sustainability

Article

Does Age Matter? Using Neuroscience Approaches to Understand Consumers' Behavior towards Purchasing the Sustainable Product Online

Ming-Chang Chiang [1], Chiahui Yen [2,*] and Hsiu-Li Chen [2]

1 Department of Life Science, College of Science and Engineering, Fu Jen Catholic University, New Taipei City 242, Taiwan
2 Department of International Business, Ming Chuan University, Taipei 111, Taiwan
* Correspondence: chyen@mail.mcu.edu.tw; Tel.: +88-62-28824564

Abstract: In recent years, online shopping platforms have displayed more sustainable products to attract consumer attention. Understanding the effect of age on online shopping patterns can provide a broader understanding of the critical role of consumer attention. Physiological measures can explain consumers' responses to features of online shopping websites and help these companies understand the decision-making process of consumers by using neuroscience-integrated tools. When consumers browse and shop on a platform, their eyes constantly move, effectively scanning the area of interest to capture information. This study attempts to evaluate the impact of consumer age on psychological and physiological responses to online shopping platforms by using eye tracking, EEG recordings, and FaceReader software. Eye tracker data on the average duration and number of fixations and saccades indicated that the older group had fewer eye movements than the younger group. The temporal and frontal cortices of the younger and older groups showed differences in EEG activity. The research also analyzed the faces of younger and older adults using FaceReader software; the main differences occured in the happy, surprised, and neutral expressions observed. This study enhances our understanding of the psychology and behavior of younger and older people in neuromarketing research, combining noninvasive physiological and neuroscience methods to present psychological data.

Keywords: sustainable product; neuromarketing; generation Z; older generation; aging; eye tracking; EEG; facereader

Citation: Chiang, M.-C.; Yen, C.; Chen, H.-L. Does Age Matter? Using Neuroscience Approaches to Understand Consumers' Behavior towards Purchasing the Sustainable Product Online. *Sustainability* **2022**, *14*, 11352. https://doi.org/10.3390/su141811352

Academic Editors: Jorge Arenas-Gaitán and Patricio E. Ramirez-Correa

Received: 29 July 2022
Accepted: 6 September 2022
Published: 9 September 2022

1. Introduction

Sustainable products could provide social and economic benefits throughout their life cycle, while protecting public health and the environment. Enterprises strive to launch sustainable products and sell them online. Online shopping has provided many challenges to information systems and marketing research. Currently, understanding the psychology and behavior of online consumers is crucial to competitive marketing [1]. Consumer responses and purchasing decisions are no longer dependent on physical stores or the offline environment. New factors, such as the online appearance of products, webpage layout, and interface with consumer interactions, are often very different from traditional marketing strategies [2]. This study aimed to enhance understanding of how age influences the decision-making processes of different generations of consumers when they purchase sustainable products. Research on online consumer behavior encompasses human physiology, neuroscience, and psychology, as people's decision-making process can be observed when shopping on the website [1]. Neuromarketing research can evaluate and predict the psychological and physiological parameters collected when consumers view sales messages related to their search for a particular product [3,4].

Decision-making is a cognitive process that translates sensory information into appropriate actions and is critical for quality of life [5]. Natural aging affects various cognitive abilities, and these changes affect our ability to perform everyday tasks and social activities [6]. As older adults make up a substantial proportion of the population worldwide, it is increasingly essential to improve our understanding of age-related differences in decision-making [7,8]. Normal aging is accompanied by a gradual decline in processing speed, task-switching capabilities, explicit memory, and working memory [9]. Cognitive decline also affects how sensory information is translated into appropriate actions and is an essential factor in age-differentiated decision-making [10]. Older adults exert more effort on judgment and reasoning tasks. In particular, limited time windows and a mixture of relevant and irrelevant information may affect older adults' performance in complex decision-making scenarios [7]. Aging is a significant challenge, especially given the current lack of understanding of how older consumers handle their needs when shopping online and their search abilities and behaviors [8,11]. Thus, marketers are increasingly interested in understanding the consumer behavior of older adults. For example, consumers may search for relevant product information to facilitate subsequent purchase decisions; however, because the search abilities of older consumers may be impacted by aging, the purchasing rate of older consumers is generally lower than that of younger consumers [8,12].

Populations are aging worldwide, drawing increased attention to understanding the complex effects of aging on consumers' psychological and physiological processes and behaviors [8,13]. For instance, how does aging affect consumer responses to decisions? To address the most fundamental issues related to consumer behavior, including the differential response of older adults to marketing campaigns compared to younger (18–30) and middle-aged (31–59) adults, marketers should consider ways to communicate with older consumers [8,14]. This involves understanding age-related changes in sensory function, cognition, needs, motivations, judgments, and decision-making processes [15]. Specifically, declines in physiological reaction times and memory are thought to be explained by a decline in neurotransmission speed, a critical phenomenon associated with age [16,17]. Delays in transmission correspond to less efficient transfer of information between neural units, which is reflected in the diminished ability of older adults to hold numbers and words in working memory [18]. In particular, the performance of older adults decreases as the number of options considered increases. Older consumers are more vulnerable to large amounts of information than younger consumers, and in distracting tasks, older adults perform similarly to younger adults only when fully engaged [19]. The current study used noninvasive scientific methods to better assess consumer behavior and decision-making processes to apply to neuromarketing.

New emotion-sensitive technology, based on expressions of emotion via text, voice, photos, and videos, can determine consumers' experiences and feelings while they shop online [20,21]. For example, eye trackers can be used to visually record consumers' journeys and predict purchasing decisions during the buying process [22]. Monitoring the distribution and duration of visual attention is a good measure of an observer's interests and preferences [23] and captures information about processes and the order and duration of those processes [24]. Specifically, the percentage of active fixations indicates extensive attention or engagement with the online shopping platform [25]. The number of fixations and average saccade time measure the depth of the information contained therein [26]. Moreover, measuring the parameters of brain waves and eye movements when shopping online allows more accurate judgment of perceptual and emotional behaviors [27]. Attention refers to the ability of participants to maintain behavioral or cognitive focus in the face of distractors or competing stimuli [28]. Therefore, attention allows individuals to select relevant stimuli from the environment and ignore irrelevant stimuli [29].

According to a survey by the Pew Research Center, online buying behavior varies by generation, from Baby boomers (Boomer) to Generation Z (Gen Z). Baby boomers were born between 1946 and 1964 and are currently 58–76 years old. Gen Z is the newest generation, born between 1997 and 2012, and these individuals are currently 10–25 years old. In the following discussion, the term "young" refers to Gen Z and the term "older" refers to Boomers (e.g., young/older adults, young/older group). Boomers have the most wealth and are in good financial shape. This generation used to shop in traditional channels and currently shop online for specific products; they use social media to connect with people but not as a primary form of leisure. Gen Z is a digitally native generation and is usually mobile-first. Individuals in this generation have been surrounded by technology, such as smart phones, since birth and take a completely different approach to social media and online shopping. They use social media to find inspiration for products, explore them, and connect with their favorite brands.

Whether an individual is young or old, they encounter a large amount of information every day, so decision-making is crucial [30,31]. Attention helps us determine the importance of external stimuli, excluding unnecessary or less relevant stimuli from further processing by the brain. This process of stimuli selection in a highly complex and constantly changing multisensory environment is influenced by many factors, such as one's interests, motivations, and cognitive strategies for assessing stimuli, which also influence the selection process of attention [30,32,33]. Therefore, selective, divided, and visual attention involve screening external information, which reflect human behavior and decision-making capabilities [34].

2. Materials and Methods

2.1. Participants and Procedures

Eye tracking, EEG, and FaceReader measurements were conducted in the neuroscience laboratory of the university to investigate the behavioral responses of consumers in different age groups to online shopping platforms from a neurocognitive perspective. In total, 80 healthy volunteers participated in the study. At the time of recruitment, a questionnaire was completed to confirm that the subjects had no history of brain injury-related medical problems. All subjects had normal or corrected-to-normal vision and no history of neurological problems or head injury. Furthermore, all participants were without any specific cognition attention disorders or mild cognitive impair. The sample consisted of 40 young subjects with a mean age of 23 years-old and 40 older subjects with a mean age of 65 years-old.

All experimental procedures were carried out in accordance with the regulations of the University Ethics Committee. Participants were informed about the purpose of the study and experimental procedures before the test and were told that they could end their participation in the experiment at any time. All participants provided informed consent. For the tests, participants were placed comfortably in a quiet room, and the relevant information was displayed on a computer screen in front of them. Experiments assess subjects' behavior and responses through eye-tracking, EEG, and FaceReader.

We tested five types of products, including clothes, shoes, food, bottles, and cosmetics. Those items are general consumer products, and the prices are between USD$30 to USD$100. Sustainable clothing and shoes are made from at least 50% organic materials, and customers could support organic farming practices, such as the restricted use of synthetic chemicals and genetically modified seeds, improved soil fertility, and better livestock management. Sustainable food measures the carbon footprint and facilitates the conservation of the environment. The food production, manufacturing, transportation, cooking, and recycling process are based on environmental protection. Water bottles are manufactured using recycled materials and reduce ecosystem impacts. Green cosmetics use environmentally-friendly formulations, production practices, or packaging methods. The products use petrochemical ingredients derived from petrol, a non-renewable and economically volatile resource.

2.2. Eye Tracking

We designed an eye-tracking experiment to explore the behavior of consumers of different age groups on online shopping platforms. This allowed participants to browse sustainable products in an online shopping platform for 60 s while the eye tracker recorded their eye movements. In this study, we used eye-tracking equipment (Ergoneers GmbH, Germany) in a manner and process previously described [35]. Briefly, the video recordings of binocular eye tracking had a 60 Hz camera tracking frequency and a resolution up to 648 × 488 pixels. In addition, D-Lab 3 software was used to record eye movements and generate a heatmap of gaze locations. These recordings can then be used for data analysis, including the determination of horizontal and vertical eye activity, the mean percentage of eyelid closure over the pupil over time (PERCLOS), mean saccade angle, mean fixation duration, number of fixations, mean saccade duration, and number of saccades.

2.3. EEG

The study also used EEG recordings to explore brain changes in consumers of different age groups on online shopping platforms. Similar to the eye-tracking methods, participants browsed the online shopping platform for 60 s while the EEG was recorded. Subjects were wearing an eye-tracking device and EEG at the same time. Therefore, EEG is set to the same number of seconds, in order to match the time of the eye-tracking device. The EEG methods used in this study have been previously described [36]. Briefly, the EEG instrument was a 21-channel Neuron-Spectrum 3 (Neurosoft Ltd., Ivanovo, Russia) with a signal sampling rate of up to 5000 Hz per channel. Brain waves were collected in frequency bands, including the α (8–12 Hz) and β bands (13–28 Hz), and their EEG data were processed via Neuron-Spectrum NET software. After the α and β frequency bands were collected, 3D representations were presented separately using standardized low resolution electromagnetic tomography (sLORETA).

2.4. FaceReader

The changes in facial expressions of consumers of different ages when using online shopping platforms were investigated by analyzing the state of various facial muscles. Participants browsed the online shopping platform for 60 s while their facial expressions were recorded. The facial expression analysis software FaceReader (version 8.0, Noldus Information Technology, Wageningen, The Netherlands) was used. In brief, FaceReader™ is a unique analysis tool that automatically analyzes facial expressions, including happiness, sadness, anger, surprise, fear, disgust, and contempt, as well as neutral expressions.

3. Results

3.1. Eye Movements in Young and Older Individuals

An eye tracker is a device that measures the position and movements of eyes for applications in psychology, cognition, neuromarketing, and other fields [37,38]. Therefore, referring to tracked positions and trajectory sweeps of the observer's eye movements, it is possible to determine the observer's eye fixation points, saccades, and frequency, from which researchers can deduce what stimuli the subject was attracted to [39,40]. The heatmap generated by the eye tracker can help us determine which features of a webpage or product are most noticed or ignored. The heatmap mainly reflects subject browsing and gaze. Heatmap differences between young and older individuals viewing online shopping platforms with eye trackers were analyzed (Figure 1A). Recordings of eye movements showed that subjects typically focused their attention on specific figure elements; thus, eye movements may reflect the subject's thought process [39]. In the heatmaps, red represents areas with the highest concentrations of browsing and fixation, while yellow and green represent areas with lower concentrations. The heatmap of young adults (Figure 1B) was more pronounced than that of older adults (Figure 1C).

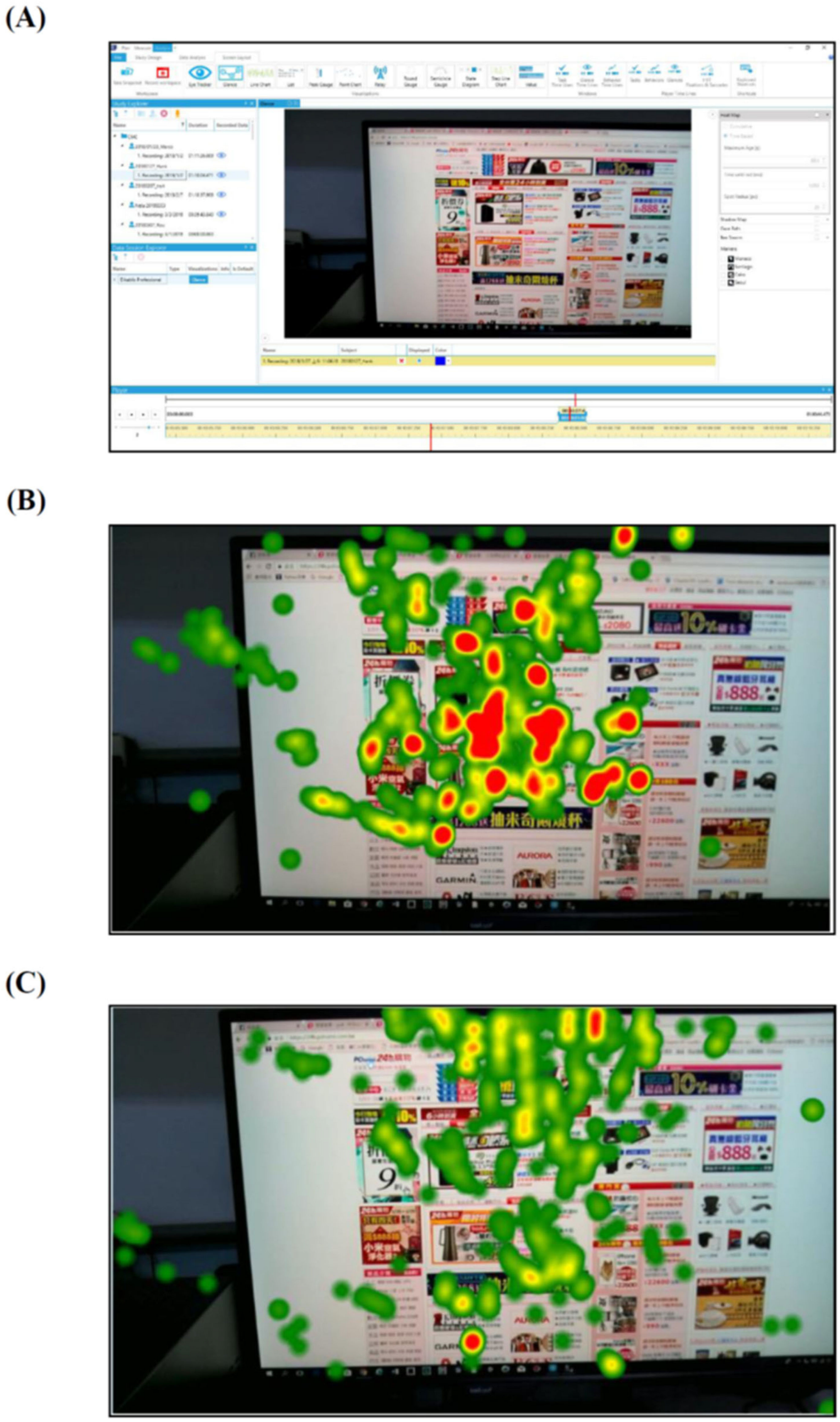

Figure 1. Heatmap of eye tracking in young and older adults. The heatmap reflects the subjects' browsing and gaze when viewing online shopping platforms according to eye tracking data. (**A**) Analysis of heatmap differences between young and old individuals. Red represents areas with the highest concentration of browsing and fixation, while yellow and green represent areas with lower concentrations. (**B**) shows the heatmap of young adults, and (**C**) shows the heatmap of older adults.

The eye tracker data included horizontal and vertical eye activity, the mean PERCLOS, and the mean saccade angle in young and older individuals (Table 1). There were no significant differences between the two groups. To explore the differences in fixations and saccades observed in the two groups, we also measured each user's fixation duration and number of fixations and saccades. Therefore, the comparison of young and older individuals focused on mean fixation duration (Figure 2A), fixation number (Figure 2B), mean saccade duration (Figure 2C), and saccade number (Figure 2D). Notably, the average fixation and saccade durations and numbers were significantly lower in older adults than those in younger adults.

Table 1. Eye tracking results. Eye tracking evidence for horizontal eye activity, vertical eye activity, perclos average, and mean saccade angle in the aging. Values are expressed as the mean ± SEM values from each independent experiments.

	Young	Elderly
Horizontal eye activity (unit: pixel)	250.1 ± 25.2	235.5 ± 20.4
Vertical eye activity (unit: pixel)	140.2 ± 18.1	128.2 ± 15.5
Perclos average (unit: %)	6.6 ± 0.8	5.8 ± 0.6
Mean saccade angle (unit: deg)	9.2 ± 0.3	8.1 ± 0.2

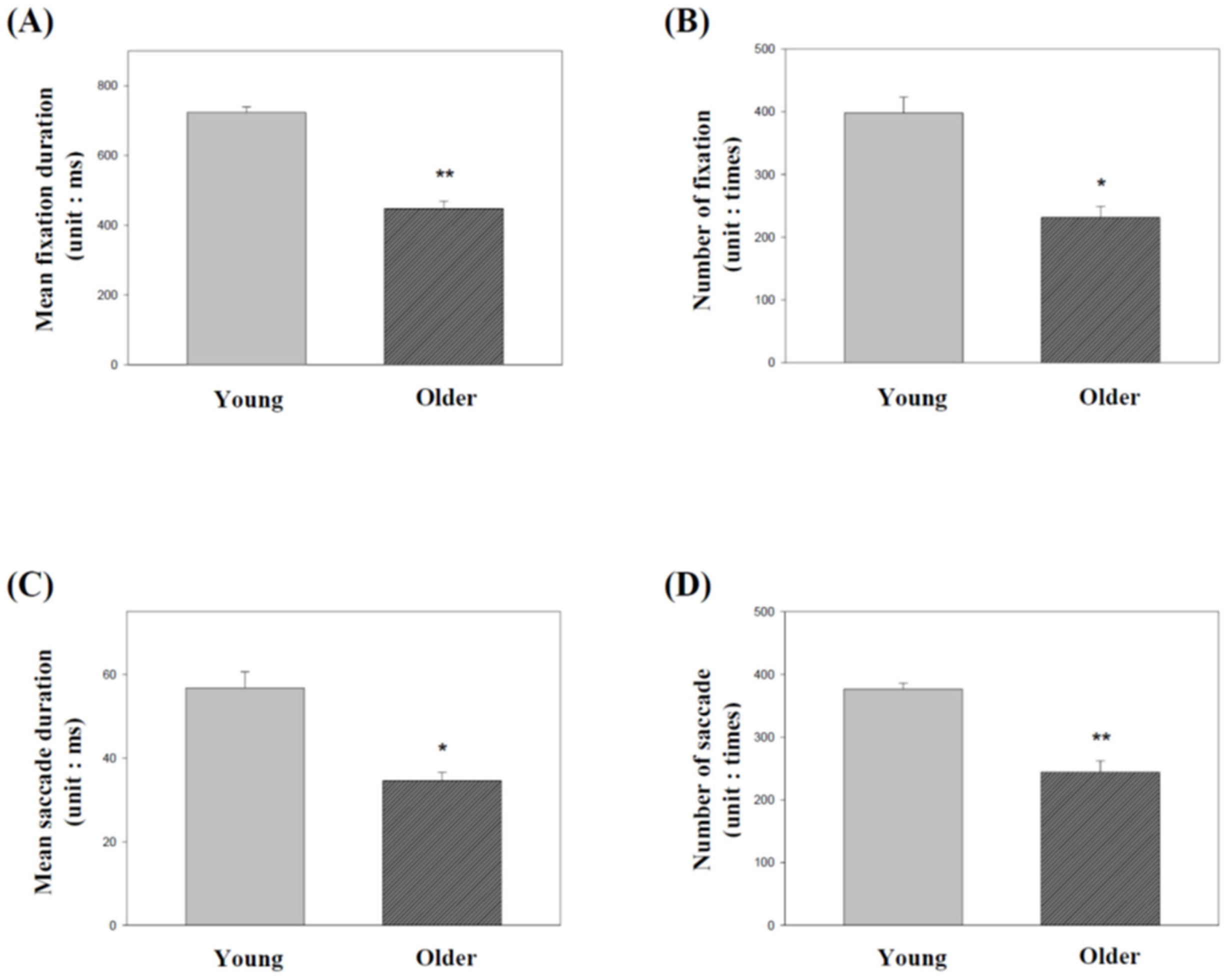

Figure 2. Eye movements results: Eye movements in young and older adults according to eye-tracking data. Eye-tracking data for (**A**) mean fixation duration (unit: ms), (**B**) number of fixations (unit: count), (**C**) mean saccade duration (unit: ms), and (**D**) number of saccades (unit: count). Values are presented as the mean ± SEM. * and ** indicate specific group differences (i.e., older vs. young individuals) ($p < 0.05$, $p < 0.001$; one-way ANOVA).

3.2. EEG Results in Young and Older Individuals

The collection of EEG data involves electrophysiological recordings of brain waves by placing electrodes on a person's scalp to record changes in the weak electrical waves produced by the ionic currents of neurons in the brain [41]. The amplified and recorded brain waves represent the sum of the activity of many nerve cells in a specific area of the brain [42]. EEG instruments are mainly used to assist in diagnosing brain-related diseases, but in recent years, they have been applied to the fields of psychology, cognitive science, and neuromarketing [27,35,36,43,44]. Many EEG findings indicate that with age, the frontal, temporal, and parietal lobes of the brain and more than half of the functional connectivity with the occipital lobe decline [45–48].

This part of the experiment aimed to explore brain changes in young and older adults using an online shopping platform. We report EEG findings to map cortical regions that change with normal aging. EEG activity was recorded from the α- (Figure 3) and β-frequency bands (Figure 4) of 2 groups of 40 participants each and processed by sLORETA software to determine electrical activity in three dimensions in the human brain. After transformation and analysis of the EEG data with sLORETA, EEG activity was visualized in the younger (Figures 3A and 4A) and older (Figures 3B and 4B) groups. The black arrows in the figures indicate the difference in the right temporal lobe. The younger group (Figure 3A) had more α-EEG activity than the older group (Figure 3B). This region of the right temporal lobe also contains the fusiform and temporal gyri. The differences indicated by the black arrows in the figures were mainly in the left temporal and frontal cortex. The younger group (Figure 4A) had more β-EEG activity than the older group (Figure 4B). This region contains the temporal gyrus, temporopolar area, auditory cortex, and parainsular area in the left temporal lobe and the primary somatosensory cortex and motor cortex in the left frontal cortex. The difference indicated by the purple arrow in the figure was mainly in the right temporal lobe. The older group (Figure 4B) had more β-EEG activity than the young group (Figure 4A) in this area. This region of the right temporal lobe contains the fusiform gyrus, temporal gyrus, angular gyrus, and supramarginal gyrus.

3.3. FaceReader Was Used to Analyze Facial Expressions in Young and Older Individuals

Human facial expressions are the most abundant and complex among almost all animals, as the facial muscles are used to express various emotional states [49,50]. Observing other people's facial expressions can provide essential clues for human interaction, as faces are the most reflective of emotional changes and serve as one of our most direct communication methods [49,51]. Thus, facial expressions allow us to identify psychological factors such as the thoughts, attitudes, emotions, and motivations of social partners. However, it is challenging to objectively label human facial expressions. FaceReader™ software is a unique analysis tool that automatically analyzes facial expressions, allowing the objective evaluation of emotions [52,53]. This software can analyze expressions including happiness, sadness, anger, surprise, fear, disgust, and contempt, as well as neutral expressions. This study applied FaceReader version 8 (Noldus), which is currently the most comprehensive and objective system for describing overall facial expressions from facial movements without subjective inference (Figure 5A). The results of the facial expression analysis, including the seven expressions listed above, did not differ between the two groups (Table 2). The responses in the young group were mainly happiness and surprise (Figure 5B,C); in contrast, the reactions of the older group were primarily neutral (Figure 5D).

Table 2. FaceReader results: FaceReader evidence for neutral, sad, angry, scared, and disgusted in the aging. Values are expressed as the mean ± SEM values from each independent experiments.

	Young	**Elderly**
Sad expression (%)	1.0	1.130 ± 0.126
Angry expression (%)	1.0	0.985 ± 0.092
Scared expression (%)	1.0	0.970 ± 0.093
Disgusted expression (%)	1.0	1.103 ± 0.104
Contempt expression (%)	1.0	0.967 ± 0.130

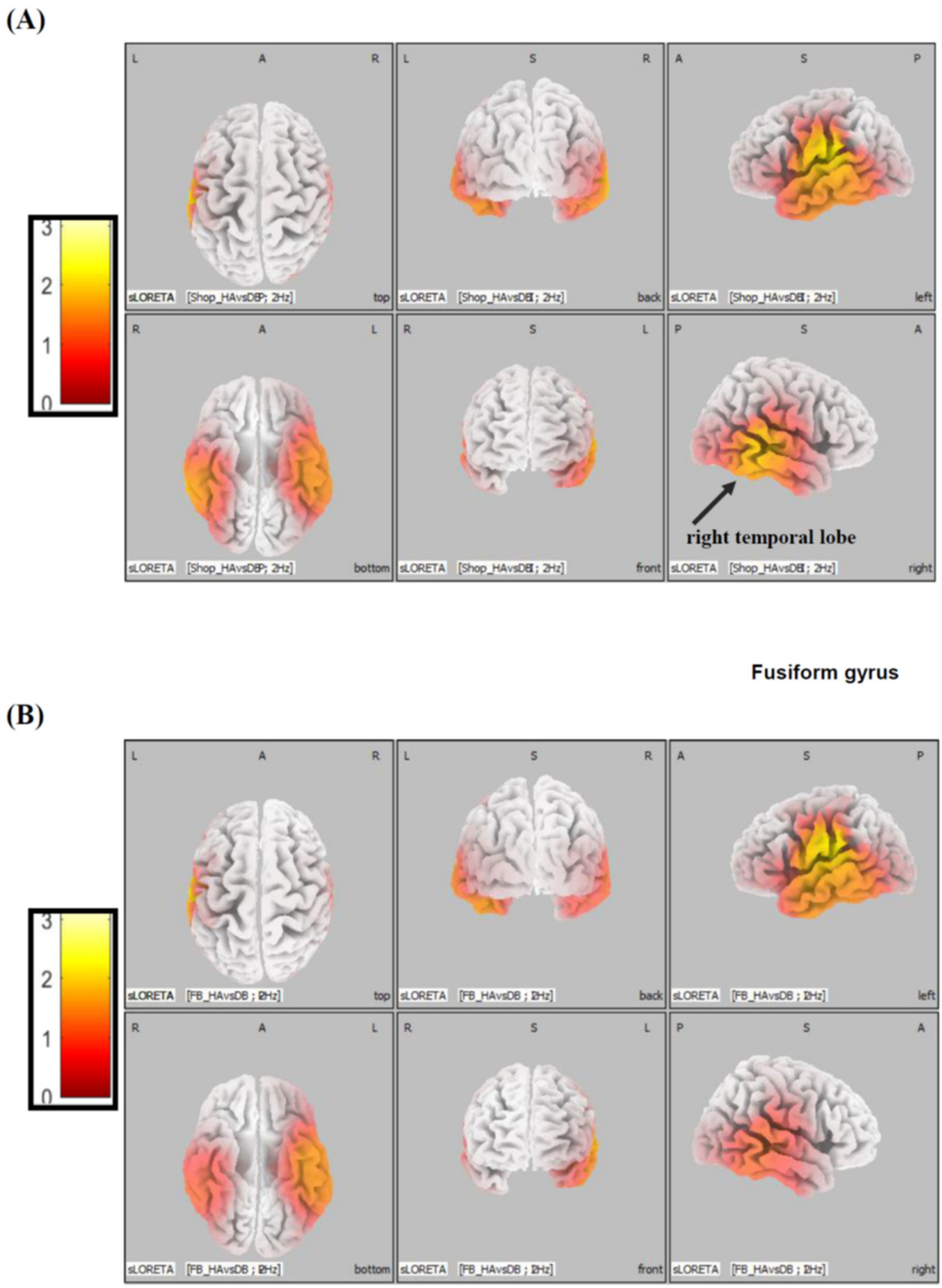

Figure 3. EEG maps of α-band activity: EEG maps of α-band activity in young and older adults from sLORETA. α-EEG activity was collected from the α-band of two groups of 40 subjects and processed by sLORETA software to determine the electrical activity. Three-dimensional representation images showing (**A**) young and (**B**) older adults.

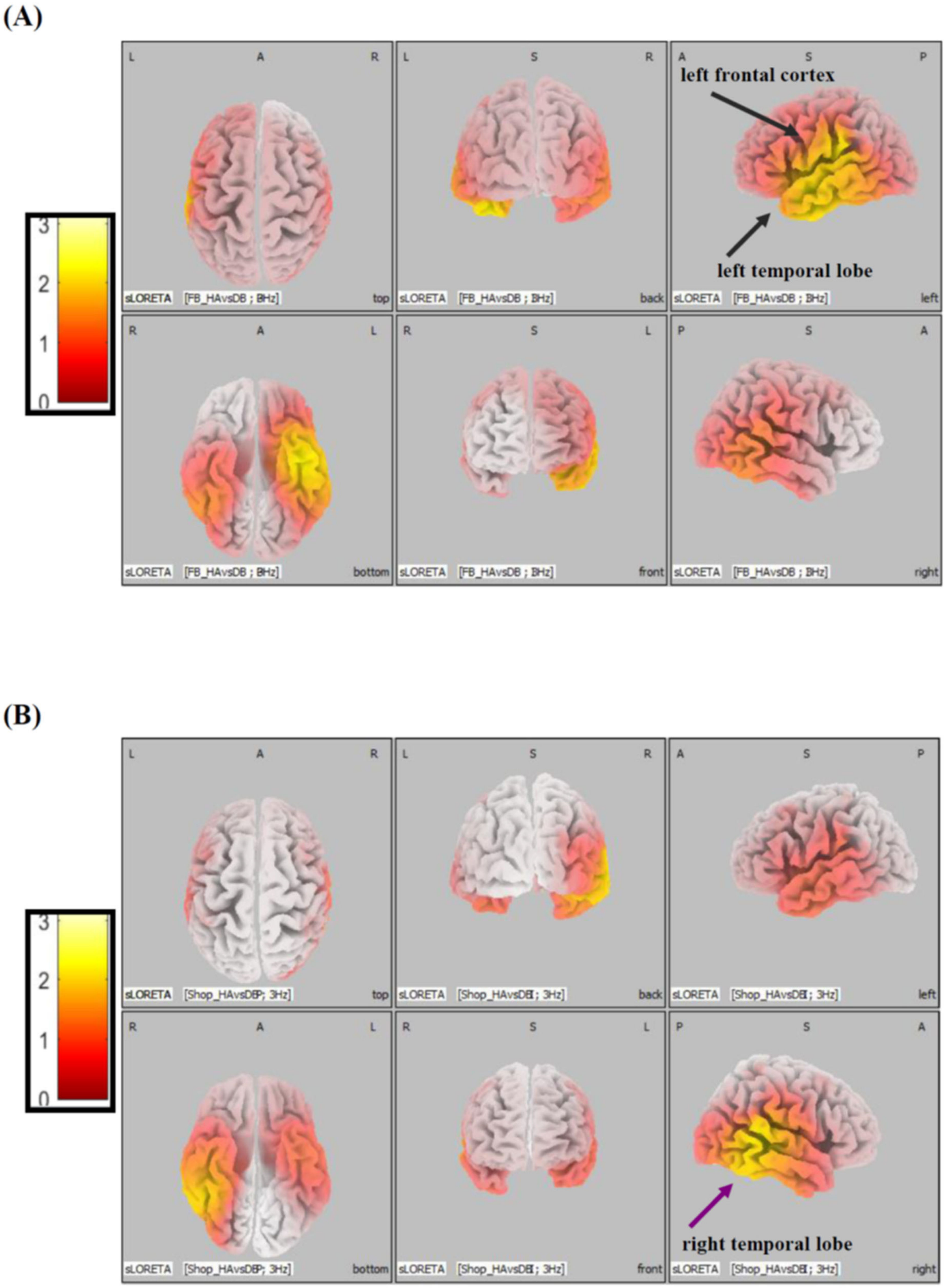

Figure 4. EEG maps of β-band activity: EEG maps of β-band activity in young and older adults from sLORETA. β-EEG activity was collected from the β-band of two groups of 40 subjects and processed by sLORETA software to determine the electrical activity. Three-dimensional representation images showing (**A**) young and (**B**) older adults.

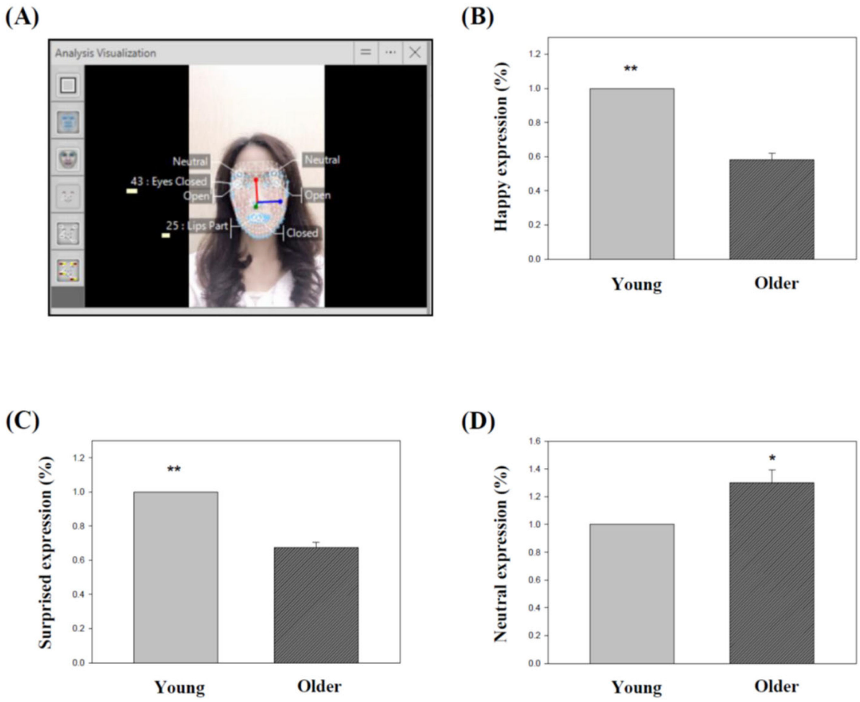

Figure 5. FaceReader facial expression analysis in young and older adults.The FaceReader automatic facial expression analysis system (**A**). Recorded happy (**B**), surprised (**C**), and neutral (**D**) expressions. Values are presented as the mean ± SEM. * and ** indicate specific group differences (i.e., older vs. young individuals) (p < 0.001; one-way ANOVA).

4. Discussion

Consumers have an important role in making product chains more sustainable. The choices consumers make when purchasing products influence which products are being produced and how they are produced. While the way products are produced can be changed through corporate regulation, market forces and consumer forces are the primary drivers of sustainable product development. In this regard, consumers play a critical role in encouraging the development of sustainable goods. Therefore, the issue of sustainability has become a focus of attention for different generations. For consumers of all ages, purchasing green goods has become an important issue.

Neurophysiological tools can be used to explore human behavior and learn more about consumers' thoughts, intentions, and decision-making processes [54]. Physiological and neuroscience data enhance our understanding of consumer behavior in online shopping platforms and inform marketing strategies [4,27]. Attention is the phenomenon of ignoring extraneous stimuli to effectively process specific stimuli [55]. "Attention" is used to refer to both the explanandum (the set of phenomena in need of explanation) and the explanans (the set of processes doing the explaining). One is selective attention: we can spontaneously choose the focus of attention [56]. The second, divided attention, refers to our inability to observe and pay attention to everything at once [56]. The mechanisms underlying attention are the cortical and subcortical networks that interact to selectively process a multitude of information [57]. Several cortical areas are essential for attention, including the ventral prefrontal cortex, superior prefrontal cortex, posterior parietal cortex, and temporoparietal cortex [58,59]. In addition, the pulvinar of the thalamus and superior colliculus are involved in the control of attention [60,61]. Attention affects how we process sensory input, store information in memory, process semantics, express emotions, and take action [62].

People usually need to pay attention to reading, processing stimuli, and searching for detection targets; older people often suffer from inattention, especially changes in selective attention and transitions [63,64]. Few studies have examined the neural basis of attention during aging. Thus, these age-related neural associations remain unclear. Neuroimaging has indicated that the brain regions associated with the aging of visual attention include areas controlled by the dorsal and frontoparietal lobes (i.e., the intraparietal sulcus, insula, fusiform gyrus, anterior cingulate gyrus, and inferior frontal cortex) [65,66].

Sensory and specific cortical areas, including the dorsal attentional network, frontoparietal control network, dorsolateral prefrontal cortex, parietal cortex, and rostral prefrontal cortex, indicate age-related differences in selective attention [67,68]. Attentional control is a core element of cognition and changes with age [6], but its exact mechanism is unclear. Attention is essential for working memory, suppressing interfering information, multitasking (as well as certain types of task switching), and higher cognitive function [69,70]. These functions decline significantly with age. Functional neuroanatomical studies point to a significant overlap between the cognitive ability of attentional focus and eye movements [71,72].

Physiological measurements apply neuroscience concepts to explain consumers' interactions with the environment and everyday decision-making [73]. EEG and eye-tracking are two of the most commonly used physiological measurement tools for describing and predicting consumer behaviors and decision-making [44]. In recent years, eye trackers have been used to assess visual attention to understand consumer behavior and decision-making processes [74]. Eye movements mirror thought processes; thus, researchers can follow consumers' thoughts to a certain extent by recording eye movements and opinions when examining specific objects [39,75]. One study assessed cognitive function using eye-tracking, which provided an instant measure of attentional focus while subjects viewed pictures displayed on a monitor [76]. Eye tracker data include heatmaps, fixations, and saccade parameters and provide valuable objective measurements of cognitive ability [54,72].

In recent years, a large amount of sustainable products have been displayed on the online shopping webpages to attract consumer attention. Consumers purchasing a sustainable product could continue its narrative and reduce the environmental impact of using new resources. Therefore, consumers need to make complex decisions, which creates a cognitive burden [77]. Modern consumers need to make rational purchasing decisions from a variety of options when shopping online [31]. A wealth of information is available on the web for making decisions about products and services. In general, gaze fixation duration varies with text, graphics, reading, and problem solving [78]. Furthermore, fixation position and duration reflect cognitive strategies and attention span [79]. The eyes are attracted to exciting stimuli on web pages, and attention follows, so eye movements are closely related to attention [80]. Eye tracking can indicate visual processing of presented stimuli, identifying consumer response processes, as changes in gaze fixation points reflect shifts in information [81]. The interaction of visual attention, activity in the cerebral cortex, and facial expressions reflect cognitive and attentional responses [82,83]. The present study conducted an eye-tracking experiment with 80 participants to measure subjects' ability to process information on online shopping platforms. We measured the duration and number of average fixations and saccades to explore the correlation between consumer visual attention and age.

Recordings of nonbrain measures (e.g., eye trackers, and FaceReader software) and measures of brain activity (EEG) aid research marketing in the field of neuroeconomics [73,84,85]. EEG data can be used to determine whether advertisements attract consumer attention and understand the brain's immediate response to stimuli [86,87]. Significantly more EEG activity in the left frontal lobe occurs during feelings of pleasure or entertainment. The greater left frontal EEG activity is usually related to the treatment of positive effects, such as happiness or pleasure [3]. In contrast, more EEG activity in the right frontal lobe is associated with processing negative feelings, indicating aversion. We collected physiological data on subjects' eye movement, brain activity, and facial emotions through two physiological techniques (eye tracker and EEG measures) and FaceReader software. Furthermore, we evaluated the influence of age on consumers' use of online shopping platforms. EEG signals measured in the temporal and frontal cortex are responses due to attention and pleasure [88]. Age-related changes in attention, memory, motivation and decision-making include changes in the medial temporal and lateral regions related to cognitive processes, prefrontal regions related to executive function, striatal pathways related to reward processing, and limbic areas associated with emotional processing [89–92].

Our neuroscience study on the psychology and behavior of healthy young and older adult consumers combined eye tracking, EEG, and FaceReader data to present physiological evidence of consumer decision-making processes and provide valuable insights [27,93]. This study combined physiological and neuroscience methods to provide physiological data to assess the responses and behaviors of healthy young and older adults during online shopping. The main findings of this study are as follows: (1) the average duration and number of fixations and saccades measured by eye trackers in young adults were higher than those in older adults; (2) the temporal and frontal cortices of young and older adults showed differences in EEG activity; and (3) FaceReader data detected differences in happy, surprised, and neutral facial expressions between young and older adults. Aging is associated with a decline in fluid cognitive abilities, such as working memory capacity, processing speed, and visual processing, leading to difficulties in some cognitive tasks in older adults. These cognitive processing abilities also affect shopping decisions. While this experiment used a younger group versus an older group, innate differences resulted in different brainwave results.

Author Contributions: M.-C.C.: Conceptualization, methodology, resources, writing—original draft. C.Y.: Conceptualization, investigation, writing—original draft, writing—review & editing. H.-L.C.: Writing—review & editing. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by grants from the Teaching practice research program (PBM1101076), Ministry of Education, Taiwan.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board of Fu Jen Catholic University (IRB Approval Number C106005).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data is contained within the article.

Acknowledgments: We thank for all participants of the survey.

Conflicts of Interest: The authors have declared no conflict of interest.

References

1. Martinez-Ruiz, M.P.; Moser, K. Studying consumer behavior in an online context: The impact of the evolution of the World Wide Web for new avenues in research. *Front. Psychol.* **2019**, *10*, 2731. [CrossRef] [PubMed]
2. Dwivedi, Y.K.; Ismagilova, E.; Hughes, D.L.; Carlson, J.; Filieri, R.; Jacobson, J.; Jain, V.; Karjaluoto, H.; Kefi, H.; Krishen, A.S.; et al. Setting the future of digital and social media marketing research: Perspectives and research propositions. *Int. J. Inf. Manag.* **2020**, *59*, 102168. [CrossRef]
3. Garczarek-Bąk, U.; Szymkowiak, A.; Gaczek, P.; Disterheft, A. A comparative analysis of neuromarketing methods for brand purchasing predictions among young adults. *J. Brand Manag.* **2021**, *28*, 171–185. [CrossRef]
4. Karmarkar, U.R.; Plassmann, H. Consumer neuroscience: Past, present, and future. *Organ. Res. Methods* **2017**, *22*, 174–195. [CrossRef]
5. Prezenski, S.; Brechmann, A.; Wolff, S.; Russwinkel, N. A Cognitive modeling approach to strategy formation in dynamic decision making. *Front. Psychol.* **2017**, *8*, 1335. [CrossRef]
6. Murman, D.L. The impact of age on cognition. *Semin. Hear.* **2015**, *36*, 111–121. [CrossRef]
7. Löckenhoff, C.E. Aging and decision-making: A conceptual framework for future research—A mini-review. *Gerontology* **2018**, *64*, 140–148. [CrossRef]
8. Hettich, D.; Hattula, S.; Bornemann, T. Consumer decision-making of older people: A 45-year review. *Gerontology* **2017**, *58*, e349–e368. [CrossRef]
9. Harada, C.N.; Natelson Love, M.C.; Triebel, K.L. Normal cognitive aging. *Clin. Geriatr. Med.* **2013**, *29*, 737–752. [CrossRef]
10. Tymula, A.; Rosenberg Belmaker, L.A.; Ruderman, L.; Glimcher, P.W.; Levy, I. Like cognitive function, decision making across the life span shows profound age-related changes. *Proc. Natl. Acad. Sci. USA* **2013**, *110*, 17143–17148. [CrossRef]

11. Peng, H.; Xia, S.; Ruan, F.; Pu, B. Age Differences in Consumer Decision Making under Option Framing: From the motivation perspective. *Front. Psychol.* **2016**, *7*, 1736. [CrossRef] [PubMed]
12. Carpenter, S.M.; Yoon, C. Aging and consumer decision making. *Ann. N. Y. Acad. Sci.* **2011**, *1235*, E1–E12. [CrossRef] [PubMed]
13. Zniva, R.; Weitzl, W. It's not how old you are but how you are old: A review on aging and consumer behavior. *Manag. Rev. Q.* **2016**, *66*, 267–297. [CrossRef]
14. Steptoe, A.; Zaninotto, P. Lower socioeconomic status and the acceleration of aging: An outcome-wide analysis. *Proc. Natl. Acad. Sci. USA* **2020**, *117*, 14911–14917. [CrossRef]
15. Fischhoff, B.; Broomell, S.B. Judgment and decision making. *Annu. Rev. Psychol.* **2020**, *71*, 331–355. [CrossRef]
16. Mattson, M.P.; Arumugam, T.V. Hallmarks of brain aging: Adaptive and pathological modification by metabolic states. *Cell Metab.* **2018**, *27*, 1176–1199. [CrossRef] [PubMed]
17. Zanto, T.P.; Toy, B.; Gazzaley, A. Delays in neural processing during working memory encoding in normal aging. *Neuropsychologia* **2010**, *48*, 13–25. [CrossRef] [PubMed]
18. Matysiak, O.; Kroemeke, A.; Brzezicka, A. Working memory capacity as a predictor of cognitive training efficacy in the elderly population. *Front. Aging Neurosci.* **2019**, *11*, 126. [CrossRef]
19. Weeks, J.; Hasher, L. The disruptive—and beneficial—effects of distraction on older adults' cognitive performance. *Front. Psychol.* **2014**, *5*, 133. [CrossRef]
20. Mehta, A.; Sharma, C.; Kanala, M.; Thakur, M.; Harrison, R.; Torrico, D. Self-reported emotions and facial expressions on consumer acceptability: A study using energy drinks. *Foods* **2021**, *10*, 330. [CrossRef]
21. Sun, G.; Shen, F.; Ma, X. The influence of face on online purchases: Evidence from China. *Front. Psychol.* **2021**, *12*, 788063. [CrossRef] [PubMed]
22. Choi, E.; Kim, C.; Lee, K.C. Consumer decision-making creativity and its relation to exploitation–exploration activities: Eye-tracking approach. *Front. Psychol.* **2021**, *11*, 557292. [CrossRef] [PubMed]
23. Hessels, R.S.; Hooge, I.T.C. Eye tracking in developmental cognitive neuroscience—The good, the bad and the ugly. *Dev. Cogn. Neurosci.* **2019**, *40*, 100710. [CrossRef]
24. Atkinson, M.A.; Simpson, A.A.; Cole, G.G. Visual attention and action: How cueing, direct mapping, and social interactions drive orienting. *Psychon. Bull. Rev.* **2018**, *25*, 1585–1605. [CrossRef]
25. Sajjacholapunt, P.; Ball, L. The influence of banner advertisements on attention and memory: Human faces with averted gaze can enhance advertising effectiveness. *Front. Psychol.* **2014**, *5*, 166. [CrossRef]
26. Enders, L.R.; Smith, R.J.; Gordon, S.M.; Ries, A.J.; Touryan, J. Gaze behavior during navigation and visual search of an open-world virtual environment. *Front. Psychol.* **2021**, *12*, 681042. [CrossRef]
27. Cherubino, P.; Martinez-Levy, A.C.; Caratù, M.; Cartocci, G.; Di Flumeri, G.; Modica, E.; Rossi, D.; Mancini, M.; Trettel, A. Consumer behaviour through the eyes of neurophysiological measures: State-of-the-art and future trends. *Comput. Intell. Neurosci.* **2019**, *2019*, 1976847. [CrossRef]
28. Kayser, J.; Wong, L.Y.X.; Sacchi, E.; Casal-Roscum, L.; Alvarenga, J.E.; Hugdahl, K.; Bruder, G.E.; Jonides, J. Behavioral measures of attention and cognitive control during a new auditory working memory paradigm. *Behav. Res. Methods* **2020**, *52*, 1161–1174. [CrossRef] [PubMed]
29. Kaiser, D.; Oosterhof, N.N.; Peelen, M.V. The Neural Dynamics of Attentional Selection in Natural Scenes. *J. Neurosci.* **2016**, *36*, 10522–10528. [CrossRef] [PubMed]
30. Firth, J.; Torous, J.; Stubbs, B.; Firth, J.A.; Steiner, G.Z.; Smith, L.; Alvarez-Jimenez, M.; Gleeson, J.; Vancampfort, D.; Armitage, C.J.; et al. The "online brain": How the Internet may be changing our cognition. *World Psychiatry* **2019**, *18*, 119–129. [CrossRef]
31. Von Helversen, B.; Abramczuk, K.; Kopeć, W.; Nielek, R. Influence of consumer reviews on online purchasing decisions in older and younger adults. *Decis. Support Syst.* **2018**, *113*, 1–10. [CrossRef]
32. Dolcos, F.; Katsumi, Y.; Moore, M.; Berggren, N.; de Gelder, B.; Derakshan, N.; Hamm, A.O.; Koster, E.H.; Ladouceur, C.D.; Okon-Singer, H.; et al. Neural correlates of emotion-attention interactions: From perception, learning, and memory to social cognition, individual differences, and training interventions. *Neurosci. Biobehav. Rev.* **2020**, *108*, 559–601. [CrossRef] [PubMed]
33. Muller-Oehring, E.M.; Schulte, T. Cognition, emotion, and attention. *Handb. Clin. Neurol.* **2014**, *125*, 341–354. [PubMed]
34. Monosov, I.E. How outcome uncertainty mediates attention, learning, and decision-making. *Trends Neurosci.* **2020**, *43*, 795–809. [CrossRef] [PubMed]
35. Yen, C.; Chiang, M.-C. Examining the effect of online advertisement cues on human responses using eye-tracking, EEG, and MRI. *Behav. Brain Res.* **2021**, *402*, 113128. [CrossRef]
36. Yen, C.; Chiang, M.-C. Trust me, if you can: A study on the factors that influence consumers' purchase intention triggered by chatbots based on brain image evidence and self-reported assessments. *Behav. Inf. Technol.* **2021**, *40*, 1177–1194. [CrossRef]
37. Wolf, A.; Ueda, K. Contribution of eye-tracking to study cognitive impairments among clinical populations. *Front. Psychol.* **2021**, *12*, 590986. [CrossRef]
38. Zito, M.; Fici, A.; Bilucaglia, M.; Ambrogetti, F.S.; Russo, V. Assessing the emotional response in social communication: The role of neuromarketing. *Front. Psychol.* **2021**, *12*, 625570. [CrossRef]
39. Higgins, E.; Leinenger, M.; Rayner, K. Eye movements when viewing advertisements. *Front. Psychol.* **2014**, *5*, 210. [CrossRef]
40. Myers, S.D.; Deitz, G.D.; Huhmann, B.A.; Jha, S.; Tatara, J.H. An eye-tracking study of attention to brand-identifying content and recall of taboo advertising. *J. Bus. Res.* **2020**, *111*, 176–186. [CrossRef]

41. Light, G.A.; Williams, L.E.; Minow, F.; Sprock, J.; Rissling, A.; Sharp, R.; Swerdlow, N.R.; Braff, D.L. Electroencephalography (EEG) and event-related potentials (ERPs) with human participants. *Curr. Protoc. Neurosci.* **2010**, *52*, 1–24. [CrossRef]
42. Feyissa, A.M.; Tatum, W.O. Adult EEG. *Handb. Clin. Neurol.* **2019**, *160*, 103–124.
43. Ariely, D.; Berns, G.S. Neuromarketing: The hope and hype of neuroimaging in business. *Nat. Rev. Neurosci.* **2010**, *11*, 284–292. [CrossRef] [PubMed]
44. Bazzani, A.; Ravaioli, S.; Trieste, L.; Faraguna, U.; Turchetti, G. Is EEG suitable for marketing research? A systematic review. *Front. Neurosci.* **2020**, *14*, 594566. [CrossRef] [PubMed]
45. Moezzi, B.; Pratti, L.M.; Hordacre, B.; Graetz, L.; Berryman, C.; Lavrencic, L.M.; Ridding, M.C.; Keage, H.A.D.; McDonnell, M.D.; Goldsworthy, M.R. Characterization of young and old adult brains: An EEG functional connectivity analysis. *Neuroscience* **2019**, *422*, 230–239. [CrossRef] [PubMed]
46. Babayan, A.; Erbey, M.; Kumral, D.; Reinelt, J.D.; Reiter, A.M.F.; Röbbig, J.; Schaare, H.L.; Uhlig, M.; Anwander, A.; Bazin, P.-L.; et al. A mind-brain-body dataset of MRI, EEG, cognition, emotion, and peripheral physiology in young and old adults. *Sci. Data* **2019**, *6*, 180308. [CrossRef]
47. Ruthig, J.C.; Poltavski, D.P.; Petros, T. Examining positivity effect and working memory in young-old and very old adults using EEG-derived cognitive state metrics. *Res. Aging* **2019**, *41*, 1014–1035. [CrossRef]
48. Trammell, J.P.; MacRae, P.G.; Davis, G.; Bergstedt, D.; Anderson, A.E. The relationship of cognitive performance and the theta-alpha power ratio is age-dependent: An EEG study of short term memory and reasoning during task and resting-state in healthy young and old adults. *Front. Aging Neurosci.* **2017**, *9*, 364. [CrossRef]
49. Kret, M.E. Emotional expressions beyond facial muscle actions. A call for studying autonomic signals and their impact on social perception. *Front. Psychol.* **2015**, *6*, 711. [CrossRef]
50. Jack Rachael, E.; Schyns Philippe, G. The human face as a dynamic tool for social communication. *Curr. Biol.* **2015**, *25*, R621–R634. [CrossRef]
51. Elliott, E.; Jacobs, A. Facial expressions, emotions, and sign languages. *Front. Psychol.* **2013**, *4*, 115. [CrossRef]
52. Skiendziel, T.; Rösch, A.G.; Schultheiss, O.C. Assessing the convergent validity between the automated emotion recognition software Noldus FaceReader 7 and Facial Action Coding System Scoring. *PLoS ONE* **2019**, *14*, e0223905. [CrossRef] [PubMed]
53. Wolf, A.; Ueda, K. Consumer's behavior beyond self-report. *Front. Psychol.* **2021**, *12*, 4338. [CrossRef]
54. Bachmann, T. Attention as a process of selection, perception as a process of representation, and phenomenal experience as the resulting process of perception being modulated by a dedicated consciousness mechanism. *Front. Psychol.* **2011**, *2*, 387. [CrossRef]
55. Hommel, B.; Chapman, C.S.; Cisek, P.; Neyedli, H.F.; Song, J.-H.; Welsh, T.N. No one knows what attention is. *Atten. Percept. Psychophys* **2019**, *81*, 2288–2303. [CrossRef] [PubMed]
56. Buschman, T.J.; Kastner, S. From behavior to neural dynamics: An integrated theory of attention. *Neuron* **2015**, *88*, 127–144. [CrossRef] [PubMed]
57. Sherman, S.M.; Usrey, W.M. Cortical control of behavior and attention from an evolutionary perspective. *Neuron* **2021**, *109*, 3048–3054. [CrossRef]
58. Shomstein, S. Cognitive functions of the posterior parietal cortex: Top-down and bottom-up attentional control. *Front. Integr. Neurosci.* **2012**, *6*, 38. [CrossRef]
59. Zhou, H.; Schafer, R.J.; Desimone, R. Pulvinar-cortex interactions in vision and attention. *Neuron* **2016**, *89*, 209–220. [CrossRef]
60. Krauzlis, R.J.; Lovejoy, L.P.; Zénon, A. Superior colliculus and visual spatial attention. *Annu. Rev. Neurosci.* **2013**, *36*, 165–182. [CrossRef]
61. Risko, E.F.; Kingstone, A. Everyday attention. *Can. J. Exp. Psychol.* **2017**, *71*, 89–92. [CrossRef] [PubMed]
62. Whiting, W.L.; Madden, D.J.; Pierce, T.W.; Allen, P.A. Searching from the top down: Ageing and attentional guidance during singleton detection. *Q. J. Exp. Psychol. Sect. A* **2005**, *58*, 72–97. [CrossRef] [PubMed]
63. Gruber, N.; Müri, R.; Mosimann, U.; Bieri, R.; Aeschimann, A.; Zito, G.; Urwyler, P.; Nyffeler, T.; Nef, T. Effects of age and eccentricity on visual target detection. *Front. Aging Neurosci.* **2014**, *5*, 101. [CrossRef] [PubMed]
64. Braunlich, K.; Gomez-Lavin, J.; Seger, C.A. Frontoparietal networks involved in categorization and item working memory. *NeuroImage* **2014**, *107*, 146–162. [CrossRef] [PubMed]
65. Sani, I.; Stemmann, H.; Caron, B.; Bullock, D.; Stemmler, T.; Fahle, M.; Pestilli, F.; Freiwald, W.A. The human endogenous attentional control network includes a ventro-temporal cortical node. *Nat. Commun.* **2021**, *12*, 360. [CrossRef]
66. Friedman, N.P.; Robbins, T.W. The role of prefrontal cortex in cognitive control and executive function. *Neuropsychopharmacology* **2021**, *47*, 72–89. [CrossRef]
67. Dixon, M.L.; De La Vega, A.; Mills, C.; Andrews-Hanna, J.; Spreng, R.N.; Cole, M.W.; Christoff, K. Heterogeneity within the frontoparietal control network and its relationship to the default and dorsal attention networks. *Proc. Natl. Acad. Sci. USA* **2018**, *115*, E1598–E1607. [CrossRef]
68. Diamond, A. Executive functions. *Annu. Rev. Psychol.* **2013**, *64*, 135–168. [CrossRef]
69. McCabe, D.P.; Roediger, H.L.; McDaniel, M.A.; Balota, D.A.; Hambrick, D.Z. The relationship between working memory capacity and executive functioning: Evidence for a common executive attention construct. *Neuropsychology* **2010**, *24*, 222–243. [CrossRef]
70. Walter, K.; Bex, P. Cognitive load influences oculomotor behavior in natural scenes. *Sci. Rep.* **2021**, *11*, 12405. [CrossRef]
71. Nikolaev, A.R.; Pannasch, S.; Ito, J.; Belopolsky, A.V. Eye movement-related brain activity during perceptual and cognitive processing. *Front. Syst. Neurosci.* **2014**, *8*, 62. [CrossRef] [PubMed]

72. Alvino, L.; Pavone, L.; Abhishta, A.; Robben, H. Picking your brains: Where and how neuroscience tools can enhance marketing research. *Front. Neurosci.* **2020**, *14*, 577666. [CrossRef] [PubMed]
73. Duerrschmid, K.; Danner, L. Eye tracking in consumer research. In *Methods in Consumer Research*; Ares, G., Varela, P., Eds.; Woodhead Publishing: Sawston, UK, 2018; Volume 2, Chapter 12; pp. 279–318.
74. Brunyé, T.T.; Drew, T.; Weaver, D.L.; Elmore, J.G. A review of eye tracking for understanding and improving diagnostic interpretation. *Cogn. Res. Princ. Implic.* **2019**, *4*, 7. [CrossRef] [PubMed]
75. Oyama, A.; Takeda, S.; Ito, Y.; Nakajima, T.; Takami, Y.; Takeya, Y.; Yamamoto, K.; Sugimoto, K.; Shimizu, H.; Shimamura, M.; et al. Novel method for rapid assessment of cognitive impairment using high-performance eye-tracking technology. *Sci. Rep.* **2019**, *9*, 12932. [CrossRef] [PubMed]
76. Allen, P.M.; Edwards, J.A.; Snyder, F.J.; Makinson, K.A.; Hamby, D.M. The effect of cognitive load on decision making with graphically displayed uncertainty information. *Risk Anal.* **2013**, *34*, 1495–1505. [CrossRef]
77. Negi, S.; Mitra, R. Fixation duration and the learning process: An eye tracking study with subtitled videos. *J. Eye Mov. Res.* **2020**, *13*. [CrossRef]
78. Raney, G.E.; Campbell, S.J.; Bovee, J.C. Using eye movements to evaluate the cognitive processes involved in text comprehension. *J. Vis. Exp.* **2014**, *83*, e50780. [CrossRef]
79. Vehlen, A.; Spenthof, I.; Tönsing, D.; Heinrichs, M.; Domes, G. Evaluation of an eye tracking setup for studying visual attention in face-to-face conversations. *Sci. Rep.* **2021**, *11*, 2661. [CrossRef]
80. Motoki, K.; Saito, T.; Onuma, T. Eye-tracking research on sensory and consumer science: A review, pitfalls and future directions. *Food Res. Int.* **2021**, *145*, 110389. [CrossRef]
81. Eckstein, M.K.; Guerra-Carrillo, B.; Miller Singley, A.T.; Bunge, S.A. Beyond eye gaze: What else can eyetracking reveal about cognition and cognitive development? *Dev. Cogn. Neurosci.* **2017**, *25*, 69–91. [CrossRef]
82. Paneri, S.; Gregoriou, G.G. Top-down control of visual attention by the prefrontal cortex. Functional specialization and long-range interactions. *Front. Neurosci.* **2017**, *11*, 545. [CrossRef] [PubMed]
83. Rawnaque, F.S.; Rahman, K.M.; Anwar, S.F.; Vaidyanathan, R.; Chau, T.; Sarker, F.; Al Mamun, K.A. Technological advancements and opportunities in Neuromarketing: A systematic review. *Brain Inform.* **2020**, *7*, 10. [CrossRef]
84. Bell, L.; Vogt, J.; Willemse, C.; Routledge, T.; Butler, L.T.; Sakaki, M. Beyond Self-Report: A review of physiological and neuroscientific methods to investigate consumer behavior. *Front. Psychol.* **2018**, *9*, 1655. [CrossRef]
85. Buzzell, G.A.; Das, B.; Cruz-Cano, R.; Nkongho, L.E.; Kidanu, A.W.; Kim, H.; Clark, P.I.; McDonald, C.G. Using electrophysiological measures to assess the consumer acceptability of smokeless tobacco products. *Nicotine Tob. Res.* **2016**, *18*, 1853–1860. [CrossRef] [PubMed]
86. Alvino, L.; Constantinides, E.; van der Lubbe, R.H.J. Consumer neuroscience: Attentional preferences for wine labeling reflected in the posterior contralateral negativity. *Front. Psychol.* **2021**, *12*, 688713. [CrossRef] [PubMed]
87. Souza, R.H.C.; Naves, E.L.M. Attention detection in virtual environments using EEG signals: A scoping review. *Front. Physiol.* **2021**, *12*, 2051. [CrossRef] [PubMed]
88. Samanez-Larkin, G.R.; Knutson, B. Decision making in the ageing brain: Changes in affective and motivational circuits. *Nat. Rev. Neurosci.* **2015**, *16*, 278–289. [CrossRef]
89. Su, Y.S.; Chen, J.T.; Tang, Y.J.; Yuan, S.Y.; McCarrey, A.C.; Goh, J.O.S. Age-related differences in striatal, medial temporal, and frontal involvement during value-based decision processing. *Neurobiol. Aging* **2018**, *69*, 185–198. [CrossRef]
90. Leh, S.E.; Petrides, M.; Strafella, A.P. The neural circuitry of executive functions in healthy subjects and Parkinson's disease. *Neuropsychopharmacology* **2010**, *35*, 70–85. [CrossRef]
91. Mather, M. The affective neuroscience of aging. *Annu. Rev. Psychol.* **2016**, *67*, 213–238. [CrossRef]
92. Alsmadi, S.; Hailat, K. Neuromarketing and improved understanding of consumer behaviour through brain-based neuro activity. *J. Inf. Knowl. Manag.* **2021**, *20*, 1–9. [CrossRef]
93. Mikalef, P.; Sharma, K.; Pappas, I.O.; Giannakos, M. Seeking information on social commerce: An examination of the impact of user- and marketer-generated content through an eye-tracking study. *Inf. Syst. Front.* **2021**, *23*, 1273–1286. [CrossRef]