap in the literature, we assessed the differential contribution of self-reported hunger and restrained eating style in predicting high-calorie food selection across young adolescents with and without attempts of dieting. A non-experimental, cross-sectional study was conducted on a total sample of 60 adolescents (female = 35; mean age = 14.6; body mass index [BMI] range of 15.3-36.4 kg/m2; sex- and age-specific BMI percentile mean = 59.9). Using a virtual reality methodology, a free buffet restaurant with fruit, vegetable, sugar and salty food stimuli were presented. The participants could choose as many and as much as they want to eat during the session. The analysis confirmed that adolescents who tried dieting in last year (n=27) have a significant higher BMI compared to the non-dieters. Regarding the hierarchical multiple regressions, self-reported hunger and cognitive restrained eating scores (regardless of dieting or weight status) predicted the number of high-calorie food items and salty items, while the number of total foods chosen was only predicted by restrained eating. Not only physiological but also cognitive mechanisms appear to be involved in food selection and prospective intake in the early stages of adolescence.

Keywords: Adolescence; dieting; eating behaviour; restrained eating; virtual reality.

1. Introduction

Although dieting is a poorly defined behaviour with different meanings to young people and professionals, it is usually understood as the attempted restriction of caloric intake aiming at changing body shape and/or weight (Haynos, Field, Wilfley & Tanofsky-Kraff, 2015). Among adolescent populations, dieting is a common practice; in particular for girls. Indeed, high prevalence of dieting among normal and even underweight teenagers has been recognized (Boutelle, Neumark-Sztainer, Story & Resnick, 2002; Neumark-Sztainer, Story, Hannan, Perry & Irving, 2002; Patton, Carlin, Shao, Hibbert, Rosier, Selzer & Bowes, 1997). For instance, Neumark-Sztainer et al. (2002) found unhealthy weight control practices (i.e., fasting, skipping meals) in 57% and 33% of adolescent girls and boys, respectively; whereas 12% and 5% of adolescent girls and boys reported extreme weight control practices (i.e., taking diet pills, laxatives or diuretics). Even more, an earlier age at dieting onset is emerging among today's adolescents, which is now estimated around 13 years old in girls (Hill, 2002).

Increases in dieting and food restriction frequency have been related to higher negative psychosocial and illness behaviour risk factors to develop nutritional deficiencies, growth deceleration, disordered eating and eating pathology, as well as overweight (Whyte & Findlay, 2004; French, Story, Downes, Resnick & Blum, 1995). In particular, evidence from observational and prospective studies with dieting as a predictor of weight change suggests that excessive restriction in adolescents may have a counterproductive effect and eventually be followed by weight gain (Field et al., 2003; Lluch, Herbeth, Mejean & Siest, 2000; Stice, Cameron, Killen, Hayward & Taylor, 1999). Lowe, Doshi, Katterman and Feig (2013) reviewed the extent to which measures of dieting (e.g., self-reported weight loss dieting in the past year) and dietary restraint (e.g., the Restrained Eating scale from the Dutch Eating Behaviour Questionnaire)

might represent predictors of weight change in non-obese participants with a body mass index [BMI] between 18.5 and 30 during early adolescence (averaged 12 years old). Interestingly, they found that self-reported weight loss dieting in the past year was a significant prospective predictor of weight gain.

The paradox that weight loss dieting predicts future weight gain raises questions about the potential mechanisms of action. Neumark-Sztainer and Loth (2017) have stated several possible explanations for the relationship between dieting and weigh gain not mutually exclusive of each other. Among them, one possibility is based on hunger (defined as the body's physiological need for food) as dieting leads to increasing hunger sensations until the point that are relieved by the over-ingestion of food. Then the feelings of failure appear and back to dieting again. A second explanation is not focused on physiological signals but cognitively controlled eating style that inhibits appetite sensations and the desire to eat (Polivy & Herman, 1985). Vegetarians or individuals who restrict their intake of certain foods for religious reasons are examples of controlled eating in response to cognitions, which may result in weight loss and successful weight maintenance. In the case of dieters, these cognitive mechanisms of control are usually related with perceptions of foods, thereby they are prone to categorize foods into "good" and "bad" foods according to whether or not it transgresses their diet or in terms of the presence or absence of guilt. Here dieting is expected to increase risk for overeating when these inhibitory cognitive processes are undermined or disrupted, e.g., after being exposed to high-calorie food (i.e., forbidden foods). Once dieters find themself breaking the diet plan, they end up eating as much as they like. In this sense, previous research has largely shown that exposure to food cues (such as smell of pizza or cookies) increases the responsivity to food and then overeating in adult restrained eaters (e.g., Fedoroff, Polivy & Herman, 2003). A third possibility is that dieting and weight-control

methods may lead to increased metabolic efficiency, in which fewer calories are needed to maintain low weight whilst slimming and over time (Klesges, Isbell, & Klesges, 1992; Prentice, Goldberg, Jebb, Black & Murgatroyd, 1991). Unfortunately, no previous studies have examined these possibilities in early stages of dieting under highly controlled laboratory conditions despite their remarkable potential for prevention and intervention.

In order to advance the understanding of the putative mechanisms by which dieting may promote later unhealthy food consumption and even weight gain in adolescents, we first investigated young dieters' perceptions of food. In particular, we compared the sensory, affective and motivational dimensions of low and high calorie food between dieters and non-dieters. It should be mentioned that dieters have been shown to hold more negative views about high-calorie food when measures explicitly and more positive views about it when measure implicitly, reflecting their conflicts about what they want to eat and what they feel they should want to eat (Hoefling & Strack, 2008). Congruently, it was predicted that high-calorie foods were evaluated as more negative by adolescent dieters using self-reported measures. Second, we examined the differential contribution of self-reported hunger and restrained eating scores in predicting the selection of high-calorie foods across adolescents with and without attempts of dieting in the past year. Based on the cognitively over physiologically controlled eating mechanism, the number of chosen high-calorie foods was inversely predicted by lower restrained eating score (to the extent that people who restrain their eating avoid calories), especially in those adolescents who had previously attempted dieting. Conversely, to the extent that non-dieters are more likely to utilize physiological signals of hunger/fullness in their daily lives to determine portions chosen and ingested, a direct association between hunger and food selected was expected in

126 those who had never tried dieting. To do so, a free buffet restaurant with virtual reality
127 (VR) methodology was used.

128 Although comprehensive analyses based on systematically reviewed data are
129 still needed, several studies have provided evidence to support the validity of VR as a
130 data collection tool for actual food intake and food selection (Siegrist et al., 2019; Ung,
131 Menozzi, Hartmann, & Siegrist, 2018; Xu, Demir-Kaymaz, Hartmann, Menozzi, &
132 Siegrist, 2021; Xu, Siegrist & Hartmann, 2021). Moreover, it should be mentioned that
133 VR is advantageous as all foods could be easily replicated in virtual environment in
134 comparison with other methods such as the fake food buffet (Bucher, van der Horst &
135 Siegrist, 2012; Mötteli, Keller, Siegrist, Barbey & Bucher, et al., 2016). It is also
136 arguable that virtual food objects to be more effective than photographs and induce
137 comparable emotional reactions as observed for real foods (Gorini, Griez, Petrova &
138 Riva, 2010; Mikkelsen, Bucher, Hieke, Verain & van den Puttelaar, 2016; Siegrist, et
139 al., 2019; Ung et al., 2018). Finally, VR in adolescent populations has the advantage of
140 their higher familiarity with new technologies, which is becoming more widespread in
141 adolescent-oriented education, entertainment, and industry (cf. Castaneda, Bindman,
142 Cechony, & Sidhu, 2018).

143

144 **2. Materials and method**

145 2.1. Participants

146 A total sample of 60 Spanish adolescents (female = 35; mean [M] age and standard
147 deviation [SD] of 14.6 ± 0.7; sex- and age-specific Body Mass Index [BMI] percentile
148 and SD of 59.9 ± 29.3; BMI range from 15.3-36.4) in third class of ordinary secondary
149 education participated. Exclusion criteria were food allergies and intolerances. The
150 researchers were always present during the study to solve any doubts or questions. The

confidentiality of all participants was maintained throughout the study. Unique codes for participant identification were used and data were stored in password-protected computers to which only the researchers had access. None of the participant received gratification for taking part in the experiment. The study was conducted in accordance with the Declaration of Helsinki (1991) and was approved by the local ethics committee of the University of Granada.

2.2. Self-reports questionnaires.

An interview was conducted in order to assess eating habits, physical activity, sedentary lifestyle, smoke habits and familiar education. In addition, the participants completed the Spanish version of the Dutch Eating Behaviour Questionnaire (DEBQ-C) from children from 10 to 14 years old (Baños, Cebolla, Etchemendy, Felipe, Rasal, & Botella, 2011; internal consistency values of 0.69-0.78). This questionnaire contains three scales to measure different eating behaviours: external eating, restrained eating and emotional eating. For each scale, mean scores were obtained by dividing the sum of the item endorsements by the total number of items of that particular scale (the items are scored on a three-option answer: "no" [1 point], "sometimes" [2 points] and "yes" [3 points]). Shortly, external eating refers to eating in response to external cues for food, such as sights or smells. Restrained eating refers to eating when an individual uses cognitive suppression of internal hunger signals with the aim to lose or maintain a particular weight. Emotional eating refers to eating in response to negative emotions in order to relieve stress irrespective of internal physiological signals of hunger and satiety. The second questionnaire was the IGroup Presence Questionnaire (IPQ; Schubert, Friedmann, & Regenbrecht, 2001; Cronbach's alpha of 0.85), which was applied to gather information about the participants' virtual reality experience and

enjoyment. The IPQ is an item self-report questionnaire used to determine the sense of presence of the user of virtual environments. Presence is referred as a person's reported feeling of being in the place. IPQ comprises four subscales: spatial presence, involvement, experienced realism and the general 'sense of being there'. Then, the self-assessment manikins (SAM; Bradley & Lang, 1994) for measuring valence and arousal ratings and Pictographic Assessment of Desire (PAD; Muñoz, Martinez, Fernandez-Santaella, Vila, & Cepeda-Benito, 2010) for desire/strength of craving evoked for food stimuli were used. SAM and PAD consists of a scale of humanoid figures, in which valence ratings were ranged from 1 ("very unhappy") to 9 ("very happy"), arousal from 1 ("very calm") to 9 (very excited), and desire from 1 ("no desire to eat") to 9 ("strong desire to eat"). Visual analogue scales (VAS) graded from 1 ("good") to 9 ("bad") were also administrated to rate the organoleptic characteristics of foods: appearance, smell, taste, aftertaste and appetizing properties. The level of hunger was measured on a 9-point Likert scale from "I am not hungry at all" to "I have never been hungrier" before and after the experiment by the questions "How hungry are you?". Finally, participants were asked if they have been tried to diet in the last year, according to which the sample was divided into two groups: adolescent who tried dieting (n=27) and non-dieters (n=33).

2.3.The virtual reality setup

The experimental setup consisted of virtual reality scenarios created with the Neuro VR 2.0 software (http://www.neurovr.org; Riva et al., 2011), headphones, virtual glasses Vuzix Wrap 1200DX with a positioning tracker that allowed to follow the movements of the participants' heads while they explored the virtual environment, and a 3D joystick Logitech Wireless Gamepad F710. The first scenario (Figure 1A) was a

square where subjects could walk and manipulate some objects. The second one consisted of a free buffet restaurant with the 24 food stimuli where participants can choose as many and as much as they want to "eat" during the session (Figure 1B). In both virtual environments, subjects were guided by an off voice with instructions while they were immersed in the virtual environment in order to train and improve their abilities in virtual environment (e.g., moving a glass of water from a table to other) and to guide them (for example: "Now, you are going to enter to a free buffet where you can eat all that you would eat at this time. Are you ready?").

-Figure 1A and 1B about here-

2.4. Food stimuli

The food stimuli were selected from the Open Library of Affective Foods (OLAF; Miccoli, Delgado, Guerra, Versace, Rodríguez-Ruiz & Fernandez- Santaella, 2016). We used twenty-four food stimuli[1], twelve of them of high-calorie food items and twelve of low-calorie food items categorized into four categories of foods (n = 6/per category): sweets (e.g., crepes with chocolate, chocolate candies); salty foods (e.g., jam with cheese, Bolognese pasta); fruits (e.g., pineapple, watermelon); and vegetables (e.g., salads, tomato soup). In order to integrated food pictures in the virtual environment, all images were edited and resized in 1024x768 pixel resolution and the background was eliminated (Figure 2A and 2B).

-Figure 2A and 2B about here-

[1]The images selected were as follows. In the case of low calorie foods, the fruit pictures were Fru0337, Fru0289, Fru0593, Fru0492, Fru0190 and Fru0389; while the vegetable pictures were Veg0011, Veg0125, Veg0281, Veg0012, Veg0725 and Veg0079). In the case of high calorie food, the sweet pictures were: Sug0150, Sug0101, Sug0152, Sug0018, Sug0141 and Sug0096; while the salty foods were: Fat0022, Fat0029, Fat6054, Fat0036, Fat0038 and Fat0224.

224

225 2.5. Procedure

226 The procedure started with the recruitment of participants. The researchers
227 contacted each school principals of the city of Granada by telephone to inform them that
228 investigators from the University of Granada were seeking volunteers to participate in a
229 study about feeding habits and they agreed to participate. There were two schools that
230 agreed to participate. Then, the parents of the potential research participant were
231 properly informed about the nature and purpose of the study by email. Finally, the
232 students were also asked to participate after being given a full explanation of the aims
233 and the methods of the study. With the exception of two students, all of them agreed to
234 participate.

235 The data were collected individually during regular lessons. The whole procedure
236 lasted an average of 90 minutes, in which socio-demographic and eating characteristics
237 were collected. Then, the participants continued with the evaluation of the food stimuli
238 through SAM, PAD and VAS measures. Later, the participants were immersed in both
239 training and experimental virtual environments with the food stimuli for 20 minutes
240 approximately in total. In particular, the participants were immersed in a virtual
241 restaurant, in which they encountered a large table with 24 food stimuli. They could
242 walk through the environment and can choose as many and as much as they wanted to
243 eat during the session. The way to choose is standing in front of the desire food and
244 pressing the “A” button of the gamepad. The participant could press “B” button to give
245 back the food to the table. The task finished when participants when the participants left
246 the buffet table. After the immersion, subjects filled IPQ questionnaire.

247

248 2.6. Design and statistical analysis

A non-experimental, cross-sectional study was conducted. A comparative analysis was carried out in order to check differences between dieters and non-dieters in BMI, DEBQ, IPQ, SAM, PAD and VAS scales using simple ANOVAs with Diet as between-subjects factor. An additional univariate ANOVA controlling for the effects of variables such as age and gender as significant covariates was also performed on BMI. The Greenhouse-Geisser epsilon correction was applied to control for violation of the sphericity assumption.

A second type of analysis was a hierarchical multiple regression with interactions in three steps. This predictive analysis was carried out in order to examine if theory-driven predictors Hunger, Restraint eating and Diet and the interactions Hunger x Diet and Restraint eating x Diet explained a statistically significant amount of variance in dependent variables after accounting for covariates of no interest (age, gender, BMI, IPQ score as covariates). The dependent variables were the number of total food items, the number of food items in each category (sweet, salty, vegetable and fruit) and the number of caloric (low, high) foods that were selected by the participants while were in virtual environment. The effect of the relevant variables (age, gender, BMI, IPQ score) was examined and controlled for by entering them into the model first (Model 1). The predictors for which we had specified directional hypotheses were entered in the next step (the main effect model, Model 2). Finally, interactions of predictors were entered into the model (interaction effect term, Model 3). Before running the predictive analysis, we checked for multicollinearity and found no significant relationships among these independent variables ($rs<.55$; largest $VIF<5$; Tolerance >2); except for the interaction terms which were calculated as products of two predictors of interest. It should be noted that the product of variables is likely to be highly correlated. In such cases, multicollinearity was safely ignored because the p-value for these products and

all the results for the other variables (including the R^2) was the same in either case. Independence of residuals was verified, as assessed by a Durbin-Watson statistic between 1.2 and 2.2. Linearity and homoscedasticity were confirmed by visual inspection of plots of standardized residuals against standardized predicted values. All statistical analyses were performed using the SPSS software (version 23 SPSS Inc, Chicago, IL, USA). Results are reported with the original degrees of freedom and corrected p values. A p-value of $\leqslant .05$ was considered statistically significant.

3. Results

3.1. Characteristics of sample

Regarding eating habits, 20% (n=12) of the participants had not had breakfast that morning. For the rest, the most chosen foods at breakfast time were milk and derivatives (78.3%, n=47), followed by bread, cereals, toast, cookies and pastries (58.3%, n=35), and squeezed natural orange juice or some piece of fruit (21,7%, n=13). About physical activity, 58.3 of the sample % (n=25) practiced some sport or did exercise between 2 or 3 hour per week. The time spent watching TV is from 1 to 2 hours per day (43.3%, n=26) followed by less than an hour (28.3%, n=17). The time using the mobile phone or tablet was from 3 to 4 hours per day (45%, n=27) followed by 1-2 hours per day (21.7%, n=11). Only 8.3% (n=5) of the participants smoke regularity a mean of 8.20 cigarettes per day with an age onset of 14.2. The familiar context of the participants was characterized for parents with high and university degrees, professional or public jobs (a full description can be consulted in Appendix A).

3.2. Comparative analysis between dieters and non-dieters

As shown in Figure 3, the adolescent who tried dieting showed a significant higher BMI compared to the non-dieters ($F(1, 59)=7.41$, $p<.01$, $\mu^2=.33$). Comparing dieters and non-dieters, additional significant differences were also obtained in IPQ scores ($F(1, 59)=5.01$, $p<.05$, $\mu^2=.28$; $mean_{dieter}= -3.81$, $SD= 7.1$ versus $mean_{non\text{-}dieter}= .1$, $SD= 6.5$). No differences were found in DEBQ total score ($F(1, 59)=3.10$, $p>.05$, $\mu^2=.40$; $mean_{dieter}= 2.1$, $SD= .4$ versus $mean_{non\text{-}dieter}= 1.9$, $SD= .4$). Given that group differences in IPQ, as well as age and gender and DEBQ may alternatively affect the effect of dieting on BMI, all of them were treated as covariates. Even after controlling for these variables, a significant higher BMI was observed in those with dieting attempts ($F(1, 52)=11.07$, $p<.01$, $\mu^2=.28$).

-Figure 3 about here-

Regarding the SAM, PAD and VAS measures, significant differences between groups were found on valence, arousal, desire and appearance scores regarding low calories foods (vegetables and fruits; see Table 1) and regarding smell, taste and aftertaste on fruits food category (all $ps<.05$). In particular, dieters reported more positive, activating, evocating of desire and better appearance of vegetables and fruits than non-dieters, as well as the organoleptic characteristics in fruits category.

-Table 1 about here-

3.3. Predictive analysis

The results of the hierarchical regression analysis of predictors on the number of total food items and number of foods by caloric density as well as on the number of items by the type of food (sweet, salty, vegetable and fruit) are shown in Tables 3 and 4

respectively. They revealed that Restrained eating and Hunger predictors significantly increased the amount of variance accounted for by the regression equation. In particular, the second model was statistically significant for high-calorie food, total number of foods and salty food items, showing that the higher number of high-calorie food items and the number of salty items were significantly predicted by lower restrained eating scores (ps<.05) and higher hunger ratings (ps<.01). The number of total foods was only inversely predicted by the restrained eating score (p<.05). The addition in the third model of the interaction with Dieting attempt did not further increase the amount of variance. Additionally, correlations between Hunger and Restrained eating scores with BMI were performed in order to test if these factors were directed associated with variations in BMI. No significant correlations were found (ps>.25).

-Tables 2 and 3 about here-

4. Discussion

The purpose of the present study was to probe the impact of physiological hunger, as well as dieting and cognitive restraint of eating behaviour, on high-calorie food choice in adolescents. Regarding the perceptions of high-calorie foods, and contrary to our prediction, no differences were found between dieters and non-dieters. Nevertheless, dieters evaluated low-calorie foods (such as vegetables and fruit) more pleasant and attractive, with a higher desire to eat. In this sense, it has been shown that attitudes to food consist of multiple dimensions related to sensory, affective and cognitive aspects of food items, which interact with each other. For example, the perceived healthiness of food products influences ratings of their palatability (e.g., Westcombe & Wardle, 1997). Therefore, it is possible that self-reported perception

might reflect beliefs of what constitutes a desirable diet and the nutritional recommendations of a healthy diet favouring low-calorie food choices rather than the actual appetitive value of these foods and what dieters really want to eat. It remains to explore whether implicit measures (e.g., automatic affective associations to high- and low-calorie food items) might more be more predictive of eating behaviours in adolescent population.

What we did confirm was that young adolescents with previous attempt at dieting revealed a higher BMI compared to the non-dieters. This observation is in agreement with previous studies in preadolescent and adolescent populations, in which weight-reduction efforts prospectively predict growth in weight status as well as the onset of obesity among female adolescents (e.g., Field et al., 2003; Stice, Cameron, Killen, Hayward & Taylor, 1999). Among the unhealthy weight control practices, it should be noted that 20% of the sample revealed skipping meals (breakfast). Other interesting finding was related to IPQ score. In comparison between dieters and non-dieters, we found that young adolescents with previous attempt at dieting revealed a lower sense of presence compared to the non-dieters. Such reduced experience of being physically inside the virtual environment might be explained as avoidance responding to caloric food. Nevertheless, this possibility remains completely unexplored.

In relation to our second prediction, we first hypothesized an inverse relationship between the (DEBQ-related) cognitive restraint score and the selection of high-calorie foods only in dieters. Our findings were partially congruent. We showed that higher cognitive restrained eating scores predicted a lower the number of high-calorie/salty food items as well as the number of total foods chosen; but regardless of previous dieting attempt condition. In line with our VR environment finding, it should be note that an inverse relationship between caloric intake and the restraint scale of DEBQ has

been also founded adult samples under naturalistic food consumption conditions. For instance, Wardle and Beales (1987) reported that the food intake recalls in the 24h before the experiment was negatively correlated (r = .-28) with restrain level in a sample of female undergraduates. Likewise, Van Strien, Frijters, van Staveren, Defares and Deurenberg (1986) found a negative relationship (r = .-47) between restrained eating and deviation of energy intake from energy requirement. In addition, they observed that subjects who score high on the restrained eating scale of DEBQ ate fewer calories than needed to sustain their current body weight, especially due to ingest fewer high-calorie fat and sugar food items.

Of interest is that restrained eating but not previous attempts of dieting was associated to food choice. Although dieting and restrained eating have been historically believed to be equivalent and there is evidence that they are largely overlapping constructs, new evidences seem to point out that both affect eating regulation differently (Lowe et al., 2013). For instance, Guerrieri, Nederkoorn, Schrooten, Martijn & Jansen (2009) reported that current dieters seem to reduce their caloric intake following the impulsivity induction, while restrained eaters seem to consume more after eating forbidden foods (Stroebe, 2008). In opposition to dieters, even if restrained eaters are continuously worried about what they eat and try to limit intake eating, these restrictions are not enough to lose weight, but to prevent weight gain instead (Benton & Young, 2017). Methodological differences have been also described. Thus, while attempt to diet appears to measure from intentions to diet to actual restrictive behaviours (Allison, Allison & Baskin, 2009), dieting focuses rather on actual restrictive behaviour. Other distinction between these constructs is the purpose of restricting caloric intake. Whereas restraint scales assess motivation to avoid weight gain, the term dieting as well as the most of the measures used to assess it reflects the intention to lose weight (Lowe

et al., 2013). In this vein, our findings add support to the Lowe (1993)'s postulates claiming that restrained eating and dieting are different factors; and against the restraint theory (Herman & Mack, 1975; Polivy & Herman, 1985), which implies that both concepts can be used interchangeably.

Regarding our last hypothesis in terms of a direct association between hunger and high-calorie foods in those without previous attempts of dieting, our results were again only partially congruent: higher level of hunger predicted the selection of more high-calorie salty food items and more food chosen but regardless of previous dieting attempt condition. This suggests that young adolescents, even those who exhibit a cognitive restrained eating style, do not ignore hunger and fullness sensations. Indeed, these sensations are still important in their daily lives to determine food preferences and prospective intake. Interestingly, given that restrained individuals have been characterized to be more unresponsive to internal hunger state (e.g., Heatherton, Polivy & Herman, 1989), it remains to be explored whether differences in the ability to translate hunger sensations into food choices and selection between cognitive restrainers and non-restrainers occurs. Moreover, that high-calorie food selection may be predicted by both hunger level and the cognitive restraint eating style during early adolescence is especially noteworthy from a progression point of view. That suggests that, while the individuals may develop a dependence on the cognitive regulatory mechanisms, the natural physiological signals of hunger are still relevant in the control of eating. Whether early adolescence might be understood as a transition period shifting from physiological to cognitive control over how much and what to eat, as observed in adult restrainers, remains to be demonstrated. In any case, early adolescence is of particular significance for prevention and intervention to the extent that it is seen as a critical period for the crystallization of dieting behaviours.

An advantage of this study was the focus on late childhood and early adolescence as this particular time period offers a unique window to study the acquisition of food restriction behaviour in general, and the relationship between dieting and weigh gain in particular. For instance, research on the onset of dieting may facilitate our understanding of how restrainers start to ignore hunger signals to maintain weight loss efforts and try to maintain control of their eating over diet-disrupting influences. Unfortunately, the physiological and cognitive processes measured by the present study do not seem to be sufficient to explain variations in body weight status. Indeed, no significant correlations between self-reported hunger or restrained eating scores with BMI were found here. More complex mechanisms have been suggested, including the possibility that feelings (or being) overweight and/or the fear of weight gain create a circular pattern embarking some subjects on a restrictive diet with the experience of constant hunger until the point that they are engaged in disinhibited eating and relieved by the over-ingestion of food. Then, another round of dieting is followed (e.g., Heatherton & Polivy, 1992; Polivy & Heatherton, 2015).

It should be mentioned that this is the first study that explores early adolescence food choice and dieting in a virtual reality environment to our knowledge. Taking into account that many studies have showed that data collection in real life and VR results in similar findings, with high correlation between the adult food choice in a virtual food buffet and in a fake food buffet (Ung et al., 2018) or even between virtual supermarket and real life without differences in terms of food selection (Siegrist et al., 2018; Visschers, Hess, & Siegrist, 2010; Xu et al., 2021), our methodology using a VR environment appears to be a promising tool for adolescent food research (Riva, Gutiérrez-Maldonado, Dakanalis & Ferrer-García, 2019). Nevertheless, further studies are needed to validate this procedure for the assessment of adolescent eating behaviour

448 in ecologically valid and highly controllable way (Botella, Baños, García-Palacios &
449 Quero, 2017).

450 Other important advantage of VR in the research of feeding habits is to deal with the
451 difficulty in getting some foods (especially warm foods) or to reduce the waste of food
452 and the economic resources compared to those using real food in the research of food
453 choice (Ung et al., 2018). Finally, while a variety of methods have been to assess food
454 consumption behaviour in adolescents, VR could be one of the most attractive. To the
455 extent that adolescents and young adults are familiar and enjoy technology in many
456 areas of their lives, this methodology could help to increase motivation to participate in
457 eating research (e.g., Celikcan et al., 2018).

458 Some limitations should however be addressed. We recruited participants from two
459 schools of Granada; the relatively modest sample size for a cross-sectional descriptive
460 study might limit the generalizability of the findings. In addition, this study was carried
461 out to explore associations between eating-related predictors and the outcome of interest
462 at one time point. Therefore, no indication of the sequence of events (e.g., whether high
463 BMI occurred before, after or during the onset of dieting) can be included. This being
464 so, it is impossible to infer causality.

465 In summary, both physiological (hunger) and cognitive (restraint eating)
466 mechanisms seem to be involved in adolescent selection and prospective intake of high-
467 calorie foods. How overeating of these foods is triggered by dieting to the extent to
468 result in weight gain remains to be explored. In order to do so, VR methodology appears
469 as a valid and useful tool to recreate the conditions of adolescent food selection in
470 laboratory settings. Given the high prevalence of unhealthy weight control behaviours
471 early in the development, and the associations between these practices and long-term

weight gain and serious restrictive food behaviours, more research is needed during the first steps of dieting.

Author contributions

All authors contributed to all phases of this study and have approved the final manuscript.

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627 **Figure captions**

628

629 Figure 1. Two examples of the virtual reality scenarios with the free buffet restaurant.

630 Figure 2. Two examples of food items integrated in virtual environments.

631 Figure 3. Differences between dieters and non-dieters in body mass index percentile
632 determined by age- and gender-specific reference values for each participant.

633

634 Table 1. Differences between dieters and non-dieters in valence, arousal, desire and
635 organoleptic properties for every category of food images.
636

Food category	Property	Non-dieter	Dieter	F (1,59)	μ^2
Vegetables	Valence	4.89 (±1.56)	6.05 (±1.77)	7.27**	.111
	Arousal	3.99 (±1.51)	5.20 (±1.67)	8.57**	.129
	Desire	4.11 (±1.84)	5.37 (±1.77)	7.09**	.109
	Appearance	4.47 (±1.60)	3.54 (±1.58)	5.03*	.081
	Smell	4.76 (±1.60)	3.96 (±1.64)	3.63	.059
	Taste	4.40 (±1.74)	3.70 (±1.69)	2.41	.040
	Aftertaste	5.04 (±1.60)	4.30 (±1.68)	2.99	.049
	Appetizing	5.28 (±1.80)	4.70 (±2.21)	1.24	.021
Fruits	Valence	6.05(±1.29)	7.61 (±1.00)	26.41**	.313
	Arousal	5.15 (±1.69)	6.34 (±1.48)	8.25**	.125
	Desire	5.28 (±1.77)	6.78 (±1.29)	13.02**	.186
	Appearance	3.03 (±1.19)	2.29 (±1.09)	6.11*	.095
	Smell	3.70 (±1.31)	2.56 (±1.15)	12.36**	.176
	Taste	3.20 (±1.36)	2.14 (±0.89)	12.03**	.172
	Aftertaste	3.79 (±1.41)	2.62 (±0.94)	13.42**	.188
	Appetizing	3.86 (±1.53)	2.81 (±1.23)	8.31**	.125
Sweet items	Valence	6.25 (±1.67)	6.67 (±1.33)	1.15	.019
	Arousal	5.33 (±1.99)	5.80 (±1.64)	0.94	.016
	Desire	5.51 (±2.06)	6.01 (±1.35)	1.12	.019
	Appearance	2.73 (±1.47)	2.83 (±1.09)	0.079	.001
	Smell	3.38 (±1.39)	3.16 (±1.15)	0.44	.008
	Taste	2.97 (±1.45)	2.74 (±1.12)	0.48	.008
	Aftertaste	3.26 (±1.42)	3.14 (±1.21)	0.11	.002
	Appetizing	3.73 (±1.86)	4.06 (±1.75)	0.47	.008
Salty items	Valence	6.66 (±1.29)	7.36 (±1.22)	4.61*	.074
	Arousal	5.86 (±1.60)	6.43 (±1.70)	1.79	.030
	Desire	6.01 (±1.68)	6.77 (±1.50)	3.34	.055
	Appearance	3.21 (±1.14)	2.66 (±1.25)	3.16	.052
	Smell	3.10 (±1.06)	2.71 (±1.39)	1.46	.025
	Taste	2.51 (±1.14)	2.30 (±1.16)	0.50	.009
	Aftertaste	3.03 (±1.09)	2.66 (1.18)	1.56	.026
	Appetizing	3.36 (±1.47)	3.35 (±1.96)	0.001	.000

637 Note: Values are expressed as mean (± standard error of the mean). * indicates $p < .05$, **
638 indicates $p < .0$ l.

Table 2. Hierarchical regression analysis of predictors on the number of total food items and number of food by caloric density.

Variable		Number of high-calorie food items[a]			Number of low-calorie food items[b]			Number of total food items[c]		
		B	**SE B**	**Beta**	**B**	**SE B**	**Beta**	**B**	**SE B**	**Beta**
Model 1										
	Constant	-2.43	6.00		0.02	6.42		-1.43	9.86	
	BMI	-0.01	0.01	-0.05	0.09	0.01	0.25	0.01	0.02	0.12
	IPQ score	0.08	0.04	0.27	-0.18	0.09	0.29	0.17	0.07	0.35*
	Age	0.28	0.38	0.10	0.08	0.41	-0.06	0.10	0.63	0.02
	Gender	-0.44	0.59	-0.10	3.71	0.63	0.02	-0.37	0.96	-0.05
Model 2										
	Constant	1.39	5.61		0.02	6.80		5.10	10.02	
	Restrained eating score	-1.46	0.56	-0.38*	-0.83	0.67	-0.21	-2.29	0.99	-0.37*
	Hunger score	0.40	0.13	0.41**	-0.14	0.16	-0.13	0.26	0.23	0.16
	Dieting attempt	0.80	0.68	0.19	0.93	0.82	0.21	1.72	1.21	0.25
Model 3										
	Constant	1.18	5.82		3.91	6.74		5.09	10.35	
	Dieting attempt x Hunger score	-0.19	0.25	-0.22	0.56	0.28	0.63	0.37	0.44	0.27
	Dieting attempt x Restrained eating score	-0.25	1.25	-0.15	1.25	1.45	0.70	1.00	2.23	0.36

Note:

[a]R2=.01 for Model 1, ΔR2= .33 for Model 2 ($F(3,49)=5.57$, $p<.01$), ΔR2= .34 for Model 3 ($F(2,47)=0.33$, $p=.72$).

[b]R2=.07 for Model 1, ΔR2= .12 for Model 2 ($F(3,49)=0.80$, $p=.50$), ΔR2= .20 for Model 3 ($F(2,47)=2.59$, $p=.85$).

[c]R2=.10 for Model 1, ΔR2= .21 for Model 2 ($F(3,49)=2.60$, $p=.05$), ΔR2= .23 for Model 3 ($F(2,47)=0.53$, $p=.59$).

*p<.05. **p<.01.

Table 3. Hierarchical regression analysis of predictors on the number of items by the type of food (sweet, salty, vegetable and fruit).

Variable		Number of sweet food items[a]			Number of salty food items[b]			Number of vegetable food items[c]			Number of fruit food items[d]		
		B	**SE B**	**Beta**	**B**	**SE B**	**Beta**	**B**	**SE B**	**Beta**	**B**	**SE B**	**Beta**
Model 1													
	Constant	0.07	4.46		-2.50	4.42		2.70	3.90		-1.71	4.23	
	BMI	-0.01	0.01	-0.09	0.01	0.01	0.02	-0.01	0.01	-0.02	0.02	0.01	0.37
	IPQ score	0.03	0.03	0.14	0.05	0.03	0.23	-0.09	0.25	-0.05	-0.09	0.27	-0.05*
	Age	0.02	0.29	0.01	0.26	0.28	0.13	-0.30	0.38	-0.11	0.37	0.41	0.12
	Gender	-0.01	0.44	-0.01	-0.44	0.43	-0.14	0.09	0.03	0.04	0.08	0.03	0.39
Model 2													
	Constant	1.67	4.71		-0.28	4.17		3.78	4.19		-0.07	4.45	
	Restrained eating score	-0.55	0.47	-0.20	-0.91	0.41	-0.33*	-0.34	0.42	-0.15	-0.49	0.44	-0.18
	Hunger score	0.10	0.11	0.14	0.30	0.10	0.42**	-0.01	0.10	-0.02	-0.13	0.10	-0.18
	Dieting attempt	-0.01	0.57	-0.01	0.80	0.51	0.26	0.23	0.51	0.09	0.69	0.54	0.23
Model 3													
	Constant	1.09	4.86		0.09	4.35		3.67	4.29		0.09	4.35	
	Dieting attempt x Hunger score	-0.22	0.21	-0.36	0.03	0.18	0.05	0.21	0.18	0.39	0.35	0.19	0.58
	Dieting attempt x Restrained eating score	0.12	1.05	0.10	-0.37	0.94	-0.30	0.65	0.92	0.62	0.56	0.96	0.49

Note:

[a]R2=.04 for Model 1, ΔR2= .09 for Model 2 (F(3,49)=0.90, p=.45), ΔR2= .11 for Model 3 (F(2,47)=0.56, p=.57).

[b]R2=.08 for Model 1, ΔR2= .30 for Model 2 (F(3,49)=5.16, p<.01), ΔR2= .30 for Model 3 (F(2,47)=0.08, p=.92).

[c]R2=.02 for Model 1, ΔR2= .03 for Model 2 (F(3,49)=0.23, p=.88), ΔR2= .07 for Model 3 (F(2,47)=1.04, p=.36).

[d]R2=.14 for Model 1, ΔR2= .19 for Model 2 (F(3,49)=1.03, p=.34), ΔR2= .26 for Model 3 (F(2,47)=2.16, p=.13).

*p<.05. **p<.01.

Figure 1 Two examples of the virtual reality scenarios with the free buffet restaurant.

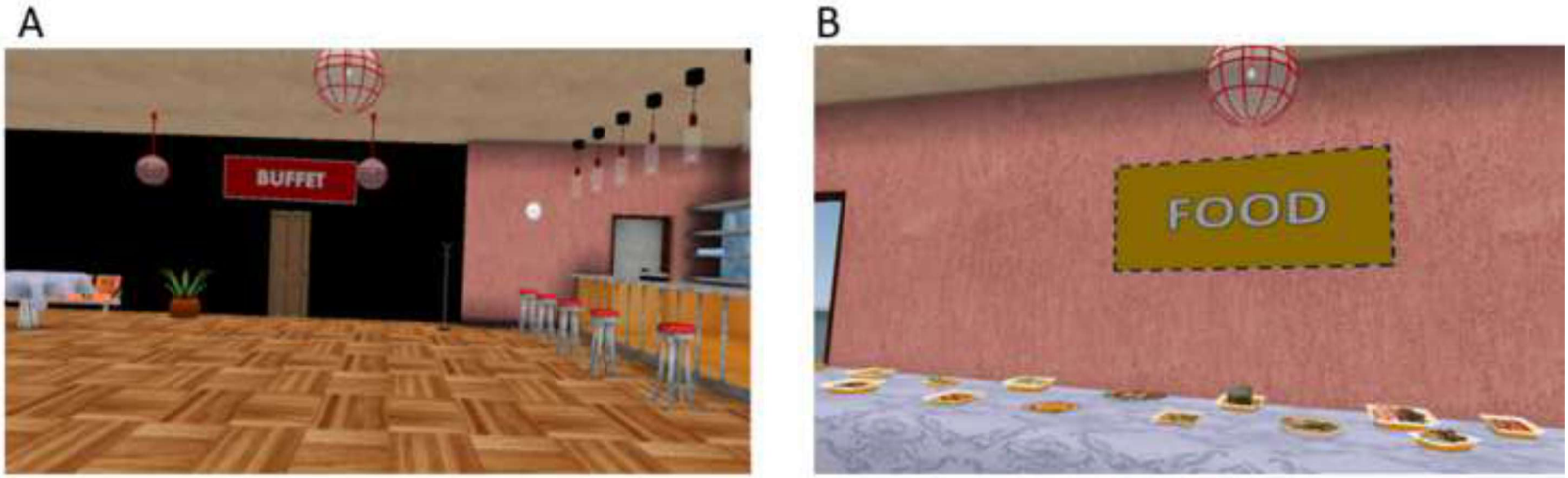


Figure 2 Two examples of food items integrated in virtual environments.

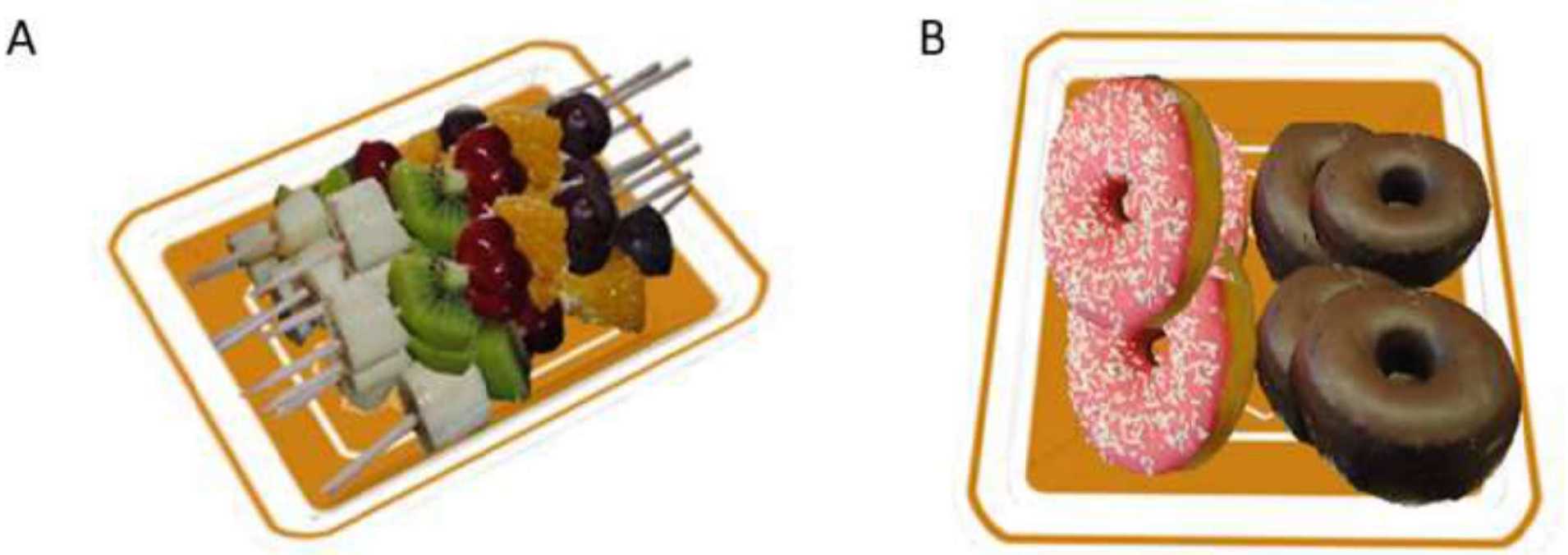
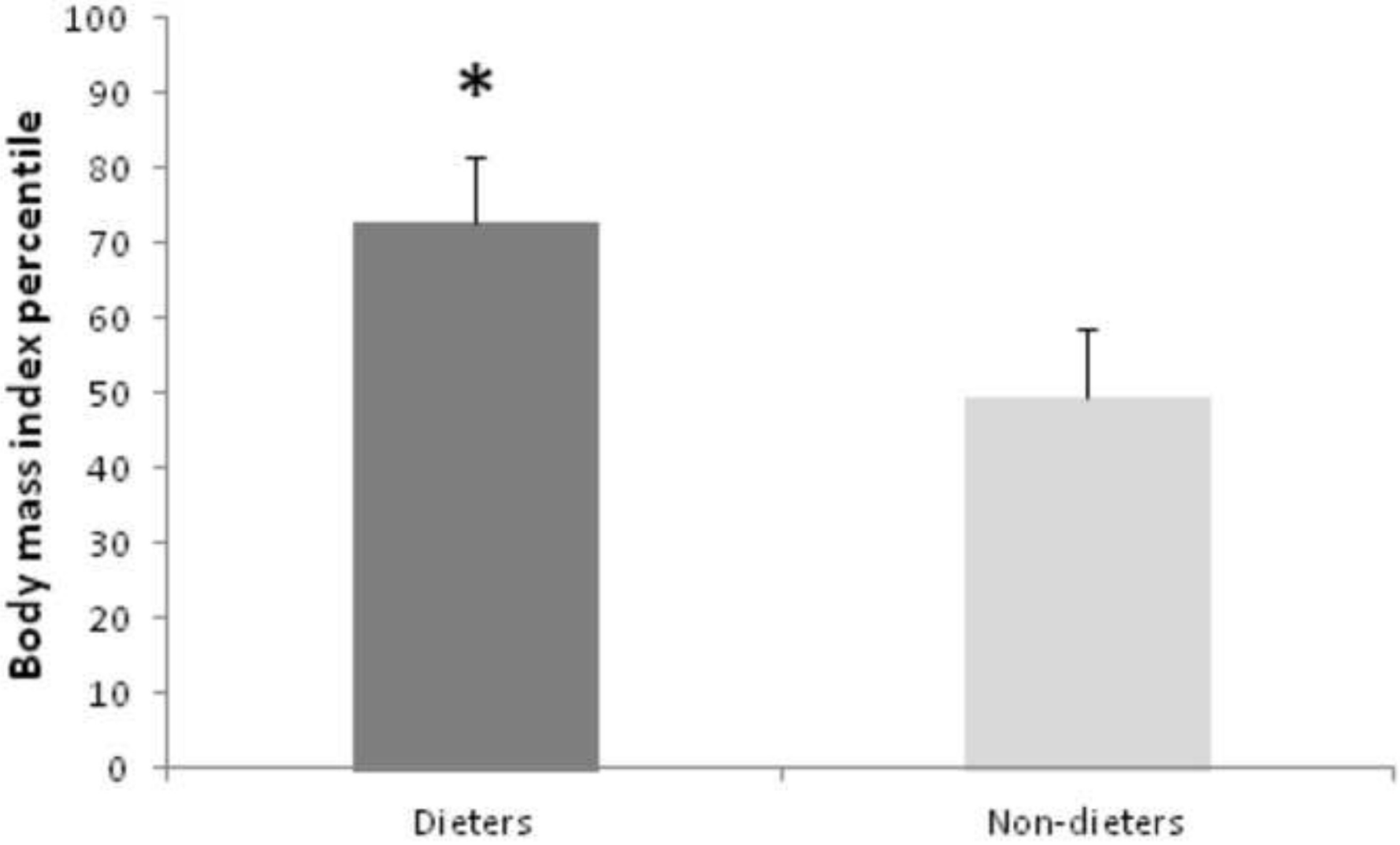


Figure 3 Differences between dieters and non-dieters in body mass index percentile determined by age- and gender-specific reference values for each participant.



DISCUSIÓN

DISCUSIÓN GENERAL

El desarrollo de los tres estudios de esta tesis tiene como objetivo evaluar la validez de la RV para su uso en la investigación y tratamiento de los trastornos de ansiedad y los trastornos de alimentación, profundizando en dos áreas realmente novedosas como son la MPA y el comportamiento alimentario temprano.

El objetivo del Estudio 1 era conocer las características del trastorno de MPA, determinando las variables que lo predicen en estudiantes de conservatorio. Un total de 295 músicos de entre 15 y 68 años, estudiantes de conservatorios andaluces, fueron evaluados mediante el KMPAI para obtener información sobre su nivel de MPA. También completaron una batería de cuestionarios sobre variables socio-demográficas, práctica musical, procesos de aprendizaje musical y otras variables relacionadas con la salud física y psicológica de los músicos. A partir de estos datos, se realizó un modelo de regresión para determinar la contribución de estas una variables en la predicción de MPA. Los resultados señalaron la existencia de un modelo compuesto por la combinación de variables pertenecientes a diferentes categorías que han mostrado que contribuyen al desarrollo del MPA de manera individualizada (Nusseck, Zander, y Spahn, 2015; Dobos, Piko, y Kenny, 2018). El modelo final señaló que las variables psicológicas son las que mayor peso tienen para predecir MPA (Barbar et al., 2014; Vaag, Bjørngaard y Bjerkeset 2016; Nicholson, Cody, y Beck, 2015; Bobos et al., 2018), siendo las variables sociodemográficas o de aprendizaje musical poco relevantes. La edad de la primera actuación en público fue la única variable de práctica musical con suficiente poder para predecir MPA, encontrando una relación positiva entre edad de comienzo de la práctica musical y el desarrollo del MPA. Nuestro modelo sugiere que una mayor edad en la primera exposición en público se asocia con una mayor probabilidad de desarrollar MPA (Bucher y Ryan, 2011).

El estudio 2, se diseñó a partir de los resultados obtenidos en este primer estudio. Así, los entornos virtuales desarrollados se inspiran en las situaciones donde los músicos manifestaban sufrir altos niveles de ansiedad durante la actuación en vivo. Además, de la muestra de 295 músicos que participaron en el estudio anterior, se seleccionaron a 30 músicos con altas y bajas puntuaciones en el KMPAI. El objetivo principal del Estudio 2 era estudiar las respuestas psicofisiológicas del MPA durante la interpretación en público, así como evaluar la capacidad de la RV para recrear una

situación de interpretación en público y generar ansiedad. Para ello se realizó un entorno virtual ad hoc consistente en un camerino y un auditorio con público. Se registró los cambios en la actividad cardíaca, conductancia eléctrica de la piel y actividad electromiográfica del cigomático y del corrugador, antes durante y después de una interpretación musical.

Los resultados mostraron que, a pesar de que los participantes con alto MPA informaban de mayores niveles de ansiedad después de la ejecución virtual y en general comparados con bajo MPA, no se observaron diferencias en los niveles de activación fisiológica entre grupos. Aunque tradicionalmente se ha supuesto que debe existir un correlato entre el arousal informado y el arousal fisiológico, nuestros datos parecen indicar que probablemente los músicos con alto MPA sean más sensibles al arousal fisiológico, etiquetándolo emocionalmente como algo negativo (Schachter and Singer, 1962). Esta interpretación estaría en consonancia con la mayor actividad del músculo corrugador durante la actuación. Tal y como esperábamos, el grupo con altos niveles de MPA manifestó también una mayor activación del músculo corrugador ante los estímulos distractores durante la actuación, indicando que estos estímulos son percibidos como más desagradables que el grupo de bajo MPA.

Respecto a las diferentes fases, los resultados mostraron un mayor nivel de activación durante la fase de interpretación en relación con la fase de preparación y post-actuación, manifestada en un incremento de la frecuencia cardiaca en todos los participantes. Estudios previos registrando la actividad cardíaca en actuaciones reales, obtiene resultados similares, indicando una mayor activación durante la actuación en comparación con las fases posterior o anterior al concierto (Fredrikson and Gunnarsson, 1992). Sin embargo, el patrón contrario en la conductancia eléctrica de la piel, se caracterizó por una disminución de la respuesta durante la actuación en comparación con las otras fases. A modo tentativo, estos resultados podrían relacionarse con un rechazo sensorial hacia los estímulos externos para mantener la atención en la ejecución. Según Lacey (1967), la atención a estímulos externos se asocia con la desaceleración cardíaca, mientras que el rechazo de estímulos externos se acompaña de la activación cardíaca. Respecto a la respuesta de SCR, la atención a estímulos externos se asocia con una mayor amplitud de la respuesta (Dawson, Schell y Filion, 2007). Podemos entender que durante la interpretación en público los músicos evitan responder a estímulos externos mientras dirigen la atención a actividades cognitivas internas, por lo que tendría sentido una disminución en la respuesta de conductancia mientras se produce una activación cardíaca.

Tomados en conjunto, nuestros resultados parecen indicar la validez de la RV para estudiar la MPA. La RV es una técnica que en los últimos años está siendo plenamente utilizada en el campo de la MPA por sus numerosas ventajas. Entre ellas, el experimentador puede controlar los eventos que ocurren en el mundo virtual, y el sujeto experimental se mantiene seguro en un ambiente protegido para poder aplicar lo aprendido en un ambiente real (Botella el al., 2007). También elimina la dificultad de encontrar entornos adecuados para la experimentación, como auditorios o escenarios con la disponibilidad de público (Bissonnete y Dubé, 2016). Así, la RV es una herramienta muy eficaz para para generar situaciones de conciertos en público, o ensayos con gente, situaciones difícilmente recreables en ambientes reales y que facilitaría la intervención y tratamiento de los problemas de MPA

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Por último, el Estudio 3 tenía como objetivos estudiar las características implicadas en la selección de alimentos y su relación con la conducta alimentaria temprana, así como conocer la eficacia de la RV y del paradigma del bufé virtual para el estudio de la conducta alimentaria temprana. Para ello se creó un entorno virtual consistente en un bufé libre con distintos alimentos (salados, dulces, vegetales y frutas) en el que 60 alumnos y alumnas de 4º de la ESO podían elegir todos los que quisieran para su consumo virtual. Con los datos de elección de alimentos obtenidos, se construyó un modelo de regresión hierática que ayudó a predecir las variables que favorecían la elección de cierta cantidad y tipos de alimentos. Los resultados de este modelo predictivo mostraron que una alta puntuación en el comportamiento restrictivo predecía un menor número de alimentos escogidos en total, especialmente la elección de un menor número de alimentos de altas calorías y de alimentos salados. Otros estudios realizados en entornos reales, señalan también una relación inversa entre la ingesta calórica y el comportamiento restrictivo. Wardle y Beales (1987) encontraron que la ingesta de alimentos en las últimas 24 horas se correlacionó negativamente con el nivel de restricción que auto informaban en el Dutch Eating Behaviour Questionnaire (DEBQ; Van Strien y Oosterveld, 2008) de forma que aquellas cuyo comportamiento restrictivo era alto, habían ingerido menor cantidad de comida. También se encuentra como las personas que puntúan alto en la escala de alimentación restringida comen menos calorías de las necesarias para mantener su peso corporal actual, ingiriendo menos contenido de grasas y azúcar (Van Strien et al., 1986). Respecto a la variable de hambre, una alta puntuación predecía un mayor número de alimentos escogidos en total, especialmente la elección de un mayor número de alimentos de altas calorías y

de alimentos salados. Así, los adolescentes, incluso aquellos que tienen un estilo de alimentación cognitivo restringido, no ignoran las sensaciones de hambre y saciedad, siendo relevantes para determinar las preferencias alimentarias y la ingesta. Estos datos sugieren también que, si bien los individuos pueden desarrollar una dependencia de los mecanismos reguladores cognitivos, las señales fisiológicas naturales del hambre siguen siendo relevantes en el control de la alimentación.

Los resultados confirman que la RV es un entorno de laboratorio válido en el que ampliar conocimientos y validar resultados obtenidos previamente en entornos reales con población sana y adolescente. Hasta ahora, la RV se había postulado como una herramienta válida para elicitar estados emocionales en pacientes con TCA (Gutiérrez-Maldonado, Ferrer-García, Caqueo-Urízar y Letosa- Porta, 2006; Ferrer-García, Gutiérrez-Maldonado, Caqueo-Urízar y Moreno, 2009; Aimé, Cotton y Bouchard, 2009) y, por tanto, útil para utilizarse con fines evaluativos y experimentales en el laboratorio. Entre las ventajas que se encuentran en la experimentación con RV en el campo de los trastornos de la alimentación y del comportamiento alimentario se encuentran el equilibrio entre la validez interna y ecológica, permitiendo un completo control de las simulaciones de RV. Además, permite a los sujetos realizar tareas idénticas a las realizadas en la vida real, como es el caso de elegir alimentos para su consumo (Riva et al., 2019), pero en este caso evitando el derroche de alimentos naturales, poco disponibles o difíciles de elaborar o de mantener frescos.

Queda expuesto que la RV funciona como un entorno de laboratorio válido en la investigación en psicología, especialmente en las áreas relativamente novedosas que se tratan en esta tesis doctoral: la ansiedad escénica musical y la conducta alimentaria temprana. Desde este punto, se augura un futuro prometedor al uso de la RV en el laboratorio gracias a las numerosas ventajas que presenta para investigadores y profanos en el desarrollo de entornos virtuales. Hasta hace poco, la implementación de la RV en el laboratorio tenía que hacerse a través de técnicos o ingenieros informáticos, pero a día de hoy la RV se encuentra al alcance de todo el mundo de una forma sencilla y económica. Tanto el hardware como el software necesario para poder elaborar y trabajar en un entorno de RV son cada vez más accesibles a nivel económico, adaptándose los diferentes requerimientos técnicos a precios muy populares. Respecto al software, se pueden encontrar numerosos programas de creación de entornos virtuales compatibles con todos los hardware del mercado. Es el caso de los usados en esta tesis, WorldViz (https://www.worldviz.com)

y NeuroVR (http://www.neurovr.org; Riva et al., 2011). Por otro lado, cada vez hay más diversidad de hardware de diferentes precios y requerimientos, encontrándose siempre una opción accesible. Así, se puede encontrar desde dispositivos HMD a precios económicos que funcionan con un smartphone, hasta costosos equipos de CAVE con altos requerimientos técnicos.

En resumen, es una realidad que la RV está cada vez más accesible en el mundo científico, suponiendo una alternativa factible y plausible a la experimentación en vivo en la investigación en psicología, así como a otras técnicas de exposición como la imaginación o la exposición con imágenes o fotografías.

CONCLUSIONES

CONCLUSIONES GENERALES

Las principales conclusiones de la presente tesis doctoral son las siguientes:

1) La MPA es una problemática relevante en la población de estudiantes de música, y por tanto se justifica su inclusión en este estudio.

a) Las variables psicológicas son las que mejor predicen la MPA, mientras que las variables sociodemográficas y las relacionadas con el aprendizaje musical tienen poca relevancia.

b) La edad de la primera actuación en público es la única variable de entrenamiento musical con suficiente poder para predecir MPA.

2) El entorno de RV elaborado ad hoc para el Estudio 2 funciona como un entorno de laboratorio válido para el estudio del MPA, ya que valida resultados obtenidos en vivo en el estudio de las respuestas psicofisiológicas tanto en MPA como en otros trastornos de ansiedad. Además, tiene la habilidad de ampliar nuevos conocimientos.

a) Al igual que se concluye en estudios realizados en vivo, los músicos con alta y baja MPA no muestran diferencias en las respuestas fisiológicas de arousal en relación con la interpretación.

b) Los músicos con alta MPA muestran mayor actividad del músculo corrugador durante la actuación en público, reflejando una mayor valoración negativa de la situación de concierto.

c) Se replican resultados de estudios llevados a cabo en vivo, donde se produce un mayor nivel de activación durante la fase de interpretación en relación con la fase de preparación y post actuación, manifestada en un incremento de la frecuencia cardiaca en todos los participantes.

d) Todos los músicos muestran las respuestas fisiológicas típicas de la realización de una tarea cognitiva interna que evita prestar atención a los estímulos externos, aumentando la frecuencia cardiaca y disminuyendo la conductancia eléctrica de la piel mientras están tocando.

3) El entorno de RV elaborado ad hoc para el Estudio 3 funciona como un entorno de laboratorio válido para el estudio de la conducta alimentaria en adolescentes sanos, pues replica resultados obtenidos previamente en entornos reales con esta población y favorece la generación de conocimiento.

a) Tal y como se describe en estudios llevados a cabo en vivo, los adolescentes con mayor comportamiento restrictivo consumen menos alimentos especialmente aquellos de altas calorías o alimentos salados.
b) Se refuta la relación entre hambre y consumo de alimentos obtenida en estudios en vivo, donde los niveles de hambre fisiológica se relacionan con un mayor consumo de alimentos en total, especialmente un mayor número de alimentos de altas calorías y de alimentos salados.
c) El hecho de hacer dieta no es un factor relevante a la hora de relacionar la conducta restrictiva y hambre fisiológica con el número y tipo de alimentos consumidos.

4) La capacidad de presencia que manifiestan los sujetos tras su participación en los entornos virtuales ratifica que estos fueron clínicamente significativos en su comportamiento dentro de la experiencia virtual.

5) Podemos confirmar que la RV funciona como un entorno de laboratorio válido en la investigación en psicología, especialmente en las áreas relativamente novedosas que se tratan en esta tesis doctoral: la ansiedad escénica musical y la conducta alimentaria temprana.

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