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Ph.D Thesis

La Neurociencia como Instrumento para medir la Eficacia de la Publicidad en Medios Audiovisuales

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Resumen

El proceso de evaluar la eficacia en publicidad es una tarea complicada. Para poder cumplir con los requisitos de los clientes, el publicista está acostumbrado a apoyarse en los criterios objetivos que garantizan las soluciones de la propuesta de comunicación. Así como los aspectos subjetivos del creativo, como la estética, la música, el argumento, y el formato, suelen ser abordados según un criterio creativo.

El objetivo de este trabajo es proponer y evaluar experimentalmente una metodología que, mediante la combinación de las respuestas psicofisiológicas, los modelos de aprendizaje automático y las técnicas tradicionales permita cuantificar y predecir, de una forma científica y metódica, el impacto emocional y cognitivo de la publicidad audiovisual.

Para ello han planteado 3 estudios experimentales que investigan diferentes características de la metodología propuesta: investigar la capacidad de medidas que provienen de la neurociencia para predecir la eficacia de la publicidad. El segundo plantea comparar el efecto de un nuevo tipo de publicidad más inmersiva de video 360º en frente de la publicidad audiovisual clásica en formato video estándar. Y el tercero la evaluación de la música en el contexto de la congruencia e incongruencia musical aplicado en los anuncios de TV.

En cuanto al estudio del impacto de la música en los anuncios se investigó los resultados de las reacciones emocionales y cognitivas de los sujetos durante la exposición a anuncios de televisión con música congruente e incongruente. Se analizaron las señales de electroencefalografía (EEG) y eye tracking (ET) de un grupo de 90 personas que vieron 6 anuncios de televisión. Los resultados mostraron que la música congruente genera niveles más altos asimetría prefrontal cerebral asociada al procesamiento positivo emocional. Por otro lado, los anuncios incongruentes con música alegre mostraron mayor nivel de atención y carga cognitiva, generando mayor recuerdo que los anuncios con música congruente. El estudio demostró, por tanto, la validez del empleo de técnicas basadas neurofisiología para evaluar el impacto de la música en los anuncios.

En el segundo estudio se comparó la eficacia de un nuevo tipo de publicidad audiovisual mediante video 360º en la que el usuario tiene una mayor capacidad de interacción frente anuncios audiovisuales clásicos (2D) en los que el visionado carece de interacción. Se comparo el impacto en términos de atención visual, reconocimiento de marca, compromiso y emociones. Las herramientas que se utilizaron fueron señales neurofisiológicas como la electroencefalografía, variabilidad cardiaca, seguimiento ocular y codificación facial. Se compararon cuatro anuncios existentes para bienes duraderos y bienes de consumo de alta rotación. En los resultados se determinó que la mirada depende del contenido del anuncio, que la atención visual es menor en los anuncios de 360º así como el reconocimiento del logo de la marca. Los productos duraderos son los que generan más emociones positivas y el nivel de engagement. Este tipo de metodología ayudara por tanto a cuantificar el mejor formato según la estrategia de contenidos.

En el último estudio se investigó la efectividad de los nuevos canales digitales de comunicación (YouTube) para predecir el número de visitas mediante el uso de las redes neuronales artificiales y nuevas métricas basadas en neurociencia extraídas de la electroencefalografía, eye tracking y variabilidad cardíaca. Se descubrieron correlaciones significativas entre la respuesta psicofisiológica del sujeto y la efectividad de los anuncios ponderada como el número de visitas en el canal de YouTube que tubo a posteriori ese anuncio.

Esta tesis proporciona por tanto contribuciones novedosas en cuanto al uso de la neurociencia y la inteligencia artificial en la investigación del impacto de la publicidad. La neurociencia del consumidor o neuromarketing puede ayudar a la aplicación de metodologías para la valoración de los estímulos audiovisuales desde una perspectiva más exacta y precisa. Además, creando modelos de aprendizaje automático podemos predecir las respuestas de los usuarios ante los diferentes estímulos publicitarios creando campañas más eficaces y económicas. El desarrollo de metodologías basadas en neuromarketing como las validadas en este Tesis, revolucionará los métodos de evaluación de contenidos audiovisuales en el campo de la publicidad. La presente tesis tiene como objetivo contribuir a este progreso aportando el conocimiento obtenido para ser de utilidad a los investigadores y publicistas interesados en medir la eficacia de la publicidad.

Resum

El procés d'avaluar l'eficàcia en publicitat és una tasca complicada. Per poder complir amb els requisits dels clients, el publicista està acostumat a recolzar-se en els criteris objectius que garanteixen les solucions de la proposta de comunicació. Així com els aspectes subjectius de l'creatiu, com l'estètica, la música, l'argument, el format, solen ser abordats segons un criteri creatiu.

L'objectiu d'aquest treball és proposar i avaluar experimentalment una metodologia que, mitjançant la combinació de les eines, tecnologia de respostes psicofisiològiques, models d'aprenentatge automàtic i les tècniques tradicionals permeti obtenir, d'una manera científica i metòdica, la resposta dels usuaris davant els anuncis de TV per obtenir la informació necessària per aportar valor a la publicitat.

Per a això es plantegen 3 estudis experimentals que investiguen diferents característiques de la metodologia proposada: investigar la capacitat de les eines de neurociència per predir l'eficàcia de la publicitat. El segon planteja mesurar l'eficàcia de Els anuncis segons el format de la publicitat, 2D vs 360º. I el tercer l'avaluació de la

música en el context de la congruència i incongruència musical aplicat en els anuncis de TV.

L'estudi on comparem l'eficàcia de la publicitat de 360º vs els anuncis estàtics (2D) en termes d'atenció visual, reconeixement de marca, compromís i emocions. Les eines que es van utilitzar van ser eines neurofisiològiques com l'electroencefalografia, variabilitat cardíaca seguiment ocular i codificació facial. Es van comparar quatre anuncis existents per a béns duradors i béns de consum d'alta rotació. En els resultats es mostra que la mirada depèn de l'contingut de l'anunci, l'atenció visual és menor en els anuncis de 360º així com el reconeixement de l'logotip de la marca. Els productes duradors són els que generen més emocions positives i el nivell d'engagement. El que comporta tenir-ho en compte per generar una estratègia de continguts que és el que es desenvolupa en el capítol 2.

Pel que fa a l'estudi de l'impacte de la música en els anuncis es va investigar els resultats de les reaccions emocionals i cognitives dels subjectes durant l'exposició a anuncis de televisió amb música congruent i incongruent. Es van analitzar els senyals de electroencefalografia i eye tracking d'un grup de 90 persones que van veure 6 anuncis de televisió. Els resultats mostres que la música congruent genera nivells més alts asimetria prefrontal que representa el gust cerebral. Així com els anuncis incongruents amb música alegre tenen major nivell d'atenció i càrrega cognitiva, generant major recordo que els anuncis amb música congruent. Demostrant la validesa de les tècniques de neurofisiologia per avaluar l'impacte de la música en els anuncis.

En l'últim estudi es va investigar l'efectivitat dels nous canals digitals de comunicació (YouTube) per predir mitjançant l'ús de les xarxes neuronals artificials i mètriques basades en neurociències com l'electroencefalografia, eye tracking, variabilitat cardíaca. Es va descobrir les correlacions significatives entre les mètriques de la neurociència i l'efectivitat dels anuncis i el nombre de visites al canal de Youtube. Creant una predicció d'un 82,9% la precisió mitjana i les visualitzacions en línia.

Aquesta tesi proporciona contribucions noves a l'ús de la neurociència en la investigació de l'comportament humà, particularment en el consumidor i com li afecta la presa de decisions. La neurociència de el consumidor pot ajudar a l'aplicació de metodologies per a la valoració dels estímuls audiovisuals des d'una perspectiva més exacta i precisa. A més, creant models d'aprenentatge automàtic podem predir les respostes dels usuaris davant els diferents estímuls publicitaris creant campanyes més eficaces i econòmiques. Creiem fermament que el neuromarketing revolucionarà els mètodes d'avaluació de continguts audiovisuals i de presa de decisions. La present tesi té com a objectiu contribuir a aquest progrés.

Els resultats d'aquesta tesi poden ser d'utilitat per als investigadors i publicistes interessats a conèixer millor el comportament de consumidor.

ABSTRACT

The process of evaluating advertising effectiveness is a complicated task. In order to meet customer requirements, the advertiser is used to relying on objective criteria that guarantee the solutions of the communication proposal. As well as the subjective aspects of the creative, such as aesthetics, music, plot, format, they are usually approached according to a creative criterion.

The objective of this work is to propose and experimentally evaluate a methodology that, through the combination of tools, psychophysiological response technology, machine learning models and traditional techniques allows to obtain, in a scientific and methodical way, the response of users to TV commercials to obtain the information necessary to add value to the advertisement.

For this, 3 experimental studies are proposed that investigate different characteristics of the proposed methodology: investigate the capacity of neuroscience tools to predict the effectiveness of advertising. The second proposes to measure the effectiveness of the ads according to the advertising format, 2D vs 360º. And the third is the evaluation of music in the context of musical congruence and incongruity applied in TV commercials.

The study where we compared the effectiveness of 360º advertising vs static (2D) ads in terms of visual attention, brand recognition, engagement and emotions. The tools used were neurophysiological tools such as electroencephalography, cardiac variability, eye tracking, and facial coding. Four existing ads for durable goods and high-turnover consumer goods were compared. The results show that the look depends on the content of the ad, the visual attention is less in the 360º ads as well as the recognition of the brand logo. Durable products are the ones that generate the most positive emotions and the level of engagement. What it takes to take it into account to generate a content strategy. 2.

Regarding the study of the impact of music on advertisements, the results of the emotional and cognitive reactions of the subjects during exposure to television advertisements with congruent and incongruous music were investigated. The electroencephalography and eye tracking signals of a group of 90 people who watched 6 television commercials were analysed. The results show that congruent music generates higher levels of prefrontal asymmetry than represents cerebral taste. Just as incongruous ads with happy music have a higher level of attention and cognitive load, generating greater memory than ads with congruent music. Demonstrating the validity of neurophysiology techniques to evaluate the impact of music on advertisements.

The latest study investigated the effectiveness of new digital communication channels (YouTube) to predict through the use of artificial neural networks and metrics based on neurosciences such as electroencephalography, eye tracking, and cardiac variability. Significant correlations between neuroscience metrics and the effectiveness of ads and

the number of views on the YouTube channel were discovered. Creating a prediction of 82.9% the average precision and online visualizations.

This thesis provides novel contributions to the use of neuroscience in human behaviour research, particularly in the consumer and how it affects decision-making. Consumer neuroscience can help the application of methodologies for the assessment of audiovisual stimuli from a more accurate and precise perspective. In addition, by creating machine learning models, we can predict user responses to different advertising stimuli, creating more effective and economical campaigns. We firmly believe that neuromarketing will revolutionize audiovisual content evaluation and decision-making methods. The present thesis aims to contribute to this progress.

The results of this thesis may be of use to researchers and advertisers interested in better understanding consumer behaviour.

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Capítulo 1. Introducción

Motivación

1 Pasado y presente de la neurociencia en marketing.

Actualmente uno de los principales desafíos de las empresas, marcas, agencias de publicidad e investigadores es entender mejor el comportamiento del consumidor.

Utilizar la neurociencia para entender como los usuarios visualizan, procesan y retienen desde una perspectiva neurocientífica un producto. Puede ser de gran ayuda a la hora de diseñar y comercializar una campaña de publicidad.

Cada vez hay un mayor interés en entender el cerebro y el comportamiento del consumidor debido al aumento de las tecnologías, la inestabilidad del mercado mundial, la poca eficacia de las campañas publicitarias con los actuales métodos tradicionales de investigación y el entorno de publicidad cada vez más competitivo ha generado una disciplina nueva que tiene como objetivo la investigación de los procesos cerebrales que dictaminan el comportamiento del consumidor y expliquen la toma de decisión mejorando la eficacia de la publicidad. Se requiere de una mayor adaptación de los contenidos de publicidad al público objetivo pero para ello es necesario disponer de herramientas que permitan cuantificar el impacto en el consumidor final para aprender a personalizar mucho mejor este tipo de contenidos.

La neurociencia del consumidor consiste en el uso de herramientas y modelos neurocientíficos para entender el comportamiento de consumo y entender los mecanismos cerebrales que afectan las decisiones diarias. A su vez el neuromarketing es el uso comercial de las herramientas de la neurociencia y sus conocimientos para medir, entender e influir atención, interés, agrado, motivación, memoria y el compromiso (engagement) del consumidor

Se han encontrado muchas concepciones del neuromarketing como parte de la neuroeconomía (Hubert y Kenning, 2008), como una ciencia dentro del marketing (Fisher, Chin y Klitzman, 2010) o como una disciplina única para la investigación del comportamiento del consumidor o neurociencia del consumidor (Green y Holbert, 2012, Orzán, Zara y Purcarea, 2012, Vecchiato, Kong, Maglione, y Wei, 2012, Hubert y Kenning, 2008, Murphy, Illes y Reiner, 2008, Perrachione y Perrachione, 2008, Fugate, 2008). Una de las principales ideas que ponen en común estas disciplinas es que es la llave de acceso a la atención, emociones y memoria durante el proceso de percepción del consumidor se debe basar en analizar las respuestas implícitas que provienen de nuestra parte inconsciente (Morewedge y Kahneman, 2010). El neuromarketing se muestra como una oportunidad para poder extraer información relevante a través de las respuestas que los consumidores no pueden verbalizar durante las investigaciones de mercado (Butler, 2008; Hubert y Kenning, 2008, Fugate, 2008).

En los últimos años se han reducido los presupuestos publicitarios sin conseguir la eficacia publicitaria, dando paso al uso de las nuevas técnicas neurocientíficas y sus resultados académicos como alternativa a los métodos de mercados aumentando la eficacia en los entornos publicitarios tanto a nivel online como offline.

Es importante recalcar la variabilidad del comportamiento del consumidor. Cada vez comprendemos mejor de la heterogeneidad de perfiles que pueden acceder a las compras online y offline (Boksem y Smidts, 2015). Es por ello por lo que cada vez es más necesario recopilar más información de los usuarios para reducir el riesgo de fracaso empresarial que tienen las empresas, marcas y agencias de publicidad. Así como múltiples estudios han demostrado que con muestras más pequeñas de usuarios la neurociencia del consumidor puede predecir las respuestas del mercado (Berns y Moore ,2021, Boksem y Smids, 2015; Christoforou, Papadopoulos, Constantinidou y Theodorou, 2017; Shen y Morris,2016).

De esta forma la neurociencia del consumidor demuestra como los estudios predictivos aumentan el porcentaje de éxito de las marcas y productos gracias a una predicción y precisión que pueden suponer un 15% de incremento de éxito en comparación con estudios tradicionales, según estudios de la universidad de Oxford (Alejandro Salgado, 2012).

2 Técnicas más relevantes en los estudios de neuromarketing.

El neuromarketing va a suponer una gran ayuda para complementar las técnicas tradicionales a través de herramientas de la neurociencia para poder aportar datos fisiológicos de los consumidores que antes no se podían medir. Pero para ello es necesario validar científicamente metodologías rigurosas que lo apliquen como se ha desarrollado en este Tesis.

Poder medir las emociones, el nivel de atención, la memoria y el nivel de satisfacción entre otras va a permitir a las marcas o las agencias de publicidad personalizar mucho mejor las campañas o los productos desarrollados en base al público objetivo al que se dirigen. Cuando se puede medir el nivel de eficacia, siempre se puede mejorar el resultado final del producto debido a la precisión de las herramientas neurocientíficas y comportamentales. La música, los personajes, el formato, los colores y los mensajes son algunos de los múltiples atributos que pueden hacer que un contenido publicitario enganche o no a un público objetivo. Gracias a las técnicas basadas en las neurociencias se está aprendiendo cómo cuantificar el impacto de cada uno de ellos para diseñar contenidos que se anticipen a las preferencias emocionales de los consumidores finales.

Hoy en día existen cada vez más herramientas basadas en la neurociencia del consumidor debido a un menor coste de las tecnologías de medida y al aumento de como procesar esta información. Este tipo de respuestas se han utilizado para demostrar cómo se puede identificar lo atractivo que nos resulta el precio y los productos (Bogomolova et al., 2015, Plassmann, Doherty, Shiv, y Rangel, 2008; Votinov, Aso, Fukuyama, y Mima, 2016), como se pueden predecir respuestas de mercado (Boksem y Smidts, 2015; Christoforou, Papadopoulos, Constantinidou, y Theodorou, 2017; Dmochowski et al., 2014; Shen y Morris, 2016) asi como modelos teóricos de los efectos publicitarios (Reynolds y Phillips, 2018) también en branding (Plassmann, Ramsøy y Milosavljevic, 2012). Es por ello, que se recoge a continuación las herramientas más importantes utilizadas actualmente en Neuromarketing (la mayoría de ellas empleadas en esta Tesis), añadiendo las ventajas y desventajas de cada una de ellas para poder ser aplicadas.

2.1 La neuroimagen

La neuroimagen no solo nos permite reproducir el cerebro a nivel de imagen, sino que además nos permite establecer las funciones de las distintas partes de nuestro cerebro (Schweitzer y Michael 2011)

La **neuroimagen** es el conjunto de técnicas que muestran imágenes del cerebro sin ninguna necesidad de cirugía o contacto directo con el cuerpo (Baker et al. 2017). Esto nos permite observar la estructura y funciones del cerebro de una forma menos invasiva gracias a técnicas que construyen imágenes a partir del campo eléctrico o magnético del cerebro.

Incluye **dos técnicas**:

- **Técnicas anatómicas o estructurales:** son las encargadas de crear imágenes de la estructura del cerebro. Dentro de este grupo se encuentra la tomografía computarizada (TC) y la imagen por resonancia magnética estructural (sMRI).
- **Técnicas funcionales:** realizan imágenes que representan la actividad del cerebro durante su registro. Miden la respuesta de las diferentes concentraciones metabólicas en situaciones cognitivamente estimuladas. Dentro de las técnicas funcionales se encuentran la tomografía por emisión de positrones (TEP o PET de sus siglas en ingles), la tomografía por emisión de fotón único (SPECT), la resonancia magnética funcional (fMRI) y la espectroscopia (NIRS).

Como resumen las técnicas estructurales nos permiten hacer un seguimiento de las imágenes estáticas del cerebro, así como las técnicas funcionales nos permiten ver el cerebro como un "video" durante la persona está realizando una actividad cognitiva. Gracias a ello, las técnicas estructurales se puede concretar la zona afectada por una lesión o los efectos de la enfermedad. Y con las funcionales podemos saber que zonas son las que se están activando cuando se está realizando la tarea cognitiva.

Se utilizan en diversidad de campos como la psiquiatría, neurología y como más recientemente en marketing, para poder entender mejor las motivaciones de la compra de los consumidores de una forma más científica.

2.2 Electroencefalografía

La **actividad eléctrica** en el cerebro se produce por unas corrientes que se generan por la transmisión de la actividad producida entre las neuronas y los axones de ellas

(Schmitt, 1994). Estas corrientes producen el movimiento de los iones de carga eléctrica en el cerebro. El análisis de estas señales registradas en el cerebro se puede realizar de forma temporal y/o espacial aportando cada tipo de análisis información cualitativamente diferente. Cuando esas neuronas en funcionamiento se sincronizan se produce unas corrientes en partes específicas del cerebro en las que se pueden medir externamente. Estas mediciones son las que sirven de base para las herramientas electroencefalográficas. Se basa en relacionar las ondas cerebrales y el estado de consciencia. Existen cuatro tipos principales de ondas: alfa (α), beta (β), theta (t) y delta (δ).

Onda	Frecuencia	Descripción
α	0.1-4 Hz	Sueño profundo
β	4-8 Hz	(meter memoria) y tal
t	8-14 Hz	Estados de relajación
δ	14-30 Hz	Estados de vigilia

Tabla 1. Principales ondas cerebrales

2.3 Eyetracking o movimientos oculares

El eyetracking es una de las técnicas más utilizadas en la neurociencia del consumidor. El seguimiento ocular es el registro de los movimientos oculares mientras un consumidor examina un estímulo visual (Collewijn, 1991). Para realizar una medida aceptable se necesita medir la posición del ojo y de la cabeza.

Las herramientas que se utilizan para medir los movimientos oculares son los comúnmente llamados eyetrackers. Se suelen utilizar en diversos campos del marketing y de la investigación de mercados como son la evaluación de productos, campañas de publicidad y páginas web. Se utilizan dos medidas principalmente para medir los movimientos oculares. Las sacadas y las fijaciones. Dentro de estas medidas, tenemos en cuenta. Creando algunas de las métricas más conocidas y utilizadas tanto a nivel empresarial como en investigación (M, Wedel et al 2017)

Mapas de calor. Pueden ser estáticos o dinámicos según el tipo de fijaciones o de las sacadas que nos muestran la distribución de la mirada. Es una métrica fácil de comprender ya que utiliza la simbología del semáforo. Las zonas rojas son las más vistas y mayor número de fijaciones obtienen (y por ello las que más atención reciben) las amarillas y verdes son las áreas que menos fijaciones reciben y por ente las que menos interés visual generan. Después están las zonas que no han sido observadas y por ello no tienen ningún color.

Ilustración 1 Ejemplo de mapa de calor. Estudio2

Las áreas de interés (AOI). Son las subregiones que se encuentran dentro del estímulo a analizar. Extrayendo las métricas de cada una de las áreas de interés se pueden sacar las métricas de diferentes zonas para videos, webs, imágenes o interfaces de programas. Además, te ayuda para comparar entre grupos de participantes con diferentes condiciones y con diferentes características.

Distancia a la pantalla: Dentro de las métricas de eyetracking, la distancia a la pantalla y la posición del participante es bastante interesante como hemos podido comprobar en las investigaciones. El hecho que el usuario se acerque a la pantalla puede mostrar un nivel de comportamiento de interés.

Pestañeos: El número de pestañeos puede proveer una información muy valiosa en lo que se refiere a la carga cognitiva, así como en la atención. A una frecuencia muy baja se le suele relacionar con altos niveles de concentración y a unos altos niveles de frecuencia se suele relacionar con bajos niveles de concentración o de sueño.

Estos son algunas de las métricas que se utilizan en estudios de eye tracking para poder entender mejor la atención visual del usuario.

2.4 Reconocimiento facial

Son las emociones las que nos hacen seres humanos (Dimberg,1982). Uno de los principales indicadores de las emociones es nuestra cara (Cohn, J., Ambadar, Z., y Ekman, P. (2007). Si lloramos o si reímos es un reflejo de nuestras emociones hacia nosotros y hacia los demás. Es por eso por lo que el estudio de las gesticulaciones faciales es tan importante para el entendimiento de las emociones.

Es por ello por lo que se pueden clasificar las emociones según las expresiones de la cara. Gracias a Ekman (2007) las gesticulaciones faciales son universales independientemente del género, edad, cultura. En las que se basan 6 principalmente, alegría, enfado, sorpresa, miedo, tristeza y disgusto

El modelo que más se utiliza es el de Dimensional models, el cual asume que las emociones pueden agrupar en dos o más dimensiones. Como la Valencia (emociones negativas, positivas y neutras) en un eje vertical y arousal (cuando estas activado vs cuando estas calmado) como un eje vertical (Pighin, et al 2006)

Gracias a este modelo que une la valencia y el arousal se puede subclasificar emociones en menos arousal y menos nivel de valencia.

2.5 Variabilidad cardiaca

El sistema nervioso autónomo (SNA) es la parte del sistema nervioso que gestiona las funciones viscerales, incluida los movimientos cardiovasculares. Se conocen que los estados mentales y emocionales afectan directamente a las respuestas del corazón. El análisis de la variabilidad de la frecuencia cardíaca también puede ser muy útil en marketing, porque el estudio de la variabilidad cardiaca es una herramienta objetiva y no invasiva para explorar las interacciones dinámicas entre los procesos fisiológicos y emocionales (McCraty et al., 2001). En la variabilidad de la frecuencia cardiaca los patrones responden a las emociones y los ritmos cardiacos tienden a ordenarse durante los periodos más positivos. Algunos estudios investigaron que el uso de la variabilidad cardiaca cuando se exponen usuarios a la visualización de anuncios es más eficaz que realizar encuestas como focus group ofreciendo mayor información para comprender a los consumidores de una forma emocional (Kim y Niederdeppe, 2014; (Da-Silva, Lourenço, Fred, y Martins, 2014)

2.6 Respuesta galvánica de la piel.

La piel nos revela mucha información sobre cómo nos sentimos emocionalmente (Montagu y Coles 1966). Tanto si estamos con estrés, que nerviosos, sorprendidos, la electricidad de la piel indicara esos pequeños cambios McCleary, R. A. (1950). Es por eso por lo que una de las métricas más utilizadas es Galvanic Skin response (GSR) también conocida como Electro dermal Activity (EDA) o Skin conductance (SC) Villarejo, et al (2012). La respuesta galvánica de la piel principalmente se origina en la activación del sistema autónomo que genera la sudoración de las glándulas en la piel. La estimulación emocional desencadena la sudoración de manos y pies. Cada que están se genera una estimulación emocional los datos de GSR muestran patrones que son visibles en las gráficas.

A continuación, se incluye un listado de estudios de neuromarketing realizados a través de las diferentes metodologías anteriormente comentadas relevantes con la eficacia del mensaje publicitario.

Autor (Año)	Tecnología Neuromarketing	Estudio Experimental	Resultados
Krugman, 1971	EEG, (Electroencefalografía)	Investigar si existían diferencias en el cerebro ante anuncios de TV e impresos	Identificaron las ondas cerebrales que se activaban en determinados estímulos y durante el visionado de la publicidad y entre elk tipo de publicidad escrita y en TV)
Robinson			
Ambler et al.,2000	MEG, Magneto encefalografía	El impacto que tienen los anuncios emocionales con la actividad cerebral	Los sujetos mostraron diferencias entre el contenido afectivo y cognitivo. Afectivo: se activaron las áreas de la corteza prefrontal, ventromedial, la amígdala y el tronco cerebral. (estímulos cerebrales)
Ioannides et al., 200	MEG	¿Qué áreas cerebrales que responden a los estímulos afectivos y cognitivos?	Se observo claras diferencias entre las áreas que responden al campo afectivo en los lóbulos frontales ventromediales. (VMFL)
Rossiter e Silberstein, 2001	EEG	Como se recuerdan los anuncios según el modelo de activación neuronal	Las escenas evocan una rápida activación en el hemisferio izquierdo fueron recordadas mejor.
Young,2002	EEG	Identificar los momentos más adecuados de la marca en la creación de los spots de TV	Se midió las cuatro bandas de frecuencia. Alfa, theta, gamma y beta que se relacionó con la importancia de los comerciales
Montange, 2003	fMRI	Identificar las diferencias cerebrales durante el consumo de la Pepsi y de Coca- Cola	Se observo que cuando se conocía la marca del cerebro se activaba otra zona del cerebro en las marcas. En ambas marcas se activó la zona de recompensa.
Klucharev et al.,2005	fMRI	Implementar estrategias para generar mayor nivel de memoria en los anuncios de publicidad.	Los usuarios mejoraron la actividad relacionada con la memoria del lóbulo temporal.
Astolfi et al.,2008	EEG	La activación del cerebro durante el recuerdo en la	La actividad cortical se muestra en las áreas parietales durante el

		visualización de los anuncios.	procesamiento de la información.
Klucharev et al., 2008	fMRI	El efecto del "poder experto modula la memoria y las actitudes	El efecto de la persuasión de los expertos esta mediado con el objeto en términos del valor percibido.
Morris et al.,2009	fMRI	El estudio investiga las regiones del cerebro validen las tres dimensiones (placer, excitación y dominancia) de los mensajes inducidos por el mensaje publicitario	Se encontraron diferencias en el lóbulo frontal inferior bilateral y el lóbulo temporal en el tamaño del placer y en la activación del giro temporal superior derecho en la emoción. Lo que indica una mejor comprensión de los mensajes debido al enfoque dimensional.
Stallen et al.,2010	fMRI	Como afecta el efecto persuasivo de los personajes famosos a la asociación del producto.	Indica un fuerte apoyo a la idea de que detrás del testimonio de una celebridad se transfiere una influencia positiva. En particular encontrar una mayor actividad en la corteza orbitofrontal medial, lo que apoya la hipótesis de que las celebridades dan lugar a las emociones positivas.
Vecchiato et al, 2010	EEG,GSR-HRV	Investigar las mediciones de EEG y periféricos y correlacionar con el placer del sujeto.	Se indico que las bandas theta en la parte izquierda estaba relacionada con el nivel de memoria.
Vecchiato et al, 2011	EEG	Se puede utilizar las asimetrías para medir el gusto de los comerciales	Se correlaciona el nivel de gusto con la asimetría. Correlacionando las ondas Alpha y los grupos de sujeto que les gusto los anuncios.
Silberstein et al.,2012	SST (Steady state Topography)	¿Cuál es el papel de la emoción en la publicidad y en la mejora de la publicidad?	El valor motivacional (MV) tiene una gran activación. El estudio muestra que las diferencias en MV están mediadas por la corteza prefrontal izquierda y la corteza prefrontal
Vecchiato et al.,2014	EEG-GSR-HRV	Muestran los cambios que se crean en la actividad cerebral por los índices	Identifican las diferencias entre dos anuncios Cartier y Prada. El anuncio de

		neurofisiológicos durante la visualización de los spots	Cartier genera en las mujeres un alto nivel de retención debido a la activación en las partes parietales izquierdas. Así como en los hombres un aumento de en los valores de retención alto y de emoción.
Nomura et al.,2015	EEG	Estudian que tipo de emociones sienten mientras que ven los anuncios con diferentes tipos de estímulos a través del EEG y cómo influye en la memoria.	Observaron la diferencia entre los anuncios galardonados y su influencia en la memoria vs los anuncios que no se premiaron.
Yang et al.,2015	EEG	Realizaron estudios con una novedosa metodología de como extraer índices como la felicidad, sorpresa y atención en los anuncios de TV.	Consiguieron mostrar diferencias significativas entre las tasas de memoria a corto plazo y las tasas de memoria a largo plazo. Identificaron estructuras semánticas y auditivas de los comerciales que indujeron felicidad.
Couwenberg et al 2018	fMRI	Exploran las respuestas neuronales a estímulos visuales de anuncios de TV, midiendo anuncios de una misma marca examinando la efectividad de cada uno de los anuncios.	Muestran que partes del cerebro influyen en los procesos cognitivos de nivel inferior y superior y en medida que se activan esas zonas se asocia con una mayor efectividad publicitaria.
Daugherty et al.,2018	EEG	Replican el estudio de Erbert Krugman(1971) para replicar y extender sus estudio sobre el papel del EEG en la evaluación de anuncios.	Apoyan en gran medida a los hallazgos en la relación inversa entre las ondas cerebrales (beta, theta y alfa) a través de múltiples medidas patrones con activaciones similares.
Zhang et al. 2018	fMRI	Utilizar el fMRI para medir las interacciones cerebrales.	Muestran como tenemos dos sistemas subyacentes de recompensa retrasada e inmediata.
Ausin et al.2021	EEG - EYETRACKING	Estudian el eyetracking y el EEG para medir el impacto de los videos 360 y 2D	Muestran como los videos 360 generan mayor nivel de atención pero menor engagement cerebral.

Bigne et al. 2021	Eyetracking	Estudian el imapacto de las redes sociales la atención visual	Identifican que el contenido integrado en las redes sociales afecta positivamente a la atención visual.

Tabla 2. Estudios con diferentes metodologías.

3.Emoción, atención y memoria en la publicidad.

Las emociones son las reacciones que tiene el cuerpo a nivel psicofisiológico que nos ayuda a la adaptación. Una de las funciones principales que tiene la emoción es generar la atención adecuada para la respuesta del individuo y poder activar las redes relevantes a la memoria. La publicidad es un gran referente acerca del uso de las emociones y por medio de ella poder atraer nuestra atención con las campañas publicitarias, los famosos y los productos y así como generar nuestro interés y codificar en nuestra memoria a través del mensaje publicitario.

En la publicidad se han utilizado estrategias a través de los creativos que provocan las sensaciones mediante su originalidad sobre las motivaciones psicológicas y sociales de los individuales (Baack, 2008)

La importancia de entender cómo se procesan los estímulos en la memoria, atención, emoción y el placer según la toma de decisiones durante la visualización de los spots televisivos.

Gracias a las técnicas de la neurociencia investigaciones actuales han descubierto que la emisión de un mensaje publicitario activa áreas cerebrales en el mero procesamiento de la información sobre los 7 segundos de la recepción del mensaje en TV y 4 segundos si es un video en Redes sociales (Ramsoy et al 2019). Esto hace que nos sintamos atraídos o no hacia el contenido en cuestión. Autores como Van der Laan, De Ridder, Viergerver, Smeets (2015) verifican que el cuerpo estriado bilateral se activa más fuertemente con los productos preferidos de los consumidores. Así es como los estudios indican como la parte prefrontal del córtex se activa en la frecuencia gamma cuando un consumidor está dispuesto a pagar más por un producto (Yang et al.,2015).

La observación de las activaciones cerebrales, podemos predecir con un alto porcentaje la preferencia de los consumidores, por ejemplo, un 61,2% en la elección de los alimentos saludables (en la activación de la circunvolución frontal superior) (knutson et al.,2007

Es en los anuncios de TV con contenidos afectivos y cognitivos donde se activa principalmente la corteza prefrontal y la zona parietal, que están asociadas con el control ejecutivo (Braeutigam, 2011).

La **atención** es un proceso que incluye varios procesos, ya que esto influye en varios circuitos interconectados que pueden que hacen posible este proceso. Gracias a las técnicas como el eyetracking y la neuroimagen que hemos comentado en el apartado anterior han permitido identificar cuáles son las regiones cerebrales más importantes y las que se activan en las tareas de atención para comprender mejor su papel en los anuncios.

La corteza prefrontal es la parte cerebral que selecciona, prioriza y coordina los estímulos que ingresan en el sistema, es la que filtra a lo que se presta atención y a lo que se ignora. Se ha definido dos redes frontoparietales como las dos redes encargadas de los procesos de orientación y control ejecutivo. La primera es la red *dorsal* que está relacionada con orientación espacial en la respuesta de los estímulos. La otra es la *ventral*, que está relacionada con la orientación a estímulos novedosos. La corteza prefrontal está conectada con la amígdala y el tronco cerebral que son los que seleccionan los estímulos emocionales. Se observa en estudios como los de Kilmesch que gracias a las técnicas de neuromarketing como el EEG. Que las ondas de Alpha y theta son osciladores que reflejan el rendimiento cognitivo. Que gracias a la desincronización de la banda alfa refleja atención. El autor explica cómo esta sincronización no es un fenómeno unitario, y hay dos patrones de sincronización de: la primera llamada "desincronización Baja Alpha" (en el intervalo de 6 a 10 Hz) y el segundo llamado "Upper desincronización alfa "(en el rango que va del 10 al 12 Hz). La sincronización de baja se obtiene en respuesta a una variedad de factores específicos. Importante para identificar en la publicidad los niveles de atención que pueden generar en la misma.

Una vez que hemos captado la atención es la **emoción** la que mantiene y aumenta nuestro interés. Las emociones son las respuestas fisiológicas primarias ante determinados estímulos externos o internos. Hay diferentes teorías sobre cómo se producen las emociones. Charles Darwin, en su obra La expresión de las emociones en el hombre y los animales (1872) o las teorías de James. Lange o de Cannon Bard o el marcador somático propuesta por Antonio Damásio. Gracias a estos estudios se han podido llegar a varios consensos. El primero es que las emociones son universales ya que podemos identificarlas en diferentes culturas, esto es gracias a las expresiones faciales, que son una respuesta refleja y automática que son igual en todas las culturas, creando configuraciones concretas en los músculos de la cara en todos los seres humanos. También hay un consenso sobre las seis emociones generales o básicas: alegría, tristeza, asco, ira y sorpresa.

Estudios recientes implican varias regiones cerebrales interconectadas entre sí como es el sistema límbico (tálamo, el hipotálamo, el hipocampo y la corteza cingulada) conectada con la corteza prefrontal.

Cuando un anuncio te llama la atención, las emociones mantiene ese interés, eso genera una mayor probabilidad de **memoria.** Durante la codificación de un mensaje en la memoria, se activas diversas áreas del cerebro, se activa la zona frontal izquierda especialmente en la oscilación eléctrica de la onda theta. A la vez aumenta la frecuencia cardiaca (HR) durante el almacenamiento en la memoria. Estudios recientes (2017) se observó que "La actividad cerebral durante la visualización de los comerciales, combinados con la gesticulación facial y la variabilidad cardiaca podrán registrar la variación de las tres actividades fisiológicas importantes, como la memoria, el placer y la atención en diversos anuncios.

Objetivos

El principal objetivo de la tesis es usar la neurociencia como herramienta de evaluación de la eficacia en la publicidad y la comprensión del comportamiento del consumidor. En particular nos hemos enfocado en el uso de las señales fisiológicas y aplicación de modelos basados en redes neuronales para desarrollar métricas para la comprensión del comportamiento de los consumidores ante la percepción de la publicidad audiovisual. Lo objetivos específicos son:

O1. Desarrollar y validar una metodología para poder medir la eficacia de la publicidad en TV.

O2. Desarrollar y validar el uso del nivel de atención visual en un anuncio de publicidad utilizando señales fisiológicas.

O3. Desarrollar y evaluar el nivel emocional de los anuncios audiovisuales utilizando señales fisiológicas.

O4. Desarrollar y evaluar el nivel de agrado de los anuncios audiovisuales utilizando señales fisiológicas y método tradicionales.

O5. Desarrollar y evaluar la memoria de los anuncios audiovisuales utilizando señales fisiológicas y métodos tradicionales.

Estructura de la tesis

La tesis se estructura de la siguiente forma:

Capítulo 1: Introducción de la tesis, describiendo la motivación detrás de la presente tesis. Además, incluye los objetivos y la estructura de la tesis.

Capítulo 2: Presenta el paper "Looking at and listening to TV advertisements: A neurophysiological study of music congruence". Se presenta una nueva metodología para medir la eficacia de los anuncios según el tipo de música a través de la respuestas fisiológicas y comportamentales (gesticulación facial, eyetracking, actividad cerebral y la respuesta galvánica de la piel

Capítulo 3: Presenta el paper "Do you see what I see? Effectiveness of 360-degree vs. 2D video ads using a neuroscience approach". Donde se analiza a la eficacia de la publicidad en diferentes formatos inmersivos. Anuncios de 180º vs anuncios en 360º con el análisis de la actividad cerebral, la respuesta galvánica de la piel, el eyetracking y la gesticulación facial para identificar el nivel de atención, memoria y gusto

Capítulo 4: Presenta el paper "Consumer Neuroscience –Based Metrics Predict Recall, Liking and Viewing Rates in Online Advertising. plica una nueva metodología para cuantificar la eficacia de anuncios a través de nuevos canales de comunicación como es YouTube y cómo es posible predecir su impacto usando redes neuronales y herramientas de la neurociencia (actividad cerebral, variabilidad cardiaca y eyetracking)

Capítulo 5: Se discuten los resultados de la tesis con los resultados generales y los trabajos futuros y se enumeran las publicaciones derivadas de esta tesis.

Capítulo 2. The background music-content congruence of TV advertisements: A neurophysiological study

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Keywords: Advertising, music, congruency, neurophysiological measurement, effectiveness.

Abstract

Music affects viewers' responses to advertisements. In this study we present the findings of an experiment that investigates the emotional and cognitive reactions of subjects' brains during exposure to television advertisements with music congruent, and incongruent, with the advertisement content. We analyse the electroencephalography signals and eye-tracking behaviours of a group of 90 women watching six TV advertisements. The study's findings suggested that incongruent music generates higher levels of attention and advertisement recall. On the other hand, frontal asymmetry measured through electroencephalography was shown to be higher with congruent music. Similarly, cognitive workload was higher when the music was congruent with the advertisement content. No significant differences were found in terms of advertisement likeability based on incongruent versus congruent music. The results demonstrated the validity of neurophysiological techniques for assessing the effects of levels of music congruence in advertisements.

Introduction

Listening to music is one of the most pleasurable experiences for individuals (Salimpoor et al., 2009). Its influence on behavioural intentions has been shown in a meta-analysis at the in-store level (Roschk et al., 2017). In advertising, music is present in 86% of television advertisements internationally (Allan, 2008), in up to 94% of German commercials (Breves et al., 2020), and is considered a "catalyst of advertising" (Hecker, 1984). It is often used as a background to advertisements to provoke consumer preference (Gorn, 1982), to increase levels of product recall and purchase intent (Lavack et al., 2008; Oakes, 2007), and to generate emotions (Alpert & Alpert, 1990; Bruner, 1990; Stout & Leckenby, 1988). Indeed, advertising studies have demonstrated the decisive emotional role of music in decision-making (Vermeulen & Beukeboom, 2016). The role of music as an emotion generator has also been demonstrated in brain activation studies (Schaefer et al., 2013) and in the brain cortex (Koelsch et al., 2018). However, some research has argued that the mechanisms through which music elicits emotions are still unclear (Valla et al., 2017), and has advocated analysis of emotions other than pleasure (Reybrouck et al., 2018).

Despite the abundant literature, controversy remains about the influence that music exerts on advertising response variables (Craton et al., 2017). Some studies have demonstrated that music increases advertisement brand and message recall (Hecker, 1984; Hoyer et al., 1984; Allan, 2008), but others have disagreed on the effectiveness of music in increasing advertisement recall (Olsen, 1995; Stout & Leckenby, 1988). This discrepancy may be due to various factors, particularly to the study methodologies employed (Fraser, 2014), and to the difficulty of capturing feelings and emotions through self-reports (Salimpoor et al., 2009). In the present study we analyze the internal neurophysiological mechanisms that trigger emotional reactions to music in TV advertisements.

Congruence between music and visual content has also been used to explain this discrepancy in results (Jeong et al., 2011). Indeed, congruence facilitates the "processing fluency" effect (Breves et al., 2020) by merging the cognitive structures that ultimately positively affect consumers' evaluations of TV advertisements and brands. However, when music and visual elements are incongruent, the viewer may have to reconfigure their meanings. Nevertheless, the relevant literature is inconclusive. For instance, while Moorman (2002) found that advertisement recall improved for advertisements that were congruent with the thematic content in magazines, Dhalen et al., (2008) demonstrated the benefits of incongruence for brand associations in thematically incongruent media.

The authors of the present study analyse, using neurophysiological measures, the role of (in)congruence in music and content in responses to TV advertising. The objective is twofold: First, to analyse the possible neurophysiological variations in outcome variables due to advertising featuring (in)congruent music; second, building on schema theory and the elaboration likelihood model (ELM) (Petty & Cacioppo, 1986), we assess how (in)congruent music affects cognitive processes (e.g., memory and level of likeability).

Two conceptual frameworks illuminate the analysis of music in advertising. First, schema theory (Bartlett, 1932) explains how individuals categorize pieces of information (Rifon et al., 2004). Second, the ELM (Petty et al., 1983; 1986), where music works as a low-involvement peripheral cue, or as a cue supporting arguments in a message (Eisend & Tarrahi, 2016). These conceptual frameworks and their hypotheses have been tested by means of self-reported studies. However, internal psychological responses to emotional stimuli, for example, unconscious processes and music, cannot be captured through self-reports (Pozharliev et al., 2017). In recent times, consumer neuroscience-based studies (Karmarkar & Plassmann, 2019) have contributed to research into advertising (Chang 2017; Guixeres et al., 2017). Advertising research using neuroscience has hitherto focused on four key constructs as indicators of the effectiveness of advertisements: attention, memory, affect, and preference (Pozharlievet et al., 2017; Venkatraman et al., 2015). We retain these four key constructs, but add cognitive workload.

Our approach differs from previous studies in two ways. First, we analyze consumer responses by means of neurophysiological continuous data. This approach is consistent with the view of human cognition as a dynamic process (Thelen & Smith, 1994). Second, the limited capacity model of motivated mediated message processing (LC4MP) proposes that processing messages involves three simultaneous major activities, encoding, storage (i.e. linking of recently encoded cues to previously stored cues), and retrieval (i.e. memory activation) (Lang, 2000). Our approach attempts to cover both types of memory. Indeed, neurophysiological measures capture encoding and storing subprocesses, while self-report measures capture the retrieval process. Prior research has, on the other hand, focused mainly on the retrieval process by asking consumers about their recall, liking, feelings, and emotions.

This research contributes to the existing literature in three ways. First, by testing, through neurophysiological measures, how viewers respond to TV advertising accompanied by (in)congruent music. Second, by evaluating the impact of (in)congruent music in TV commercials on attention, memory, liking, cognitive workload, and preference. The remainder of the present study is organized as follows. First, we discuss the main features of the neurophysiological tools used. Thereafter, to develop the hypotheses, we review the literature on congruence and advertisement content. Next, we describe the method used to test the hypotheses; through an experimental design we evaluate cognitive variables of responses to advertising, attention, memory, advertisement likeability, cognitive workload as a proxy for processing effort, and frontal asymmetry as a proxy for advertisement preference. Then we discuss the results and implications, both conceptual and managerial and, last, we address the conclusions and limitations of the study.

Literature review

Measurement of neurophysiological and emotional reactions to advertising

The growing acceptance of neuroscientific research tools in consumer research is based on the accurate measurement of consumer processing, including unconscious processes (Ohme et al., 2010), and the neurophysiological reactions of consumers to marketing stimuli (Karmarkar & Plassmann, 2019) in continuous real-time recording. Neuroscientific tools can accurately analyze responses to (in)congruent music by tracking unconscious and emotional effects. Indeed, growing attention is being paid to the psychophysiological analysis of music-induced emotions (Gingras et al., 2015; Ohme et al., 2011). However, no studies using neurophysiological tools have considered music and advertisement content congruence. This study adopts a multitool method by using the following measurements:

2.1.1 Eye-Tracking (ET)

ET registers where the experimental subject is looking at each moment, and the sequencing of his/her gaze (Bulling & Wedel, 2019). The growing literature on ET, now widely used as a measure of attention in advertisement studies, has shown that visual attention has systematic effects on brand memory, and can predict responses to advertising (Pieters & Wedel, 2004). More specifically, Wedel and Pieters (2000) found a positive, direct correlation between average fixation duration and recall.

Electroencephalography (EEG)

EEG measures electrical brain activity based on temporal resolution by means of electrodes placed on the scalp. Most studies have investigated memory, emotions, and attention (Gordon et al., 2018; Guixeres et al., 2018; Lin et al., 2018; Shestyuk et al., 2019; Venkatraman et al., 2015). Frontal asymmetry is recognized as a valid indicator of approach-withdrawal tendencies that, ultimately, are associated with emotions (Ohme et al., 2010). Lin et al., (2010) found a link between emotional states, recorded through EEG, and music to an accuracy of 82.2% with joy, anger, sadness, and pleasure.

2.2. Congruence of music with advertisement content

Music congruence has been defined as the degree to which consumers perceive that background music is important or appropriate for the central message being communicated (Kellaris et al., 1993; MacInnis & Park, 1991). In communication research, congruency, fit, or the match-up effect, has been applied in different contexts, such as sponsorship (Rifon et al., 2004) and spokesperson characteristics (Lynch & Schuler, 1994). In the present study we focus on the effects of the congruence of music and TV advertisement content.

Congruence in advertising has attracted research attention, with contradictory results (Dahlen et al., 2008; Oakes, 2007), also highlighted in more recent literature (Craton et al., 2017; Guido et al., 2016). From one perspective it has been argued that the fit between advertising messages and executional cues facilitates information processing (MacInnis & Park, 1991) and improves attitude toward brands and advertisements (Galan, 2009; Lavack et al., 2008). On the basis of schema theory it has been argued that advertisements containing incongruent elements are more difficult to process and recall, as more cognitive effort is needed to resolve their inconsistencies (Meyers-Levy, 1989). Kellaris et al., (1993) found that high-congruence music-message advertisements positively influenced information processing and improved recall and recognition. When congruence is low, however, music seems to be a distracter and hinders advertisement processing.

From another perspective, incongruent stimuli have been found to enhance advertisement processing (Dahlen et al., 2008), elicit consumer attention, and are more likely to be processed and stored than congruent stimuli (Peracchio & Tybout, 1996). Overall, these contradictory views call for further research with neurophysiological tools able to capture emotions and unconscious processing.

These results may be contradictory because music perception involves complex brain functions (Kumagai et al., 2017), and/or due to the methods used to measure its influence, which have mostly been based on self-reports (for a review, see Oakes 2007). In this regard, unconscious reactions can be more reliable in capturing emotions, especially when the stimuli, that is, the music and the visual content, are presented simultaneously, as opposed to discretely (i.e., as in print advertisements); neurophysiological tools are more appropriate than self-reports for measuring unconscious reactions.

Congruence has been explained from a conceptual point of view by schema theory (Bartlett, 1932). This theory argues that all knowledge is organized into units. These knowledge units, driven by both cognitive and emotional interactions, are stored, related to previous knowledge, and retrieved when needed. Thus, a congruent unit of information elicits better comprehension. In addition, and consistent with the ELM

(Petty & Cacioppo, 1983; 1986), incongruent music-content advertisements require greater elaboration and cognitive effort. As congruence between the spokesperson and the brand has positive effects on the knowledge of, and affection felt toward, brands (Misra & Beatty, 1990), it is anticipated that music-content congruence will have positive effects, from the advertiser's perspective, on the viewer. The literature also suggests that musical stimuli influence the emotional response of the viewer to visual stimuli, can modify consumer behavior in terms of likeability (Gorn, 1982), and enhance brand image (Kellaris et al., 1993).

The visual attention given to advertisements depends on a variety of factors, including content, message, music, brand, and advertisement characteristics (Calder & Malthouse, 2008). The literature on the effects of music in advertisements has found that listening to particular types of music activates different brain areas (Lin et al., 2010) and influences the cognitive processing of visual events (Boltz, 2001). The eye-mind hypothesis argues that cognitive processes are reflected in the idiosyncrasies of gaze movement (Just & Carpenter, 1980). Thus, longer fixation duration and fewer fixations represent more detailed processing (Horstmann et al., 2009). Accordingly, this study uses average fixation duration (AFD), fixations per second (FpS), and ambient vs. focal (AvF) attention, which has ~~recently~~ been shown to have high explanatory value in processes related to attention type (Holmqvist et al., 2011). These metrics are discussed in the methodology section.

As noted previously, incongruent cues require more information processing effort. Schema theory also suggests that, when incongruencies arise, humans need to increase their cognitive effort to resolve them. Thus, the visual attention paid to TV advertisements with incongruent music will be higher than that paid to advertisements with congruent music. Therefore, the following hypothesis is proposed:

H1: The visual attention paid to advertisements with incongruent music is greater than that paid to advertisements with congruent music.

At the cognitive level, the literature has shown that frontal brain asymmetry is an indicator of user preference (Balconi et al., 2014) and engagement with advertisements (Çakar et al., 2018). The concept of frontal asymmetry has received attention in the advertising research literature (Ohme et al., 2010; Vecchiato et al., 2013; Schmidt & Trainor, 2001). The EEG literature suggests that asymmetry is enhanced by pleasant music (Arjmand et al., 2017). Accordingly, consumers will engage with advertising if the music facilitates cognitive processing and matches the cognitive hypothesis (Calder & Malthouse, 2008). As to the evaluation of music through EEG, specifically through measures of frontal asymmetry, correlations between oscillations in the alpha band and the frontal regions suggest preferential engagement. Thus, advertisement preference is associated with greater affective response, an effect on neural activity being observed. Studies in which this technique has been used confirm its ability to assess how to increase advertisement effectiveness (Tandle et al., 2016; Trainor & Schmidt, 2003).

Therefore, based on the proposal that frontal asymmetry is a valid indicator of the approach-withdrawal reaction, we propose that:

H2: Approach response is greater in advertisements with congruent music than in advertisements with incongruent music.

Measurements of the level of mental workload involved in the processing of audio-visual content can be useful in the analysis of how the brain processes advertisements. As discussed earlier, elaboration is higher for advertisements with incongruent music than for advertisements with congruent music. Evidence from other study types suggests that the presence of roadside advertisements increases vehicle drivers' subjective ratings of mental workload (Young et al., 2009), and the time needed to respond to road signs and errors in driving (Edquist et al., 2011). Therefore, it is expected that distractions, such as incongruent stimuli, will cause more cognitive workload. Fraser (2014) found that images evoked by music focused the attention of experimental participants on the advertisement message and on the brand, and thus improved brand recall. As cognitive workload is based on cognitive processes, such as memory and task demand levels, distracting stimuli, for example, incongruent music, create higher workload. Therefore, it is expected that, in a non-congruent condition, consumers will face extra cognitive workload. Therefore, we propose that:

H3: The cognitive workload used is lower in advertisements with congruent music than in advertisements with incongruent music.

Music triggers the same type of mechanisms as other stimuli that induce emotions (Juslin & Västfjäll, 2008). However, the unanswered question is, which stimuli have the most influence? In the present study we measure whether music exerts more influence than images on emotions. Aaker et al., (1986) showed that tenderness is the most persuasive emotion for brand and message because it puts the viewer in a positive mood. Sánchez-Porras (2013) noted that Coca-Cola attaches paramount importance to music, and that 94% of its advertisements are designed to match their background music with the feelings evoked by the images and, in the great majority (95.3%), the music is an integral part of the advertisement's visual action. Musical stimuli are especially effective in enhancing the effects of visual imagery, but some studies have shown that imagery enhances emotional responses to music (Juslin & Västfjäll, 2008). Furthermore, executional advertising cues (e.g., music) have a very significant effect, with low-involved consumers, on attitude toward brands, but also exert influence on central-route processing among both high- and low-involvement consumers (Macinnis & Park 1991). Craton et al., (2017) found that in TV commercials the effect of the images is stronger than the effect of the music, and that the music itself does not evoke visual imagery.
Advertising likeability can be also used diagnostically for advertisements (Leather et al., 1994). Empirical findings have shown that the consumer's liking for an advertisement is directly related to his/her attitude toward the advertisement and brand, and toward his/her purchase intention (Du Plessis, 2005). Based on schema theory and ELM, in terms of the amount of cognitive effort needed, it is expected that congruent music will be more liked. Therefore, music-content congruence in advertisements might increase their likeability. Furthermore, advertisements perceived as more likeable produce more positive judgments and are more effective (Smit et al., 2006). Therefore, we propose the following:

H4. Advertisements with congruent music are liked more than advertisements with incongruent music.

Three competing research streams are associated with the influence of music on advertisement recall. The first stream states categorically that music helps consumers remember information about products and messages (Allan, 2008); in addition, it argues that music has a positive impact on memorization and the perception of advertisement duration (Galan, 2009). The second stream argues that music has a negative effect on the consumer's memory because it distracts his/her attention (Fraser & Bradford, 2013). The third stream combines the first two; the effect of music depends on two fundamental factors, the congruence between the music and the product, and the characteristics of the music. As suggested above, congruence involves less elaboration, aids memory and, therefore, congruent music is associated with higher recall than is incongruent music. Furthermore, the prior literature on congruence shows it has a myriad of beneficial effects, for example, the creation of positive attitudes, an increase in the credibility of sponsors (Rifon et al., 2004) and, in the match-up hypothesis, it has been shown that endorsements are more effective when there is a fit between the endorser and the product (Wright, 2016). In a self-report analysis, Guido et al., (2016) found significant differences based on the type of ending to the music that accompanied advertisements; they concluded that normal endings increase memorization of products and messages, and that truncated endings hinder memorization as they divert the attention of consumers toward the music, and away from the products and the messages. As an abrupt ending can be considered as a form of incongruence, thus, consistent with schema theory, we propose the following:

H5. Advertisement recall is higher in advertisements with congruent music than in advertisements with incongruent music**.**

Methodology

Stimuli

The first stage of the pretest used 45 advertisements. The chosen advertisements had to fulfill the following requirements: (i) They had to last between 30 and 90 seconds to minimize the bias effect on recall caused by very short, or overly long, advertisements; (ii) they had to use only background instrumental music to avoid the influence of lyrics; (iii) they had to be absent of dialogue/voice-overs to avoid the effect of language and ensure effective manipulation; (iv) they had to use music congruent with the images; (v) they had to show non-native brands so that the participants, who were of one particular nationality, would not previously have seen them. A pretest, similar to tests carried out in past research (Alpert & Alpert, 1990; Brooker & Wheatley, 1994; Gorn, 1982; Kellaris & Cox, 1989; Macinnis & Park, 1991), was conducted to select the final 6 commercials to be used in the experiment. We chose two groups of advertisements, one with happy music, and one with sad music. The participants were asked: "Do you think the music is congruent with the video?", using a scale of 1 (not congruent), to 10 (totally congruent);

In the second stage, the 15 most congruent advertisements were manipulated by the removal of the original music and the addition of incongruent music. Thus, sad classical music replaced happy classical music (Alpert et al., 2005; Alpert et al., 1990), and vice versa.
In the last stage, the 6 most congruent advertisements of the 15 most congruent advertisements examined in the second stage were manipulated by the removal of the original music, and the addition of incongruent music. These 6 advertisements, now with incongruent music, were tested on a new group of 60 participants. The participants were asked: "Do you think the music is congruent with the video?", using a scale of 1 (not congruent), to 10 (totally congruent); "What emotions do you feel when hearing the music?", from the 5 basic emotions. More than 90% of the subjects reported emotions in line with those that the advertisements had been designed to evoke (Figure 1).
As to the music stimuli, two orchestral pieces, Samuel Barber's "Adagio for Strings", and "Ode to Billy Jo", were chosen to evoke sadness, and Beethoven's Symphony no. 6, and Well-Tempered Clavier, were chosen to evoke happiness (Alpert et al., 2015). The other two advertisements used sad/happy pop music. The music was taken from the database of the YouTube audio library (Dougan, 2016). The videos with the incongruous music were produced by professionals who made the harmony, timbre and rhythm sound the same as in the original versions (Table 1).

Ads	Product	Congruent Music	Congruent Song	Incongruent Music	Incongruent Song	Duration (sec)	Link
Douwe Egberts	Coffee	Happy / Classical	Douwe Egberts song	Sad/ Classical	Samuel Barber, Adagio for Strings	37´	https://goo.gl/mVBqpt
Fresh n' Fruity	Food	Happy/ Pop	The Third Cup	Sadness/ Pop	Finals	60´	https://goo.gl/1SxFeB
Goicoechea	Perfume	Happy/ Classical	Joy to the World	Sad / Classical	Tomaso Albinoni, Adagio in G minor for Strings and Orchestra	42´	https://goo.gl/MPPum4
Jell O Faces	Food	Happy/ Pop	More Smiles - The Jump Ups	Sadness/ Pop	Desert Sky	30´	https://goo.gl/UwyjmA
Embrace Life	Social	Sadness/ Classical	Sad Minuet	Happy/ Classical	Beethoven, Symphony no.6 (3rd mvt).	90´	https://goo.gl/uQoAyX
Domestic National Violence	Social	Sadness/ Classical		Happy / Classical	Well-Tempered Clavier III in C#-major	50´	shorturl.at/uyBH0

Tabla 3. Estímulos y música

Experimental design

The participants were exposed to six advertisements. Half (45) watched advertisements with their original congruent music, and the other half watched the same six advertisements, but with newly inserted incongruent music, resulting in two scenarios. The advertisements were randomly distributed to avoid data-gathering bias.
The experimental design was based on viewing, through a 1920 x 1080-pixel monitor, a 30-minute naturalist documentary on marine life, with three ad-breaks. Two advertisements were shown during each two-minute ad-break, which is consistent with real-world television advertising. The advertisements were presented randomly to avoid primacy and recency effects, which might have produced higher levels of recall in the subjects based on order of participation (Murdock, 1962).
As dependent variables we evaluated the experimental participants' cognitive levels (frontal asymmetry, workload) and recall of six television advertisements and the brands advertised. Two hours after they viewed the advertisements the participants were

interviewed to measure, on a 7-point Likert-type scale, their spontaneous memory of the brands and the level of likeability of the advertisements. In this way we verified the relationships between the cognitive states, and recall, and the likeability responses of each subject.

Sample

The neurophysiological literature has shown that women are better than men at detecting non-verbal cues (Hall et al., 2000), and that "the gender effect for visual-plus-auditory studies was significantly larger than for visual-only and auditory-only studies" (Hall, 1978, p. 845). Previous research has indicated that males and females perceive music differently (Zander, 2006). To control for potential gender differences, only females were recruited. The initial sample consisted of 100 women with normal vision and hearing (mean age 36.2; SD = 5 years), recruited by a company based in the same city as the laboratory where the experiment was carried out. Ten participants were removed due to corrupted data in signals obtained in the experimental sessions, giving us a final sample of 90. The participants were assigned randomly to the two scenarios (advertisements with congruent music vs. advertisements with incongruent music). They watched the marine life documentary shown in the preliminary study. No mention was made of the significance of the advertisements. The institutional review board of the university approved the study[1] based on the written informed consent of all subjects, in accordance with the Helsinki Declaration.

Recording of the physiological signals

Table 2 contains a summary of the constructs, tools, and metrics used, related to each hypothesis. The ET and EEG signals were synchronized with the stimuli through iMotions software (https://imotions.com).

Measures	Attention	Approach	Likeability	Memory
ET AFD AvF	H1			
EEG Frontal asymmetry Cognitive workload		H2 H3		

[1] The name of the university is not revealed at this stage to guarantee the anonymity of the manuscript.

Questionnaire				
Likeability			H4	
Recall				H5

Tabla 4. Construcciones y medidas de herramientas neurofisiológicas para cada hipótesis.

The EEG device was placed on the subjects while they listened to the explanation about the documentary that was about to be shown. The ET device was embedded in the desk monitor. The measurement began with a baseline task consisting of tests of attention, relaxation, and cognitive load for each of the participants (Berka et al., 2007).

The Tobii Pro TX300 device was used to analyze the ET. This records at 300 Hz and has a built-in 23-inch monitor. The subjects' gaze behavior was recorded, and a fixation detection algorithm based on speed, with a threshold of 30 degrees/sec, measured the fixations and saccades. Total scan (TS) is the sum of the length of the saccades in degrees. It is greater if the viewers explore more. AFD, FpS, and AvF attention data were obtained for each advertisement. To calculate AvF the saccades were classified into ambient (long) and focal (short), using a threshold of eye movement of 4.8º (Zangemeister, Sherman, & Stark 1995), and dividing the number of ambient saccades by the number of focal saccades. A high AvF indicates that the visual exploration has been ambient, with long saccades, and a low value indicates a focal exploration, with small saccades.

Electrical brain activity was recorded using the B-Alert X10 device (Advanced Brain Monitoring, Inc.). It records at 256 Hz and includes 9 channels, using the international location system 10-20, positioned in the frontal, central, and parietal-occipital areas. First, corrupted channels were identified by applying the fourth standardized moment (kurtosis). In addition, if a channel contained more than 10% of flat signal the electrode was classified as corrupted. The EEG baseline was removed by applying a bass pass filter between 0.5 and 40 Hz, and the signal was segmented into epochs of one second. The intra-channel kurtosis level of each epoch was used to reject the epochs with high noise levels. To detect artifacts caused by muscular activation, blinking, and eye movements, an independent component analysis (ICA) (Gao et al., 2010) was applied; a trained expert manually analyzed all the components, rejecting those related to artifacts. Finally, frontal asymmetry was calculated using the alpha band of the decontaminated signal. As noted earlier, right and left asymmetry are related to approach-withdrawal behavior (Davidson, 1977, 2004). We refer to approach-related tendencies (or left-hemispheric dominance) as "positive emotional reactions", and withdrawal-related tendencies (or right-hemisphere dominance) as "negative emotional reactions" (for a technical review, see Fischer et al., 2018; Harmon-Jones & Gable, 2009).

Specifically, we performed an EEG spectral analysis in each epoch using Welch's method, with 50% overlapping, and calculated the spectral power of the alpha band (8-12 Hz). Frontal asymmetry was computed using the formula:

$$Frontal\ asymetry = \log(f3_{alpha}) - \log(f4_{alpha})$$

To obtain the EEG-workload metric, a four-class quadratic discriminant function analysis (DFA) was conducted for each participant. Similarly, a metric benchmark was developed for all participants, and the model was individualized using a DFA coefficient. A linear two-class DFA model was used to assess the level of cognitive workload. A detailed explanation of the model is presented in Berka et al. (2007).

A questionnaire was used to measure the relationships between the subjects' neurophysiological responses and their levels of self-reported liking for, and recall of, the advertisements. The questionnaire asked the subjects how much they liked the advertisements. The level of liking was measured on a 7-point, 3-item Likert-type scale, as used by Berryman, (1984): "I think the commercial that I just saw is 1 (bad) to 7 (good)." As for the reliability of the test, Cronbach's *alpha* was calculated to be 0.72, which is considered acceptable (Cronbach, 1951). In the questionnaire the participants were shown one frame from each of the advertisements they had previously viewed, and two from advertisements that had not been screened (Pepsi and Reebok), and were asked which advertisement contained the frame.

Results

Figure 1 shows the results of the pretest; this analyzed the level of audio-visual congruence between the two advertisement alternatives, (in)congruent music, on a Likert-type scale between 1 and 7. All the congruent advertisements presented averages between 6 and 7, and the incongruent averages between 1 and 2. Due to the non-Gaussian distribution of the data ($p < 0.05$ from the Shapiro-Wilk test), Wilcoxon signed-rank tests were applied with a Bonferroni correction. Significant differences were found in all the advertisements (p-value<0.001), which suggests that the audio manipulation changed the level of congruence of the advertisements.

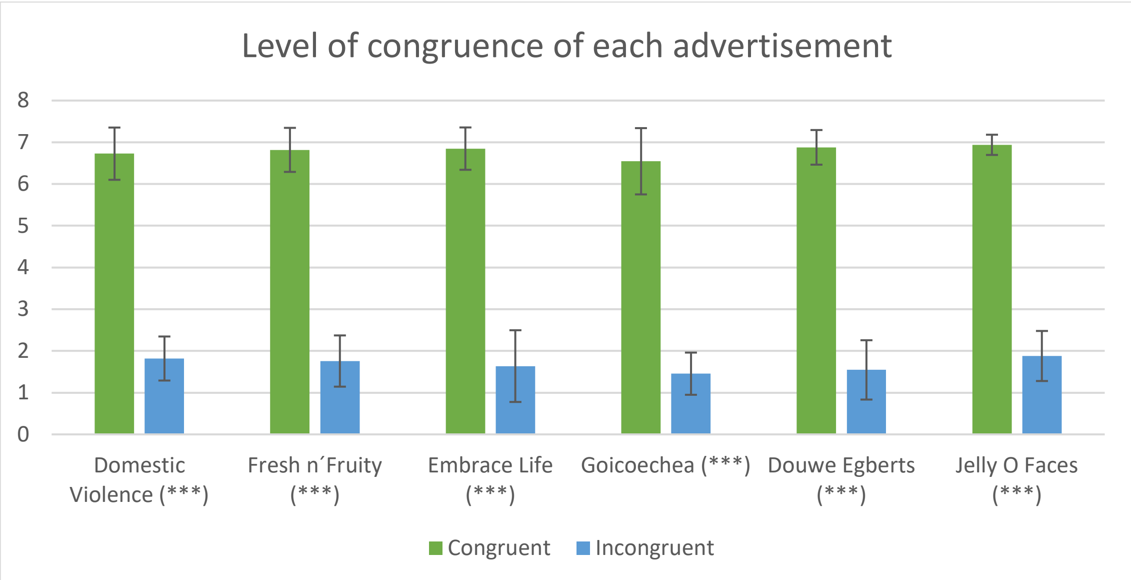

Ilustración 2. Diagrama de caja del nivel de congruencia de cada anuncio en la prueba previa mediante cuestionarios.

Concerning H1, related to visual attention, Figures 2, 3, 4, and 5 show the gaze patterns in terms of fixation per second (FpS), average fixation duration (AFD), ambient vs focal exploration (AvF), and total scan (TS), respectively. Due to the Gaussianity of the data ($p > 0.05$ from the Shapiro-Wilk test with null hypothesis of having a Gaussian sample), t-tests were applied to assess if there were significant differences between the congruent and incongruent advertisements. The incongruent advertisements presented more fixations per second (FpS_{con}=2.086±0.523 vs. FpS_{inc}=2.247±0.4016, p-value=0.0018), and longer fixations (AFD_{con}=330.3±81.9 vs. AFD_{inc}=353.7±80.1, p-value=0.0043), indicating a higher level of attention. In addition, the incongruent advertisements presented more explorative gaze patterns as they showed a higher ambient vs focal ratio (AvF_{con}=1.263±0.571 vs. AvF_{inc}=1.568±0.726, p-value<0.001), that is, the saccades were longer with the incongruent stimuli, which also provoked a higher total scan time (TS_{con}=580.7±327.8 vs. TS_{nc}=688.6±382.1, p-value<0.001).

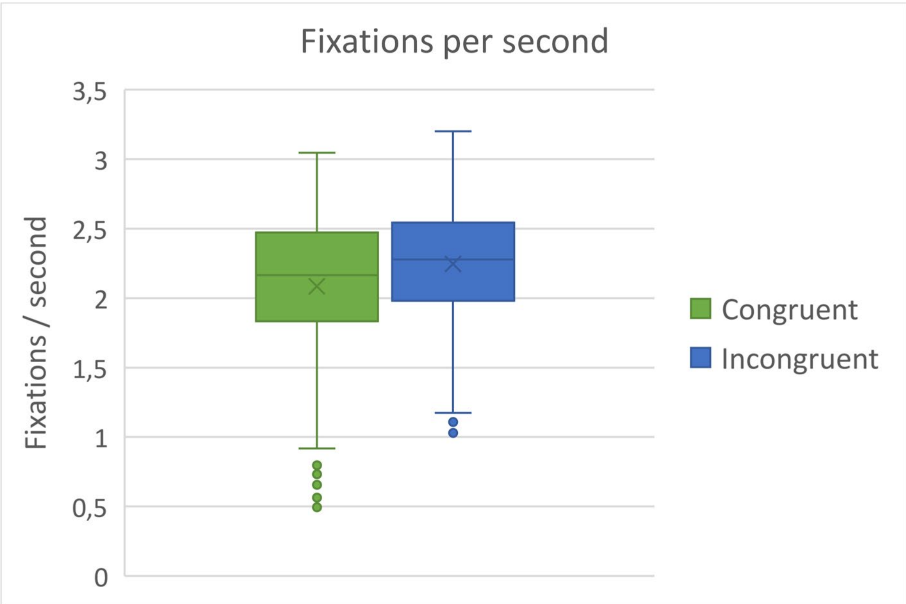

Ilustración 3.Diagrama de caja de fijaciones por segundo de anuncios congruentes e incongruentes.

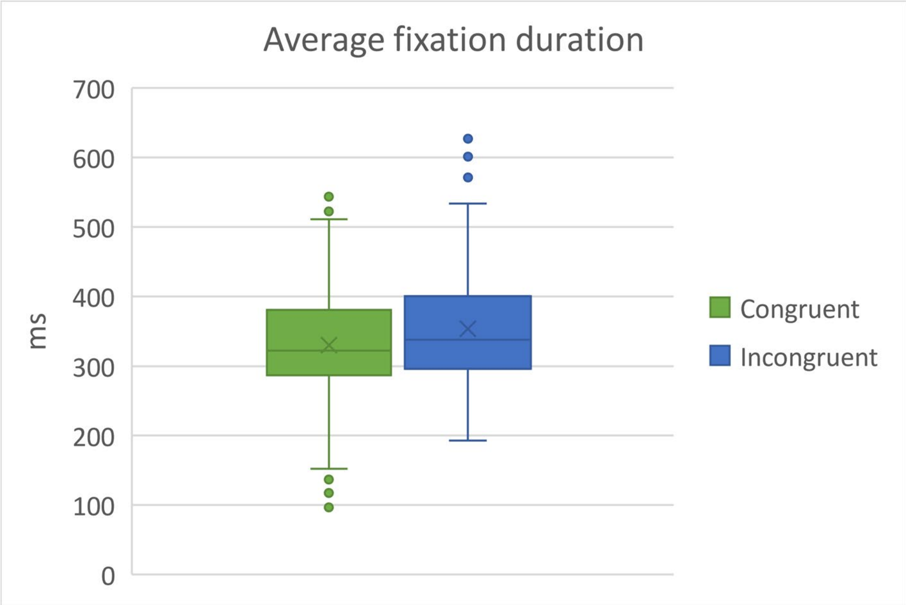

Ilustración 4. Duración media de la fijación de anuncios congruentes e incongruentes.

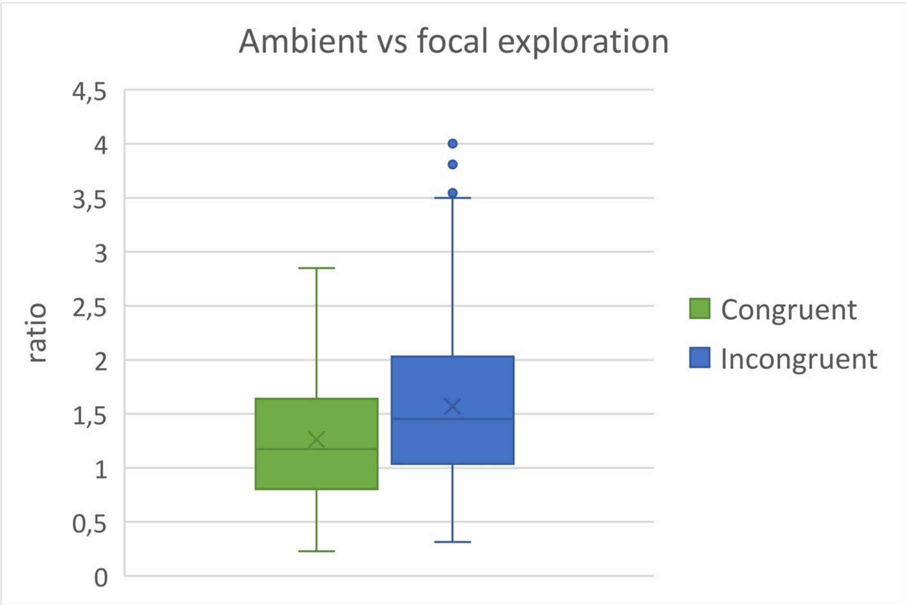

Ilustración 5. Diagrama de caja de exploración ambiental vs focal de anuncios congruentes e incongruentes.

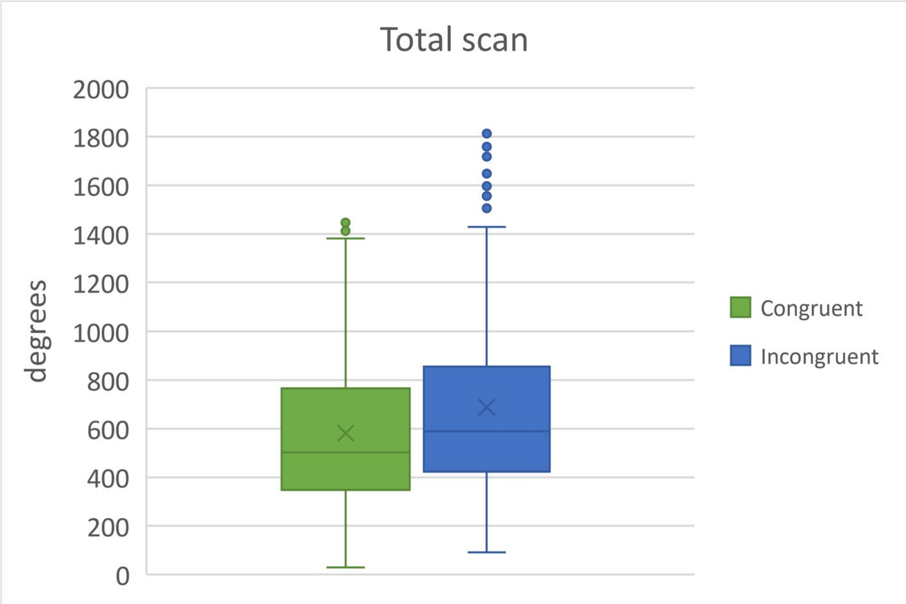

Ilustración 6. Diagrama de caja del escaneo total de anuncios congruentes e incongruentes.

Figures 6 and 7 show the EEG responses in terms of frontal asymmetry (FA), confirming H2, and cognitive workload (WL), confirming H3. Due to the Gaussian distribution of the data ($p > 0.05$ from the Shapiro-Wilk), in both cases t-tests were applied to analyze if there were significant differences between the congruent and incongruent advertisements. The congruent advertisements showed a higher percentage of time with positive asymmetry (FA_{con}=0.510±0.248 vs. FA_{inc}=0.452±0.213, p-value=0.005), suggesting that congruent stimuli are associated with higher approach behavior. In contrast, the incongruent advertisements showed a higher level of workload (WL_{con}=0.567±0.111 vs. WL_{inc}=0.603±0.090, p-value<0.001), indicating that greater cognitive effort is needed to process incongruent stimuli.

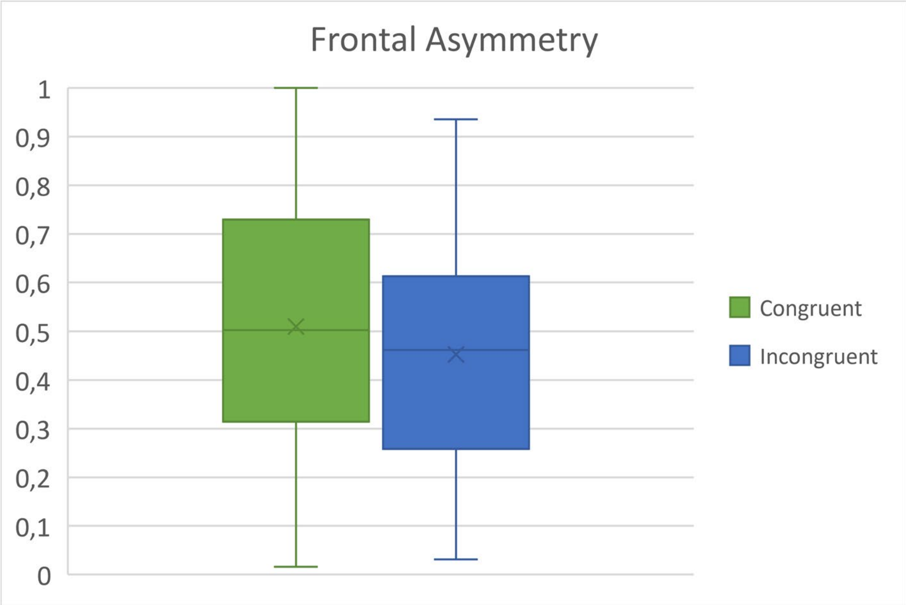

Ilustración 7. Diagrama de caja de asimetría frontal de anuncios congruentes e incongruentes.

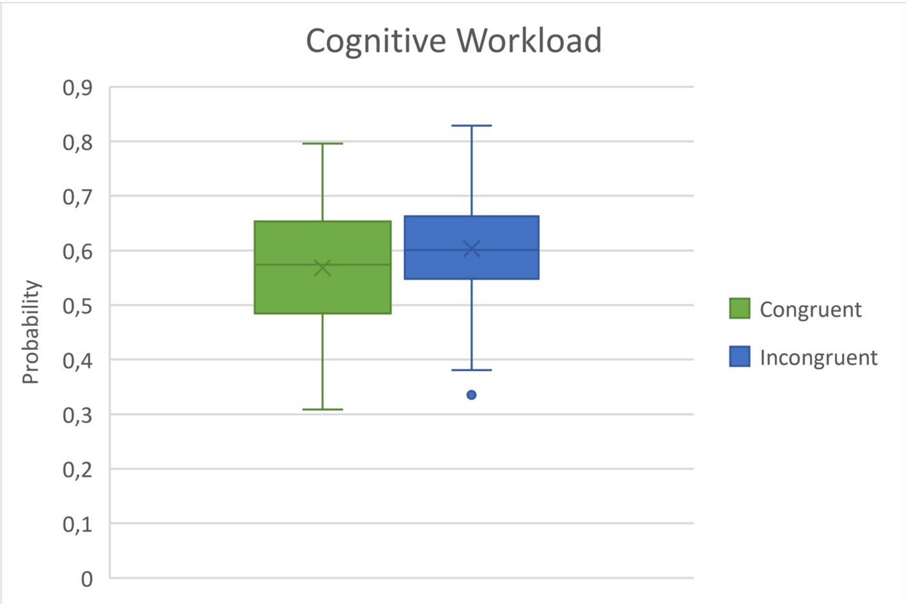

Ilustración 8. Diagrama de caja de la carga de trabajo cognitiva de anuncios congruentes e incongruentes.

Regarding H4, Figure 8 shows the liking ratings of the congruent and incongruent advertisements, using a 7-point Likert-type scale. Due to the non-Gaussian distribution of the data ($p < 0.05$ from the Shapiro-Wilk), in both cases t-tests were applied. No significant differences were found.

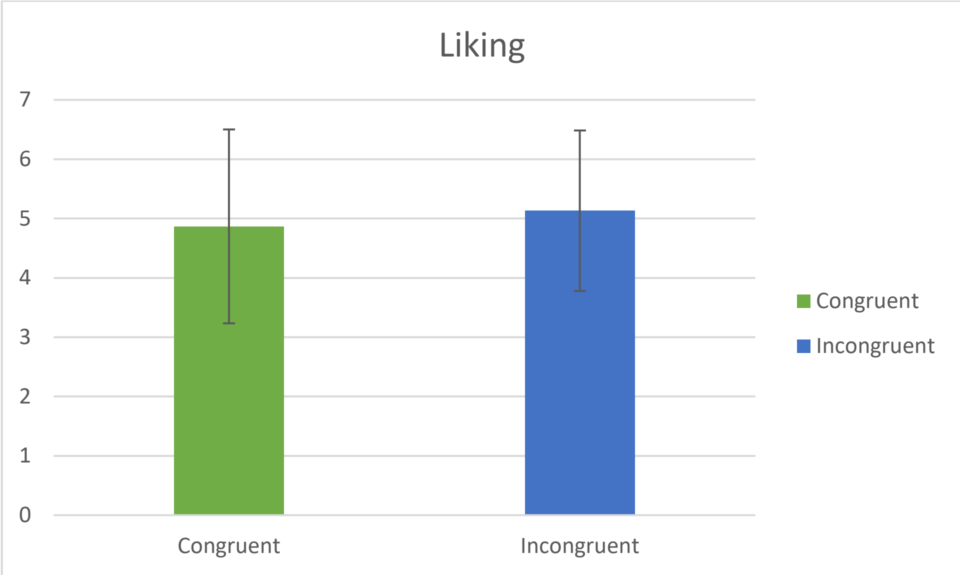

Ilustración 9. Gusto en anuncios congruentes e incongruentes. Las barras representan las medias y las líneas verticales representan la desviación estándar de las medias.

Regarding H5, Figure 9 shows the level of advertisement recall (RC) based on the congruence of the stimuli. Given the categorical nature of the data (recall vs no recall), a chi-square hypothesis test was applied to the congruent and incongruent advertisements. A higher percentage of subjects recalled the incongruent advertisements (RC_{inc}=58.30% vs. RC_{con}=71.52%, p-value<0.008), rejecting H5.

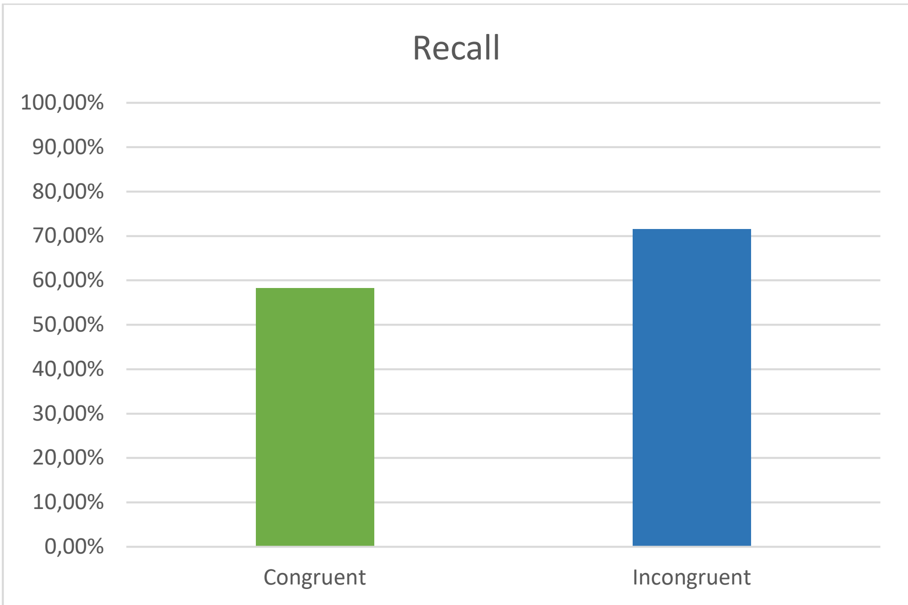

Ilustración 10. Promedio de recuerdo publicitario en anuncios congruentes e incongruentes.

Discussion and implications

The results support the advisability of using congruent music in advertisements. The use of neurophysiological tools gives our findings more robustness than previous studies and sheds light on the specific effects of congruent music, as follows: First, the findings provided further evidence of the influence of music and its effectiveness in television commercials; second, our analysis goes beyond advertisement recall by examining unconscious responses such as visual attention, cognitive workload, and frontal asymmetry.

The study found significant differences in metrics related to visual attention, AFD, TS, FPS, and AvF, between advertisements with congruent music and advertisements with incongruent music, as anticipated by H1. The EEG recordings confirmed there were significant differences in frontal asymmetry. Thus, asymmetry is shown to be a very effective metric for measuring music and advertisement content congruence; higher levels of approach versus withdrawal reactions were observed in advertisements with congruent music, confirming H2. Significant differences in cognitive workload levels were found in five of the six advertisements with congruent music, when compared to the advertisements with incongruent music, which partially confirms H3. Last, the responses to the questionnaire did not show that advertisements with congruent music are more liked than advertisements with incongruent music, as H4 proposed. This finding might suggest that reported liking is not an accurate measure for discriminating between incongruent versus congruent music in advertisements. Furthermore, we found that incongruent music helped the subjects remember the advertisements, as predicted in H5. These findings are in line with schema theory, and with the value that the ELM attributes to music as an executional cue.

Interpreting our findings holistically, the implications for managers are twofold. First, music congruent with advertisement messages is associated with lower visual attention levels and lower levels of recall. The assumption that incongruous music elicits higher memory performance can lead to complex interpretations based on existing theories. First, schema theory suggests that when consumers process a cue that does not fit well with previous schemes, probably learned over years, they allocate extra efforts to process it, which results in higher visual attention being devoted to it, but provokes withdrawal approaches. This is consistent with the limited capacity model of motivated mediated message processing (Lang, 2000), and the underlying concept of attention and effort propounded by Kahneman (1973). The LC4MP proposes that the human processing system has limited capacity. There is no doubt that cognitive load reduces, in small or large proportions, the cognitive resources available for processing other cues. Second, on the basis of the ELM it can be argued that music acts as a peripheral cue that may contribute to attitude change. When consumers mentally process advertisements with incongruous music, this may increase their attention levels, but not necessarily focus them on the main message the advertisers wish to convey. Other studies have suggested that thematic incongruence can enhance viewers' evaluations of advertisements (Dahlén et al., 2008). However, our findings suggest that conflict between music and message results in withdrawal behavior. It seems that conflict between auditory and visual cues resulted in higher visual attention being paid, and a withdrawal approach. Since the withdrawal approach is an emotional reaction, interpreted as a proxy for preference, it can be concluded that advertisers should be cautious about including incongruent music. The present study is based on a forced video watching activity and, therefore, visual attention has to be interpreted with caution. In addition, higher attention levels were associated with higher levels of advertisement recall, which is in line with previous research (McDaniel et al., 2000).

Second, our results showed that content-music congruent advertisements generate lower cognitive workload and more positive emotional reactions. The finding that higher attention provokes higher mental workload is also in line with previous research (Kantowitz, 2000). Since performance and mental comprehension decline when mental workload is too high, or too low, the role of attention and its involvement with cognitive load in advertising is critical. The study methodology validates the use of implicit measures to assess the balance between attention and workload, which can be used by advertisers in the development of audio-visual advertisements. Moreover, in the set of advertisements used in the present study, the congruent stimuli provoked higher positive reactions than the incongruent stimuli. This is reflected in the fact that frontal asymmetry, which measures the behavioral approach system, and is associated with positive emotional states, was greater. The fact that no differences were found in likeability based on the self-assessments, but positive reactions were recorded by the encephalogram, shows that implicit measures are a powerful analytical tool for managers in their assessments of the emotions that advertisements can generate. This methodology can be applied to the decision-making processes involved in evaluating different alternatives of advertisements in terms of their audio-visual congruency.

Conclusions, limitations and further research

This study uses neurophysiological measures to explain the effects of (in)congruent music in TV advertisements on unconscious, and conscious, responses.

We hope this study helps better explain responses to (in)congruent music in TV advertisements, and how they can be measured. The results for H1 showed a strong correlation between the quantity of fixations and attention level; in this case the incongruent music advertisements generated more attention and more mental processing. This is consistent, in that advertisements with incongruous music, at first, generate more surprise, which provokes a higher level of attention due to the viewer's inability to understand the connectivity, which creates a greater demand for resources, and an increase in neural processing resources. The approach constructs raised in H2 and H3 showed a strong relationship between the EEG measures frontal asymmetry and cognitive workload. This frontal asymmetry measure, that is, the increased activity in the alpha band in the left hemisphere (F3), suggests that the viewer undergoes an emotionally positive response; and negative responses were noted in the right hemisphere, associated with incongruent music (Moore, 2012). Cognitive workload measures the level of mental resources necessary to process information. The distractions provided by the incongruent stimuli caused more cognitive workload, as H3 predicted (Seneviratne et al., 2015). The test of H4 did not find any statistical differences in terms of likeability between congruent and incongruent advertisements, based on the self-assessment questionnaire. Finally, the test for H5, where we measured the effects of music on advertisement recall, showed that incongruent music is remembered more than congruent music. This shows the importance of measuring psychological constructs through both neurophysiological and traditional means; this allowed us to more comprehensively evaluate the responses generated by (in)congruent music in the advertisement videos.

Our findings suggest that incongruent music in advertisements demands higher mental processing resources than does incongruent music. Thus, incongruent music generates more visual attention, but higher mental workload and withdrawal reactions, than advertisements with congruent music. Overall, these findings suggest that incongruent music leads to higher visual resource allocation. However, the viewers showed a withdrawal reaction. Given that this study is based on a forced exposure to stimuli, it can be argued that, in real situations, if consumers have a high level of involvement with the advertisements and/or the brand, their visual attention will remain high. On the other hand, if their involvement is not high, the withdrawal reaction might mitigate visual attention.

This study has some limitations that restrict the generalizability of the results. First, the quantity and type of advertisements analysed were limited. Although the advertisements were for products unknown in the country where the study was conducted, and the sample was homogeneous in terms of gender, it is possible that previous purchase experience with the product category could have affected the results. Schema theory would suggest that product category might act as a complementary unit of information. Our study did not control for attitude toward the advertising, which might affect the results. Similarly, the music genre might be controlled. Furthermore, the advertisements about social issues (i.e., Embrace Life and Domestic Violence) showed greater strength in the measured effects. Thus, for example, they had higher levels of asymmetry. Accordingly, future research might explore the moderating effect of involvement with the product category on the emotional impact of music congruence. Second, it seems that the type of music used might influence the subjects' responses. Third, we intentionally excluded lyrics to avoid biasing the subjects' responses. However, congruence between lyrics and music might also be influential. These three limitations should guide future research. Since our findings are restricted to women, future research might also explore the influence of gender by analyzing the effects of the music congruency of advertisements on men.

Two more future research approaches might address effects over time and the influence of other potential (in)congruent cues. Thus, a future study might consider the effect of (in)congruence over several exposures to the advertisements, and address if the effects remained stable or decreased/increased after multiple exposures to the same advertisement. Other cues might be considered, such as the role of message credibility and executional style (Eisend & Tarrahi, 2016), also using neurophysiological tools.

Capítulo 3. Do you see what I see? Effectiveness of 360-degree vs. 2D video ads using a neuroscience approach.

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Keywords: 360-degree advertisement, effectiveness, electroencephalography, eye tracking, facial-coding, electrodermal activity, consumer neuroscience.

Abstract

This study compares cognitive and emotional responses to 360-degree versus static (2D) videos in terms of visual attention, brand recognition, engagement of the prefrontal cortex, and emotions. Hypotheses are proposed based on the interactivity literature, cognitive overload, advertising response model and motivation, opportunity, and ability theoretical frameworks, and tested using neurophysiological tools: electroencephalography, eye-tracking, electrodermal activity, and facial coding. The results revealed that gaze view depends on ad content, visual attention paid being lower in 360-degree FMCG ads than in 2D ads. Brand logo recognition is lower in 360-degree ads than in 2D video ads. Overall, 360-degree videos for durable products increase positive emotions and viewer engagement of the prefrontal cortex with the ads, which carries the risk of non-exposure to some of the ad content. In testing four existing ads for durable goods and fast-moving consumer goods (FMCG) this research explains the mechanism through which 360-degree video ads outperform standard versions.

Introduction

The aforementioned features of 360-degree videos can drive new research that can capture the dynamic view and emotional responses they evoke by using continuous implicit measures. The literature shows that unconscious responses and emotions measured through implicit metrics influence decision-making (Eijlers, Smidts and Boksem, 2019). Unlike explicit responses, which are associated with conscious thoughts and emotions that can be assessed through self-report measures, implicit responses are associated with subconscious, automatic, and moment-to-moment reactions that lie outside the individual's awareness. Implicit responses are highly influential in decision-making processes (Khushaba et al., 2013). As Li (2019) pointed out, a high proportion of consumer responses is unconscious and intuitive. Thus, there is a need to assess the emotional and unconscious responses to advertising (for details, see Pozharliev et al., 2017). Furthermore, neuroscientific-based methods measure response changes in subjects on a continuous basis and are not, thus, affected by post-hoc reflection (McDuff, 2017). Among neuroscientific-based methods, eye-tracking (ET) has been extensively used as a tool for measuring visual attention in advertising (for a review, see Pieters and Wedel, 2014). The nature of 360-degree videos, which provide different viewing angles, makes gaze behavior (e.g. eye movements and fixations) an appropriate metric for measuring the visual attention given to ad content (Jacob and Karn, 2003). Greater fixation time is associated with more detailed processing, and a lower number of fixations with poorer processing (Zhang and Yuan, 2018). Frontal Asymmetry (FAA) is one of the most popular electroencephalography (EEG) metrics used to measure consumer choice (Telpaz et al., 2015). Based on the alpha band and, as pointed out earlier, right or left asymmetry is related to approach/ withdrawal behavior (Davidson 1993, 2004). In this paper we refer to approach-related tendencies (or left-hemispheric dominance) as "positive emotional reactions", and withdrawal-related tendencies (or right-hemisphere dominance) as "negative emotional reactions" (for a technical review, see Fischer, Peres and Fiorani, 2018; Harmon-Jones et al., 2010). Electrodermal activity (EDA) measures the electrical conductance of the skin through amount of moisture (i.e. sweat). An increase in conductance shows physiological activation (see for a review Caruelle et al., 2019). Facial coding (FC) measures emotions through observing changes in the human facial muscles (McDuff, 2017). FC uses an objective-coding scheme, the Facial Action Coding System (FACS) (Ekman and Friesen, 1978), which describes the appearance of face muscle movements and the emotions related to the movements. Despite the advantages of neuroscientific measures, they have been used very little in advertising research (Chang, 2017). 360-degree video ads can help advertisers create emotional connections with their customers and elicit neurophysiological responses that can be used to measure their effects.

No previous consumer neuroscience studies have compared 360º and 2D ads. Therefore, this study compares cognitive and emotional responses to 360-degree and static videos watched on PC screens; the neurophysiological metrics are based on electroencephalography (EEG), eye-tracking (ET), facial-coding (FC), electrodermal activity (EDA). This study differs from others reported in the previous literature in (i) the type of responses measured, that is, unconscious measures; (ii) the scope of the analysis is a continuous measure of the unconscious measures and attention paid to specific elements of ads.

Based on the interactivity and cognitive overload literature, and on the motivation, opportunity, and ability theoretical frameworks, and adopting the advertising response model (ARM), we compare the effects of existing dyads of 360-degree and standard video ads on consumers' emotions and cognition. The research goal is twofold. First, to measure the effectiveness of 360-degree video ads vs. standard format video ads based on visual attention paid to specific elements of the ads, such as the embedded brand logo, and the bonds of emotional connection developed between the consumer and the brand. Second, to analyze whether interactivity and users' control result in higher levels of engagement of the prefrontal cortex.

Through this research we provide a theoretically grounded explanation for the persuasive power of 360-degree ads. The study contributes significantly to the knowledge of how consumers process interactive advertising. First, we explain the information processing of online video ads by assessing the influence of interactivity on the visual attention paid by the viewer to the ad, and on central (brand logo recognition) and peripheral information processing (emotions and asymmetry). Second, using unconscious measures, the present study is the first to explain the mechanism through which 360-degree video ads outperform standard versions.

Conceptual framework

Interactivity in 360-degree video ads

With its ability to give the user the control to manipulate his/her point of view, a 360-degree video provides two-way communication between the viewer and the message/interface and touches on a core concept in communication technology, that is, interactivity (Feng, 2018; Macias, 2003; Sundar et al., 2014). The ability to interactively change one's viewpoint resembles real-world navigation, which enhances the customer experience and increases emotional responses.

In a 360-degree format, in contrast to the traditional video format where the point of view is determined by the creative director, and viewers are passive, viewers have a free and omnidirectional viewpoint which they can move arbitrarily through all the angles of a 360-degree radius. Thus, consumers have the freedom to explore ad content based on their interests, and are not restricted by the creator's or the director's choices, to "navigate" in real time through the video scenes (Wijnants et al., 2015), and to decide "where and what" to look at (Hsiao and Grauman, 2017). That is, consumers are able to control, customize, and change their viewing experience and information flow. Active control, as a dimension of interactivity, has been described as a voluntary, instrumental action that directly influences the controller's experience (Liu and Shrum, 2002). Previous evidence suggests that, overall, viewers prefer dynamic videos (e.g. 360-degree) over static view videos (Broeck et al., 2017; Feng et al., 2019).

Interactivity in this context may result in users paying different levels of attention and varied amounts of cognitive workload (Feng, 2018). Consumer interaction with online ads can be categorized into a hierarchy of stages: preattention, attention, and behavioral decision (Chatterjee, 2001). A successful ad must initially grab the consumer's attention and then elicit emotions and induce recall. The multiple views provided by 360-degree videos make it necessary to address their effectiveness on a continuous basis to capture these dynamics.

Visual attention and persuasion in advertising

Attention has been recognized as the primary factor in advertising effectiveness since the appearance of the earliest models, such as AIDA (Edward, 1925). Without attention, advertising cannot persuade the consumer (Edward, 1925; Cao, 1999). The advertising response model (ARM) provides a framework for evaluating advertising performance; it integrates several measures and explains that winning the customer´s attention is the most important feature in advertising (Wells and Loudder, 1997). Two alternative persuasion routes are described in the ARM, the central and the peripheral. During central processing the focus is on the product/brand, whereas during peripheral processing the creative executional aspects of the advertising are dominant. Both central and peripheral processing lead to ad liking and, ultimately, to purchase intention. Both routes were adopted also in the earlier formulated elaboration likelihood model (ELM) (Petty et al., 1983). Both processing routes are expected to be influenced by involvement levels. Under high involvement, recipients process information via the central route using a high level of brand-related message elaboration. Peripheral processing occurs under low involvement conditions, and subjects typically rely on available peripheral cues, such as music, the source, or the spokesperson.

The advertising literature suggests that the motivation, opportunity, and ability (MOA) to process information are key factors in advertising content processing (MacInnis et al., 1989). *Motivation* relates to areas of the consumer's interest that condition his/her *opportunity* to view some parts of the ad, and *ability* relates to the users' competence in navigating in 360-degree videos. Therefore, the MOA approach provides a good explanation for the differential responses to 360-degree and standard videos. The attention capture and transfer model by elements of advertisements (Pieters and Wedel, 2004) describes a top-down (person and process) and bottom-up (stimulus) mechanism of the visual attention paid to brands, pictorial content, and text in print advertisements. Extending this model to 360-degree videos it can be argued that bottom-up factors (e.g. the angle of view of the ads) determine the level of attention paid. Furthermore, the top-down factors, which are driven by the viewer's motivation and interest, are in line with the motivation and ability variables of the MOA model, and also determine attention.

Central processing route of advertising

The advertised brand is widely recognized as one of the relevant cues in any ad (Belch and Belch, 2018; De Peslmacker et al., 2017). Attention and memory are the processes through which viewers become aware of, encode, store, and retrieve information. Thus, brand awareness plays a key role in advertising effectiveness. Brand awareness has been described as the recognition or memory of a brand (Huang and Sarigollu̇, 2012). In 360-degree videos an interesting research question is how to evaluate whether the consumer's interactivity with video ads impacts on his/her processing of brand logos embedded in online video ads. As previously mentioned, in traditional ads the advertiser drives and schedules attention flow. However, in 360-degree ads the viewer selects the focal points and might avoid, even unintentionally, some parts of the ad, such as the brand name or logo. Accordingly, and irrespective of the consumer's interest in the ad, his/her exposure to the brand might be influenced by the reduced attention (s)he might pay to the brand. Following the MOA approach, certainly, if consumers are motivated by the brand as a key communication element, their attention will be high in either format (e.g., traditional and 360-degree). However, an interactive format may lead to less attention being paid to the brand logo because the angle of view adopted by consumers might reduce their opportunity to be exposed to some specific cues, such as the brand.

Peripheral processing route of advertising

In 360-degree ads consumers view some elements based on their personal choice. This active way of watching ads can be associated with the "functional view" of interactivity, as opposed to the "contingency view" suggested by Sundar et al., (2003). This type of functional interactivity leads to higher peripheral processing (Sundar and Kim, 2005). On the basis of distinctiveness theory (Rosenkrans, 2009) it can be argued that motion supports salience because human beings prefer moving objects (Sundar and Kalyanaraman, 2004). Furthermore, in web ads, the dynamism conveyed by changes in ad content (e.g. animated ads) is more appealing than the static content in traditional ads (Sundar and Kim, 2005). Extending previous research to 360-degrees ads, the ad elements that viewers look at under their own control will elicit a positive attitude. The limited capacity model (Lang, 2000) proposes that consumers encode, store, and memorize only a few information cues. This view suggests that the salience of information is determined by the consumer's goals or by the novelty and unexpectedness of the stimuli (Lang, 2000). The ARM suggests that the attitude formation process is shaped by the novelty of the interaction, which is dominant in peripheral processing.

Contradictory emotions and processing over time

The advertising effectiveness literature discusses the positive influence of emotional responses on post–exposure attitude and recall (Holbrook and Batra, 1987; Morris et al., 2002). From the cognition perspective, emotions are mental states of readiness that arise from cognitive appraisals elicited by consumption; and they are accompanied by physiological processes (e.g., facial features) (Bagozzi et al., 1999, p. 184). The basic emotion approach (Li et al., 2015; Plutchnik, 1982) proposes there are eight basic emotions innate to all humans (i.e., fear, anger, joy, sadness, disgust, surprise, trust, expectancy) and many secondary emotions derived from these primary emotions.

When consumers are exposed to continuous stimuli (e.g. online video ads), their information processing might evolve over time from cognitive to emotional reactions, and from positive to negative encodings. Furthermore, Feng, (2018) found that in 360-degree videos emotions can be positive or negative depending on ease of navigation. In neuroscience studies these effects have been associated with the term "frontal brain asymmetry". To explain frontal brain asymmetries in valence emotional processing, Davidson's model (1979) proposed that emotion-related lateralization is observed because emotions contain approach and/or withdrawal components. Therefore, emotion will be associated with right or left asymmetry to the extent to which it is accompanied by approach or withdrawal behavior (Davidson, 1993, 2004). In the present study we refer to approach-related tendencies (or left-hemispheric dominance) as "positive emotional reactions", and withdrawal-related tendencies (or right-hemisphere dominance) as "negative emotional reactions" (for a review, see: Fox, 1991; Davidson, 1993; Davidson and Rickman, 1999). Frontal brain asymmetry has been applied in consumer choice (Ravaja et al., 2012; Telpaz, Webb and Levy, 2015) and advertising studies (Daugherty, Hoffman and Kenedy, 2016; Guixeres et al., 2017; Ohme et al., 2009; 2010). In interactive environments, to measure moment-to-moment emotions the optimum approach is to undertake brain wave analyses (e.g. EEG) in parallel with eye movement observations. This form of integration can enrich the understanding of what emotional reactions consumers experience when they view an advertisement (Guo et al., 2018; Ohm, 2011).

Hypotheses development

Grounded in the ARM model, this study posits that 360-degrees video ads have superior advertising effectiveness in terms of affective responses to the ad (engagement with the ad and intensity and arousal of the emotions evoked by the ad), and that 2D ads are more effective in terms of the cognitive processing of the brand logo. In this section we discuss the expected relationships among the proposed variables, taking as our reference the ARM framework, and propose a set of hypotheses. Figure 1 shows the conceptual framework scheme and the neurophysiological tools used to measure the unconscious responses of consumers to online video ads with high/low interactivity.

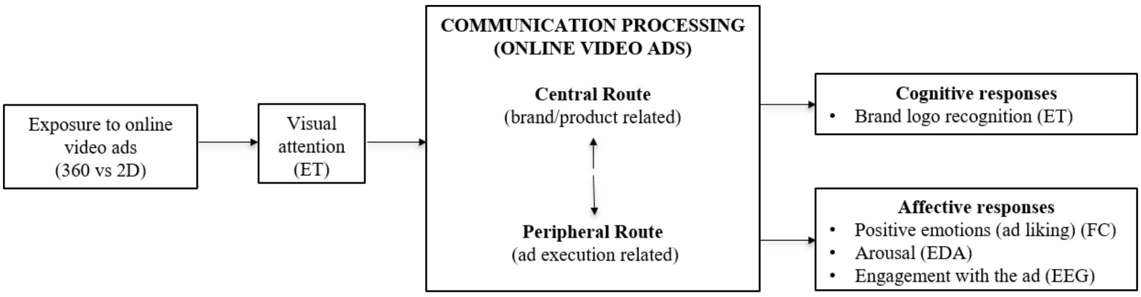

Ilustración 11. Esquema del marco conceptual y las herramientas neurofisiológicas.

Interactive advertising and visual attention

During 360-degree interactive ads the consumer has to focus his/her attention more and make higher cognitive processing effort than for traditional ads (Jung et al., 2014), which increases the use of his/her cognitive resources (Ariely, 2000; Feng, 2018; Hupfer and Grey, 2005; Tremayne and Dunwoody, 2001). Lang (2000) argued that people have limited information processing capacity. When an individual is faced with an overwhelming amount of information, (s)he needs to use a large amount of cognitive resources to process it. During these processes, if the individual's allocated cognitive resources fall short of the required level, cognitive overload can occur (Feng, 2018). In this regard, Hernández-Mendez and Muñoz-Leiva (2015) used eye tracking technique to assess the tourist' visual attention differs depending on the degree of interactivity of online advertising. They found that as animated banners require higher cognitive resources than static banners, less visual attention is paid to them compared to static banners (consumers fixate first on static banners than animated banners). Using FMRI, Oren et al., (2016) provided evidence of performing a secondary task during viewing videos, impaired viewers' memory for those videos. In the context of this study, given that the consumer decides the angle at which (s)he views the 360-degree ad, his/her visual attention may vary. Therefore, it is expected that the higher interactive content will lead to higher cognitive processing levels. As curiosity stimulates interactivity it leads to lower attention being paid to each piece of information. Interactivity is driven by the mouse and, therefore, it requires more brain activity, which creates a negative impact on other physiological activities, such as viewing. Thus, the dynamic nature of 360-degrees ads means that fixation time, and the number of fixations, on specific parts of an ad will be lower in 360-degrees ads than in 2D-ads. Thus, we posit that the greater is the consumer's interactivity with video ads (360-degree vs. 2D), the lower will be the visual attention (s)he pays to the ad content.

H1. The visual attention paid to 360 video ads content is lower than visual attention paid to 2D video ads content.

Effects of interactivity on cognitive processing: brand recognition

It is still unclear how 360-degrees videos affect the processing of the different pieces of information embedded within ads. Of particular interest is the brand logo. Several explanations have been proposed in other contexts. First, previous research has demonstrated that television viewers have poorer recall of commercial content in highly involving program contexts, compared with low-involvement contexts (Coulter, 1998; Coulter and Punj, 1999; Coulter and Sewall, 1995). Pieters and Wedel (2004) found content of animated online ads is remembered less than content of static online ads. Second, although a highly interactive ad helps immerse consumers in the brand story, this may cause cognitive overload (Feng, 2018). Pleyers and Vermeulen (2019), using eye-tracking, showed viewers' attention to the ad and ad effectiveness can be impaired by interactivity and control offered by interactive online media. Compared with the traditional television medium, memory for the ad is significantly reduced when the ads are presented with surrounding stimuli in interactive online media. These explanations fit well with the MOA and the ELM, as follows. The opportunity to watch a specific piece of information, such as the brand logo, is conditioned by navigation behavior, that is, the viewer can chose to look at it, or not. In 360-degrees video ads the least novel piece of information is the brand itself. Therefore, it is expected that consumers will look at it less or, at least, for a shorter period. Also, the brand is part of the central processing domain. As previously discussed, the novelty or unexpectedness of a stimulus relates to peripheral processing. Based on the above discussion, we argue that greater is the consumer's interactivity with a video ad (360-degree vs. 2D), the less the brand logo is viewed. Therefore,

H2. The visual attention paid to brand logo embedded in 360 video ads content is lower than visual attention paid to brand logo embedded in 2D video ads content.

Effects of interactivity on affective processing: engagement with the ad

The digital communications' literature has shown that engagement with the media context increases advertising effectiveness (Calder, Malthouse and Schaedel, 2009). As Van Doorn, et al., (2010) suggested, customer engagement behavior evolves over time; this perspective can be applied to 360-degree video ads because their content varies over time, albeit a short period of time. Therefore, a moment-to- moment measurement of the user's response (i.e. emotions) should be undertaken. Previous literature on customer engagement is still inconclusive depending on the conceptual framework used. In this study we adopt frontal alpha asymmetry (FAA), captured by the alpha wave of the EEG, that reflects engagement in paying attention to, or avoiding, an external stimulus (Ramsoy et al, 2018; Clark et al., 2018). Greater activation in the left or right brain hemispheres has been shown to indicate an approach toward the stimulus, and activation on the right shows avoidance (Harmon-Jones, Gable and Peterson 2010). At a cognitive level, the literature on brain response (Berka et al., 2007) and advertising research (Ohme et al., 2010; Ravaja et al., 2012, Venkatraman et al., 2015) has proposed that frontal asymmetry is an indicator of user preference and engagement with advertisements and their content (Çakar and Gez, 2017). Thus, higher lateralization in the left part of the brain is an antecedent of positive connection with an ad (Ohme, 2011). Emotional connectedness is a process guided by dialogue, authentic connection, and relevance to the customer. Ohme et al., (2010) and Vecchiato et al., (2011) found a dominance of the left hemisphere related to the pleasantness of TV commercial advertisements. Smith and Gevins (2004), using EEG, demonstrated that manipulations of a TV commercial's visual structure that result in rapid pacing or frequent scene changes can be engaging because they require a frequent redirection of visual attention. In 360 video ads, the viewer can enjoy an engaging experience deciding at every moment the point of view to see the video scenes and moving their viewpoint in an arbitrary way to each one of the angles of a 360-degree radius. Customer participation, customization, and emotional connectedness are intrinsic to the 360-degree format and have been identified as important drivers of customer engagement (Bleier, De Keyser and Verleye, 2018; Kumar and Pansari, 2016). Thus, it is proposed that the greater is the consumers' interactivity with video ads *(360-degree vs. 2D)*, the greater will be their engagement of the prefrontal cortex with the ads.

H3: 360 video ads elicit higher frontal asymmetry than 2D video ads.

Effects of interactivity on affective processing: emotions evoked by the ad

Emotions play an essential role in consumer behavior and understanding them is crucial for marketers (Laros and Steenkamp, 2005). Viewers usually experience a mixture of emotions (Hemenover and Schimmack, 2007). The literature argues that emotions are characterized by high excitement (Berger, 2011), such as joy and frustration (Gross and Levenson, 1995). Conversely, sadness or liking to activate low excitation. Since sharing information requires action, activation has the same effect to the social transmission and arousal-evoking content (Berger and Milkman, 2012). Previous research has explored how interactivity impacts users' content perceptions with regard to positive emotions. For example, Horning (2017) examined the effectiveness of second screen interactions on perceived enjoyment of news contents. Oh et al., (2020) demonstrated and indirect effect of 360-degree videos on positive emotions evoked by the video content through enhanced perceived interactivity compared to 2D videos. Recent studies using automatic facial expression detection to measure emotion in advertising demonstrate that interactive advertising elicits positive emotions (e.g. Castellanos et al., 2018; Lacroix et al., 2020; Lewinski et al., 2014; Teixeira et al., 2012). Castellanos et al., (2018) used facial coding to evidence the percentage of time expressing joy was higher in interactive video ads compared to 2D video ads. Lacroix et al., (2020) using Face Reader facial expression recognition software evidenced that advertising perceived as experiential (highly interactive) produce more positive emotions (happiness) than advertising perceived as less experiential. Lewinski et al. (2014) using Face Reader found amusing video ads elicit higher happiness than non-amusing video ads. Teixeira et al. (2012) using face coding found that emotions as joy and surprise can be leveraged to engage consumers in watching Internet video advertisements. The higher interactivity and richer contents of 360 video ads, indeed, may create a higher sense of amusement in consumers than 2D video ads, and therefore elicit positive emotions.

We expect that 360-degree videos will elicit positive emotions. The interactivity between a viewer and stimuli captivates the viewer and engenders positive moods through visual and auditory stimulation (Batat and Wohlfeil, 2009). Thus, the it is proposed that the greater is the consumers' interactivity with video ads *(360-degree vs. 2D)*, the greater will be the intensity of their positive emotions.

H4. Positive emotions elicited by 360 video ads are more intense than emotions elicited by 2D video ads.

A higher level of excitement leads to more effective message processing (Belanche et al., 2017). Previous research has suggested that interactivity affects involvement (Petty et al., 1983) and arousal (Fortin and Dholakia, 2005), which, in turn, elicit higher levels of attention and interest (Kensinger and Corkin, 2003). Bettiga et al., (2017) demonstrated, using EDA, that the context involvement may moderate or even cause observable differences in emotional responses (arousal) toward products, being the higher the consumer interactivity with the product, the greater the influence of unconscious arousal on attitude. Barreda-Ángeles et al., (2020) evidenced an increase in arousal, as measured by EDA, associated with the immersive mode of viewing non-fictional videos. If we extend this reasoning to the context of this study, it is expected than the higher consumers' interactivity with 360 video ads will lead to higher arousal than 2D video ads.Therefore, we propose the following hypothesis:

H5. Arousal evoked by 360-degree videos is greater than arousal evoked by 2D ads.

Material and Method

Sample

The study was conducted in the neuromarketing laboratory of a large European university. The sample consisted of 100 participants (47 females and 53 males, 19-67 years old, M= 43.09, SD=6.49) recruited in the city where the laboratory is located. The participants were recruited by a professional market research company. The initial sample was reduced to 90 due to corruption in some of the acquired signals, i.e. disconnection of a sensor during the test (3 subjects) or signals affected by artifacts (6 participants). The participants all had normal, or corrected-to–normal, vision and hearing. They were compensated for their participation with a gift card of 20€. The study was approved by the ethical committee of the Institutional Review Board of the University. Written informed consent was obtained from all subjects, in accordance with the Declaration of Helsinki.

Experimental design and stimuli

A 2 factor (ad video format display: 360-degree vs. traditional ad) X 2 (product type: FMCG vs. durable product) between-subjects experimental design was implemented. Car and beverage brand ads were chosen because of their popularity and because one captures a durable product and one a FMCG. The criteria for selecting the ads were: (i) to find two official advertisements for each brand in the two different formats (360-degree and 2D); (ii) two products within the same category were needed to control for brand influence and different market share levels, and to address brand familiarity.

	2D	360-degree
Nescafe	https://www.youtube.com/watch?v=VOOvpXFOPpY	https://www.youtube.com/watch?v=beo_Ln00RGc
Lipton	https://www.youtube.com/watch?v=7Myri_gIqT4&t=2s	https://www.youtube.com/watch?v=S_hpD7teoow&t=11s
Honda	https://vimeo.com/158687455	https://youtu.be/p3JKK32xkaU

BMW	https://www.youtube.com/watch?v=AfmMAVWK4Sw	https://www.youtube.com/watch?v=EEmuY2bC3SE

Tabla 5. Descripción del anuncio

Based on these criteria the following four brands were chosen: BMW, Honda, Nescafe, and Lipton. BMW has 6 times the sales of Honda, which is less popular in the market under study (Statista, 2019). Nescafé is the leading instant coffee brand in Spain (5.9 million drinkers); Nestea is the leading iced tea brand in Spain (6.4 million drinkers), much more popular than Lipton iced tea (1.6 million drinkers) (Statista, 2019). Furthermore, per capita consumption of coffee is 3.8 times that of tea in the market under study (Ministerio de Agricultura, Pesca y Alimentación/Ministry of Agriculture, Fisheries and Food 2019).

After the participants were welcomed into the laboratory, they were asked to complete an informed consent form and the study was explained. First, the participants brain and eye movements were calibrated and then, they visualized one of the 4 groups of ads shown in figure 2. The EEG/EDA device was placed on the subjects while they listened to the explanation about the visual stimuli they were about to be shown. The ET and FC devices were embedded in the desk monitor. A specific baseline for EEG was used, which included a three-choice psychomotor vigilance task (3CVT), an eye-open task (EO), and an eye-closed task (EC), each of which were three minutes long. The ET was then calibrated through 9 points that appeared on the monitor. When calibration was excellent or good, participants were randomly assigned to each of the four scenarios depicted in figure 2 to avoid bias in the data gathering. Depending on the scenario where they were assigned, participants visualized four video ads in the sequence shown in figure 2. For example, participants of the first group were exposed to the ads as follows:

(i) 360-degree video ad of Nescafé, (ii) 2D video of Lipton, (iii) 360-degree video ad of Honda and (iv) 2D video of BMW. The resolution of the ads was 1920 x 1080 pixels in both formats. The 360-degree format was viewed using Kolor 3.2. software that allows the users to interact with the video, and the quality is similar to YouTube videos.

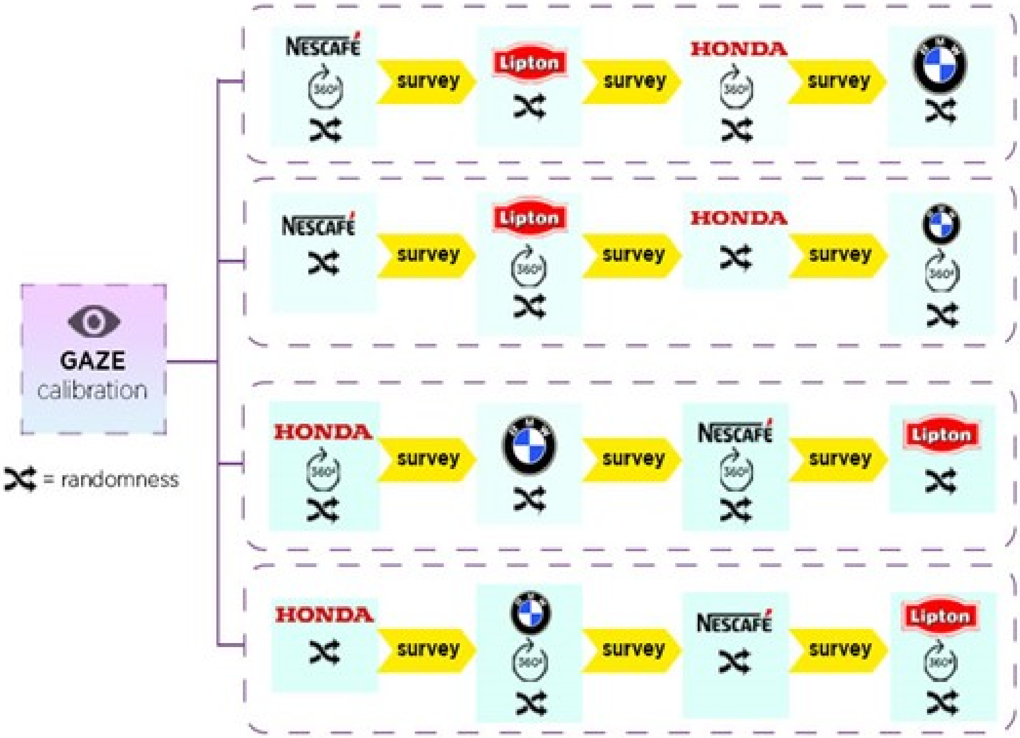

Ilustración 12. Estímulos y diseño experimental.

After watching each video, all groups completed a short survey of likeability towards the ad (one item, five-point scale -"none" to "a lot"-), and willingness to buy the product if money were available (1 item, 5 points scale –definitively not" to "definitively yes"). Table 2 shows behavioural measures of purchase intention and ad liking. The two ads more liked by the viewers were the 2D version of Nescafe video ad and 360 degrees version of Lipton video ad, and no significant differences were found across brands on each format.

Brand	Variable	2D ads		360-degree ads		p_value
		mean	S.D.	mean	S.D.	
BMW	Purchase intention	2.96	0.87	2.94	0.94	0.929
	Ad liking	3.71	1.07	3.52	1.16	0.400
Honda	Purchase intention	2.50	0.85	2.25	0.86	0.147
	Ad liking	3.13	0.87	3.19	1.09	0.733
Nescafe	Purchase intention	3.08	0.84	3.08	0.85	0.969
	Ad liking	4.02	0.87	3.56	0.72	0.661
Lipton	Purchase intention	3.00	0.77	2.88	0.79	0.423
	Ad liking	3.65	0.99	4.10	1.09	0.599

Tabla 6. Medidas de comportamiento.

Measurement of the neurophysiological responses

Visual attention: Eye-tracking

Visual attention was analyzed using the Tobii Pro TX300 eye-tracking device. This records at 300 Hz and has a built-in 23-inch monitor. Following the recording of the gaze behavior, a speed-based fixation detection algorithm, with a threshold of 30 degrees/second, was used to identify the number of fixations and the average fixation time for each stimulus. To measure brand exposure, every second that the brand logo was shown in the advertisement was monitored through a dynamic AOI (area of interest) (Guixeres et al., 2017). We analyzed the percentage of visitors who fixated at least once on the AOI, the number of fixations, and the time spent viewing the brand related AOI. The signals were synchronized with the stimuli through the iMotions Attention Tool (https://imotions.com/guides/).

Consumer engagement of the prefrontal cortex **to the ad: Frontal asymmetry**

To compute the FAA an EEG spectral analysis was performed in each epoch using Welch's method with 50% overlapping. In particular, we calculated the spectral power of the alpha band (8-12 Hz), and frontal asymmetry was calculated using the following formula:

$$[Frontal\ asymetry = \log(F3_{alpha}) - \log\ (F4_{alpha})]$$

Electrical brain activity was recorded using the B-Alert X10 device (Advanced Brain Monitoring, Inc., USA). This records in a total of nine channels, located in the frontal (Fz, F3 and F4), central (Cz, C3 and C4), and parietal – occipital areas (POz, P3, and P4), using the international location system 10-20. The recording was made at 256 Hz. First, data from each electrode were analyzed to identify corrupted channels using the fourth standardized moment (kurtosis). If a channel presented more than 10% of flat signal the electrode was classified as corrupted. The EEG baseline was removed and a bass pass filter between 0.5 and 40 Hz was applied. The signal was segmented into epochs of one second, and an intra-channel kurtosis level of each epoch was used to reject the epochs with high noise levels. To detect artifacts caused by eye movements, blinking, and muscular activation, independent component analysis (ICA) (Gao et al., 2010) was applied; a trained expert manually analyzed all the components, rejecting those caused by artefacts.

Emotions: Electrodermal activity and facial coding

The consumers' emotions were measured using EDA and FC. The EDA signal was measured using the Shimmer 3 device. The signal was pre-processed in two phases. First, the signal was down sampled to 10 Hz (Lang, 2000). Second, in the re-sampled signal, the artefacts were visually diagnosed and corrected using Ledalab (v.3.4.8, www.ledalab.de) via Matlab (v.2016a; www.mathworks.com). The EDA was measured in micro-Siemens, the number of peaks and their amplitudes being identified during each stimulus. These measures are correlated with an increasement in the subject's arousal caused by external stimuli (Bach et al., 2010).

The FC was assessed with a Logitech QuickCam Pro 900 webcam (1600 x 1200, 30 fps) using the Emotient FACET library (Stöckli et al., 2017). This is based on the Facial Action Coding System, and it recognizes the probability from 0 to 1 that a subject is experiencing a specific emotion. It offers a set of seven basic emotions (joy, anger, surprise, fear, contempt, disgust, sadness). For each stimulus, we calculated the percentage of the time that a subject was experiencing a specific emotion, using a threshold of 0.75.

Data analysis

The Gaussianity of the data was checked using the Kolmogorov-Smirnov test ($p > 0.05$, with null hypothesis of having a Gaussian sample). To explore the differences between the subject's responses in 2D and 360-degree format, we carried out the unrelated two-tailed t-test. The data analysis was performed using Matlab 2018b. In order to consider the multiple comparison of four ads simultaneously, a Bonferroni correction was applied decreasing the threshold to consider a test significant to p-value<0.0125

Results

H1 predicts that the visual attention paid to the entire ad content or to specific parts of the ad will be lower in an interactive setting, such as a 360-degree ad, than in a 2D format. As Figure 3 shows, the number of fixations was higher in 2D ads than in the 360-degrees for FMCG. Furthermore, the average fixation time was greater in three out of the four ads. Overall, the participants paid more attention (longer fixation time) to the 2D video ads, except for BMW, than to the 360-degree ads. Therefore, H1 is supported for FMCG, but not for durables. It seems that the 360-degree format elicits a more dispersed view pattern that ultimately leads to a smaller number of fixations (except for durables with a high degree of narrative structure) and less average fixation time.

The higher number of fixations for the durable products can be attributed to the greater attention needed to choose a durable, based on their multiple product attributes, the narrative structure of the ad, and the complexity of the task to be performed in the car ad. The FMCG ads analyzed had a low, or moderate, level of narrative structure (Feng et al., 2019), with no clear plot connections between the scenes. Lipton's "Magnificent Matcha Tea" transports the viewer to a world of flavor represented by a series of exotic scenes (e.g., a woman stands in front of cherry blossoms outside a temple, a woman practices yoga beside the sea, a woman holds a cup of tea she intends to drink) and the Nescafé ad presents multiple scenes simultaneously featuring people from different countries at their breakfast tables starting the day with a cup of coffee and the song "Don't Worry" by Madcon. In contrast, in the BMW ad the viewers are immersed in a simulated ride where they have to keep sight of a fashion model (Gigi Howard) driving a car in a race with other BMW cars (high narrative structure and goal-directed task). A closer look at the BMW ad shows that it demands a task be undertaken; "Can you keep your eyes on Gigi?" If the consumer wishes to perform the task it would not be logical for him/her to change the angle of view because some pieces of the ad content would be lost and, consequently, it would be harder to "keep your eyes on Gigi". Therefore, in the 2D format it is expected that participants will make fewer fixations. These fixations would be focused only on Gigi's position, not the rest of the ad. Conversely, in the 360-degree video, the participants might be motivated to look at other parts of the ad. The interactive viewing experience and the control needed to manipulate the point of view requires higher visual attention to be paid to specific parts of the BMW ad in the 360-degree version, than is required in the 2D version, to perform the task.

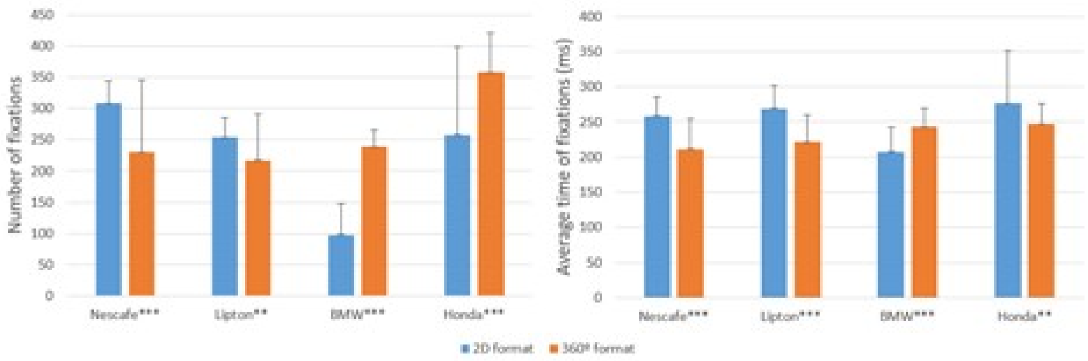

Ilustración 13. Atención visual prestada a los anuncios.

H2 addresses brand recognition through its logo. Figure 4 shows the results of the eye-tracking measures of the brand logo area of interest in the 2D and 360-degree video ads. Results are shown for the three metrics used: percentage of visitors, number of fixations, and time spent viewing the brand. The 2D stimuli attracted a higher percentage of visitors (p=0.000), a higher number of fixations (p=0.000), and more time spent (p=0.013) viewing the brand, confirming H2. As expected, the visual attention paid to the brand logo is lower in the 360-degree video ads, because exposure to this specific element is influenced by the navigation paths adopted by the consumers. This finding is consistent with the MOA model, and more specifically with the motivation and opportunity to process some parts of the ad. Furthermore, the areas viewed by the participants can be explained following the attention capture and transfer model (Pieters and Wedel 2004), that is, they are based on a combination of personal factors and stimuli.

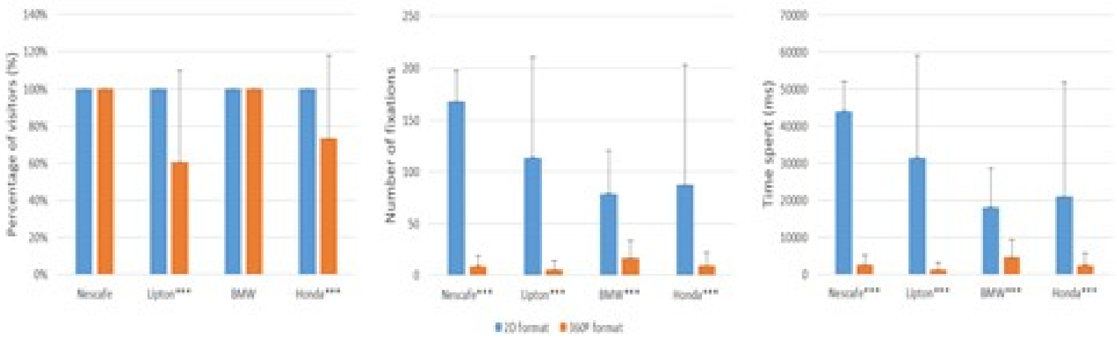

Ilustración 14. Atención visual prestada al logo de la marca.

The FAA was measured using EEG. The results of the brain responses measured through the EEG comparing the 2D and 360-degree stimuli were analyzed using the mean and standard deviations of the asymmetry. The higher the FAA index the higher the approach behavior, with low values indicating withdrawal behavior. This metric has been related to level of engagement of the prefrontal cortex with content viewed (Ramsøy et al., 2018). The 360-degree stimuli presented higher asymmetry than the 2D stimuli for the durable products BMW and Honda, and less asymmetry for the FMCG coffee and tea, as shown in Table 3. Again, the consumers' unconscious responses produced an interesting result. The high interactivity of the 360-degree ads had a greater positive impact on the consumer's engagement of the prefrontal cortex with the ad for high-involvement products (durables), than for low-involvement products (FMCG). However, durables showed no significant differences in frontal asymmetry (H3 not supported). One possible explanation of the higher engagement of the prefrontal cortex of the participants with the 2D version of Nescafe ad compared to the 360 version is the cognitive overload among viewers of the 360 version. The ad presents simultaneously multiple scenes featuring people from different countries at their breakfast tables starting the day that don´t follow any casual order. Multiple self-directed navigation possibilities offered to viewers in the 360 version may make even more difficult to understand the chronology and causality of the narrative structure of the ad, leading to cognitive overload among viewers.

Stimulus	Mean of Frontal Asymmetry		
	2D format	360-degree format	p-value
Nescafe	0.0259 (0.097)	-0.0302 (0.108)	0.0105**
Lipton	-0.00155 (0.102)	-0.0188 (0.113)	0.454
BMW	-0.0255 (0.122)	0.00854 (0.077)	0.121
Honda	-0.0347 (0.101)	0.0124 (0.084)	0.0206

Tabla 7. Asimetría frontal.

As regards H4, which relates to the positive emotions elicited by the 360-degree ads, the FC results (depicted at Table 4) demonstrated that the 360-degree format showed

significant differences, evidencing higher levels of joy and surprise. In the 360-degree ads the viewer is transported to vicariously share the story character's positive feelings and thoughts through an identification process likely to generate positive affect. However, significant differences were observed only for the durable products. This can be attributed to the higher cognition needed for durables and to the focus of the ads. In the car ads the product (the car) is central, whereas the FMCG ads are based on evoked fantasy. Unsurprisingly, it seems that ad content type may elicit different emotions. Moreover, and based on the differences between integral and incidental emotions

Emotions	Stimuli	Mean of the percentage of time experiencing the emotion		
		2D format	360-degree format	p-value
Joy	Nescafe	38.35% (37.01%)	39.61% (33.86%)	0.870
	Lipton	20.64% (22.00%)	28.96% (29.53%)	0.146
	BMW	16.96% (19.92%)	44.57% (38.35%)	<0.001***
	Honda	21.78% (28.29%)	43.37% (34.60%)	<0.001***
Surprise	Nescafe	19.60% (21.63%)	15.51% (16.07%)	0.341
	Lipton	20.75% (23.47%)	21.71% (24.57%)	0.851
	BMW	12.38% (15.72%)	26.54% (23.72%)	<0.001***
	Honda	21.10% (21.13%)	33.99% (28.35%)	0.030

Tabla 8. Emociones positivas

proposed by Achar et al., (2016), the FMCG ads, which focused on fantasy, may be evoking incidental emotions, while the durable product ads, where the product was the focus, may be eliciting integral emotions. Therefore, H4 is partially confirmed

H5 predicted that 360-degree ads would elicit higher arousal; the EDA results comparing the 2D and 360-degree stimuli were analyzed using the mean and standard deviations of the number of peaks and their amplitude. Significant differences were found in the number of peaks and their amplitude, as follows. A greater number of arousal peaks were found in the FMCG ads with 2D formats than in the 360-degree versions, with the Lipton ad showing significant differences in the amplitude of its peaks. In the durable ads, on the other hand, more peaks were observed in the 360-degree ads. Therefore, H5 is supported for durables.

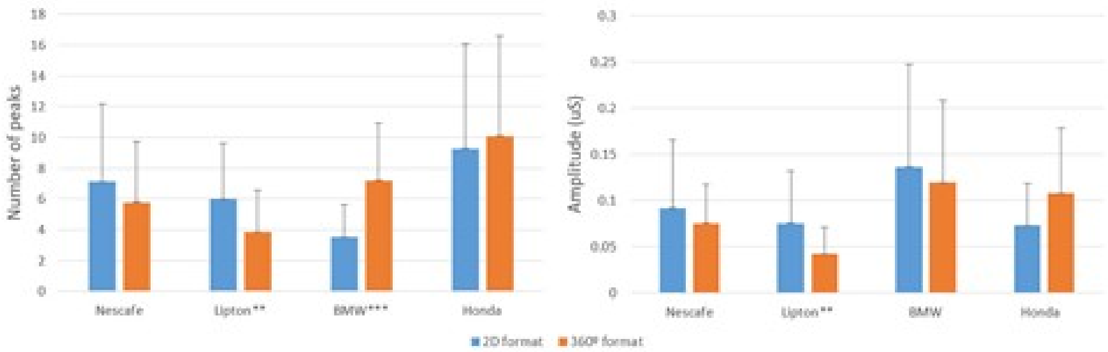

Ilustración 15. Número de picos y amplitud de excitación.

Discussion, conclusions, and implications

The main goal of this study is to compare the effectiveness of traditional and 360-degree video ad formats through consumers' unconscious and continuous (e.g. moment-to-moment) responses to advertisements obtained from EEG, ET, FC, and EDA.

The results showed significant differences in the visual attention paid, measured through ET, in the 360-degree versus 2D ads. Indeed, the number of fixations and the time spent metrics were lower in the 360-degree videos than in the traditional, 2D videos. Therefore, 360-degree videos motivate viewers to watch specific parts of a video less than do 2D ads. This finding is consistent with the nature of the 2D format ads. The 360-degree format allows viewers to look from multiple angles and, therefore, fixation can be dispersed, and the time spent on each stimulus will be lower. As previously stated, this conclusion is consistent with the MOA model and the top-down and bottom-up paths suggested by Pieters and Wedel (2004). Thus, motivation and top-down and bottom-up (i.e. stimuli) factors drive visual attention.

Although it is well recognized that audiences actively participate in the online video advertising process by going beyond the messages presented in the videos themselves, and draw conclusions about brands, this inference process has received little attention in studies into interactive video ads. The application of the ARM model to online video ads provides insights that help to explain how online video advertising is actually processed and to identify the strengths and weaknesses of 360-degree videos in comparison to standard versions. Brand recognition, measured through brand logo exposure and fixation time, was higher in the 2D ads. In other words, the gaze view directed toward the brand logo was higher in the 2D format than in the 360-degree format. Lower visual attention values are related to the viewer's freedom to explore content based on his/her interests (Su and Grauman, 2017). This finding is of importance for the design of brand communications as it is consistent with the MOA model. As in the 360-degree format the consumers' gaze cannot be directed, consumers will pay attention to desirable stimuli based on their motivations. Therefore, exposure to the brand logo cannot be guaranteed and will be conditioned by the consumers' opportunity to view the logo and by their ability to handle the mouse to access different angles of view. In this vein, the present study advances our understanding of interactive advertising by examining cognitive overload from the perspectives of Lang's (2006) LC4MP and the interactivity literature. The results of this study challenge the proposal made in previous research that there is a positive relationship between degree of interactivity and ad persuasion effectiveness. Another interesting finding is that frontal asymmetry is higher in the 2D online FMCG video ads (Nescafe and Lipton) than the 360-degree ads. Therefore, engagement with the ad depends on a combination of the interactivity of the ad and the cognitive overload of the ad.

This research assesses the influence of ad interactivity on emotions through facial recognition and EDA; 360-degree videos evoked more positive emotions, such as joy and surprise, than did traditional ads. As previously discussed, it is expected that greater interactivity will lead to more positive emotions (Rossiter and Bellman 2005; Bellman et al., 2017). Our results showed joy and surprise in longer time frames. Moreover, the required active task in the 360-degree ad might elicit higher interaction with the brand for durable products which, in turn, would lead to more positive emotions. In 360-degree ads viewers have to interact with the brands through the mouse; this evokes higher joy and surprise. We found that arousal, measured through number of peaks and EDA amplitude, was higher in FMCG 2D ads than in the 360-degree ads. This unexpected result might have arisen because other variables, such as involvement with the ad or with the brand, are exerting a mediator effect. Also, in the 2D videos the creative director and producer decide the view sequence. If viewers change their point of view of the content, as they can in 360-degree videos, they can lose the thread of the story, which might cause lower levels of arousal. This result is quite close to the findings of Fortin and Dholakia, (2005), who found no direct relationship between interactivity and arousal in a website setting. However, they found an indirect relationship mediated by involvement.

As regards the managerial implications, it is recommended that practitioners use 360-degree technologies to enhance positive emotions and customer engagement. However, the specific attention paid to the brand logo may vary depending on the viewing angle adopted by the users. The 360-degree video ads conveyed positive emotional responses, but these must be analyzed carefully throughout the entire ad. Thus, the 360-degree format is recommended under certain conditions. First, level of brand awareness must be high. This would mitigate the effect of the viewers not looking at particular stimuli, such as the brand logo, name, and other brand-related elements that may not be recognized by the consumer. Second, the length and content of the videos must be controlled to produce a balanced combination of joy and surprise. 360-degree videos provide more emotional and immersive experiences for customers, which makes them powerful tools with which to create emotional connectedness. Third, advertisers of FMCG goods might use 2D online ads, which can lead to high ad engagement of the prefrontal cortex than the 360 versions. 360-degree commercials need to be more detailed than 2D ads. Instead of looking at one scene from one angle, as in the 2D format, producers must take into account other angles, which will entail more sophisticated and expensive production. Four, advertisers need to make the effort to pre-test how ads are viewed, and from what angles. The challenge is to get the consumers to stick with the 360-degree video and keep them engaged.

From an academic viewpoint, this study makes the following contributions. First, it has been demonstrated that interactivity in video ads boosts positive emotions and enhances engagement. These two variables are commonly described as mediated objectives in advertising campaigns (Pavlou and Stewart, 2000). A strong relationship between interactivity, emotions, and engagement of the prefrontal cortex has been demonstrated in other digital formats, such as social media and websites. As Pavlou and Stewart, (2000) noted, interactive advertising opens up new avenues for communication, but requires new measures of consumer responses (information search, visual attention, and ad information processing). Second, unconscious and continuous metrics based on neurophysiological tools are excellent means of accurately measuring advertising effects in interactive ads. Measures cannot be only explicit, they must also dynamically capture unconscious attention paid and view angles. To the best of the authors' knowledge, the present study is first to measure 360-degree video ads using neurophysiological tools. Third, 360-degree ads represent customized visual communication driven by user participation. 360-degree ads allow viewers to take an active role that challenges the traditional assumptions about the sender and receiver of advertising messages. This new view is in line with customer participation approaches.

Despite the benefits they provide in measuring continuous stimuli types, such as online videos, the physiological methods used in this study have some limitations and challenges. The study results have some limitations that can be sorted into two groups, the stimuli and the participants. First, our results derive from only four ads, and thus conclusions cannot be generalized to other type of ad comparisons with different creative content. Although the study controlled the brand influences and market share levels within the same category, the categories were not control for. The authors sought to analyze both well-known brands, such as Nescafe and BMW, and others with lower brand awareness in the market under study (Lipton and Honda). However, previous consumer experience with the brand might also bias the results of the study. Furthermore, participant-related factors, such as involvement with the brand, and with the ad, might also have exerted some influence. One of the limitations we found is being able to measure the preferences of the participants of the stimuli used in the study. In future studies we will carry out a filter depending on preferences to be able to have that variable more controlled.

Future research might expand in the following directions. First, the influence of content and executional factors, such as music and motion, might be considered. These executional factors might impact on emotions and cognitive workload. Second, the device used might have an impact. In this sense it would be interesting to analyze 360-degree videos viewed on mobile phones or in social media, and include cross-platform synergies, as suggested by Lim, Ri, Egan and Biocca, (2015). Future research might also explore other 360-degree formats, such as 3D, and immersive settings based on augmented and virtual reality (Alcañiz, Bigne and Guixeres, 2019; Wedel, Bigne and Zhang, 2020). This study measures engagement of the prefrontal cortex using frontal asymmetry, future studies may complement our findings with other measures of engagement. This paper uses neuroscientific measures (eye-tracking, FC, EDA and EEG) to measure consumers' responses to advertising, it may strengthen the results obtained to compare the results obtained with self-reported measures of the variables analyzed.

Capítulo 4. Consumer Neuroscience-Based Metrics Predict Recall, Liking and Viewing Rates in Online Advertising

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Abstrat

The purpose of the present study is to investigate whether the effectiveness of a new ad on digital channels (YouTube) can be predicted by using neural networks and neuroscience-based metrics (brain response, heart rate variability and eye tracking). Neurophysiological records from 35 participants were exposed to 8 relevant TV Super Bowl commercials. Correlations between neurophysiological-based metrics, ad recall, ad liking, the ACE metrix score and the number of views on YouTube during a year were investigated. Our findings suggest a significant correlation between neuroscience metrics and self-reported of ad effectiveness and the direct numberof views on the YouTube channel. In addition, and using an artificial neural network based on neuroscience metrics, the model classifies (82.9% of average accuracy) and estimate the number of online views (mean error of 0.199). The results highlight the validity of neuromarketing-based techniques for predicting the success of advertisingresponses. Practitioners can consider the proposed methodology at the design stagesof advertising content, thus enhancing advertising effectiveness. The study pioneers the use of neurophysiological methods in predicting advertising success in a digital context. This is the first article that has examined whether these measures could actually be usedfor predicting views for advertising on YouTube.

Keywords: neuromarketing, YouTube, artificial neural networks, eye tracking, heart rate variability, brain response

Introduction

Advertising effectiveness is still challenging academics and practitioners. Neuroimaging and physiological measurement tools are becoming popular within marketing (Daugherty et al., 2016). Their primary uses are related to unconscious measures based on eye movement, heart rate and brain activity, among others (see Venkatraman et al., 2015 for more details). Such tools aim to provide better understanding of the impact of affect and cognition on memory (Vecchiato et al., 2013). Furthermore, neurophysiological methods can capture the dynamics of television commercials content because they provide continuous data unlike traditional measures, such as interviews and surveys that only reflect a global indicator for every commercial. Global expenditure on media has been rising over the years and digital advertising is the fastestgrowing category (McKinsey, 2015). Marketers are still calling for accurate assessments about advertisement effectiveness and about the return on advertising expenditure (McAlister et al., 2016). Nowadays, Internet advertising has evolved dramatically and a platform like YouTube is a good example on how to reach viewers at a global scale.

Advertisers pursue the attention of viewers and seek ad recall, brand recall and positive emotions. If this occurs, ads will be stored in the viewers' long-term memory. Humans may not remember each advertisement they have been exposed to, but neuroscience techniques can detect conditions that lead to the memorization of advertising. The usage of neuro metrics in measuring advertising effectiveness overcome some of the weaknesses associated with traditional measures (Varan et al., 2015). Despite the benefits of using such measurements, the key question is the choosing of the variables of advertising effectiveness. Among the different types of effects pursue by advertising (see Moriarty et al., 2012), three types of effects have been considered. First, perception, and particularly exposure to the ad is recognized as the first step in any evaluation process. In this study, we adopt the online views as the measure of advertising effectiveness of online ads; secondly, the emotional dimension is typically used in evaluating the effects of advertising, thus we adopt the liking as an emotional metric; lastly, the cognition effect of advertising is measured through ad recall.

Neurophysiological methods offer richer data than self-report measurements of particular interest in advertising research. Firstly, physiological measurements of emotion allow researchers to analyze emotional activity without cognitive bias.

Secondly, neurophysiological methods provide instant and continuous data that allow researchers to decompose the data analysis into small pieces of study. Lastly, physiological measurements typically offer a myriad of metrics. In the present study several metrics are compared and two new metrics derived from eye tracking (ET) are also proposed: "number of quadrants per second" (Quad_sec) and "gaze brand effectiveness ratio" (Brand_ratio).

However, physiological measures have their own limitations: a strong reliance on physiological data to measure emotions leaves room for misinterpretation of physiological noise (e.g., natural changes in body status) and burdens researchers with the difficult task of attributing specific physiological changes (e.g., increase in heart rate) to complex and subjectively experienced emotions (e.g., hate, love, or fear). Scholar research has recently adopted neurophysiological measures to better understand consumer responses to advertising (Astolfi et al., 2009). To the best of our knowledge, no articles in marketing have previously examined whether these measures could actually be transferred into real life views on advertising on YouTube. The work by Venkatraman et al. (2015) was one of the first pieces of research that tried to establish correlations between brand performance and physiological responses whilst viewers watched ads. So far it has been hard to gauge the number of viewers who will watch an ad, which in turn is one of the main objectives for marketers. However, digital platforms overcome this situation enabling researchers to measure consumer unconscious reactions to ads and the number of views.

Neurophysiological methods to measure advertising effectiveness are becoming popular including consolidated tools such as ET and facial reader (Wedel and Pieters, 2014), EGG (Ohme et al., 2010) and more recently sophisticated tools such as fMRI (Venkatraman et al., 2015; Couwenberg et al., 2017).

New extensions to sales are emerging, Thus, biomarkers can, to some extent, predict sales figures (see Kühn et al., 2016) and even in virtual reality experiments have been developed (see Bigné et al., 2016). This paper aims to answer whether neurophysiological methods contribute anything beyond traditional methods in predicting ad success in a digital context. Specific research goals are listed below. Firstly, to analyze whether three of the most cited neurophysiological and behavioural techniques: electroencephalogram (EEG), heart rate variability (HRV) and ET correlate with common cognitive states typically used in advertising research (e.g., liking and recall measures) (Morin, 2011; Ruanguttamanun, 2014; dos Santos et al., 2015).

Secondly, we aim to explain whether the variance in the number of views on a brand's official YouTube channel is related to any of the neurophysiological measures and their metrics.

A study to assess subjects' responses to nine 30-s online television ads was conducted. Data gathered from 47 subjects were split into six datasets based on three conditions: recall (RMB) vs. no-recall (FRG), liking (LIKE vs. DISLIKE) and Internet views (>5M vs. <5M). All the metrics extracted from physiological and behavioral responses were compared and correlated between these groups.

The contributions of this paper are listed hereafter. First, we show how different metrics from three neurophysiological devices correlate in an attempt to select the most accurate ones for digital commercials. Second, Artificial Neural Networks (ANN), using biometric data can predict digital views of ads, hence common physiological patterns related to unconscious responses can predict when an ad is going to be remembered or liked.

Finally, two new metrics are proposed to measure advertising effectiveness in digital advertising, which show a high level of accuracy in predicting digital views. In this paper, we build on the later works that reviewed Super Bowl ads with ET and heart rate (Christoforou et al., 2015), and brain response (Deitz et al., 2016), but adding for the first time joined in neural networks models, three of the most employed signals in advertisement research (EEG, HRV and ET) and proposing two novel metrics based only on eye-tracking data that predicts viewer's preferences in video advertisements.

The rest of the paper is organized as follows. Firstly, we provide a brief literature review of advertising research effectiveness and we introduce neurophysiological methods related to ad recall and ad likeability. Secondly, we describe the experimental design and signal recording and processing techniques used to extract biometric data. Then, we describe the study results in three parts. In the first part, a comparison of the metrics from neurophysiological signals related to likeability of the ad and ad recall. In the second one, the correlations between these biometrics, the score given by participants in a poll (e.g., ACE score) and the number of views on YouTube are exposed; and thirdly, by applying ANN to these biometric datasets, we predict the number of views on YouTube for each ad tested during the study. Finally, we discuss the contributions and implications for researchers and practitioners.

Established Methods in Advertising Research

Despite the diverse approaches used in advertising research (Vakratsas and Ambler, 1999), advertising success on ad execution has focused on traditional measures such as liking, excitability, and recall (Venkatraman et al., 2015). Acknowledging the established literature (Astolfi et al., 2009; Kim et al., 2014), this paper focuses on liking and recall as traditional measures. Online polls have been adopted in academic research as a valuable data source (see Strach et al., 2015). Based on a US national-representative Internet sample of 500 respondents, Ace Metrix has been providing advertising effectiveness scores since January 2009 and it is used in this study. Advertising Research in a Digital Setting Digital channels have changed advertising research dramatically and, as a result, a new paradigm is emerging (Ha, 2008; Bigné, 2016). One of the major gains is that analytics are available at ad level, including exposure measured through number of views and likeability through "likes."

Neurophysiological Tools in Advertising Research

This study focuses on three neurophysiological methods, aiming to collect data from different angles: eye movements, heart variability and brain responses. Eye tracking is a well-established measure of visual attention (Wedel and Pieters, 2014; Venkatraman et al., 2015) to different stimuli, such as product choice (Guerreiro et al., 2015), static images (Mould et al., 2012), printed ads (Elsen et al., 2016) banner ads (Lee and Ahn, 2012) and videos of the Super Bowl (Christoforou et al., 2015).

Heart rate variability is the physiological phenomenon of variation in the time interval between heartbeats. It is measured by the variation in the beat-to-beat interval (Task Force of the European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996). This variability of the heart is related to activations of the sympathetic and parasympathetic systems of the autonomic nervous system. HRV provides an independent measure of attention (Lang et al., 1999) and it has been applied to television commercials (Acharya et al., 2006; Grandjean et al., 2008; Geisler et al., 2010; Bellman et al., 2013; Valenza et al., 2014; Venkatraman et al., 2015). Electroencephalogram is an electrophysiological monitoring method to record the electrical activity of the brain. The relationship between affection, engagement and brain activation in frontal brain activity has been well documented in psychology and neuroscience research (Harmon-Jones et al., 2010; Khushaba et al., 2013). Emotional frontal asymmetry as hypothesized by Davidson (2004) has been applied to analyze commercials (Ohme et al., 2010; Vecchiato et al., 2011), including Super Bowl ads (Deitz et al., 2016) and advertising success (Venkatraman et al., 2015). Vecchiato et al. (2011, p. 582) showed that "activity" in the left-frontal cortex related to "pleasant" commercials and activity in the right-frontal cortex associated with "unpleasant" commercials.

Hypothesis Development

As briefly discussed earlier, ET, HRV and EEG provide measures of responses to advertising stimuli and might be related to ad performance. This study attempts to examine the relationship between three types of data from neurophysiological tools, ET, HRV and EEG, and three advertising variables typically used in advertising research, such as ad recall, ad likeability and ad views. Hypotheses will be anchored in three streams of research aiming to integrate them into a single approach: (i) theoretical advertising literature; (ii) online advertising; (iii) neurophysiological research related to advertising. An integrative approach is useful because neurophysiological primary data per se are non-meaningful for advertising research. Therefore, this type of data must be interpreted in relation to classic advertising assumptions in order to prove their validity. Most of the data gathered in this type of studies are based on a different methodological paradigm that derives from psychophysiology (Bolls et al., 2012).

1. Advertising research shows a positive relationship between recognition and attention. Donthu et al. (1993) found a positive relationship between attention and recall for outdoor advertising. In an ET study, Pieters et al. (2002) found that attention led to ad recognition. Baack et al. (2008) posit that recognition is considered an immediate measure of attention.

2. As discussed earlier, ET and some metrics from EEG can capture attention, hence if attention leads to recall, it could be argued that each neurophysiological tool can capture attention.

The Advertising Research Foundation's Copy Research Validity Project (CRVP) showed in the early nineties that advertising likability is the single best measure of effectiveness (Rossiter and Eagleson, 1994). Furthermore, likeability has been considered relevant and important in measuring commercial effectiveness in the ads aired in the Super Bowl, showing stable scores between 1990 and 1999 (Tomkovick et al., 2001). The positive influence of likeability has also been highlighted recently in online settings. Thus, likeability of online video ads has successfully linked to intention to share them (Shehu et al., 2016), which can be interpreted as a successful performance. Recent literature in neuromarketing also highlights a relationship between liking and HRV, ET measurements and fMRI signals (Venkatraman et al., 2015). Online video platforms, such as YouTube, have been largely approached from the user-generated content perspective (see Smith et al., 2012). However, its dimension as a digital channel for watching commercials has almost been neglected, with some related exceptions (Verhellen et al., 2013). The number of views of each online video, including commercials, is available on YouTube, and it is commonly seen as a valid measure of its popularity. Given its social media nature, recent research is addressing two main fields of interest: the sources that drive views to a video and the preferred type of content. A recent study by Zhou et al. (2016) identified YouTube search and related video recommendation as the major view sources. In adopting YouTube views, the age of the video and the potential replays must be considered. Research shows that user's preference seems relatively insensitive to the video's age (Cha et al., 2007). More recently, Chen et al. (2014) analyzed a lifetime model of online video popularity that features the following three main characteristics of interest here, adopting views as a potential variable in explaining our intended relationships: (i) views follow a Zipf distribution; (ii) replay percentage is very low; (iii) and only video content on news and sports are strongly dependent on age, with popularity being much less sensitive to age in music videos, which can be considered closer to ads. Therefore, views can be adopted as a valid measure over time of ad exposure.

Based on previous reasoning on recall, likeability and number of views, and their relationship with neurophysiological tools, therefore:

– H1: Eye tracking, HRV and brain activity capture (a) recalled and non-recalled online ads, (b) liked and disliked online ads, and (c) ads with high numbers vs. low numbers of YouTube views.

1. Online polls (e.g., Ace Metrix, YouGov) are becoming popular in the industry and have been used for academic purposes. Established scores in the market are considered by marketers as a valuable source of information. Ace Metrix is a company that tests ads within 24–48 h of each ad's initial airing and provides meaningful scores. Ace Metrix component scores range between 1 and 950. Scores for the general population are normally distributed and approximately centered around 530. For obtaining Ace Score, every ad is shown to a unique set of 500 respondents who complete standardized surveys that assess the ad both quantitatively and qualitatively providing rich insights by demographic segment. All ads are scored on 6 factors most likely to influence

consumer behavior including relevance, likeability, information, change, attention and desire—as well as re-watch ability, purchase intent and brand linkage. After respondent scores are collected, Ace Metrix component scores are computed and assigned to each ad, creating an overall score called the Ace Score. Since its inception, Ace Metrix has consistently used the same methodology to measure the effectiveness of every ad they have tested. As a result, they are in a unique position in the field of advertising effectiveness to assess relative advertising performance between any competitive set of ads imaginable, both across different industries and different time periods.

2. In addition, the digital world is changing data availability and triggering new analytical research methods where new research avenues for unstructured data, including neurodata, and new methods like ANN call for new research (Wedel and Kannan, 2016). Venkatraman et al. (2015) conducted a similar study but in the offline context. They found that deceleration correlated with liking (r D 0.37, p < ◎05) and recognition (r D 0.34, p < 0.05).

The current study differs in two ways: (i) we parse neurophysiological correlations in a different context, such as digital exposure featured by searching rather and displaying; (ii) Venkatraman et al. (2015) captured advertising effort, through GRPs, and advertising outcome, through advertising elasticities; however, our study attempts to find out the correlates of neurophysiological metrics from ET, HRV and EEG with independent variables of ad effectiveness based on both, survey data and digital views. Therefore, we predicted:

– H2: Eye tracking, HRV and brain activity capture correlate ith (a) self-reported score of ad effectiveness and (b) online views on YouTube.

As stated before, YouTube as a digital channel to watch commercials has almost been neglected with some related exceptions (Verhellen et al., 2013). Our aim here is to use ANN to predict the number of online views of ads placed in YouTube, where the input variables are metrics from ET, HRV, and EEG. ANN is useful for parsing non-linear relationships and adopt feed forward and back propagation approaches (West et al., 1997). ANN has been successfully applied in advertising since the mid-nineties (Curry and Moutinho, 1993). Research posits the superiority of these methods over other statistical approaches. Surprisingly, this is the first attempt to use ANN to predict online views. In our study, we aim to classify and to predict online views based on metrics from ET, HRV, and EEG. Therefore, we predicted:

– H3: Artificial neural networks based on mixed data from ET, HRV and brain activity predict the number of online views on YouTube.

Materials and methods

Participants and Design

Final sample consisted of 35 randomly healthy volunteers (15 women and 20 men, mean age D 25; SD D 5 years) recruited from the city where the lab is located. Initial sample measured was 47 subjects but after an examination of the dataset was carried out, 12 participants were removed due to corrupted data from experimental sessions in some of the acquired signals. All of the participants showed corrected-to-normal vision and hearing. They were asked to pay attention to the documentary as in a common situation. No mention of the importance of the ads was made. The study was approved by the Institutional Review Board of the Polytechnic University of Valencia with written informed consent from all subjects in accordance with the Declaration of Helsinki.

The experiment was conducted in a neuromarketing lab of a large European university and comprises the three parts shown in **Figure 1**. In Parts 1 and 2, participants sat comfortably on a reclining chair with a 32-channel EEG device, with two electrodes to measure heart variability and an eye-tracker (**Figure 1**). In Part one, participants were exposed to a mindfulness audio designed by experts to help them relax and disconnect from past experiences of the day (Fjorback et al., 2011; Demarzo et al., 2014). Then, in Part two they were shown a 30-min long.

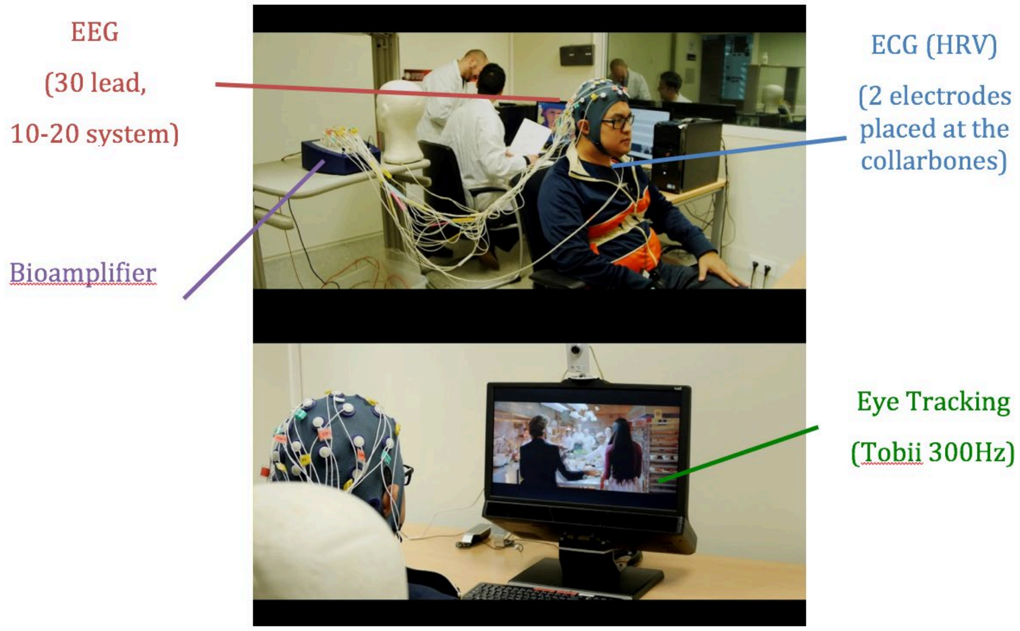

Ilustración 16. Participante en el estudio.

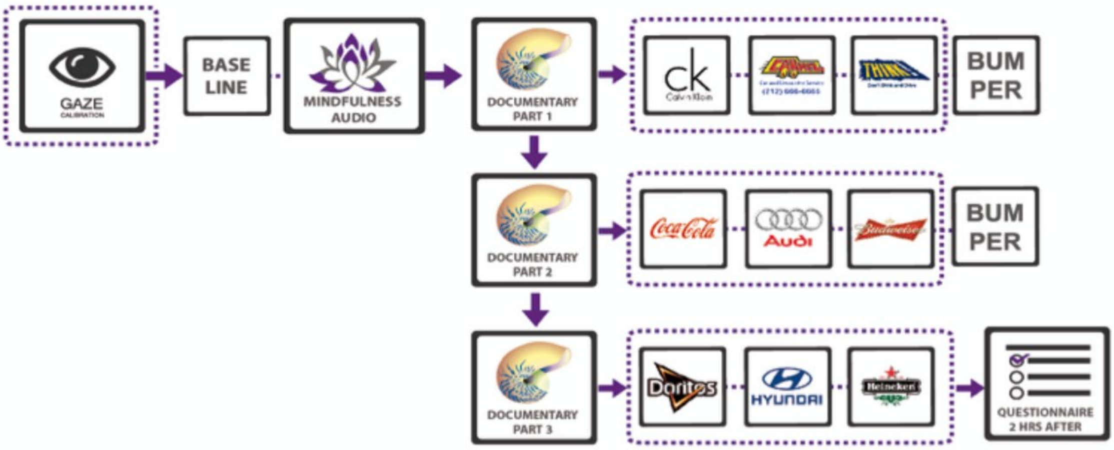

Ilustración 17. Estímulos y diseño experimental.

documentary with three commercial breaks of three ads lasting about 30 s each; the first break occurred after 7 min, the second in the middle of the documentary, and the third 7 min before the end as **Figure 2** depicts. At the end of this second part, participants were informed that an interview would be held 2 h later (Part 3).

Pretesting and Stimuli

Television commercials from the final of the Super Bowl 2015 were chosen because they are a good representation of the most searched high impact ads. We wait for a year to get results of number of views on the brand's official YouTube channel and a final selection of eight from 47 ads was made to represent a uniform distribution of ads ranked by number of views and also to represent a distribution of different commercial products (**Table 1**). In addition to the number of views, the ACE Metrix1 score was also obtained for some ads. The ACE Metrix is the most employed US scale drawn up by consumers that evaluates the ad creative effectiveness based on viewer's reaction to national TV ads. The results are presented on a scale of 1–950. The selected television commercials belong to international brands of commercial products such as drinks (3), food (1), cars (2), textiles (1) and services (1). None of the ads had been broadcasted in the country where the experiment was performed in order to remove previously unchecked exposure of the subjects to the proposed stimuli. These videos were randomly distributed were chosen because they are a good representation of the most searched high impact ads. We wait for a year to get results of number of views on the brand's official YouTube channel and a final selection of eight from 47 ads was made to represent a uniform distribution of ads ranked by number of views and also to represent a distribution of different commercial products during the sessions with participants to avoid bias in data analysis.

Data Recording and Processing

Cerebral Recording (EEG)

Electrical activity of the brain was recorded by a stationary 32-channel system (REFA 32, TMSI hardware). EEG activity was gathered at a sampling rate of 256 Hz. The experiment used 30 Ag/AgCl water-based electrodes and bracelets attached to the opposite wrist of the subjects' dominant hand. The montage of brain electrodes followed the international 10–20 system (Jasper, 1958).

The EEG baseline was removed and channels detected as having corrupted data were rejected and interpolated from the closest electrodes (Colomer Granero et al., 2016). When a channel with erroneous data was identified, kurtosis was employed computing the fourth standardized moment in the signal of each electrode. This kurtosis is defined in Equation 1

$$K(x) = \frac{\mu_4}{\sigma_4} = \frac{E[(x-\mu)^4]}{E[(x-\mu)^2]^2} \qquad (1)$$

where m4 was the fourth moment of the mean, s was the standard deviation and E[x] was the expected value of signal x. The EEG signal was segmented in one second acquired accordingly to the experiment events. The intra-channel kurtosis level of each epoch was used to reject the epochs with high levels of noise.

To detect artifacts from eye movements, blinking and muscular activation, Independent Component Analysis (ICA) (Gao et al., 2010) and automatic method (ADJUST) (Mognon et al., 2011) were implemented. Each EEG artifact-free trace was band pass filtered twice in order to isolate only the spectral components in delta (1–3 Hz), theta (4–7 Hz), alpha (8–12 Hz), beta (13–24 Hz), beta extended (13–40 Hz) and gamma bands (25–60 Hz).

To quantify the cerebral activity in each band, the Global Field Power (GFP) (Wackermann et al., 1993) was calculated as explained in previous work (Colomer Granero et al., 2016). Recent studies have shown that the main areas involved in the phenomena of memorization and pleasantness are the frontal areas (Astolfi et al., 2009). For that reason, calculation.

	ACE_score	No. visits	Rank of visits*
Drink 2	665	12,037,414	D
Car 2	394	10,583,315	D
Drink 3	Non-evaluated	10,356,789	D
Drink 1	641	6,652,069	C
Food	626	4,594,507	B
Textile	362	2,952,014	B
Car 1	611	1,453,022	B
Service	167	15,340	A

VISIT_RANK: A: = <1M views; B = 1M–5M views; C = 5M–10M views; D = >10M views.

Tabla 9. Puntuación ACE metrix, número de visitas al canal oficial de YouTube de una marca durante un año y ranking de visitas establecido para los anuncios de video seleccionados con respecto al número de visitas.

of electrodes in frontal lobe were taken into account. A GFP signal was then calculated for each frequency band considered in the experiment. GFP associated with each ad analysed and GFP during a period taken as the baseline of watching a 2-min neutral documentary before the block of ads were compared and normalized to obtain the corresponding z-score index.

In addition to the z-score of GFP for each EEG band, two metrics applied in advertising research were also calculated: The Pleasantness Index (PI), and the Interest Index (II). The PI is a metric calculated over time that provides information about the pleasantness of the stimuli presented (Vecchiato et al., 2011). Brain activity gathered by left-frontal electrodes is compared with brain activity registered by the right-frontal electrodes (frontal asymmetry). These comparisons are made with GFP in the theta and alpha bands, comparing asymmetric pairs of electrodes.

The questionnaire generated the likeability score for each ad under study. Using this information, participants were segmented into two groups: "LIKE" and "DISLIKE." Then, the brain Pleasantness Index, PI was calculated for each group as describes

(Colomer Granero et al., 2016). The II, enables an advertising evaluation of user interest in theta and beta bands (Vecchiato et al., 2010). The most relevant peaks of these signals are selected. Two parameters were obtained: the number of peaks during a particular ad (PNtotal) and the number of peaks during the periods the brand name appeared in that particular ad (PNbrand). Accordingly, the II was calculated as describes (Colomer Granero et al., 2016).

Heart Rate Variability

To analyze HRV, the electrocardiogram, ECG signal needs to be filtered (Blanco-Velasco et al., 2008), analyzed to detect QRS zones (Pan and Tompkins, 1985) and revised manually by an expert, because the appearance of a single ectopic can produce variations in certain key parameters extracted from this analysis (Clifford, 2006). HRV analysis can generate a set of metrics that can be extracted from different dimensions: time, frequency, time-frequency and non-linear. Parameters extracted from the time domain used in this study were: average heart rate (t_meanHR), standard deviation of continuous HR values (t_sdHR), the square root of the sum of successive differences between adjacent RR intervals (t_RMSSD) and the number of successive pairs of RR intervals showing a difference of more than 50 ms between them (t_NNx). Power spectral density (PSD) analysis provides information about the amount of power in the frequency bands defined for the beat-to-beat interval signal generated. In this case, we employed the Lomb-Scargley method (Castiglioni and Di Rienzo, 1996). The frequency bands defined (low frequency, LF and high frequency, HF) are stated by Task Force of the European Society of Cardiology and The North American Society of Pacing and Electrophysiology (1996). Power metrics can be presented in absolute values (aLF, aHF, aTotal), normalized to total energy (nLF, nHF) or in a percentage value of total energy (pLF, pHF).

The ratio established between the LF and HF band provided information on the sympathetic/parasympathetic balance. The power value of the peak in the fundamental frequency (peakLF, peakHF) was also extracted.

Non-linear analysis was run using techniques such as the Poincaré graph that give us SD1 and SD2 metrics (Fishman et al., 2012). Sample entropy (sampen) is another non-linear technique that attempts to quantify the complexity or degree of new information generated (Richman and Moorman, 2000). If entropy is equal to zero, then consecutive sequences are identical. Similarly, bigger values show higher complexity of the analyzed signal. To summarize, for each ad analyzed by subject, HRV metrics were computed by means of a computational analysis plug-in based on Matlab (Guixeres et al., 2014). For the purpose of this study, the seventeen most relevant metrics employed in HRV analysis (Task Force of the European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996) were selected based on time, frequency and non-linear domains.

Eye Tracking

The Tobii TX300 eye tracker2 was used in this experiment as **Figure 1** depicts. This eye-tracker collects gaze data at 300 Hz. The subsequent analysis of raw data used Tobii Studio 3.2 software. For each commercial the following metrics were obtained from the gaze data: (i) number of fixations during each ad (Fix_Count_Advert); (ii) average duration of fixations during an ad (Fix_Dur_Advert); Furthermore, we obtained several metrics from the times the brand appeared in each ad.

To calculate such metrics, a dynamic Area of Interest (AOI) that followed the brand was created using TOBII studio software to obtain (iii) the average duration of fixations exclusively focused on the brand (Fix_Dur_Br); (iv) the number of fixations during the brand appearance that focused on it (Fix_Count_Br); (v) the time from the appearance of the brand until it was fixated on for the first time (FFIX_Dur_Br); (vi) the number of visits inside the brand's AOI (Visit_Count_Br); and (vii) average duration of visits to the brand's AOI (Visit_Dur_Br). For the last two metrics, it should be remembered that a visit is the event that starts when the eye enters an AOI until it leaves such AOI. In addition to these metrics, two new metrics are proposed in this study: (viii) Number of Quadrants per second (Quad_sec); and (ix) the Gaze Brand Effectiveness Ratio (Brand_ratio). Quad_sec enables the way the user explores a space with his eyes to be quantified. To calculate this metric, the screen surface was divided into a grid of 4 _ 4 equal-sized quadrants. Then, the average quantity of different quadrants that the eye visited per second was calculated for each commercial. Higher values for this metric meant that the subject explored the space in "ambient mode," covering all the space with his eyes, whilst lower values meant that the subject explored the space in "focus mode," centering his visual attention on specific zones. These two modes of watching an image stimulus have been reported in previous works (Bradley et al., 2011; Holmqvist et al., 2011).

$$Quad_{seg}=\frac{N_q}{t_s} \qquad (2)$$

where Nq is the number of visits to quadrants during stimulus presentation and ts is the duration in seconds of the stimulus. Brand_ratio enables the effectiveness of visual attention toward the brand during the ad to be quantified. To calculate Brand_ratio, brand appearance was controlled by setting an AOI around the brand every time it appeared in the commercial.

Then this metric was defined as the number of seconds that the subject looked directly at the brand divided by the total time that the brand was present on the screen during the commercial.

This metric could be related to the participant's interest in and familiarity with the brand as it relates to the time that eye and brain are able to identify a brand, a concept related to familiarity (Kent and Allen, 1994).

$$Brand_{ratio}=\frac{t_{bf}}{t_b}$$

where tbf is the time in seconds that the gaze fixed on the brand and tb is the total time in seconds that the brand appeared during the ad.

Questionnaire

Data were sorted using three criteria: (i) spontaneous ad recall; (ii) ad liking; (iii) the number of online views was used as a control variable. The criterion for ad recall was to remember without clues brand names of the commercials 2 h after the study. Accordingly, participants were split into two subgroups. The first dataset was related to the biometric activity collected during the observation of the recalled commercials 2 h after being exposed to them. This dataset was named RMB. The second subset included the biometric activity collected during observation of the non-recalled commercials, (FRG). The ad liking criterion was related to the biometric activity collected during observation of the television commercials that the subjects rated 5 or above on a 10-point Likert scale, being this subset named LIKE and DISLIKE, respectively.

Statistical Methods

In order to test comparisons of means of the metrics calculated, a set of Shapiro-Wilk tests (W) were conducted to test whether dependent variables deviated from normality. Then a statistical analysis was carried out using ANOVA for metrics with normal distribution and the Mann Whitney non-parametric test for metrics that did not show a normal distribution. A corrected p-value less than p D 0.005 was chosen to correct multiple comparisons effect (Feise, 2002).

To get the correlation of neurometrics with the ACE score and the number of online views of the ads on YouTube, a Pearson correlation was applied to the number of visits so it could be considered as a linear scale. However, Spearman's correlation was applied to the ACE score so it could be considered as a rank variable instead of a linear scale.

Artificial Neural Networks

We adjusted two neural networks with SPSS statistics using all metrics defined for EEG, HRV and ET, and including gender, as our input variables. The first network was adjusted to classify advertising responses into a ranking for the number of views on YouTube (RANK_VISITS). This ranking divided ads into four clusters (<1M: ads with less than 1 million visits, 1M–5M, 5M–10M, and >10M: ads with more than 10 million visits). The second network was adjusted to predict the real number of visits for each ad.

Two kinds of network were compared with the same data. Multi-layer Perceptron networks (MLP) and Radial Basis Function networks (RBF). Regarding accuracy for classification and estimation of the data, MLP networks were selected finally for the two purposes instead of RBF. After testing results changing several parameters in MLP architecture, a final structure was chosen for the both neural networks (see Appendix). To validate accuracy of networks, cross-validation technique was employed. Entire sample was divided into two groups (70% of cases for training the network and 30% of cases to assess classification accuracy) and that validation was repeated 10 times (k D 10), selecting each time different groups for training and assessing. Final results were averaged from the 10 turns.

Results

Biometric Mean Comparison

In order to test H1, we conducted a comparison among means of the metrics calculated from EEG, HRV and ET. As stated earlier, these metrics were compared by means of the following two conditions, recall vs. non-recall after 2 h (RMB vs. FRG) and by likeability (LIKE vs. DISLIKE).

Brain Response Comparison

Figure 3 shows the comparison among means for z-score indexes in each frequency band for the different factors chosen. In the case of remembered ads, the RMB group shows significant differences compared to the FRG group with higher values in the delta, theta, beta ext. and gamma bands. The LIKE group showed significant differences compared to the DISLIKE group with higher values in the delta, theta, beta ext. and gamma bands.

In the pleasant index (PI) and II, there were no significant differences in the comparison between the recalled and liked groups.

HRV Response Comparison

Table 2 shows the comparison of means for HRV metrics for the different factors chosen. In the case of the remembered ads, the RMB group showed significant differences compared to the FRG group, with higher values in the non-linear SD2 Poincaré index (p_SD2) that reflect higher continuous beat-to-beat variability (Piskorski and Guzik, 2007). The LIKE group showed significant differences compared to the DISLIKE group with higher values in the energy of the low frequency band (f_aLF_lomb) which is associated with sympathetic activation (Task Force of the European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996).

ET Response Comparison

Table 3 shows the comparison of means for eye-tracking metrics for the different classic metrics and the two-new metrics proposed. In the case of the recalled ads, the RMB group showed significant differences vs. the FRG group, generating lower values in (Visit_Dur_Br). The LIKE group did not show significant differences compared to the DISLIKE group.

Hypothesis 1 is confirmed, as there are significant differences in each signal (EEG, HRV and ET) between ads (i) recalled and non-recalled (22% of comparisons) and (ii) liked and disliked (16% of comparisons).

As regards H2, centered on the correlation of neurometrics with the ACE score and the number of online views of the ads on YouTube, 19 of the 25 metrics showed significant ($p < 0.01$) correlation with the ACE score and 15 of the 25-metrics showed significant correlation with the number of online views. In EEG, the z-score in the delta band correlated with both indexes and the z-score in the theta band correlated with the ACE score. Both indexes, pleasantness and interest, showed high values in terms of significant correlation with the ACE score.

In particular, there was a high level of correlation between PI_theta and the number of visits. In terms of ET, the proposed metric (Brand_ratio) showed significant correlations with both indexes, PI and II. In addition, Quad_sec showed significant correlation with the ACE_score. Visit duration and Fixation count on the brand showed significant correlation with the number of visits. Fixation duration showed a negative correlation with the ACE score and the value of the correlations of the Fixation count during the ad for both indexes was relevant.

Focusing on HRV, t_NN50 showed significant correlations with both indexes. The total energy band; LF and HF bands, also showed correlations with both indexes. The normalized values of LF and HF and the sympathovagal index (LFHF) showed significant correlations with the ACE score. Frequency with the maximum peak on the HF band (peakHF) and the SD2 Poincaré index also showed significant correlations with the number of visits. The type 1 non-linear parameter sample entropy index (sampen1) showed significant correlations with both indexes whilst sampen2 only correlated with number of visits.

Therefore, H2 is confirmed, showing significant correlations between metrics for EEG, HRV and ET with ACE score and number of visits on YouTube.

Predicting Ad Effectiveness on the Internet with ANN

ANN to Rank Visit Classification

Two kinds of ANNs were compared with the same data: MLP and RBF. In terms of accuracy when classifying data, MLP networks worked better than RBF. After testing results and changing several parameters in the MLP architecture, the final structure chosen had one hidden layer with a tangent hyperbolic activation function and an output layer with a softmax activation function. All the co-variables were typified (see Appendix for more details).

Table 4 shows the final results for the classification of the training and the test dataset using the neural network. The percentage of correct predictions in the test dataset was 82.9%. Three higher ranking levels (1M–5M, 5M–10M, and >10M) showed high effectiveness ratios of classification (88.5, 100, and 90%, respectively). Only the first group (<1M) showed a poor effectiveness ratio of 36.4%, mistaking more than 54% of cases for second level (1M–5M).

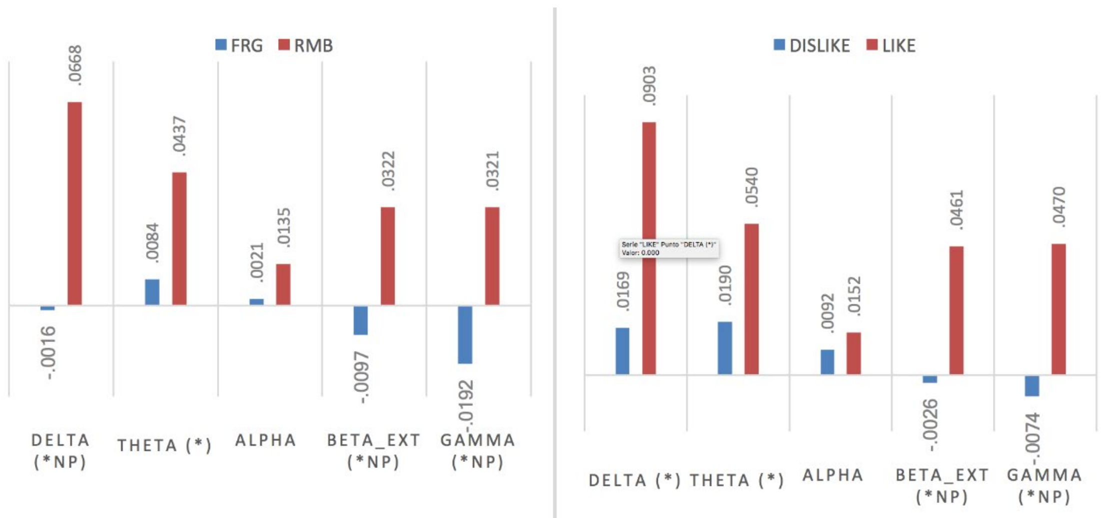

Ilustración 18. Resultados de la respuesta cerebral (EEG) comparando los resultados de GFP para 5 bandas específicas.

Of the 37 input variables used in neural networks, the importance of each normalized metric to predict was extracted from the neural network. This metric shows the most relevant variables for classifying each case according to the correct ranking. The pleasantness index extracted from the theta band (PI_theta, 100%) was the most important parameter for brain metrics, followed by II_theta (56.6%) and PI_ alpha (56.5%).

Regarding HRV metrics, the mean of HR (64.20%) was the most representative parameter, followed by SD1 Poincaré (61.40%) and t_RMSSD (58.30%). In terms of eye-tracking metrics, the fixation count during the ads (59.30%) was the most important index, followed by the average fixation count during brand appearance (59.30%), and the average duration of fixations during brand appearance (45.30%). Gender inclusion and whether the ad was consciously remembered came last in the ranking with very little importance. The proposed metrics from ET showed medium importance (Ratio_Brand: 40.80% and Quad_sec: 40.20%). When comparing the frequency brain bands, the theta band behaved best, in the PI index (100%), II index (56.6%) and z-score (37.50%).

	RMB		FRG			UNLIKE		LIKE		
HRV Metrics	Mean	SD	Mean	SD	p	Mean	SD	Mean	SD	p
t_meanHR	71.9	12.3	70.6	8		69.6	8.8	71.1	7.8	
t_sdHR	5.2	7.3	5.5	4.5		5.1	5.6	5.3	2.7	
t_NN50	13.3	18.4	13.8	12.7		13	13.6	13.5	13.3	
t_RMSSD	43.5	32.3	54.6	112.3		43.2	26	60.1	142.7	
f_aLF_lomb	0.031	0.015	0.033	0.013		0.031	0.014	0.035	0.014	(*NP)
f_aHF_lomb	0.027	0.020	0.027	0.017		0.029	0.021	0.026	0.017	
f_aTotal_lomb	0.060	0.027	0.061	0.022		0.062	0.028	0.062	0.024	
f_nLF_lomb	0.539	0.223	0.573	0.2		0.547	0.203	0.594	0.194	
f_nHF_lomb	0.461	0.223	0.427	0.2		0.453	0.203	0.406	0.194	
f_LFHF_lomb	2.022	2.156	2.121	2.057		1.786	1.545	2.412	2.412	
f_peakLF_lomb	0.1	0.02	0.09	0.02		0.09	0.02	0.09	0.02	
f_peakHF_lomb	0.27	0.07	0.26	0.07		0.26	0.07	0.25	0.07	
p_SD1	30.7	22.8	32.8	21.4		30	18	32.9	19.8	
p_SD2	66.1	28	77.6	36.7	(*NP)	68.8	30.4	80.3	38	
p_SD1vsSD2	0.497	0.382	0.441	0.192		0.462	0.224	0.423	0.154	
nl_sampen1	2.175	0.227	2.141	0.243		2.179	0.25	2.143	0.217	
nl_sampen2	1.803	0.486	4.19	0.532	(*NP)	9.373	0.788	1.66	0.389	

*Values with significant differences $p < 0.005$; NP, non-parametric test.

Tabla 10. Comparaciones de medias de métricas de VFC en los dominios de tiempo, frecuencia y no lineales.

ANN for Estimating the Number of Online Views

As described above, MLP and RBF were compared only in terms of accuracy (time execution was extremely low in both cases). MLP networks also worked better than RBF networks in terms of accuracy when estimating the number of visits. After testing results and changing several parameters in the MLP architecture, the final structure chosen had one hidden layer with a tangent hyperbolic activation function and an output layer with an identity activation function. All the co-variables and the dependent variable were typified. For the final MLP structure, the first subset was used to train the MLP and the estimated values of the number of visits were obtained from the second subset to test the accuracy of the network. Final results for the estimation of training and the test dataset using an ANN. Relative error from the test dataset was 0.199, that is, a significant level of variance.

Of the 37 input variables used in the neural networks, the pleasantness index extracted from the theta band (PI_Theta, 100%) was again the most relevant variable in the neural network in predicting the number of views. Regarding brain metrics, PI_theta was followed by PI_alpha (13.10%) and II_theta (11.60%), though these were a long way behind. In HRV metrics, sample entropy (53.70%) was the most important parameter, followed by the total energy of frequency band (43.40%) and t_RMSSD (41.70%). Regarding eye-tracking metrics, the count of fixations during ads (44.30%) was the most important index, as on the first occasion, followed by number of visits during brand appearance (27%) and then followed very closely by the count of fixations during brand appearance (26.60%). The inclusion of gender in the model and whether the ad was consciously recalled ranked last and do not improve prediction. The proposed new metrics extracted from ET showed different results. Quad_sec showed a medium-low importance (16%) and Ratio_Brand a low importance (6.70%). Half the HRV metrics were in the upper positions.

Figure 4 represents predicted vs. observed values as a scatterplot for each case. Figure shows that neural network classifier worked well in classifying real data regarding biometric response, specifically observing the cluster of ads with higher number of views vs. ads with poor audience. There was some dispersion in all the ads in terms of real values.

	RMB		FRG			UNLIKE		LIKE		
Eye Tracking Metrics	**Mean**	***SD***	**Mean**	***SD***	***p***	**Mean**	***SD***	**Mean**	***SD***	***p***
Brand_ratio	0.36	0.25	0.32	0.25		0.37	0.26	0.31	0.24	
Visit_Count_Br	6.7	2.42	6.65	2.33		7.29	2.53	6.32	2.38	
Visit_Dur_Br	0.76	0.24	0.63	0.25	(*NP)	0.75	0.23	0.62	0.38	
FFix_Dur_Br	0.18	0.14	0.16	0.13		0.17	0.13	0.15	0.13	
Fix_Dur_Br	0.18	0.12	0.17	0.11		0.18	0.15	0.17	0.12	
Fix_Count_Br	28.23	28.97	23.73	22.87		33.76	37.48	21.98	19.29	
Quad_sec	2.47	1.35	2.48	1.29		2.65	1.62	2.58	1.24	
Fix_Dur_Advert	0.24	0.1	0.24	0.11		0.24	0.12	0.21	0.11	
Fix_Count_Advert	273.32	120.34	281.8	200.12		340.73	180.73	270.83	165.43	

**Values with significant differences p < 0.005; NP, non-parametric test.*

Tabla 11. Comparaciones de medias de métricas de ET.

	Classification					
	Real rank order	**Predicted**				
		<1M	**1M–5M**	**5M–10M**	**>10M**	**% succ.**
Training	<1M	17	1	0	0	94.4%
	1M–5M	0	60	0	0	100.0%
	5M–10M	0	0	23	1	95.8%
	>10M	0	0	0	67	100.0%
	Overall percentage	10.1%	36.1%	13.6%	40.2%	98.8%
Test	<1M	4	6	1	0	36.4%
	1M–5M	2	23	0	1	88.5%
	5M–10M	0	0	9	0	100.0%
	>10M	0	0	3	27	90.0%
	Overall percentage	7.9%	38.2%	17.1%	36.8%	82.9%

Number of cases in each possible class and percentage of successful cases.

Tabla 12. Resultados de la clasificación exitosa del conjunto de datos de entrenamiento y prueba aplicando una red neuronal ajustada.

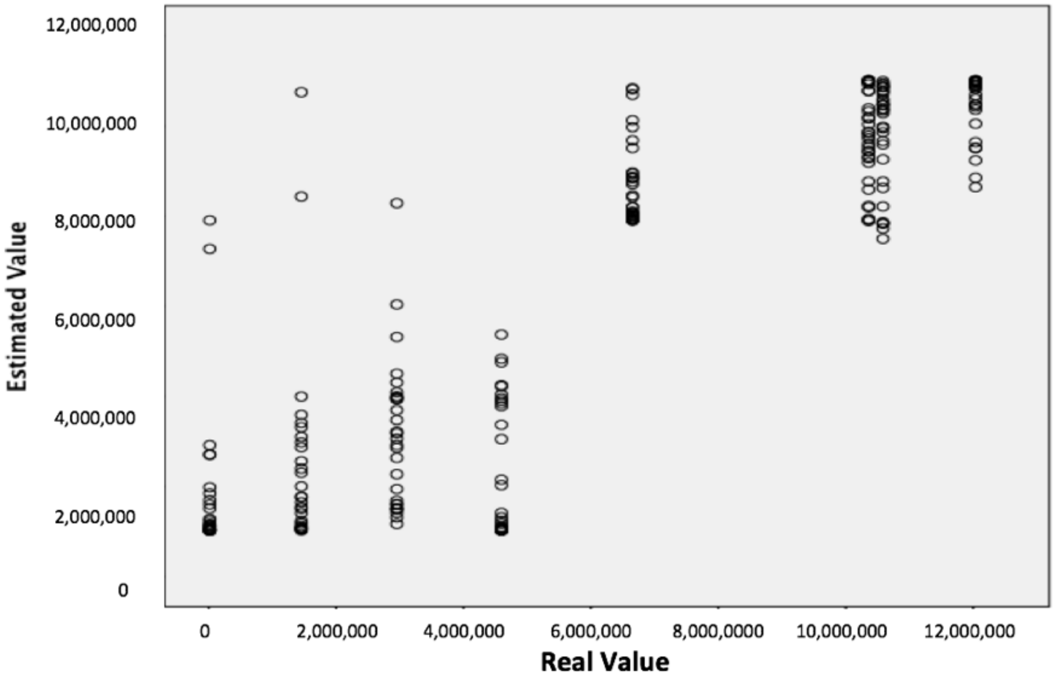

Ilustración 19. Diagrama de dispersión que muestra los valores predichos frente a los observados para el número de visitas.

Discussion

In this study, several hypotheses have been confirmed. The first hypothesis was supported, showing significant differences in physiological responses (EEG and HRV) and ET for each of the three dimensions raised (i.e., recall, liking and visits). In cases where participants remembered the ad after 2 h, results showed higher probability that the spectral amplitude in the RMB condition was always higher than the power spectra in the FRG conditions (Astolfi et al., 2008). A statistical increase of PSD in the prefrontal and parietal areas for the RMB dataset compared with the FRG dataset was in line with the suggested role of these regions during the transfer of sensory perceptions from short-term memory to long-term memory storage. Specifically, there were higher values in the theta band for the cases where the ad was remembered, which is in line with other studies (Werkle- Bergner et al., 2006; Boksem and Smidts, 2014; Vecchiato et al., 2014). Regarding this condition, an interesting future analysis should look at the biometric response differences between people that remember the ad without remembering the brand or vice versa.

In terms of the HRV analysis, the means of the sample entropy parameters were significant, showing the higher complexity of heart variability in cases where the ad was remembered. Valenza et al. (2012), showed that Approximate Entropy, decreased during arousal elicitation using images from International Affective Picture Session (IAPS) but there are no studies until now that have related HRV entropy with remember cognitive function.

In ET, cases where ads were unrecalled showed longer duration of visits to the brand when it appeared on screen. Higher values for this metric are related to difficulty in identifying an object (Goldberg et al., 2002; Wedel, 2013). This fact could be explained by poor identification of the brand, which could indicate that the ad will be forgotten in the short term.

Regarding cases where participants rated the ad positively or negatively, brain activity was stronger in terms of PSD in the LIKE group than in the DISLIKE group. These results are congruent with another EEG studio based on the observation of pictures from the international affective picture system (Aftanas et al., 2004). In HRV, there were only significant differences in energy in the LF frequency band associated with sympathetic activation. In ET, no significant differences were found for the proposed metrics.

The second hypothesis was supported showing significant correlations between physiological and eye-tracking responses with the ACE score and with the number of online visits.

All the indexes (pleasantness and interest) calculated showed significant correlations. The pleasantness index in the theta band presented an especially high correlation with the number of visits and the ACE score. In ET, there were relevant correlations with both metrics proposed in this work. Brand_ratio showed a positive linear relation between the percentage of time watching a brand and the number of views on the Internet. The number of fixations for the brand showed a positive relation with the number of views on the Internet. Regarding HRV, there was a positive correlation with tNN50 for both outputs. All the energy values in the frequency bands (total, LF and HF) were negatively correlated with both outputs. The ACE score was positively related to the normalized LF band associated with sympathetic activation. Non-linear entropy parameters also showed a negative correlation with both outputs revealing that an increase in the complexity of the HRV signal is associated with less quality and effectiveness of the ad on the Internet.

Hypothesis three aimed to test whether ANN with relevant biometrics could represent an interesting technique to classify ads based on their ranking on the Internet and to estimate the number of visits on the Internet. The results obtained showed that the ANN were able to accurately classify and estimate the effectiveness of each ad on the Internet via their biometric response. The results for the first network, which were adjusted to classify each ad based on a four-level ranking, showed a global average accuracy of 82.9%. Poor accuracy was obtained with ads with a lower number of views but this could have been improved if more ads in this ranking had been selected in the stimulus group. The relevant metrics for this classification were the pleasantness index and II in the theta band, the mean heart rate and the SD1 Poincare in HRV, the number of fixations during the ad and inside the brand for ET. Results for the second network to estimate the number of views on the YouTube for each ad showed a relative error of 0.199. The most important metrics for this estimate were the pleasantness index in the theta band, entropy in HRV and the number of fixations during advertising in ET. Despite good results to estimate the number of views, it would seem that classifying ads according to a ranking constitutes a better approach, taking into account the excellent results obtained in the first classifier.

Further research is needed, with more studies comparing new techniques for classification, such as Linear Discriminant Analysis, Marquardt Backpropagation Algorithm, and Deep Learning. In addition, new metrics and new signals extracted from biometric responses must be tested to find out which parameters are best to evaluate the effectiveness of advertising. The group of different categories of advertising must also be increased. Future studies should also focus on adjusting personalized classifiers to advertising categories (fashion, food, social, etc.), different channels (e.g., Facebook) and formats (desktop or mobile). Also, new metrics like facial gesture coding (McDuff et al., 2015) and fNIRS (Kopton and Kenning, 2014) could be mixed in new models for predicting Ad effectiveness.

Conclusion

This study has shown that aspects related to the impact of advertising, such as whether the ad is going to be remembered or whether it is going to be highly rated can be detected from an analysis of consumers' biometric responses during the viewing of these ads. We also found differences in the impact of advertising in terms of gender, which encourages the use of these biometric data to design advertising content that is tailored to each individual group of population. Other variables, such as age, cultural level, and even personality could be explored in future studies to test whether there are similar differences to the ones found in gender. The final conclusion that this study has yielded is that the effectiveness of a new ad on YouTube can be predicted using metrics extracted from EEG, HRV and ET. Up until now, there has been no evidence that biometric responses can help to classify the numbers of views on YouTube for an ad. This study has also contributed with two new metrics for ET that can be used in research on advertising. These results will help to explain the success of advertising responses showing an interesting methodology to be use by practitioners designing advertising content.

AUTHOR CONTRIBUTIONS

JG is the corresponding author. JG, EB, and MAR designed the study. JAA conducted the study. JG, EB, and JAA conducted the literature review and wrote the research summaries. ACG and VNO analyzed the EEG data, JP and JAA analyzed HRV and ET data. MAR and EB are the directors of this work. JG wrote the first draft of the manuscript, and all authors contributed to and have approved the final manuscript.

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Capítulo 5. Discussion

En este capítulo discutimos las implicaciones principales del trabajo realizado. El uso de la neurociencia del consumidor en la investigación del comportamiento humano centrándose en las medidas neurofisiológicas que desempeñan en los próximos años un papel fundamental y critico como herramienta para generar y evaluar un contenido publicitario eficaz. Hemos analizado la sinergia del formato, la música y los canales digitales del anuncio de publicidad con las medidas neurofisiológicas y la predicción aplicando redes neuronales.

La neurociencia del consumidor como metodología para la medición de la efectividad en la publicidad.

La publicidad actual se ha visto marcada por la profunda crisis que ha influido en la cesta de los consumidores y las campañas publicitarias han visto una reducción de la efectividad del impacto de la publicidad con el mensaje del público. La era digital ha multiplicado los canales de publicidad y dispositivos en los que la competencia es cada vez mayor. Esta consecuencia ha tenido una mayor dificultad para poder acceder al objetivo perfecto debido al aumento de número de impactos, lo que hace aumentar el nivel de rechazo sobre los anuncios perdiendo la eficacia en la publicidad.

Debido a los avances y accesibilidad en los dispositivos de medición de las respuestas fisiológicas nos quisimos enfocar principalmente en el electroencefalograma, reconocimiento facial, eyetracking, respuesta galvánica de la piel y variabilidad cardiaca. Para poder explorar y analizar su alcance en el uso de la evaluación de la publicidad y así medir los constructos psicológicos utilizados en publicidad como es la atención, asimetría, carga cognitiva, satisfacción y la memoria.

Es por ello por lo que en esta tesis hemos investigado canales digitales como Youtube y la eficacia de los anuncios en ellos. Como se puede observar en el Capítulo 3 donde se midió la efectividad de los videos de la Superbowl a través de la medición cerebral, frecuencia cardiaca y movimientos oculares en la que se relacionó con dimensiones cuantitativas como son el número de visitas, el nivel de memoria y el gusto. En este caso pudimos concluir mediante la densidad espectral de potencia (PSD) en la parte prefrontal y parietal que son las encargadas de codificar la memoria de corto a largo plazo, que los anuncios con mayor nivel de recuerdo tenían mayores valores en la banda cerebral theta como otras investigaciones lo muestran (Werkle-Bergner et al., 2006;

Boksem and Smidts, 2014; Vecchiato et al.,2014). Así como a nivel de satisfacción o disgusto se mostraron diferencias significativas en la banda alpha en el grupo de la gente que les gusto más los anuncios. En el trabajo se desarrollaron dos nuevos indicadores: por un lado se desarrolló el índice del nivel de satisfacción llamado "Pleasantness index" (PI). También se desarrolló el "Interest index" (II), que permite una evaluación publicitaria del interés del usuario procesando los picos de las bandas theta y beta (Vecchiato et al., 2010).

En cuanto al eye tracking, se descubrió que los usuarios que no tenían fijaciones más largas que el resto correlacionaba con la falta de recuerdo en los anuncios vistos.

Otra de las aportaciones a la medición de la efectividad fue la creación de dos métricas propias, una métrica llamada "Quad_seg" para medir la forma de mirar el anuncio dividiendo el anuncio en 4 por 4 celdas, y midiendo el número de visitas por segundo a cada una de ellas durante la presentación del estímulo como un indicador del nivel de exploración de este. Esta métrica mostro diferencias significativas que se relacionaban con las evaluaciones más empeladas en publicidad como el "Ace Score"como se muestra en el capítulo 4 , identificando la forma de ver un anuncio y el éxito con el público.

También se creó la métrica Brand Ratio. Esta métrica se definió como el número de segundos que el sujeto miró directamente a la aparición del logo de la marca dividido por el tiempo total que la marca estuvo presente en la pantalla durante el comercial. Esta métrica muestra el nivel de interés del participante y la familiaridad con la marca al respecto en que el ojo y el cerebro son capaces de identificar la marca. En la que identificamos había correlaciones directas con el nivel con el índice de interés y con el interés de placer.

Otra de las partes importantes de la medición de la efectividad del anuncio es la composición del anuncio ya que la estructura de la composición audiovisual también influye significativamente en la efectividad del anuncio (Price et al 2012). Uno de los aspectos más importantes en la composición de un anuncio es la música y su conexión cognitivo-afectiva. Para investigar más esta conexión medimos la influencia de la música congruente e incongruente en los anuncios como se puede observar en el Capítulo 1 donde analizamos desde un análisis de respuestas fisiológicas que la música congruente genera un nivel de emociones más positivas en especial con música alegre que la refuerza positivamente y a su vez genera un mayor nivel de satisfacción y mejor nivel de recuerdo en los usuarios que los visualizaron. Así como la música incongruente genera un mayor nivel de atención visual y un aumento de carga cognitiva cerebral (Lin, M et al 2018). En este estudio se observó a través del eye-tracking como la música incongruente genera un mayor nivel de atención visual a través de las fijaciones por segundo y la media de fijaciones, identificando ese nivel alto de procesamiento mental.

Debido al avance en los dispositivos móviles, los formatos en la era digital han aumentado, las marcas están trabajando para conectar con los sensorial y para ello necesitan datos de cómo funciona el sistema de procesamiento del cuerpo humano en relación con determinados formatos publicitarios que pueden ser relativamente novedosos. En este caso en esta tesis en el capítulo 2 hemos investigado el impacto que podían tener anuncios en formato tradicional vs anuncios en un formato más inmersivo e interactivo como son los videos de 360º en los que el cliente puede orientar el encuadre del video en todo momento. En este trabajo observamos que a través de los anuncios de 360 grados se generaban emociones más positivas y una mayor engagement con el cliente. La publicidad en 360 obtuvo mayor atención en los anuncios de bienes de consumo. Así como en la mirada del logo que fue menor en los anuncios de 360 que en los de 2D. Dado que los anuncios de 360 generaron experiencias más emocionales e inmersivas para los clientes, son un gran aporte para crear una conexión emocional. Referente a los anuncios de formato tradicional se comprobó que tienen mayor nivel de engagement en la corteza prefrontal en anuncios de bienes de consumo masivo.

El objetivo de la tesis se ha centrado en validar el uso de la neurociencia como herramienta para medir la eficacia de la publicidad. En los 3 trabajos se evaluaron a nivel metodológico el uso de nuevas señales, su procesamiento creando así nuevas métricas de alto impacto para conocer de una forma exacta las veces que se miraba la marca y la manera de observar el anuncio en función del producto y el cliente. Incluso se valido la capacidad de predicción del impacto en YouTube aplicando el uso de modelos basados en aprendizaje máquina. Por otro lado también se evaluaron estas metodologías a la hora de cuantificar el impacto de alteraciones de ciertos atributos de estos contenidos como pueden ser la música o el tipo de interacción.

Usar neurociencias y el machine learning en el neuromarketing.

A parte de las evaluaciones directas a través de la respuesta neurofisiológica, en esta Tesis se ha mostrado especial atención a validar si se pueden desarrollar modelos basados en la Inteligencia artificial que puedan predecir por ejemplo el número de visitas de los videos en Youtube. Se demostró que gracias al uso de redes neuronales (Wedel and Kannan, 2016) se puede predecir de la efectividad de cada anuncio en internet a través de la respuesta implícita obtenida del eye tracking, de la variabilidad cardiaca y de la señal cerebral (Hakim et al 2020; Aldayel et al 2020). Los resultados de la primera red neuronal se ajustaron con una precisión del 82,9% con los anuncios con más visitas. No se obtuvo iguales resultados con los anuncios que tenían menores visitas. Se tuvo en cuenta las métricas de clasificación con las de índice de agrado y las de memoria en la banda theta, así como la frecuencia cardiaca y el número de fijaciones del eyetracking. Pudiendo así clasificar cada anuncio según el ranking y generar un clasificador que pudo predecir el número de visitas en YouTube y anticipar la efectividad de los anuncios gracias a las medidas de la neurociencia y el machine learning. Generando una metodología que ayude a diseñar mejores contenidos en los anuncios de televisión y de YouTube.

Capítulo 6. Conclusión

Esta tesis presenta un enfoque novedoso del uso de la neurociencia en la investigación del comportamiento del consumidor en particular en la relación con la atención, memoria, satisfacción y emociones. El marco desarrollado incluye evaluación de anuncios de música, formatos y canales diferentes. Tiene implicaciones en la metodología, así como en las métricas para aumentar el entendimiento de los consumidores. Puede ayudar a metodologías clásicas de investigación de mercados como la evaluación de estímulos audiovisuales para mejorar anuncios y contenidos audiovisuales, superando así las limitaciones actuales que existen a la hora de medir el impacto afectivo y cognitivo en los contenidos de publicidad en imágenes, videos y de audio. La respuesta de señales como el eye tracking y la electroencefalografía ante estímulos publicitarios ha demostrado su efectividad para cuantificar los niveles de satisfaccion y de atención frente a los métodos tradicionales ayudando además a identificar los momentos exactos de mayor nivel de satisfacción y de recuerdo en los anuncios. Además, se ha podido validar el impacto en los niveles de atención en cada frame y por tipo de anuncio en cuanto a la música (congruente vs incongruente), el formato (360º vs 2d) y canal (YouTube) pudiendo predecir el número de visitas de los videos de la superbowl.

Por lo tanto, se ha demostrado que la dinámica del cerebro, el corazón, la gesticulación facial, respuesta galvánica de la piel y los movimientos oculares es muy efectiva para analizar la atención, nivel de satisfacción, memoria y emoción. Este resultado aumenta nuestro conocimiento de las respuestas fisiológicas relacionadas con los procesos emocionales y atencionales especialmente en las bandas de frecuencias cerebrales y en movimientos oculares. Los resultados ayudaran a las investigaciones a analizar y medir el impacto de diferentes parámetros de las respuestas emocionales y cognitivas de los clientes potenciales ya que pueden entender mejor sus respuestas.

Esta Tesis resulta especialmente importante puesta que valida el uso de nuevas metodologías basadas en respuestas implícitas provenientes de la neurociencia. En esta tesis se ha demostrado en línea con las últimas investigaciones de neurociencia del consumidor que solamente a través de este tipo de respuestas implícitas será posible cuantificar aspectos relativos al impacto cognitivo y emocional de la publicidad. El hecho de disponer de estas nuevas herramientas permitirá extrapolar el impacto de nuevos contenidos publicitarios a través de pequeños tamaños muéstrales haciendo rentable los estudios de mercado. En este aspecto las tecnologías que se han empelado en esta Tesis están cada vez siendo más escalables y aplicables lo que permitirá en un futuro incluso poder hacer estudios online masivos basados en neurociencia aplicando por ejemplo señales como el eye tracking y facial coding a nivel remoto sin tener que hacer desplazarse a los usuarios.

También el uso de la neurociencia en estudios de percepción va a ofrecer muchas aplicaciones en el campo de la educación para poder explicar cómo funciona cada uno de los contenidos educativos y medir la eficacia de los estímulos hacia los alumnos. No obstante, se necesitan más estudios con muestras más amplias como los propuestos en este Tesis para poder abordar las limitaciones actuales. Los estudios futuros deberían de analizar nuevos modelos de reconocimiento de estados emocionales y cognitivos aplicando nuevas tenías de análisis como el Deep learning y explotar más señales fisiológicas como el EMG, EDA o el FNIRS, al igual que otras medidas implícitas como la voz y la postura corporal. Además, será de mucho interés el poder aplicar estas metodologías de eficacia publicitaria en nuevos canales como la realidad virtual y la realidad aumentada.

En conclusión, las emociones y estados cognitivos juegan un papel fundamental en nuestras vidas diarias, por lo que la comprensión y el reconocimiento de las respuestas cognitivas y emocionales son cruciales para entender nuestro comportamiento. Creemos que la neurociencia del consumidor revolucionara los métodos de evaluación de contenidos audiovisuales tanto en entornos de laboratorio como en entornos más ecológicos como las casas. Esperemos que el presente trabajo marque un nuevo paso para esta dirección.

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