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Gender- and Age-Dependent Brand Perception

Evaluation of Cortical Activation Patterns with
Functional Magnetic Resonance Imaging

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Meinen Eltern

Abstract

Background:

Neuroimaging studies today are of great interest for marketing strategists who try to understand the different brand perception of people. Using modern imaging methods, researchers are now able to go beyond marketing surveys and gather information on how the brain responds to a particular brand at the most basic level. This study was performed to evaluate differences of brain activation while watching different title pages of well known german news magazines. Of particular interest are the differences in brand awareness between the age classes and genders.

Methods:

Within the framework of this study 31 participants were examined. The functional magnetic resonance imaging (fMRI) examination took place at the Institute for Clinical Radiology of the Ludwig-Maximilians-University, Munich in Großhadern. For the scans an ultra high field MRI (3.0T, Magnetom, Siemens, Erlangen, Germany) was used. The preconditions for the participants were physical and psychological health, as well as brand knowledge of the three magazines and an appropriate reading condition. The participants were recruited from three age classes (young: 20-35y; middle: 36-49y; elderly: 50-65y) and gender classes (16 women; 15 men). The precondition was that each age class or gender class has the same allocation of participants. For the beginning of the fMRI experiment, the nature, the rules and possible risks of the experiment were explained to each participant included. The study was approved by the Ethics Committee of the Medical Faculty of Ludwig-Maximilians-University Munich.

Before the fMRI measurement the reading behaviour was assessed by a questionnaire ("How often do you read the three magazines?", "Do you know all of the three magazines?"…). While lying in the scanner, the participants watched a 1.5 x 1.5 meter screen through a mirror that was attached to the head coil. The stimuli in this study were the covers of three well-known German news magazines projected on this screen by a magnetic resonance compatible video projector. Each picture was underlined by a short caption (f.e. "Offers more than another", "Provides topics", "Is pleasant", "I like it", "Differs from others") to evaluate the perception of the brand using a four-point scale ranking from "I agree strongly" to "I do not agree". The participants had the possibility to press four different buttons to evaluate the pictures shortly after they had seen them.

Objective:

It was the aim of the study to evaluate the neural correlates of brand perception with special regard to the difference between age classes and gender classes. The brands referred to three different well-known German news magazines (Brand1, 2 and 3, respectively).

Results:

There were clear distinctions discovered between the different news magazines with regard to the brain activation. In this connection the central issue was made by the different lateralization of the brain activation.

Brand2 showed a left dominant activation pattern whereas Brand1 and Brand3 showed a right dominant activation pattern. In comparison Brand1 and Brand3 showed a weaker brand perception and brand presence. These results correlated with the evaluation of the questionnaires.

Equally, clear results are shown by the differentiation between the three age classes. While the young participants had a left dominant activation pattern and had the lowest activation in comparison with the other age classes, the middle-old and elderly subjects showed a bilateral activation with increasing activity in correlation to the age. This holds for all three age classes and showed that the age dependent decreasing brain achievement is compensated by increasing brain activation. Besides, the left dominance of the young could be explained by a more emotional brand perception in comparison to the elderly. The elderly participants evaluated brands more rationally because of their life experience.

The comparison of gender showed clear distinctions, too. The men showed a right dominance with high brain activity. This could be interpreted as a rational and less emotional evaluation. In comparison to this the women showed a clear left dominance with lower activity.

Conclusion:

These results emphasize the significance of neuromarketing studies with functional magnetic resonance imaging. Especially the differences of the brain activation between the age classes and genders confirm the necessity of intensive research.

Deutsche Übersetzung der Zusammenfassung

Hintergrund:

Kernpunkt der Arbeit war die Evaluation von kortikalen Aktivierungen während der visuellen Präsentation verschiedener Marken (es handelte sich hierbei um drei bekannte deutsche Nachrichtenmagazine) mittels funktioneller Magnetresonanztomographie (fMRT). Besonderes Augenmerk lag hierbei auf den Geschlechts- und Altersunterschieden. Das Gehirn mit seinen komplexen Funktionen und Strukturen ist nach wie vor ein Feld von höchstem Interesse für die Wissenschaft, die das Geheimnis um den Ursprung der Gefühle, des Denkens, der Entscheidungsfindung und anderer Gehirnaktivierungen zu lösen versucht.
Studien mit Hilfe der funktionellen Magnettomographie sind von großem Interesse in der Marktforschung, die sich erhofft, die unterschiedliche Markenwahrnehmung und Markenbevorzugung der Konsumenten zu verstehen. Mit dieser neuen bildgebenden Methode ist es nun möglich über die Marktforschung hinaus Informationen darüber zu sammeln, auf welche Weise das Gehirn auf bestimmte Marken reagiert.

Methoden:

Im Rahmen der Studie wurden insgesamt 31 Probanden untersucht, davon 16 Frauen und 15 Männer. Die fMRT Untersuchungen fanden am Institut für Klinische Radiologie der Ludwig-Maximilians-Universität, Standort Großhadern, am Ultrahochfeld MRT (3.0 T, Magnetom, Siemens Erlangen, Deutschland) statt. Einschlusskriterien für die Probanden waren physische und psychische Gesundheit, sowie Kenntnis der verschiedenen Magazine und entsprechendes Leseverhalten. Die Probanden wurden in drei verschiedene Altersgruppen aufgeteilt: 20-35 Jahre, 36-50 Jahre und 51-70 Jahre. Jede der drei Altergruppen war zahlenmäßig gleich besetzt (einer, der 31 Probanden musste auf Grund von Bewegungsartefakten aus der Studie wieder ausgeschlossen werden). Die Studie wurde von der Ethikkomission der medizinischen Fakultät der Ludwig-Maximilians-Universität München angenommen. Die Probanden wurden vor der Untersuchung über die Studie und eventuelle Risiken aufgeklärt. In einem Gespräch vor der eigentlichen fMRT-Messung wurde das Leseverhalten der Probanden ermittelt („wie oft lesen Sie die drei Magazine?“, „kennen Sie alle drei Magazine?“, …). Danach wurde der Proband im MRT gelagert. Über einen an der Kopfspule befestigten Spiegel konnte er während der Messungen auf eine Leinwand blicken, auf die mit einem MRT kompatiblen Projektor die verschiedenen Titelbilder der drei Magazine projiziert wurden. Diese Bilder

waren mit kurzen Fragen untertitelt, die der Proband mit Hilfe von vier verschiedenen Druckknöpfen auf einer Skala von 1-4 spontan zu bewerten hatte.

Ziele:

Ziel der Studie war es die kortikalen Aktivierungen während der visuellen Stimulation mit verschiedenen Marken zu evaluieren. Bei den Marken handelte es sich um drei bekannte deutsche Nachrichtenmagazine (Marke1, 2 und 3), deren Titelbilder miteinander verglichen wurden.

Ergebnisse:

Es wurden klare Unterschiede zwischen den verschiedenen Magazinen hinsichtlich ihrer Auswirkung auf die Hirnaktivierung entdeckt. Kernpunkt hierbei war die unterschiedliche Lateralisation der Hirnaktivierungen.

Marke2 zeigte ein linksdominantes Aktivierungsmuster wohingegen Marke1 und Marke3 ein rechtsdominantes Aktivierungsmuster aufwiesen. Dies spricht für eine gute Markenwahrnehmung der Marke2 und, auf Grund der insgesamt am niedrigsten Aktivierungsgröße, auch für eine anstrengungslose Verarbeitung, welche für eine gute Markenpräsenz spricht. Marke1 und Marke3 wiesen dagegen eine schwächere Markenpräsenz und Markenwahrnehmung auf. Diese Ergebnisse wurden auch durch die Fragebogenauswertung gestützt.

Klare Ergebnisse zeigte auch die Differenzierung zwischen den drei Altersklassen. Während die jungen Probanden ein linksdominantes Aktivierungsmuster aufwiesen und im Vergleich zu den anderen Altersklassen eine insgesamt niedrigere Aktivität, zeigten die Probanden der mittlern und älteren Altersklassen eine beidseitige Aktivierung mit ansteigenden Aktivierungen im Verhältnis zum steigenden Alter auf. Dies war für alle drei Marken gleich und könnte darauf hinweisen, dass mit zunehmendem Alter die sinkende Leistung der ursprünglich aktiven Hirnregionen durch eine Umverteilung und steigende Aktivierung kompensiert wird. Die Linksdominanz in jungen Jahren könnte mit einer emotionaleren Markenwahrnehmung erklärt werden, wohingegen die älteren, erfahreneren Probanden die Marken eher nüchterner bewerteten.

Der Geschlechtervergleich zeigte ebenfalls deutliche Unterschiede. Die Männer wiesen hierbei eine Rechtsdominanz mit hoher Hirnaktivität auf, was als Nüchternheit und weniger emotionale Beurteilung gedeutet werden kann, wohingegen die Frauen eine klare

Linksdominanz mit niedrigerer Hirnaktivität aufwiesen, was wiederum als emotionale Beurteilung des Gesehenen interpretiert werden könnte.

Ausblick:

Die Ergebnisse dieser Studie unterstreichen noch einmal die Möglichkeiten der Marketingstudien mittels funktioneller Magnetresonanztomographie. Gerade die Unterschiede der Gehirnaktivität zwischen den Altersklassen und zwischen den Geschlechtern bestätigen die bereits mittels Fragebogenerhebungen bekannten Unterschiede des Markenverhaltens. An diese Ergebnisse sollte die Forschung mittels fMRT-Studien mit den Schwerpunkten Altersunterschiede und Geschlechterunterschiede anknüpfen.

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List of Abbreviations

Ant. INS	Anterior Insula
ACPC	Anterior Commissur Posterior Commissur
BA	Brodmann Area
BOLD	Blood Oxygenation Level Dependent
BV	Brain Voyager
CBF	Cerebral Blood Flow
CBV	Cerebral Blood Volume
Cu	Cuneus
DTPA	Diethylene Triamine Pentaacetic Acid
EPI	Echo Planar Imaging
FA	Flip Angle
FDR	False Discovery Rate
fMRI	Functional Magnetic Resonace Imaging
FoV	Field of View
GC	Cingulate gyrus (*Gyrus cinguli)*
GFd	Gyrus frontalis superior pars medialis (*Gyrus frontalis medialis)*
GFi	Inferior frontal gyrus (*Gyrus frontalis inferior)*
GFm	Middle frontal gyrus *(Gyrus frontalis medius)*
GML	General Linear Model
Gsm	Supramarginal gyrus *(Gyrus supramarginalis)*
GTm	Middle temporal gyrus *(Gyrus temporalis medius)*
GTs	Superior temporal gyrus (*Gyrus temporalis superior)*
HF-Impuls	High Frequence Impulse
Loc	Localisation
LPi	Inferior parietal lobule (*Lobus parietalis inferior)*
MPRAGE	Magnetization Prepared Rapid Acquisition Gradient Echo
MR	Magnetic Resonance
MRI	Magnetic Resonance Imaging
n/a	Not applicable

NC	Caudate nucleus (*Nucleus caudatus)*
PACS	Picture Archiving and Communicating System
PCu	Precuneus
Pu	Putamen
SPSS	Statistical Package for the Social Sciences
T	Tesla
TE	Echo Time
TR	Repitition Time
VS	Versus
Y	Year

1 Introduction

„The processes in brain come just as near to the science as the source of universe.” (Antonio Damasio, University of Iowa, Neurology) (1).

Up to these days the brain with its complex functions and structures has been a field of highest scientific interest. Many scientists are still questing to disclose the secrets of feelings, thinking, decision making and other brain activations.

What are the structures that coordinate information and where does defined thinking take place? How does decision making take place in daily life? Does the thinking of elderly people differ from that of young people or is it indistinguishable? Are there any differences between the gender classes and if so, what are the differences and how do they look like?

1.1 Role of fMRI in Cognitive Neuroscience

In the past cognitive neuroscience, which tries to understand correlations between cognitive phenomena and biological patterns, definitely made a lot of effort using electroencephalography, positron emission tomography or single photon emission tomography and provided a basis for today's research, but it is only since functional magnetic resonance imaging has been established that cognitive neuroscience made a great leap in development.

Thus technical effort has been able to cast some light on this field of research and during the last fifteen years a kind of revolution in cognitive neuroscience took place because of the new imaging technique. The study of human brain function has been greatly facilitated by neuroimaging techniques that enabled research on increasingly complex cognitive phenomena, including emotions, personality features, and real-world behaviours.

This progress was the result of the invention of functional magnetic resonance imaging (fMRI) in 1990. Since then, fMRI has proven a useful tool for observing neural BOLD (blood-oxygenation-level dependent) signal changes during complex cognitive and emotional tasks. Functional magnetic resonance imaging is of particular interest for widespread non-invasive (therefore allowing a greater degree of repeatability than before) and widespread use by the research community.

In addition, the strength of fMRI is the - by a substantial degree - relatively high temporal and spatial resolution and the ability to measure brain activation without radioactive agents.

The application of fMRI can be compared to a window opening up on the human brain works, awareness processes, decision-making and assimilation. The human brain is no longer a “black box”. The conscious and unconscious processes of the brain can be better understood and the respective shares of cognitive and affective processes of brain regions can be determined. The direction (positive or negative), the intensity and kind of affects (i.e. happiness, anger and sorrow) can be understood (2).

1.2 Magnetic Resonance Imaging

The advantages of magnetic resonance imaging are its high spatial resolution and contrast, its lack of ionising radiation and its ability to make the images sensitive for blood flow and blood composition, therefore providing a method of measuring the function of neurons by virtue of their localised coupling to hemodynamics in brain.

The magnetic properties of haemoglobin were discovered by *Pauling and Coryell* as early as in 1936 (3). The technical principle of MRI was discovered by *Bloch and Purcell* in 1946 and forty-four years later (1990) (4) researchers found out that the properties of haemoglobin can be used for measuring brain activity in mice and rats without any help of contrast agents, only through the structural shift of the oxygen concentration (5, 6). The same researchers were able to apply this method to human studies (7) and thus the technical principle of functional MRI was discovered.

The foundations of MRI are all atomic nuclei with an odd mass number, which means an odd number of protons and neutrons. These have a nucleus spin and so an own magnetic moment μ. The chief ingredient of the human body is water and so the important element with nucleus spin is hydrogen. If the hydrogen atomic nucleus runs parallel to the z-axis within an external magnetic field Bo (the strength of the field is 1.5 or 3 Tesla (T) in clinical scanners), the rotation axis of the nuclei performs a precision movement around the z-axis with the larmor frequent ώo.

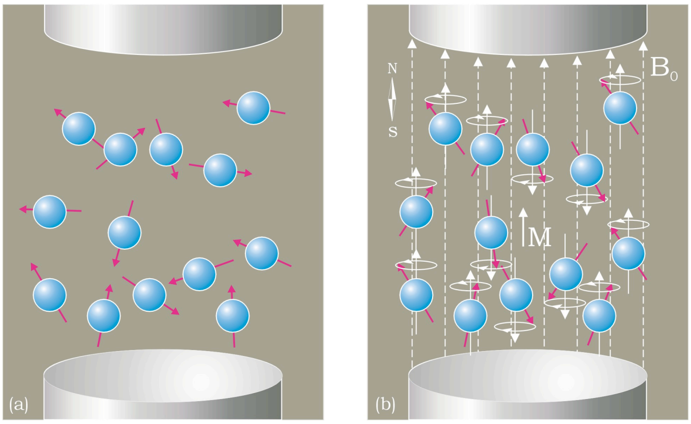


Figure 1: *Nucleus spin without and with external magnetic field.*
(a): Without the external magnetic field the not aligned magnetic dipoles of the separated nucleus spin neutralize each other. (b): Under the effect of the external magnetic field Bo the magnetic dipoles align in parallel or in antiparallel. The parallel alignment is lower energetic and so it is the more frequent alignment and the net magnetism is M.

A high-frequence-impulse (hf-impulse) has to be irradiating in addition to the constant magnetic field. Thus the atomic nuclei can rise to a higher energetic level and tip the additional vector downward from z-axis to xy-axis (= transverse magnetisation).
Normally the hf-impulse is produced by a transmitter coil (for example a head coil or body coil) and with it the synchronisation of the precession movement is achieved and the magnetic vector straightens to xy-axis.

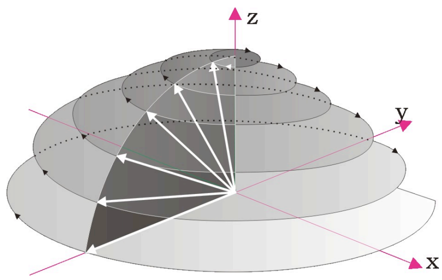


Figure 2*: Alignment of the magnetic vector M with an hf-impulse.*
The magnetism rotates with the lamor frequence ώo around the z-axis Bo.

After the disconnection of hf-impulse the hydrogen atomic nuclei return to their original position and give back their acquired energy. The changes in magnetisation generally only last a few seconds. The return of the magnetic vector into its original position (= relaxation) is described by the relaxation time T1, T2 and T2*.

There follows firstly a description of the T1 relaxation time (= spin-gitter relaxation time):

The T1 relaxation time means the half-life which is needed to return from transverse to longitudinal magnetisation.
This procedure is caused by the exponential energetic delivery of the atomic nuclei to their surroundings. The T1 relaxation time is dependent on the external magnetic field Bo and on the energetic coupling of the atomic nuclei to the general system. If the movements of the protons and neutrons in the tissue correspond to the movements of the atomic nuclei and if they are near the lamor sequence ώo, the energetic transfer is maximal. Hence it follows that different tissues have different T1 relaxation times.

The T2 relaxation time (or spin-spin relaxation time) states the half-life which is needed by the part vector Mxy after an hf-impulse for losing its energy. The loss of phase coherence of the spins is the source of this.
After the hf-impulse is turned off, the atomic nuclei dephase, because of the fluctuation of the magnetic inhomogenities in their close surroundings, but independently of the external magnetic field. By contrast to the T1 relaxation time no energy transfer is needed.

The third mechanism of relaxation, the T2* relaxation time, is caused by external field inhomogenities. These interactions produce another factor that triggers a dephasation. The inhomogenities are caused by different magnetic attributes of non-ferromagnetic substances i.e. the susceptibility. The susceptibility describes the dimension in which a substance is magnetized if an external magnetic field is produced. The source of this phenomenon is the reciprocal action between the external magnetic field Bo and the magnetic moment of the electron covering.
In diamagnetic substances, as water or other organic molecules, the induced magnetisation points to direct opposition to the external magnetic field.
In paramagnetic substances, like deoxyhemoglobin, or metallchelates, as Gadolinium-DTPA a magnetisation is built in the same direction as the external magnetic field. Because of this support of the local magnetisation it results in a signal loss, which is characterised by the time constant T2*. This effect increases in proportion to the field straightness of the system.
The T1 and T2 time constants are affected by tissue type and T2* by blood flow changes. The T1 and T2 contrasts are based on the number of protons in a voxel, which differs across different tissue types.

By applying a spin-echo pulse frequency we can get rid of the nuisance signal, which can be caused by the equipment (an imperfect external field). After the excitation pulse another echo-generating pulse is applied at a defined point or time. This reverses the dephasing and that part of it which is caused by external field inhomogenities is eliminated (8, 9, 19). For deeper comprehension detailed literature of magnetic resonance (11, 12, 13) and magnetic resonance imaging should be consulted (14, 15).

1.3 Functional MRI

Functional Magnetic Resonance Imaging (fMRI) is a special method within the field of Nuclear Magnetic Resonance Imaging. With fMRI it is possible to measure neuronal reactions to external stimuli, especially in the neocortex. The fMRI is based on local blood flow changes and blood oxygenation changes in response to neural activity. Functional magnetic resonance imaging can detect these hemodynamic changes.

Whenever neurons process information their metabolic requirements increase. Energy is provided through glucose and oxygen, i.e. the oxygen is bound to hemoglobin molecules. The differential magnetic properties of deoxygenated and oxygenated hemoglobin can be used to measure images by blood-oxygenation-level dependent (BOLD) contrast. This contrast is a consequence of a series of indirect effects. It results from changes in the magnetic properties of water molecules, which in turn reflect the influence of paramagnetic deoxyhemoglobin. The deoxyhemoglobin is the physiological correlate of oxygen consumption, which in its turn is a correlate of a change in neural activity evoked by cognitive processes.

The increase of blood flow and oxygen delivery flushes deoxyhemoglobin from blood vessels. The deoxyhemoglobin has magnetic field gradients which are diffusing hydrogen nuclei after the spins nearby. Whenever paramagnetic deoxyhemoglobin is present the MR signal intensity of the hydrogen nuclei decreases, caused by a decrease in the dephasing of hydrogen. The T2* decay changes allow the spin alterations caused by changes in the composition of the local blood supply to be measured. When deoxyhemoglobin is displaced by oxygenated hemoglobin through increased blood flow, a local increase in the T2* MR signal can be observed. The increase in cerebral blood flow overcompensates for the decrease in oxygen caused by oxygen consumption in neurons, delivering an oversupply of oxygenated blood. Thus neural activity can be measured indirectly with the help by means of T2*changes. In summary, the BOLD response provides unprecedented visibility of the neural activity in the human brain. The BOLD signal has been shown to be correlated to the presynaptic activity and to the local neuronal activity.

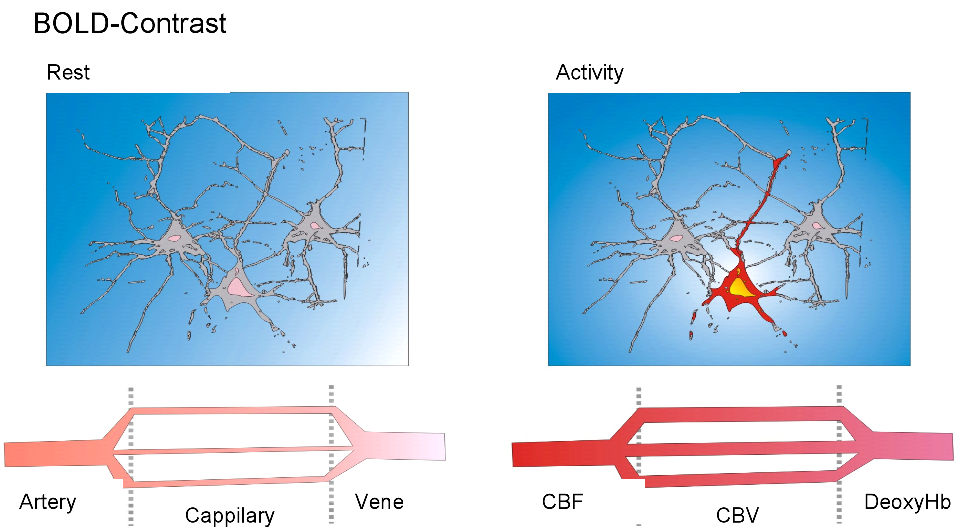


Figure 3: *The principle of BOLD contrast:*
The changes in hemodynamics cause a rise in MR signals. The cerebral blood flow (CBF) and the cerebral blood volume (CBV) rise under neuronal activity. The oxygen content drops because of the higher use-up of oxygen and so the deoxyhemoglobin content of venous blood drops, too (modified according to LeBihan 1996) (16).

A fMRI experiment needs a series of anatomical scans, which at a later point of time will be used to relate the functional findings to known anatomical landmarks in the brain. The anatomical scans provide the information for a better localization of the place of the activation due to cognitive tasks.

The fMRI sequences differ from conventional MRI by rapidly variable magnetic field gradients. Echo planar imaging (EPI) is the fastest method of magnetic resonance imaging. The classic EPI-sequence uses one single stimulus and subsequently accumulates all the data in gradient echo technique. One magnetic resonance image can be developed in under 100 msec, thus minimizing the susceptibility to moving artifacts. Because of the relatively short acquisition time, the EPI-sequence is specially qualified for the recording of physiological parameters in functional imaging.

There are two major design formats for fMRI experiments. The design of the task may be block design, where a “steady state” of neuronal and hemodynamic change is set up, or event-related design, where the hemodynamic response to each stimulus is measured. The design has to include other tasks or a period of rest, as activation results are based on the comparison between two cognitive states. The advantage of block-designed tasks is that they are less susceptible to disturbances than event-related design, but not every stimulus can be assigned exactly to its hemodynamic response.

The signal modulation in fMRI typically is 0.5-1.5%. In the magnetic field it is very important to minimise head motion to be able to detect the actual signal. The fMRI technique is particularly effective at 3.0 Tesla (T), owing to its sensitivity, resolution and high signal, reduced scanning times and overall improved diagnostic ability. 3.0 Tesla allows an exploration in greater detail of more complex phenomena, which are not clearly depicted on 1.5 Tesla systems (17).

The radio-frequency magnetic field oscillations do generate internal body heat. However, there are guidelines that secure a safe environment for the subject (18, 19, 20, 21, 22, 23).

1.4 Perception of Brand-related Information - the Mechanism of Brain Branding

Brain branding is a new, interdisciplinary approach to improve the understanding of the question: How does the mind perceive and process brands? Using modern imaging methods, for example functional magnetic resonance imaging, researchers are now able to go beyond marketing surveys and gather information on how the brain responds to a particular brand at the most basic level. Brand is essentially the sum of all experience related to the product, service and companies that make and deliver the product. Brand perception is shaped by functional experience (i.e. speed, quality, reliability, ease of use) as well as the emotional experience that the customer associates with the product and the company.

With the former methods (measurement of eye movement, skin resistance, classical questioning) scientists have already tried to measure the effect and sustainability of brands and advertising, but without any modern imaging methods (i.e. functional magnetic resonance imaging) they soon reached their limits. The method of brain branding offers new possibilities for the measurement of brain activity in connection with the brand perception. It is the interest of the marketing strategists to revolutionize brand science and brand management with the assistance of brain science.

> *"…with the use of neurobiological science in the economy we stand in front of a new way of looking at brands and their effects to the thinking and behaviour of the costumer…"* (*Vernon L. Smith*, Nobel Prize winner for economy 2002) (24).

Neuroeconomic methods offer the hope of separating and characterizing distinct components of the purchase decision process in individual consumers. One of these new methods is named brain branding, which means the interaction of brand management and brand science. It is the head objective of this approach to make the effort of brain science usable for brand management. Especially the combination of both competences offers an enormous potential for the marketing, because brain science may open a new perspective on the consumer.

The method of brain branding is built on three columns:
Market analysis, which means identification of the potential of a brand, followed by the positioning of the functional imaging and at last the optimizing of the embedding of the brand. Here the functional magnetic resonance imaging combines experimental procedures like the measuring of reaction time and classical examination with qualitative and quantitative procedures. This combination guarantees quality and is a precondition for the correct interpretation of the results. Using the new knowledge of brain branding, the marketing strategists aim at rendering a customer a purposeful consumer and getting the brands anchored in the brain of the customer. Besides, it is a point of interest for them to optimize the reflection of brands, enterprises and products (25).

To conclude, it has to be underlined that branding is one of the most interesting areas in neuromarketing. It seems to be clear that individuals have strong and usually subconscious responses to brands and, obviously, brand familiarity is important, but other dimensions like the different brand perception of different age and gender classes have to be considered, too.

1.5 Differences between Age and Gender in Brand Perception

Familiar brand images are processed in brain areas associated with positive emotions, while unfamiliar brands require more effort in brain processing and activate areas of the brain associated with negative emotions. Thus it can be concluded that both strong and weak brands may be perceived as familiar or unfamiliar and cause the corresponding activation patterns. Additionally, activation was measured in areas which are related to potentially negative outcomes (26).

For marketing it is important to examine and classify the different brands. So the question matters why one brand is more successful than another one. In this connection it is not only important to determine which brand performed better or worse in the mind of the consumer, but to consider, which collective was examined. Today there exist many functional resonance imaging studies about brain perception and brain activation in general. But one point which seems to have been neglected until today is the difference of cortical activation among the different age classes and among the different genders.

That women and men should react variably to different products may seem probable, but hasn‘t been established yet. It would be very informative to see if different brain areas are activated. Another interesting point would be to examine the different age classes, because it seems to be probable that life time experience plays an important role in product perception and it would be enlightening if there could be detected different cortical activation areas correspondingly.

It could be a great advantage to make distinctions between age and gender classes and their different perception of brands. A record with help of functional imaging would to objectify the judgment. It would be a progress to see which brain area is activated during the perception of different brands among different age and gender classes, to accommodate the needs and wishes of the consumer.

2 Working Hypothesis

It was the aim of the study to detect cortical activation patterns caused by well established brands. For the experimental setting three well known German brands (news magazines) were chosen, which have been well established for years and show a similar layout and similar contents (political information as well as society themes).

In this connection the primary objective was to show that there exists a significant difference in cortical perception and semantic processing between them. It was a matter of particular interest to examine if there can be observed any difference in their cortical activation and if it is possible to show the same grading in different activation patterns between supposedly well established brands that are already shown in comparison between familiar and unfamiliar brands.

Another important aim was to prove that there exists a change in brand perception between the age classes. Therefore, the subjects were split up into three age classes with similar allocation. One assumption was that the region of cortical activation may change in the course of life or/and that the intensity of possible activation may increase or decrease.

After the examination of the different age classes it is consequent to observe the difference of brand perception among the genders. Accordingly, here as well the participants were split up into gender groups with identical numbers of participants. Matter of particular interest was the question if there can be shown any different cortical activation patterns during the experiment and if so, what the difference is about.

In summary, the focus of the study was the neuronal activation of the brands in comparison with each other under consideration of the neuropsychological testing. To answer these questions the results of brain activation were analysed in correlation with questionnaires and connected to the behavioural response data.

3 Materials and Methods

3.1 Subjects

Thirty-one physically and psychologically healthy participants were included in the study. The recruiting of the subjects took place with an announcement inside the University Hospital of Großhadern. The examined brands were three well known German news magazines (**Brand1**: „*Focus*", Hubert Burda Media, since 1993, QII 2009: circulation of 656.776 copies; **Brand2**: „*Der Spiegel*", SPIEGEL-Verlag Rudolf Augstein since 1947, QII 2009: circulation of 1.029.558 copies; **Brand3**: „*Stern*", Gruner + Jahr, since 1948, QII 2009: circulation of 949.546 copies).Precondition was that the probationers knew and read the news magazine occasionally (see chapter 3.3). The participants were subdivided in three age classes and two gender classes. The precondition was that every age class or gender class had nearly the same number of participants (**Table 1**).

Age Class	**Gender**		
	female	male	n=
young	6	5	11
middle-aged	5	5	10
elderly	5	5	10
n=	16	15	**31**

Table 1: *Resorting of participants.*
Every age class or gender class with its number of participants, n = number.

Written informed consent was obtained from all participants after the proceedings had been fully explained. The study was approved by the Ethics Committee of the Medical Faculty of Ludwig-Maximilians-University Munich.

3.2 Methods

3.2.1 Functional (fMRI) Data Acquisition and Data Analysis

3.2.1.1 Data Acquisition

Functional imaging was performed using a state-of-the-art, clinically approved MRI systems with a multi-channel capability and coil concept operating with following specifications:
The 3.0 T whole body magnetom (Magnetom, Siemens Erlangen, Germany) with its maximum gradient strength of 45mT/m, its maximum slew rate of 200T/m/s and its 12 element head coil. The head coil was equipped with a detachable double mirror system.

For the functional imaging, an echoplanar gradient-echo sequence was used with the following imaging parameters: repetition time (TR) 3000ms, echo time (TE) 30ms, flip angle (FA) 90deg, spatial resolution 3x3x3mm, matrix 64, Field of View (FoV) 192mm, number of slices 36. Exactly the same sequence parameters were used for the phantom measurements.

The functional images were acquired in axial orientation, parallel to the ACPC (anterior commissur – posterior commissur) line, covering a subject's brain from the cerebellum to the vertex. For anatomical reference, a sagittal high resolution 3D inversion recovery gradient-echo sequence (MPRAGE) was performed (FoV, 250mm, spatial resolution, 0.8x0.8x0.8mm, TR, 14ms, TE, 7.61ms, FA, 20deg, number of slices 160).

For the visual presentation of instructions during the examination, a commercially available, shielded video beamer (*InFocus LP 640*, InFocus Corporation, Wilsonville, OR, USA, resolution = 1024 x 768 pixel) was used. The instructions were projected on a translucent video screen at the subject's feet. Lying in the scanner, the participants watched the screen by a head coil compatible mirror system (eye-to-mirror distance 15cm, mirror-to-screen distance 2.5m, screen-to-beamer distance 1.5m). Instructions were presented by means of commercially available software (*Presentation*®, Neurobehavioral Systems Inc., Albany, CA, USA.). The timing of stimulus presentation was triggered by a pulse produced by the scanner at the start of each functional scan.

3.2.1.2 Data Analysis

3.2.1.2.1 Data Post-processing

All data were archived by the institutional PACS (picture archiving and communicating system) and subsequently transferred to a stand-alone evaluation platform (*Windows2000*, Microsoft, USA) for further evaluation.
All the image post-processing and statistical analysis was done by *BrainVoyagerQX*®, Ver. 1.7 (BrainInnovations BV, Maastricht, Netherlands). Before further processing, the first 4 functional volumes of each run were discarded to avoid T1 saturation effects. The functional data pre-processing was done in a standardised fashion provided by *BrainVoyager*® using the following procedures: Slice scan time correction, motion correction and the spatial smoothing following the talairach transformation were performed using a 4 mm (full width at half maximum) isotropic Gaussian filter. For anatomical reference, the high resolution T1-weighted sequence was used. Functional data were co-registered simultaneously with the anatomical sequence in an automated process using spatial position files produced by the scanner for each scan. Afterwards the results of the alignment process was visually evaluated and corrected whenever necessary for optimal alignment. The anatomical sequence was transferred to talairach reference space. Using the parameters of this transformation, functional data were also transferred to the reference space.

Results and success of motion correction and talairach transformation (e.g. misalignment, distortion) were reviewed by two radiologists with neuroradiological training (a fellow of radiology and an attending radiologist, section MRI) in agreement.

3.2.1.2.2 Statistical Analysis

Separately for each participant and run a first-level analysis was done using the General Linear Model (GLM). The resulting activation maps were subsequently checked for plausibility. For the second-level analysis (group analysis) a multi-study multi-subjects GLM was created. Functional maps were calculated for the contrasts "Brand1 > Brand2 > Brand3" for gender and age classes. Statistical maps were whole-brain-corrected automatically for multiple comparisons.

For each contrast, identification of activation clusters was made by two radiologists in agreement. Anatomical regions were identified in correspondence with the *Talairach and Tournoux* atlas (27) and using the nomenclature of *Brodmann* (1909).

3.2.2 Stimuli and Experimental Design

At the beginning of the fMRI experiment, each included participant was explained its nature and rules. All participants filled in a questionnaire, which was standardised and included the evaluation of brand knowledge and strength and the individual involvement of the participants with them was measured by ten questions with subordinate points. While lying in the scanner, the participants watched a 1.5 x 1.5 meter screen through a mirror that was attached to the head coil. The stimuli were projected to this screen by a video projector. Stimuli in this study were the covers of three well-known German news magazines (Brand1, Brand2 and Brand3). Under each picture there was set a short question (i.e. “Offers more than another”, “Provides topics”, “Is pleasant”, “I like it”, “Differs from others”) to evaluate the perception of the brand according to a four-point scale ranking from “I agree strongly” to “not agree” (**Figure 4**, **Figure 5**). The test person had the possibility to press four different buttons to evaluate the pictures shortly after he/she had seen them and was instructed to press the button immediately after his/her first impression of the picture and question.

“Provides topics” **“I like it”** **“Offers more”**

Figure 4: *Covers of the three brands.*
The cover pictures of the three well-known German news magazines were matched by short questions. Each picture was shown for three seconds. Response scale: 1= “agree strongly”, 2= “agree”, 3= “moderate agree”, 4= “not agree”.

All the components of the experimental design had to be MR-compatible. The stimulus unit and the workstation necessary for performing the scans were located outside the MR room. The participant held response buttons in his/her hands.

Figure 5: *Experimental fMRI setup with the Magnetom TRIO, Siemens in Großhadern.*
a) 1.5x1.5 meter screen and video projector, b) 12-channel headcoil with an attached mirror, response buttons, c) computer set-up.

The subjects of the experiment were instructed to press four different buttons with two fingers of the right and left hand whenever they had seen a picture. One picture was projected for three seconds before it changed to the next. Prior to the scanning it was emphasised that the individual should be concentrated and answer the accompanying question quickly and spontaneously. As a control condition, a coloured abstract image was displayed for 24 seconds after every eighth picture (**Figure 6**).

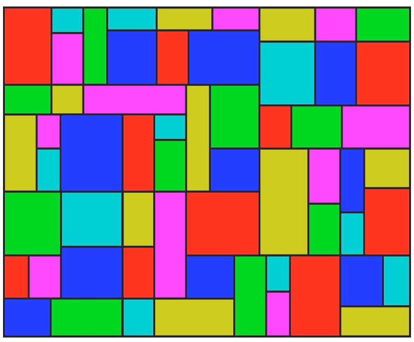


Figure 6: *The relaxation picture for the baseline control condition was shown for 24 seconds after every eighth picture.*

During the fMRI session, none of the subjects reported any difficulties in performing the task. Two different fields of the behavioural response data were examined: Which button was pressed by the participant during the experiment and what time he needed for this decision. So the assessment as well as the reaction time of the participants had to be analysed. A precondition for the measurement was that the participant wasn't allowed to move his head during the scans. To make it easier for him the participant's head was fixed up with vacuum cushions in the head coil.

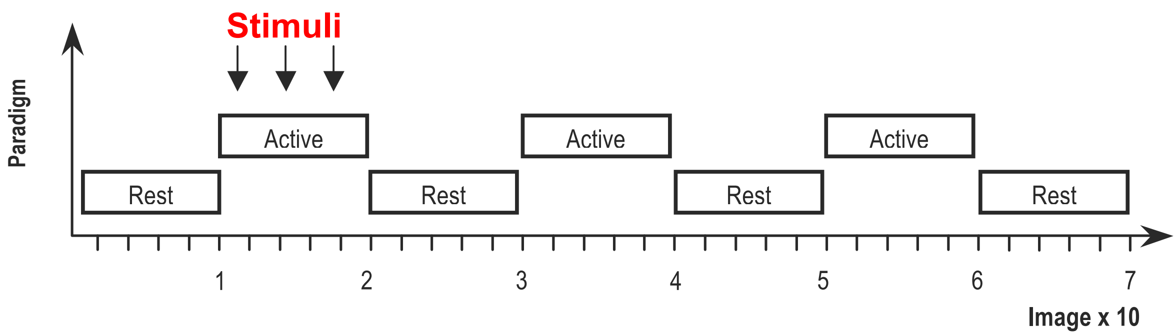


Figure 7: *Stimuli paradigm.*
Four active blocks consisting of eight stimuli every three seconds.

The fMRI was block-designed with 4 active blocks consisting of 8 stimuli every three seconds for each news magazine's title page, which meant that a "steady state" of neuronal and hemodynamic change was set up (**Figure 7**). For anatomical reference 3D-T1w images were obtained. The whole analysis took approximately 40 minutes. Shortly after the scanning the participants were tested again by means of a further questionnaire to evaluate the effect of the pictures and the imagination of the different products.

3.3 Questionnaires

All subjects filled in a questionnaire developed by professionals in marketing (BBDO Consulting and Burda-Media Germany), which was standardised and included the evaluation of brand knowledge and strength and the individual involvement of the participants. First the personal data of the participants were documented: age, gender and handedness for the statistical analysis. After that some questions about their reading behaviour were asked. The inclusion criteria were that a participant should know the individual news magazines and read them. Next the participants were classified into three age classes [young: <35y (middle age 28y); middle: 35-49y (middle age 41y); elderly: >50y (middle age 60y)] and gender classes (female: 16; male: 15).

The questionnaire was divided into two parts: the first part was answered before the fMRT examination; the second part was answered immediately after the scans to record the examination result.

In the first part of the questionnaire the participant had to answer 4 main questions. The first question was about the participant himself: gender, age, handedness and visual aid. The second referred to his general brand knowledge of six different German newspapers (brand 1, 2 and 3 were included). The participants were asked, how often they read these. Then the brand image and the brand attractiveness were questioned.

After the experiment the participant answered the rest of the questionnaire. This was the main part of the interrogation. The participant had to answer questions about his imagination, identification, attraction and his personal experience with the different brands, especially in the context with the pictures he had seen before. Three times in succession, for each of the three newsmagazines, nineteen questions were asked about the contents of the news magazines, as for example: “Brand1 is trustworthy”, “Brand1 is understandable”, “...is superficial”, “...is critical”. In the same way the reception of Brand2 and Brand3 was inquired. It was also asked for the personal reading behaviour and presented eleven newspapers / news magazines for choice. Every question had five answer possibilities on a five-point scale ranking from “agree strongly” to “disagree strongly”, “very clear” to “unclear” or “very attractive” to “absolutely not attractive”. For the evaluation and analysis of the questionnaires the questions were classified in four main groups: the reading conditions, the imagination, the attractiveness and the contents of the news magazines. The different questions were worked out by summing up the answers. The questionnaires were analysed by a Chi^2-test and by SPSS 15.0 (Statistical Package for the Social Sciences). The data were analysed in general and again the gender and age classes were distinguished. Throughout the experiment the questionnaire was the scale of reference for both the response data and the brain activation.

I. Before the experiment						
S0	**Gender:**	Man	Woman			
S1	**Age class:**	< 35y	35y < 50y	50y <		
S2	**Handedness:**	left	right			
S4	**Seeing aid:**	yes	no			
S5a	**Brand knowlegde:**	read/leafed	only known	not known		
	Brand1					
	Brand2					
	Brand3					
S5b	**Reading condition:**	every edition	2./3. edition	seldom	never	
	Brand1					
	Brand2					
	Brand3					
S5b	**Imagination:**	very clear	clear	less clear	not very clear	unclear
	Brand1					
	Brand2					
	Brand3					
S8b	**Attractiveness:**	very attractive	attractive	less attractive	not very attractive	unattractive
	Brand1					
	Brand2					
	Brand3					
II. After the experiment						
3a	**Contents** Brand1:	agree strongly	agree	agree moderately	rather not agree	not agree
	..is truthworthy					
	..is comprehensible					
	..gives topics					
	..is objective					
	..is clear					
3b	**Contents** Brand2:	agree strongly	agree	agree moderately	rather not agree	not agree
	..is truthworthy					
	..is comprehensible					
	..gives topics					
	..is objective					
	..is clear					
3c	**Contents** Brand3:	agree strongly	agree	agree moderately	rather not agree	not agree
	..is truthworthy					
	..is comprehensible					
	..gives topics					
	..is objective					
	..is clear					

Table 2: *Summary of the questionnaire.*
The questions number 3 a-b are only a short version of the nineteen original questions of the questionnaire.

The questionnaire includes the main questions and their answer possibilities. Questions S0 to S5b were asked to find out the suitability of the test persons for this study. By asking questions 3a-b the intention was to find out the impression of the shown pictures on the probationers and the opinion of the participants on the different news magazines. With questions 3a-c only five of the originally nineteen questions feature in this table, as it should be a general one.

4 Results

4.1 Behavioural Response Data

During the fMRI session, none of the subjects reported any difficulties in performing the task.

4.1.1 Brand1 vs. Brand2 vs. Brand3

Reaction time:

The reaction time of the participants was analysed first to control the usability of the response data. The response time (RT) is the length of the time interval between the moment when the stimulus (the different title pages with questions) appears on the screen and the moment when the subject presses the button making his choice. The reaction time of the participants for the three news magazines kept within the limits and there were no significant differences between them (ANOVA-test between the gender classes: p=0.641 and between the three title pages: p=0.114). Only the reaction time for Brand3 had a wider frequency range (**Figure 8**).

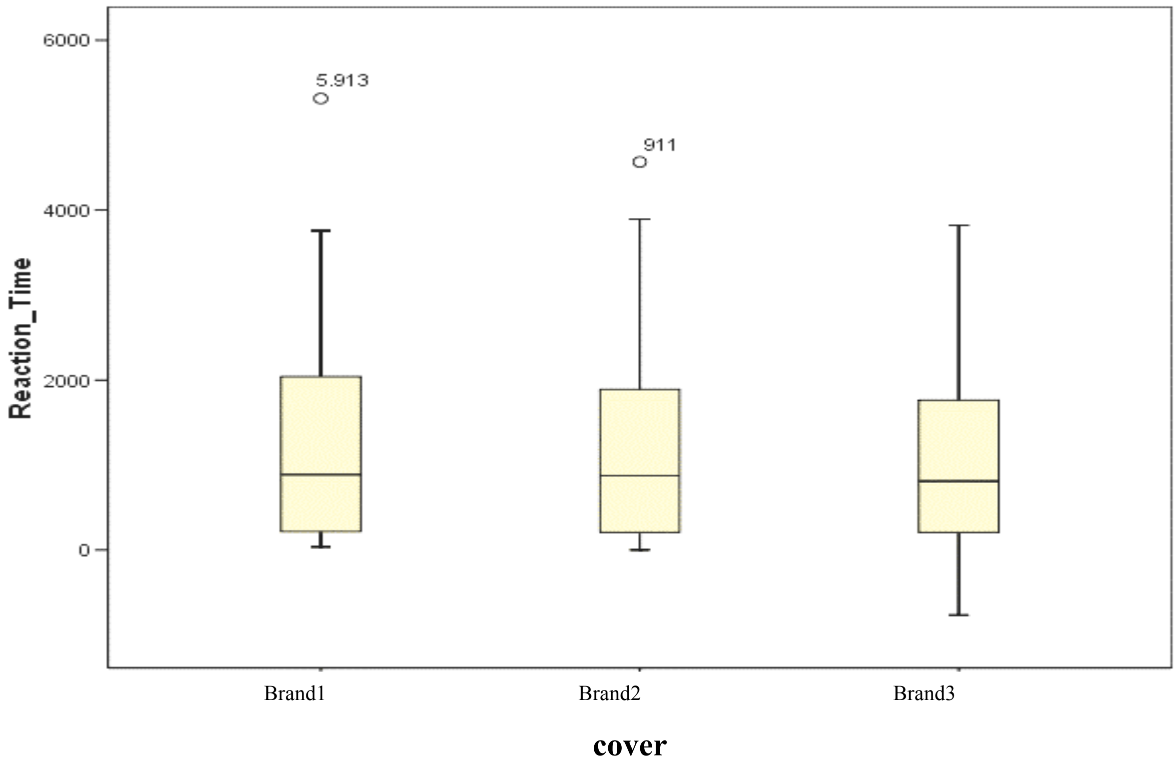


Figure 8: *The boxplot graph of the reaction time.*
Reaction times of the participants for news magazines kept within the limits, no significant difference between them. The boxplot is a graph which is used to show number lines.

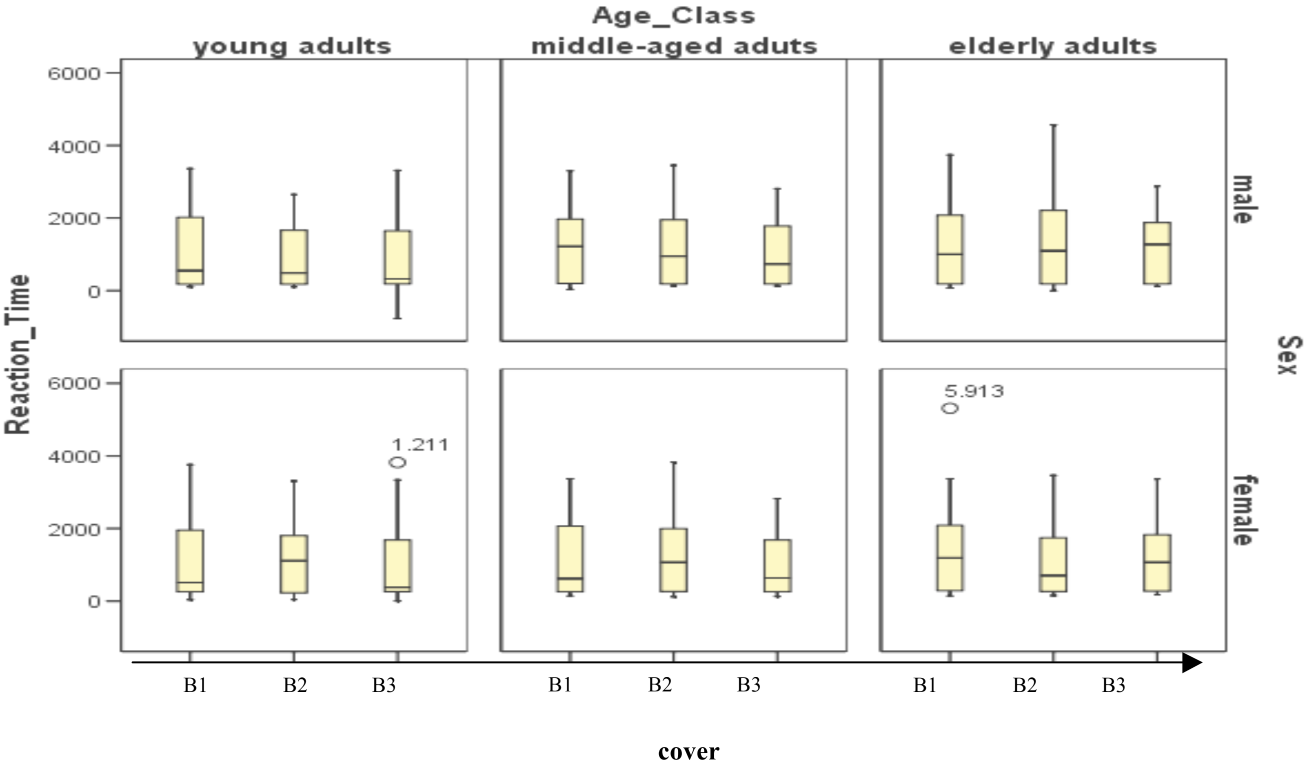


Figure 9: *Reaction time of the different age and gender classes.*
No significant differences between the different age and gender classes (B1=Brand1, B2=Brand2, B3=Brand3).

The reaction time was approximately 900ms on the average. The medians, 25th and 75th percentile, showed no difference. The statistical anomaly (marked with a circle in the graph) represents participants who reacted very late on different occasions (**Figure 9**).

Response data:

The evaluation of Brand1 showed a similar result. 49.3% (235/425) of the participants pressed the buttons for “agree strongly” and “agree”, 44.9% (191/425) for “agree moderately” and “not agree”. The participants evaluated Brand2 at 65.1% (276/424) with “positive” answers (“agree strongly” and “agree”) whereas merely 34.9% (148/424) opted for the “negative” answers (“agree moderately” and “not agree”) and just 6.4% (27/424) for “not agree” at all. Brand3 showed a result with 53.5% (202/377) for the “negative” answer possibilities and only 46.7% (175/377) for the “positive” answers.

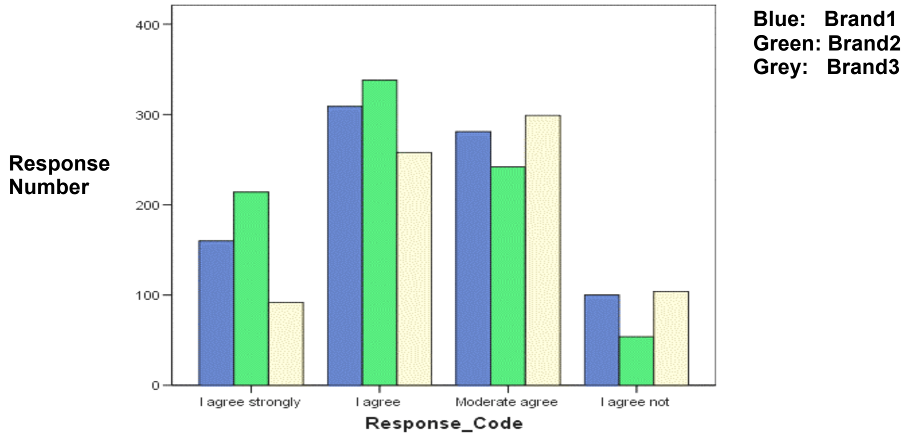


Figure 10: *Response number of the different brands.*
Evaluation of the three news magazines of all participants

The three news magazines showed significant difference in ranking (**Figure 10**, **Table 3**).

Chi2	*p-value*
B1 pos > B2 pos	0.00351
B1 pos > B3 pos	0.00001
B3 pos > B2 pos	0
B1 neg > B2 neg	0.0004
B1 neg > B3 neg	0.4
B3 neg > B1 neg	0.00001

Table 3: *Response data of the three brands in summary.*
Strongly agree and agree = positive evaluation; moderately agree and not agree = negative evaluation. B1=Brand1, B2=Brand2, B3=Brand3.

In summary, there was a general ranking: Brand2 first, Brand1 second and Brand3 third.

4.1.2 Age Class

As mentioned before, the participants were subdivided into three age classes [young: <35y (middle age 28y); middle: 35-49y (middle age 41y); elderly: >50y (middle age 60y)] and checked for the difference.

*Age classes **Brand1**:*

The young adults assessed Brand1 at 31.4% (48/153) with “agree” and at 42.5% (65/153) with “agree moderately”. With “agree” judged 36.2% (43/124) of the middle-aged adults and 30.8% (38/124) with “agree moderately”. The elderly adults evaluated Brand1 at 42.4% (63/149) with “agree” and at 25.3% (37/149) with “agree moderately” and so Brand1 got its best score of the three age classes in this gender group (**Figure 11**).

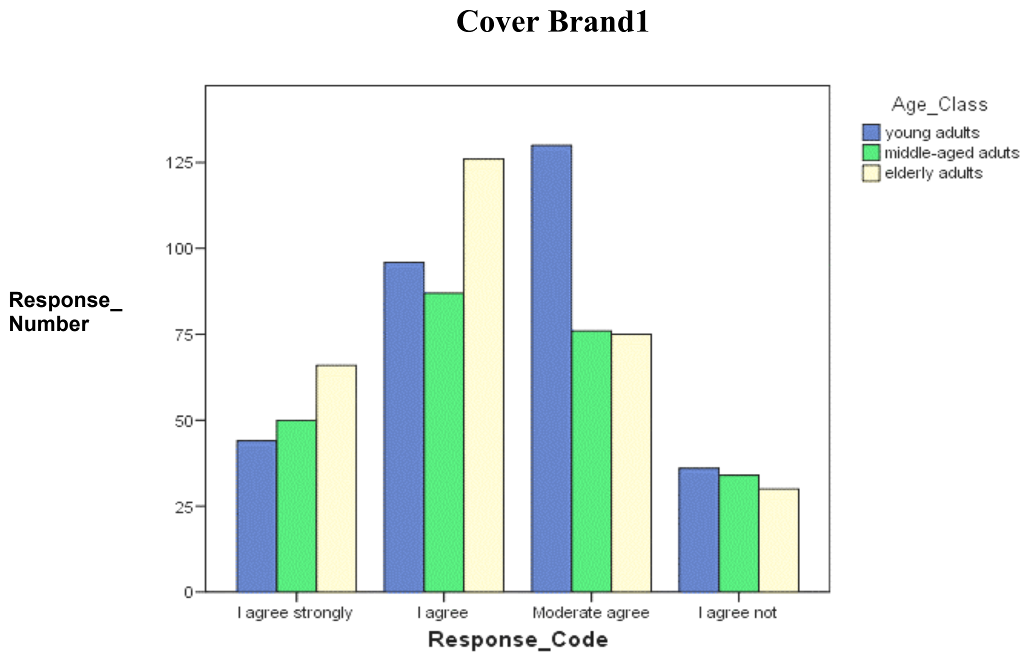


Figure 11: *Response number cover Brand1.*
Evaluation of the cover Brand1 among all age classes.

Table 4 shows the significance between the evaluation of the young and evaluation of the elderly participants.

Chi2		***p-value***
young>middle	agree	0.1
young>elderly		0.005
elderly>middle		0.3
young>middle	not agree	0.06
young>elderly		0.00001
elderly>middle		0.02

Table 4: *Evaluation of Brand1 among the different age classes.*

On the whole, the assessment of Brand1 was ambiguous within each age class. The younger adults didn't prefer Brand1, the middle-aged judged Brand1 inconspicuous and the elderly voted positively.

*Age classes **Brand2:***

Brand2 was evaluated best within the three age classes: 32.6% (47/144) chose "strongly agree" and 29.2% (42/144) "agree", 6.2% (9/144) voted "not agree". Brand2 was placed fist by the young adults. The middle-aged adults evaluated Brand2 with 41.6% (52/125) opting for "agree" and 24.0% (30/125) for "strongly agree". "Not agree" was chosen by 4.8% (6/125). This means the best result for Brand2 among the three news magazines. The elderly adults voted at 48.4% (75/155) with "agree" and at 19.4% with "strongly agree" (30/155). The elderly participants responded most strongly to Brand2, too (**Figure 12**).

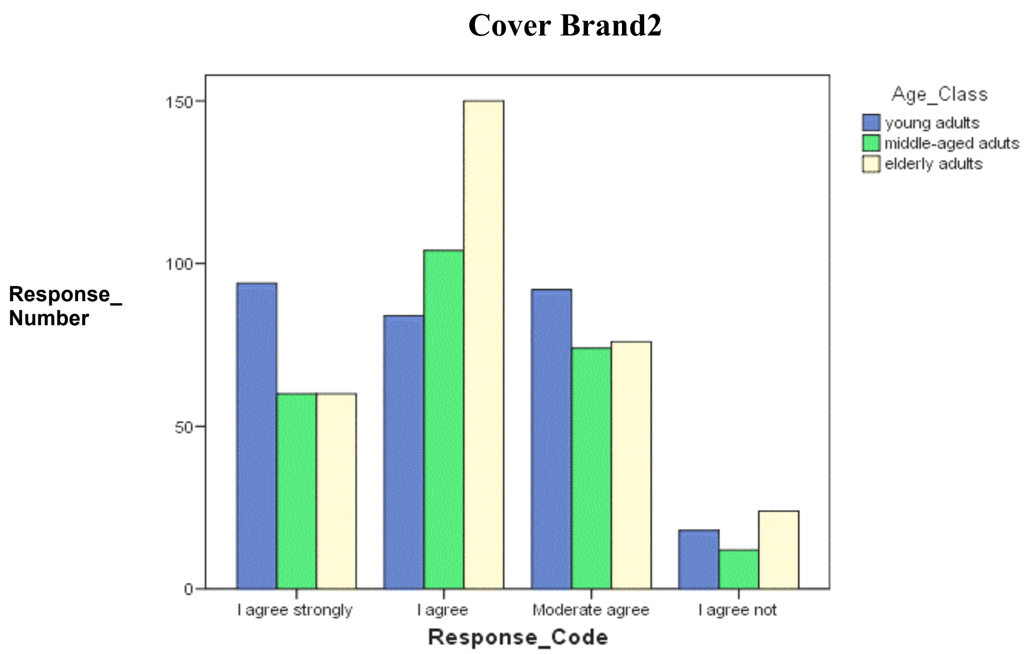


Figure 12: *Response number cover Brand2.*
Evaluation of the cover of Brand2 among all age classes.

As presumed; there was no significant difference in the evaluation of the age classes in the Qui²-test, because all three age classes ranked the news magazine Brand2 first. All in all, of the three news magazines Brand2 was the preferred one.

*Age classes **Brand3**:*

The young adults assessed Brand3 at 45.1% (60/132) with “moderately agree” and at 15.9% (21/132) with “not agree”. So from 132 examined reactions, there were 82 negative ones for Brand3. The middle-aged adults voted at 39.8% (60/103) with “agree moderately” but on the other hand at 34.0% (40/103) with “agree”. The elderly adults evaluated at 34.6% (35/142) with “agree” and 38.5% (41/142) with “agree moderately”. In comparison with the other age classes they voted more positively in tendency (**Figure 13**).

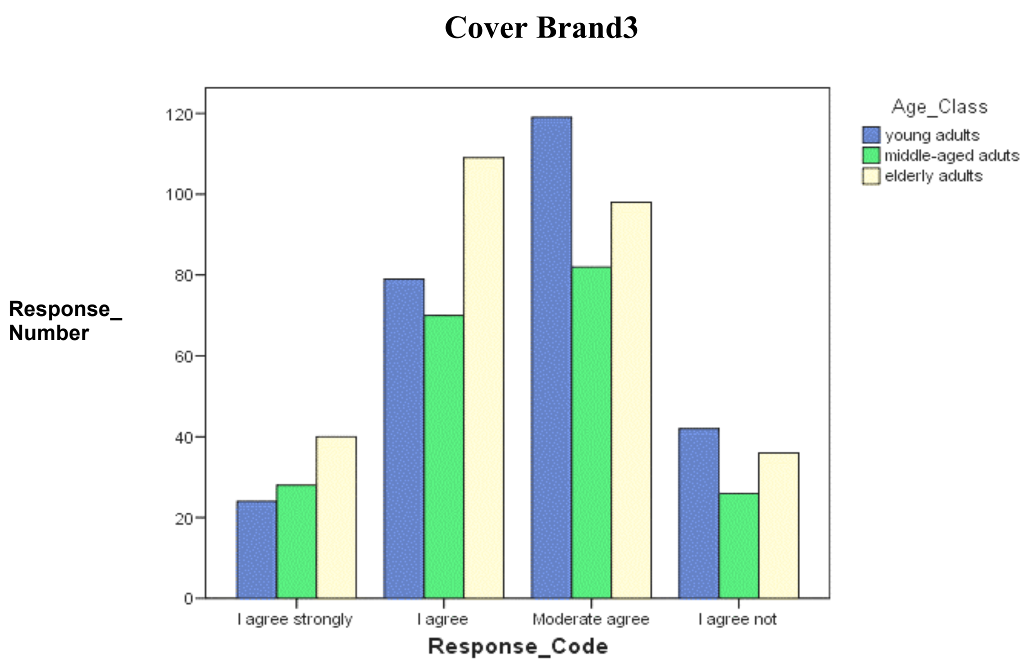


Figure 13: *Response number cover Brand3.*
Evaluation of the cover of Brand3 among all age classes.

Table 5 shows the significance between the negative evaluation of the young and the more positive evaluation of the elderly participants.

Chi2		*p-value*
young>middle	Agree	0.3
young>elderly		0.005
elderly>middle		0.1
young>middle	not agree	0.08
young>elderly		0.04
elderly>middle		0.9

Table 5: *Evaluation of Brand3 among the different age classes.*

On the whole, Brand3 got a less positive assessment. Its shared the last place in ranking with Brand1 among the young and elderly adults and had its worst result among the middle-aged adults in comparison with the other news magazines.

Summary of the age class results ***Brand1, Brand2 and Brand3****:*
Brand2 was best assessed among the three age classes. The ranking among all age classes was the same: Brand2 on top, Brand1 next and Brand3 last. The young and elderly participants saw Brand1 and Brand3 ranking pari passu, but on different levels. The young adults evaluated both magazines more negatively in contrast to the elderly adults who, on the whole, voted for both in a positive way. The middle-aged participants ranked Brand3 last.

4.1.3 Gender

The subjects were subdivided equally into gender classes and the difference between them considering the different news magazines was analysed. The thirty-one participants consisted of sixteen women and fifteen men.

Gender ***Brand1****:*
The male participants evaluated Brand1 at 33.0% (72/218) with “agree” and at 35.3% (77/218) with “agree moderately”. Only 15% of the males rated Brand1 with “strongly agree” (**Figure 14**). The females assessed Brand1 much more positively than the males. The women opted at 22.7% (47/207) for “strongly agree” and at 39.9% (83/207) for “agree”, so Brand1, in comparison to Brand2 and Brand3, got its best judgment from the women (**Figure 15**).

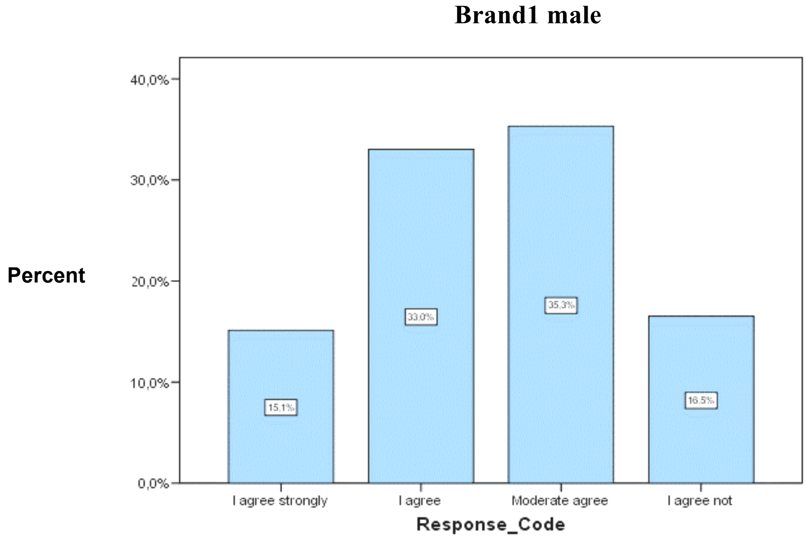


Figure 14: *Response code Brand1, male*

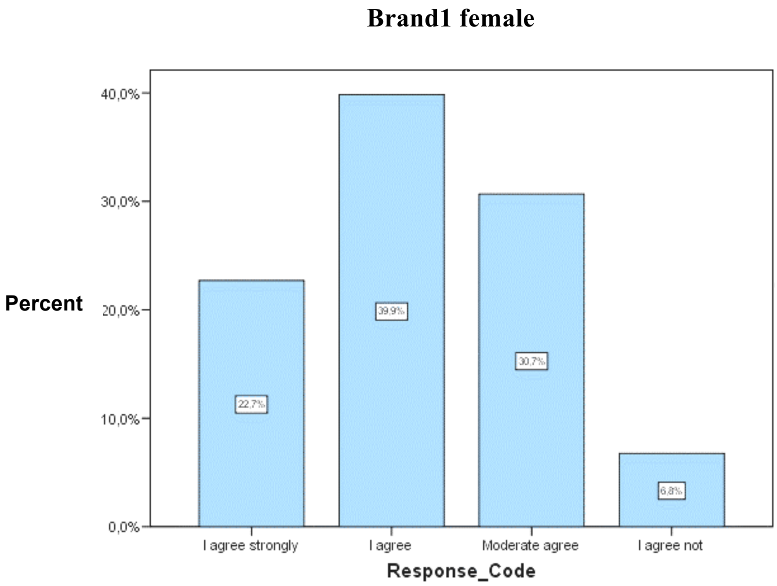


Figure 15: *Response code Brand1, female.*

Table 6 shows the significance between the mediocre assessment of the male and the quite good assessment of the female participants regarding Brand1.

Chi2		***p-value***
male>female	agree	0.003
male>female	not agree	0.0003

Table 6: *Evaluation of the different gender classes of Brand1.*

Brand1 took a more mediocre position with the male and quite a good position with the female subjects. Only this time Brand1 was generally ranked first.

*Gender **Brand2**:*

The male participants estimated Brand2 at 31.9% (69/216) with “strongly agree” and at 41.2% (89/216) with “agree”. So Brand2 got its best score from the male participants compared to Brand1 and Brand3 (**Figure 16**). 38.5% (80/208) of the female participants rated it with “agree” and 34.6% (72/208) with “agree moderately” (**Figure 17**). The women thought of Brand2 fairly positively but not as positively as the men.

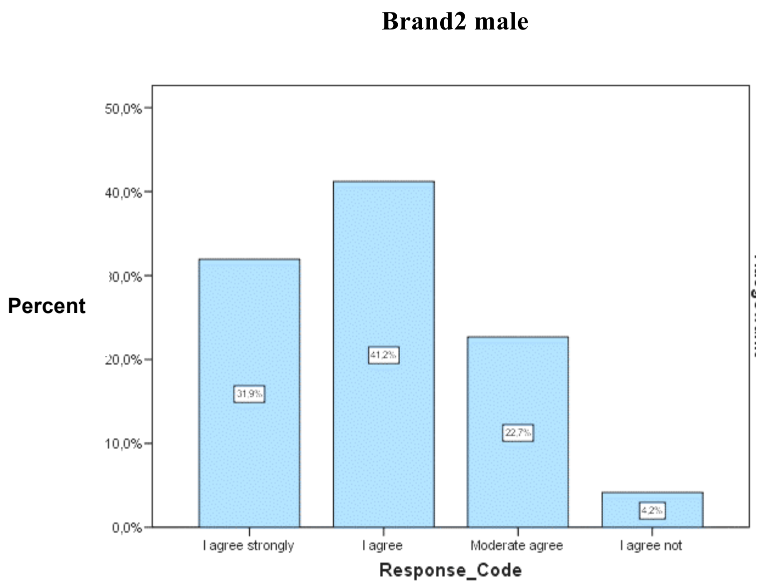


Figure 16: *Response code Brand2, male.*

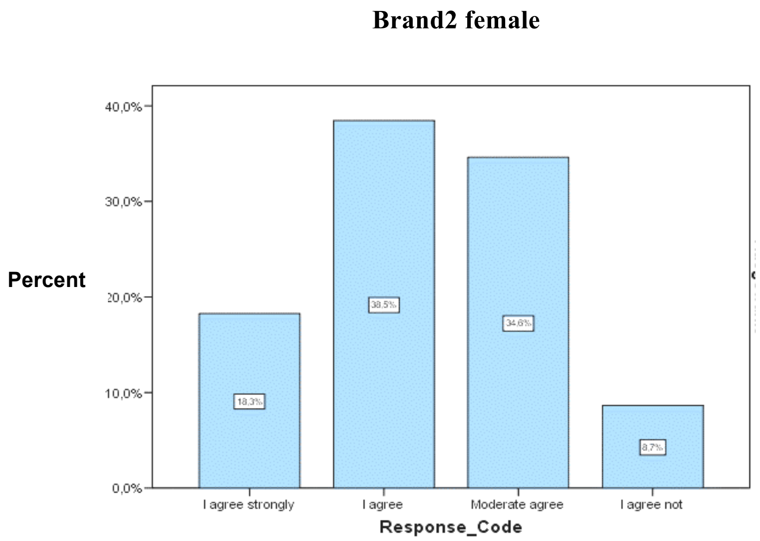


Figure 17: *Response code Brand2, female.*

Table 7 shows the significant differences between the male and female assessments as far as Brand2 is concerned.

Chi2		*p-value*
male>female	agree	0.0007
male>female	not agree	0.00002

Table 7: *Male and female assessments, Brand2.*

The male participants put Brand2 on top of the ranking of the news magazines. The female participants saw Brand2 second. This was the only time that Brand2 was not generally ranked first.

*Gender **Brand3**:*

The male participants evaluated Brand3 at 45.0% (86/190) with "moderately agree" and at 35.0% (67/190) with "agree" (**Figure 18**). The female participants assessed at 33.5% (63/187) with "agree" and 34.3% (64/187) of them with "moderately agree" (**Figure 19**).

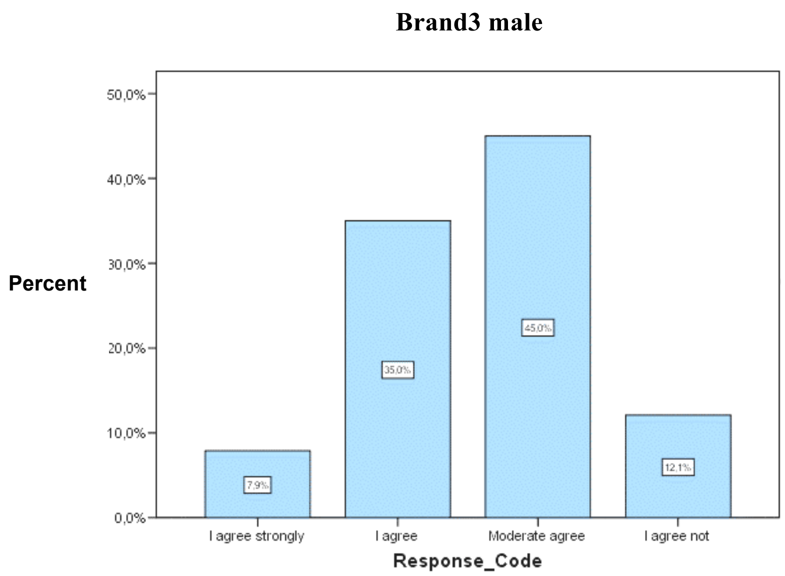


Figure 18: *Response code Brand3, male.*

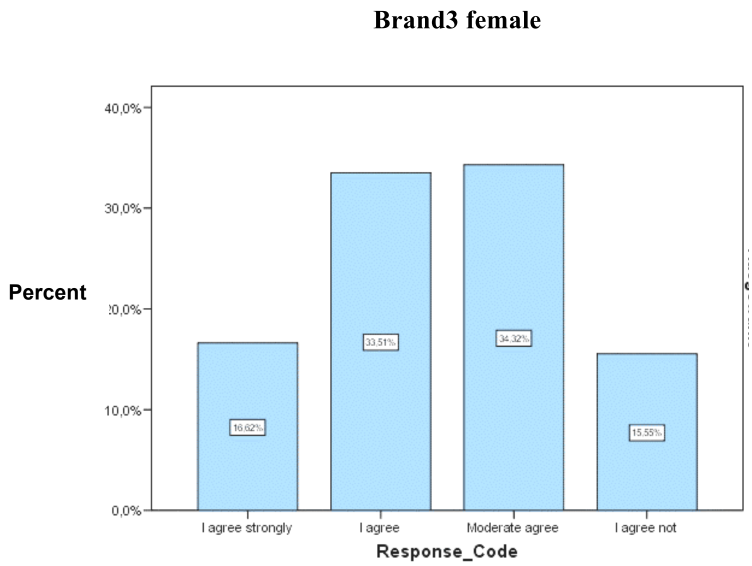


Figure 19: *Response code Brand3, female.*

There was no significant difference between the gender classes in the Qui²-test of Brand3. In comparison with the other news magazines Brand3 got its worst score from the women. The judgment of the male participants regarding Brand3 was similar to Brand1. The strength of both news magazines was regarded as modest.

*Summary of the gender results **brands 1, 2 and 3**:*
The male participants judged Brand2 first, followed by Brand1 and Brand3. The female participants gave Brand1 the best mark, Brand2 the second best and ranked Brand3 third.

4.2 Brain Activation during the Perception of Stimuli

In the following chapter the focus is on the results of brain activation during the perception of stimuli. First of all an explanation of a few parameters of the analysis of the brain activation has to be given. The functional base data were analysed with the false discovery rate (FDR) which is a representative number for a population. The comparison with the baseline is shown by a FDR of q: 0.001 and the comparison between the different groups with a FDR of q: 0.01. So the results are highly significant. For each ROI there was determined a t-value with a minimum and a maximum value. The scans of one participant (elderly adult, male) had to be excluded because of movement artefacts.

4.2.1 Brand1 vs. Brand2 vs. Brand3

The hypothesis was that established brands within one product category generate differences in the cortical activation caused by them. The news magazines were compared to each other and importance was attached to the difference in activation as a function of gender and age class. The three news magazines were considered to be well-known in Germany. For the study the print media were examined and compared to each other. First the general difference was measured without any discrimination of gender and age classes.

*Cortical activations **Brand1**:*

Altogether there was rather more activation on the right hemisphere than on the left. Especially the middle temporal gyrus (GTm) showed a high activation on the right hemisphere and a smaller one on the left hemisphere. The anterior insula was activated more on the right than on the left hemisphere, too. The parietal cortex was activated more on the right hemisphere than on the left, the putamen only on the left hemisphere.

The comparison of Brand1 with Brand2 and Brand3 was also measured, but both, Brand1 versus Brand2 and Brand1 versus Brand3, showed none activation at all. Even on a higher level of significance no relevant activation could be seen in the separate brain areas (**Figure 20**, **Table 8**).

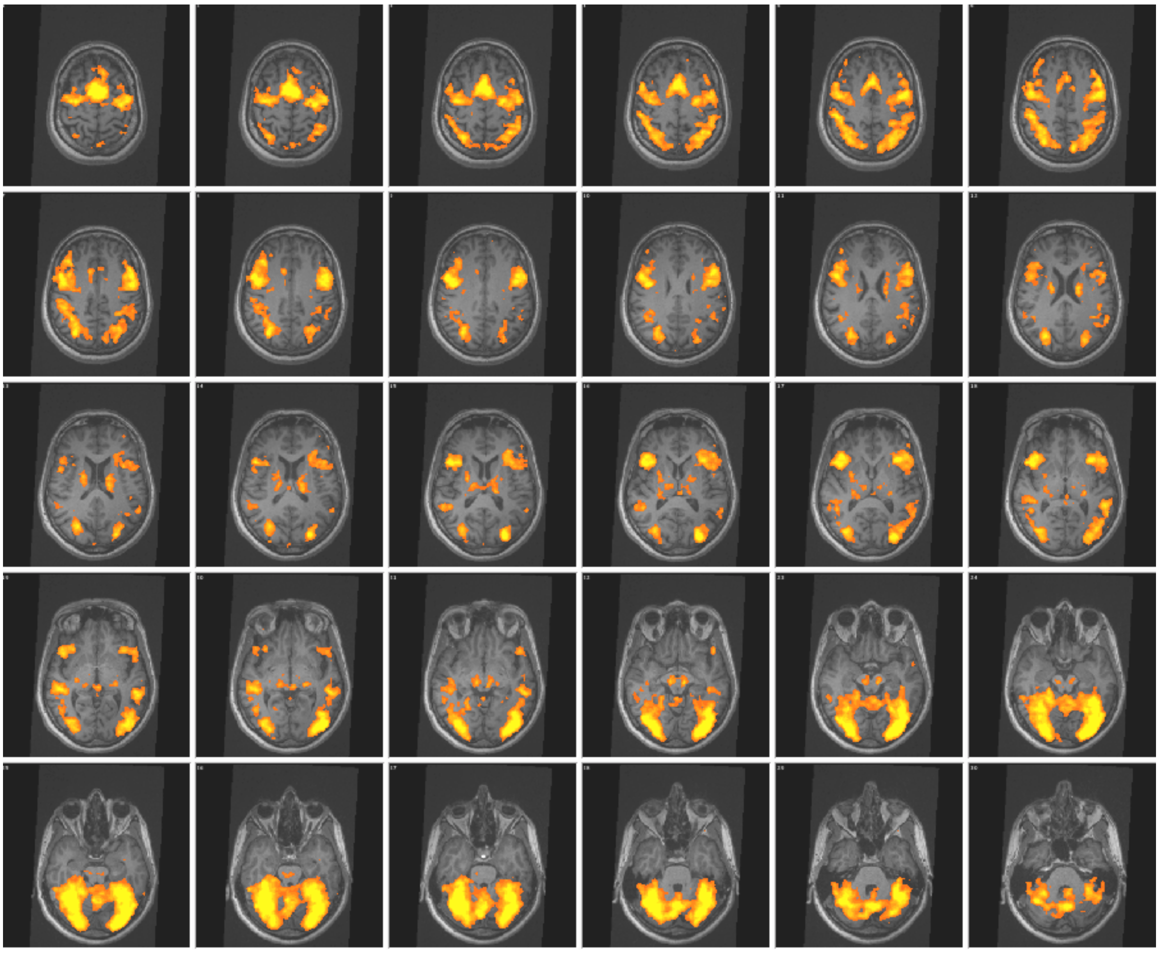


Figure 20: *Cortical activation Brand1, all participants.*
Displayed in axial view, radiological convention. Comparison with the baseline shown by a FDR of q: 0.001.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Superior frontal gyrus (pars medialis)	6	n/a	n/a	7672	6.83
Inferior parietal lobule	40	5822	5.36	5508	5.23
Inferior frontal gyrus	44	9095	5.47	5568	5.7
Anterior Insula	45	8511	5.37	7598	5.03
Middle temporal gyrus	21	3871	4.91	3595	5.04

Table 8: *Different regions of cortical activation and the number of voxels, Brand1.*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area, FDR = q: 0.001.

Cortical activations ***Brand2:***

As opposed to the results of Brand1 and Brand3, the activation by Brand2 was predominantly left-sided and in comparison with the other two showed the lowest activation pattern. The anterior insula was activated more on the left than on the right hemisphere, and so was the middle temporal gyrus (GTm). The caudate nucleus (NC) and the parietal cortex were activated more on the left hemisphere than on the right one.

The data of Brand2 were compared with the observations of Brand1 and Brand3. Brand2 versus Brand1 showed no activation, neither showed Brand2 versus Brand3. As the analysis of Brand1 had been examined before, no relevant activation could be seen in the separate brain areas even on a higher level of significance (**Figure 21**, **Table 9**).

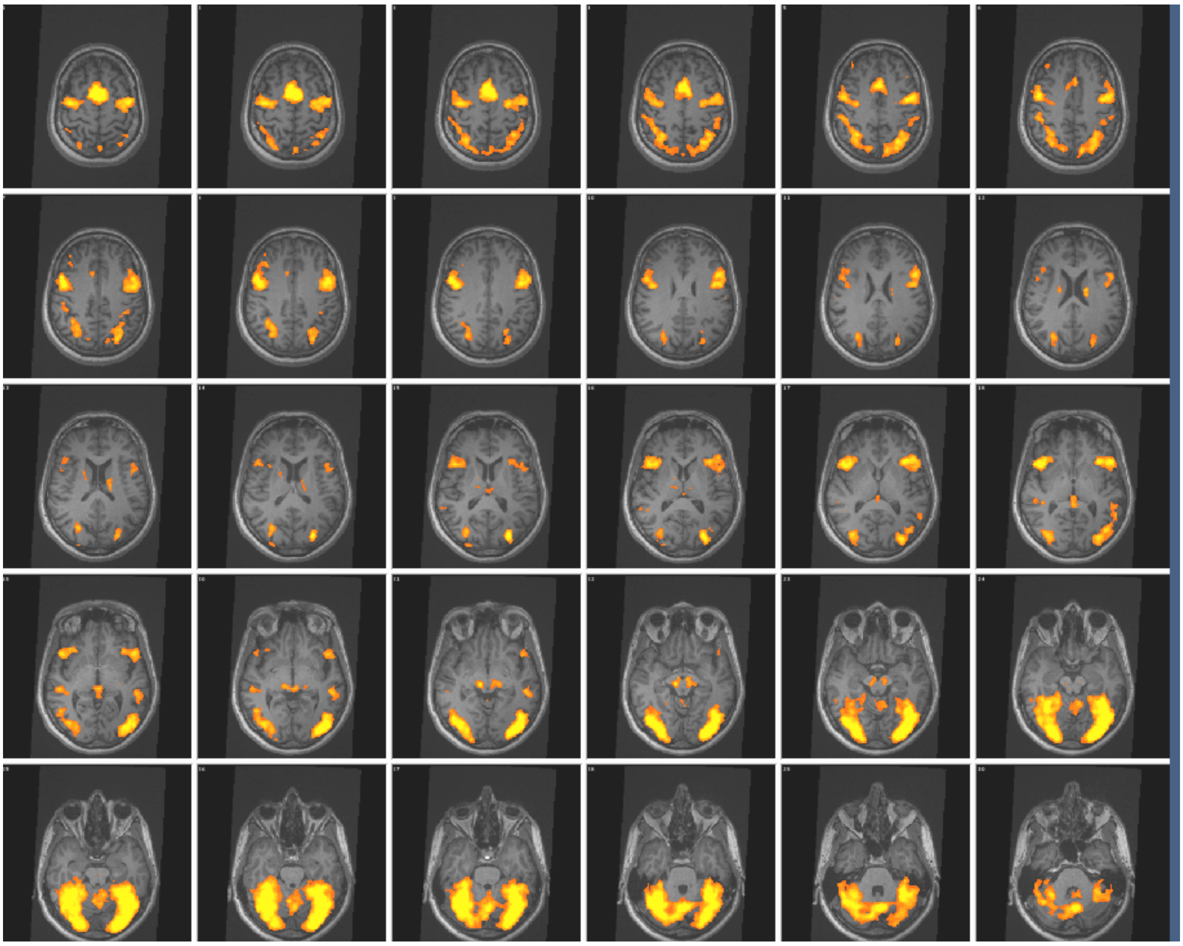


Figure 21: *Cortical activation Brand2, all participants.*
Displayed in axial view, radiological convention. Comparison with the baseline shown by a FDR of q: 0.001.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Precentral gyrus	6	5042	5.58	5544	5.53
Anterior Insula	45	3907	5.53	4408	5.29
Middle temporal gyrus	21	727	4.75	803	4.78
Caudate nucleus	n/a	n/a	n/a	703	4.78
Inferior parietal lobule	7	n/a	n/a	4684	5.16

Table 9: *Different regions of cortical activation and the number of voxels, Brand2.*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area, FDR = q: 0.001.

Cortical activations ***Brand3:***

The activations were predominantly right-sided. Similar to the results for Brand1 the anterior insula showed more activation on the right than the left hemisphere as well as on the middle temporal gyrus (GTm). In general, Brand3 evoked the highest activation level in comparison with Brand2 and Brand1 (**Figure 22**, **Table 10**).

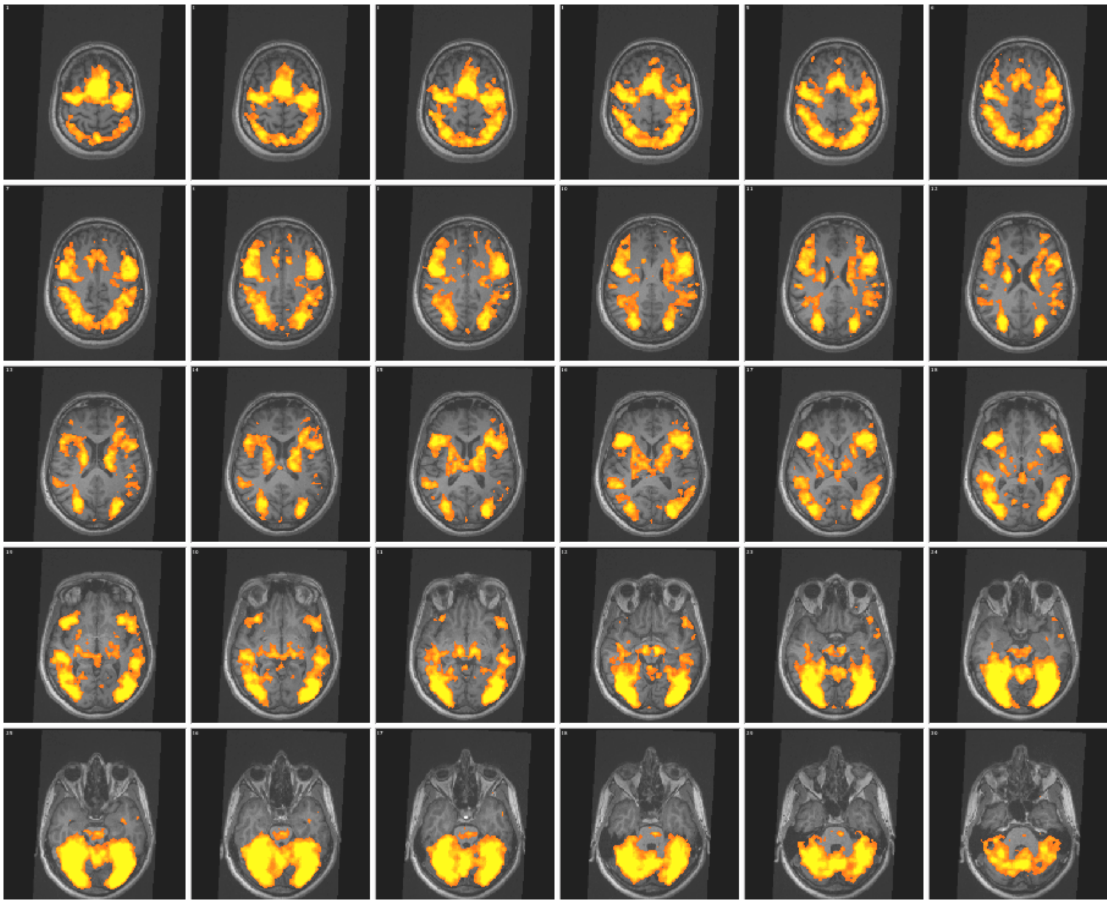


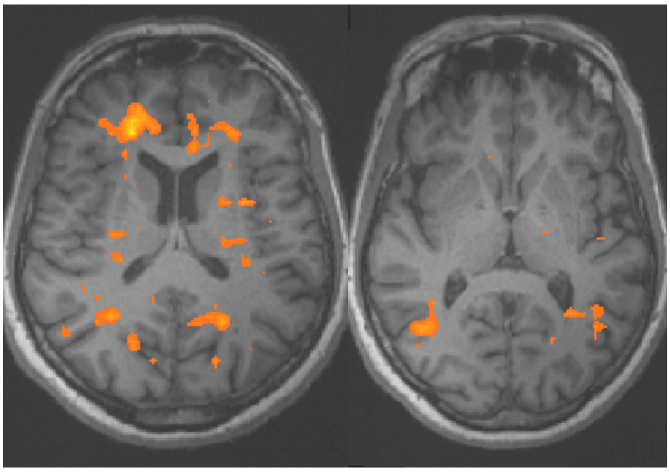
Figure 22: *Cortical activation Brand3, all participants.*
Displayed in axial view, radiological convention. Comparison with the baseline shown by a FDR of q: 0.001.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Inferior frontal gyrus	44	6658	6.35	7566	6.36
Inferior parietal lobule	40	6255	6.04	6255	6.04
Anterior Insula	45	7264	6.30	6451	5.97
Middle temporal gyrus	21	6246	5.29	5328	5.32

Table 10: *Different regions of activation and the number of voxels, Brand3.*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area, FDR = q: 0.001.

Contrasts:

The differences of Brand3 versus Brand2 and Brand3 versus Brand1 were also measured. Brand3 versus Brand2 showed activation in the cingulate gyrus region predominantly on the right side. The superior temporal gyrus (GTS, BA21) was activated on the right hemisphere. A clear activation in the superior frontal gyrus (GFs) could be observed rather more on the left than on the right hemisphere with a more frontal located activation on the left side. The comparison of Brand3 versus Brand1 showed no activation on a higher level of significance (**Figure 23**, **Table 11**).



Cingulate gyrus Superior temporal gyrus

Figure 23: *Cortical activation Brand3 vs Brand2, all participants.*
Displayed in axial view, radiological convention. Comparison between the different groups is shown by a FDR of q: 0.01.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Superior frontal gyrus	8	n/a	n/a	524	4.2
Cingulate gyrus	32	1744	4.58	1037	4.28
Superior temporal gyrus	21	1049	4.40	n/a	n/a

Table 11: *Comparison of different cortical activations Brand3 vs Brand2 and the number of voxels.*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area, FDR = q: 0.01.

In general, Brand1 and Brand3 showed rather more activation on the right hemisphere and, by contrast, Brand2 activated predominantly the left hemisphere. Brand3 showed the highest activation and Brand2 the lowest, when compared directly.

4.2.2 Age Class

The different patterns of brain activation between age class and gender are of high interest with respect to marketing and must be taken into special account for the interpretation of the results. As described above, the participants were subdivided into three age classes [young: <35y (average age 28y); middle: 35-49y (average age 41y); elderly: >50y (average age 60y)] and the difference between them was ascertained. One elderly man had to be excluded because of movement artefacts and so the data from 11 young, 10 middle-aged and 9 elderly participants were analysed. The results of our measurements were highly significant because of a FDR of 0.001 was chosen for the analysis of the functional data.

Age class ***Brand1****:*

Young subjects:

In the age class of the young the activation was localised significantly inside the precuneus (PCu) rather on the right hemisphere than on the left whereas the activation of the anterior insula was more left sided. The cingulate gyrus was activated on both sides and the middle temporal gyrus showed activation on the left hemisphere (**Figure 24**, **Table 12**). The comparison of young participants with middle-aged and elderly was also measured. The young versus the middle-aged showed unilateral activation on the left in following regions: precuneus, cingulate gyrus, middle temporal gyrus and anterior insula (**Table S43**). The young versus the elderly participants showed no relevant activation at all.

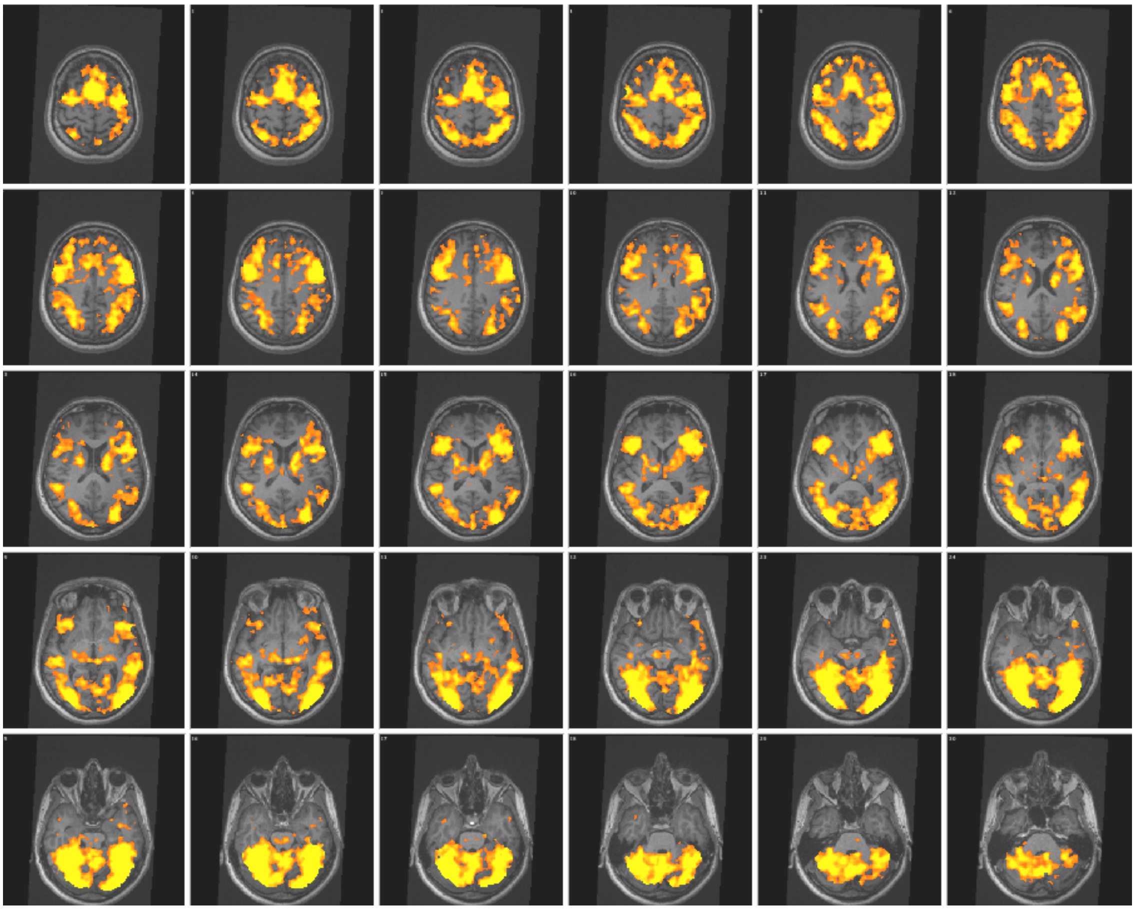


Figure 24: *Cortical activations Brand1, young participants.*
Displayed in axial view, radiological convention. Comparison with the baseline shown by a FDR of q: 0.001.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Precuneus	19	845	4.68	175	4.41
Cingulate gyrus	32	1109	5.10	1399	5.00
Middle temporal gyrus	39	n/a	n/a	1319	4.79
Anterior Insula	n/a	1530	4.93	2289	5.22
Middle temporal gyrus	21	523	4.65	1783	4.95

Table 12: *Different regions of cortical activation and number of voxels, Brand1 young vs baseline.*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area, FDR = q: 0.001.

Middle-aged subjects:

With the middle-aged subjects the activation was in the precuneus more on the right than on the left hemisphere and the caudate nucleus showed only activation on the right hemisphere. The anterior insula was activated more on the right hemisphere than on the left and so was the middle temporal gyrus. The putamen was activated bilaterally. The parietal cortex and the inferior frontal gyrus (GFi) were activated more on the right hemisphere than on the left

(**Figure 25**, **Table 13**). The comparison of middle-aged participants with young and elderly was also measured. The middle-aged versus the young displayed minimal activation on the right hemisphere only, but it was too little and not significant. The middle versus the elderly population showed no significant activation at all.

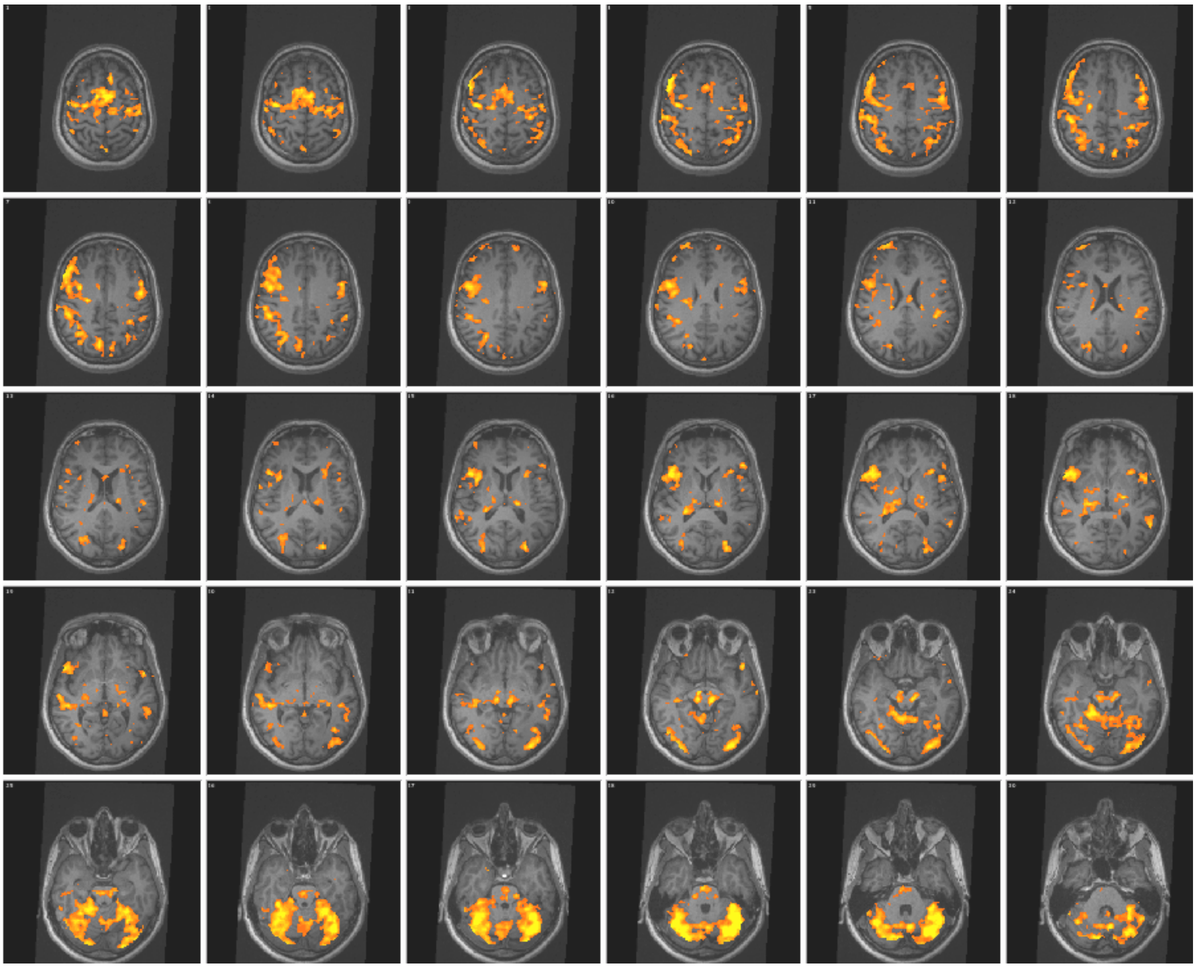


Figure 25: *Cortical activation Brand1, middle-aged participants.*
Displayed in axial view, radiological convention. Comparison with the baseline shown by a FDR of q: 0.001.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Precuneus	7	711	5.18	1294	4.70
Inferior frontal gyrus	45	912	4.82	1858	5.28
Caudate nucleus	n/a	n/a	n/a	1006	4.76
Putamen	n/a	969	4.74	1194	4.81
Middle temporal gyrus	21	417	4.69	1173	4.83
Anterior Insula	n/a	2580	5.03	4340	5.60

Table 13: *Different regions of cortical activation and number of voxels, Brand1 middle vs baseline*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area, FDR = q: 0.001.

Elderly subjects:

The elderly participants showed significant activation in a few regions. The middle temporal gyrus was activated only on the right hemisphere while the anterior insula was activated predominantly on the right hemisphere. The cingulate gyrus and the putamen were activated more on the left one. The precuneus was activated bilaterally (**Figure 26**, **Table 14**).

In addition, the elderly, young and middle-aged subjects were also measured and the characteristic brain activation patterns were compared. No significant activation could be observed in comparison of the elderly with the young participants. A similar result was obtained when the elderly were compared with the middle-aged subjects.

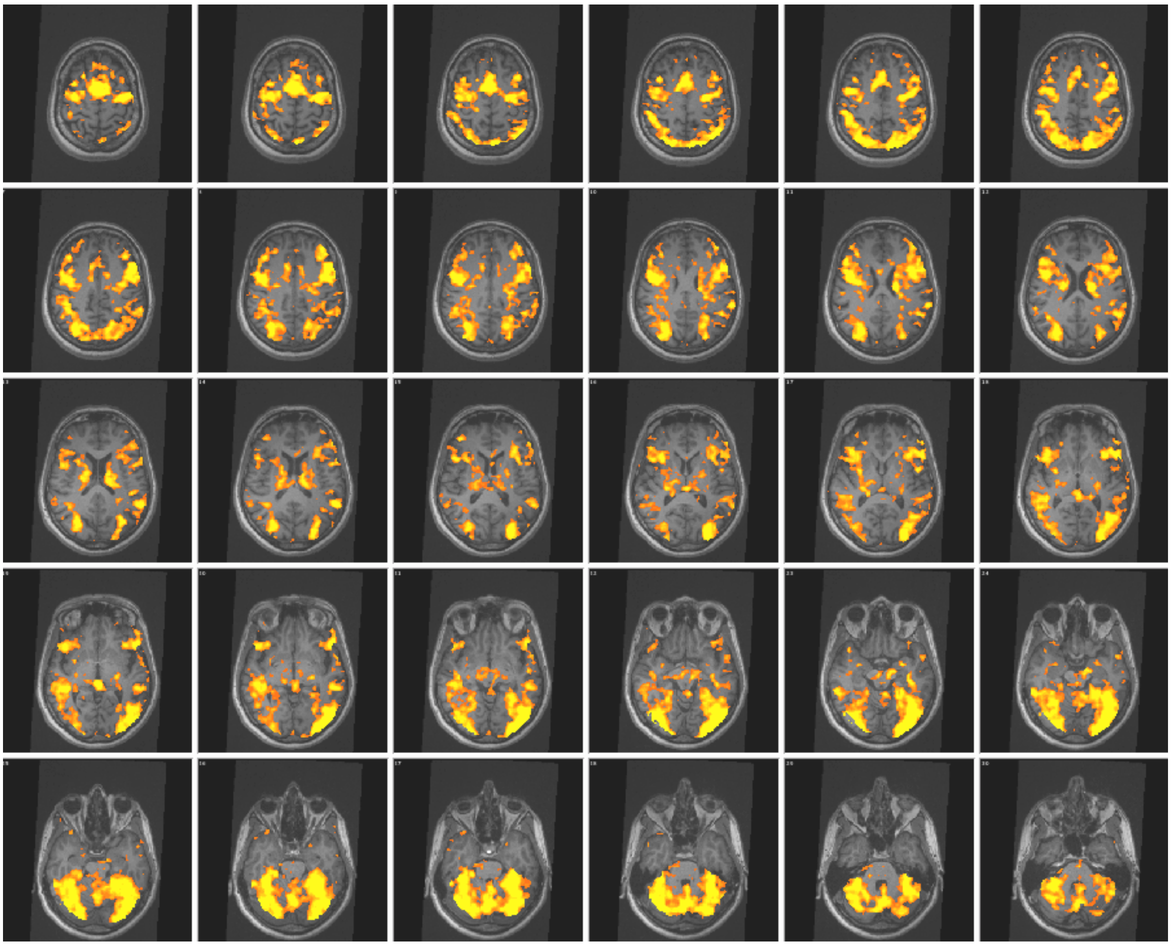


Figure 26: *Cortical activation Brand1, elderly participants.*
Displayed in axial view, radiological convention. Comparison with the baseline shown by a FDR of q: 0.001.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Cingulate gyrus	32	795	5.83	1958	6.78
Precuneus	7	817	5.59	718	6.14
Anterior Insula	n/a	2371	5.13	1966	5.04
Middle temporal gyrus	21	2122	4.89	n/a	n/a
Putamen	n/a	201	4.33	324	4.66

Table 14: *Different regions of cortical activation and number of voxels, Brand1 elderly vs baseline.*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area, FDR = q: 0.001.

*Age class **Brand2**:*

Young subjects:

The young participants displayed activation in the precuneus region, the frontal cortex, the middle temporal gyrus and the anterior insula region rather on the left brain hemisphere than on the right. The putamen showed activation only on the left hemisphere (**Figure 27**, **Table 15**). The data of the young participants were compared with those of the middle-aged and the elderly. The young versus the middle-aged in general showed little activation, this occurring unilaterally on the left hemisphere in the middle temporal gyrus (**Table S42**). The young versus the elderly participants showed even less activation, the middle temporal gyrus being equally activated only on the left side (**Table S41**).

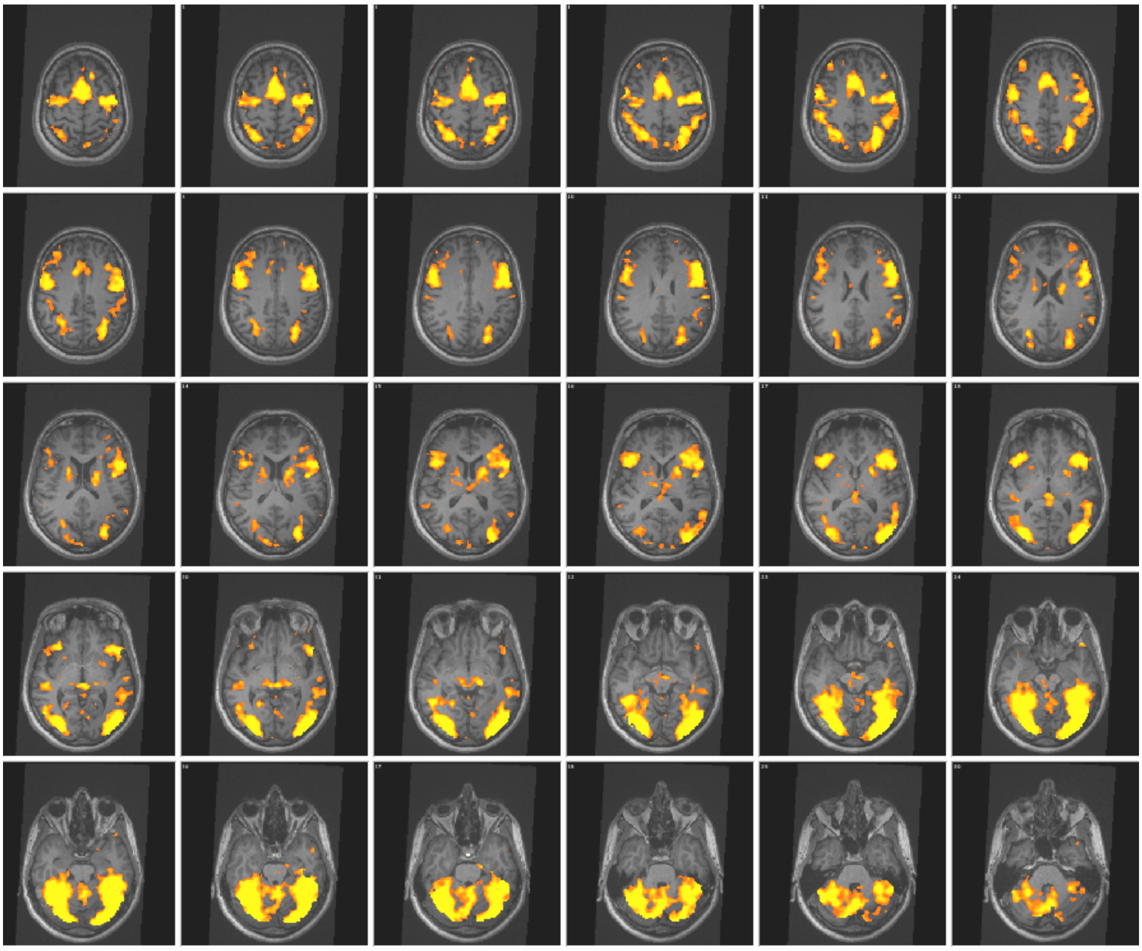


Figure 27: *Cortical activation Brand2, young participants.*
Displayed in axial view, radiological convention. Comparison with the baseline shown by a FDR of q: 0.001.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Superior frontal gyrus (pars medialis)	6	1532	5.77	3259	6.24
Precuneus	7	1869	5.40	2908	5.29
Putamen	n/a	n/a	n/a	1491	4.70
Anterior Insula	n/a	3239	5.58	4344	5.61
Middle temporal gyrus	21	580	4.81	1478	4.73

Table 15: *Different regions of cortical activation and number of voxels, Brand2 young vs baseline.*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area, FDR = q: 0.001.

Middle-aged subjects:

The middle-aged subjects exhibited activation in the cingulate gyrus on the left hemisphere as well as in the parietal lobule and frontal lobule on both hemispheres. The right hemisphere was activated in the precuneus and middle temporal gyrus. The anterior insula displayed activation on the right side rather than on the left (**Figure 28**, **Table 16**). As far as the measurement compared activation between the middle-aged and the young participants on the one hand and between the middle-aged and elderly ones on the other the results were as follows: While the middle-aged versus the young participants showed activation in the middle temporal gyrus and activation on the right hemisphere only (**Table S40**), no relevant activation at all could be detected in the group of the middle-aged versus the elderly, however.

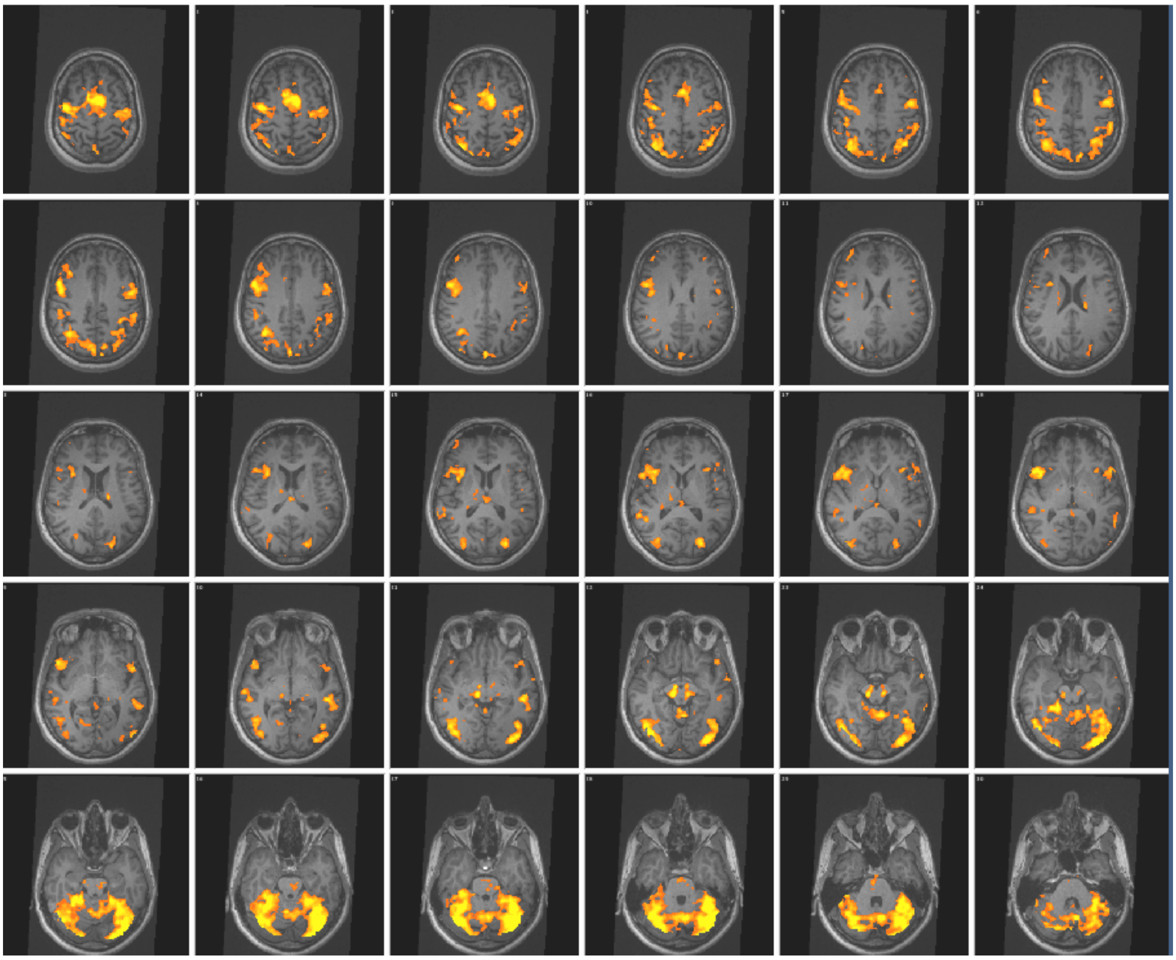


Figure 28: *Cortical activation Brand2, middle-aged participants.*
Displayed in axial view, radiological convention. Comparison with the baseline shown by a FDR of q: 0.001.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Cingulate gyrus	32	n/a	n/a	1885	5.43
Anterior Insula	n/a	1950	5.04	327	4.72
Middle temporal gyrus	21	1177	5.05	n/a	n/a
Precuneus	7	106	4.56	n/a	n/a

Table 16: *Different regions of cortical activation and number of voxels, Brand2 middle vs baseline.*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area.

Elderly subjects:

The elderly participants displayed activation in the anterior insula predominantly on the right hemisphere and in the cingulate gyrus only on the left hemisphere. The precuneus and middle temporal gyrus (GTm) were activated rather on the right hemisphere (**Figure 29**, **Table 17**). Once again the comparison of activation was measured between elderly and young subjects on the one hand and between elderly and middle-aged participants on the other. The elderly versus the young participants showed activation in the precuneus, anterior insula and parietal lobule respectively on the right hemisphere (**Table S39**). The elderly versus the middle-aged on the whole showed no activation.

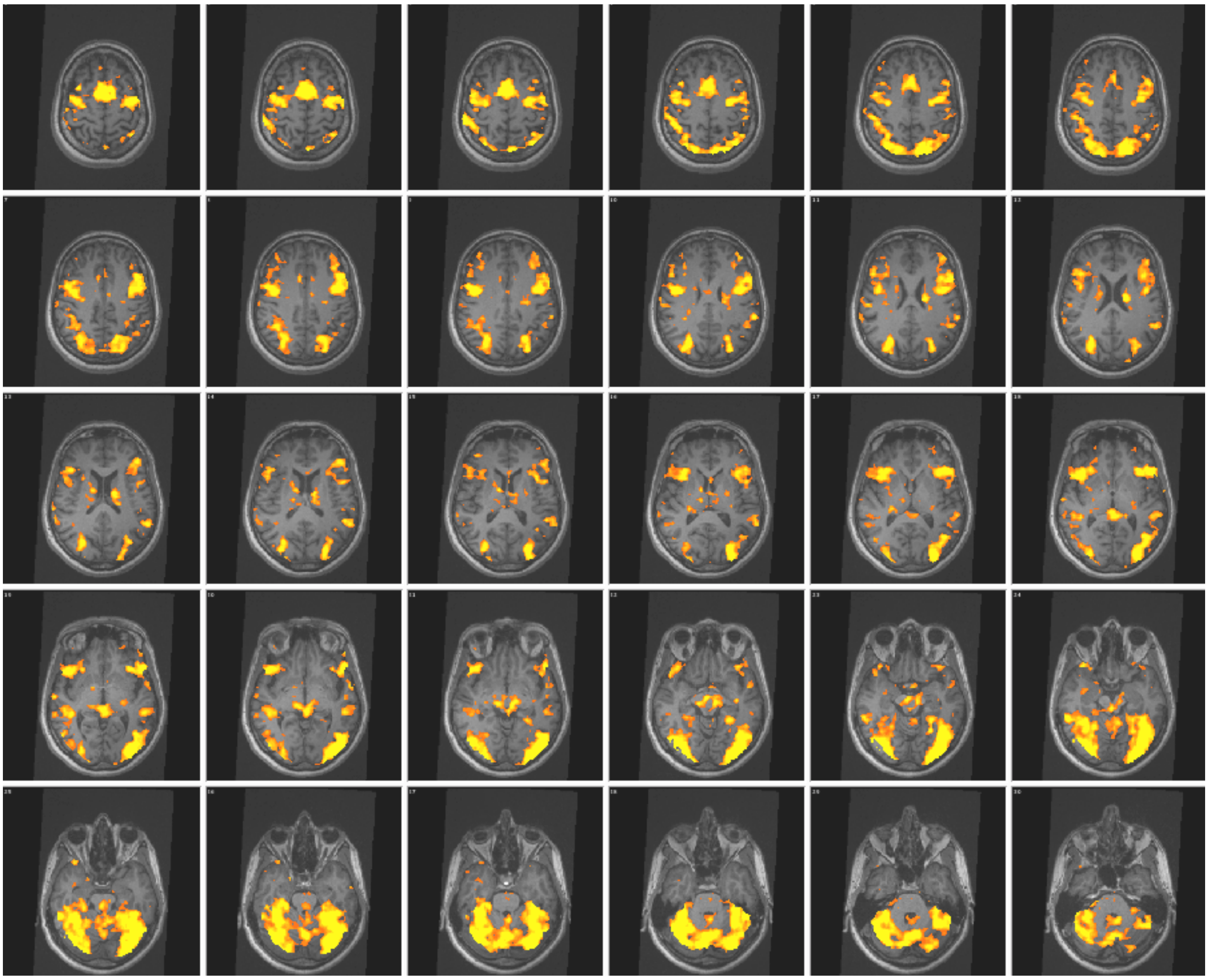


Figure 29: *Cortical activation Brand2, elderly participants.*
Displayed in axial view, radiological convention. Comparison with the baseline shown by a FDR of q: 0.001.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Cingulate gyrus	32	377	5.42	1589	6.06
Precuneus	19	2520	5.52	1435	6.26
Middle temporal gyrus	19	2240	5.35	1763	5.28
Anterior Insula	n/a	3443	5.12	2484	5.35

Table 17: *Different regions of cortical activation and number of voxels, Brand2 elderly vs baseline.*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area, FDR = q: 0.001.

*Age class **Brand3**:*

Young subjects:

The young participants' activation was significant in the anterior insula, putamen and parietal lobule rather on the left side than on the right. The cingulate gyrus and middle temporal gyrus were activated more on the right hemisphere. Because of the very high activation patterns of the young participants during the Brand3-task a higher p-value had to be chosen, so it should be taken into consideration that the pictures and the determination of voxel were taken with the high p-value, too (**Figure 30**, **Table 18**).

The data resulting from the comparison of young participants with middle-aged and elderly participants were as follows: The young versus the middle-aged participants showed more activation in the cingulate gyrus (GC) and the middle temporal gyrus on the right hemisphere than of the left. The putamen and the anterior insula were activated on the left hemisphere. The caudate nucleus and the precuneus (PCu) were activated only on the right hemisphere (**Table S38**). The young participants versus the elderly showed activation in the areas of the cingulate gyrus, the caudate nucleus and the precuneus (PCu) only on the right hemisphere, whereas the anterior insula and the middle temporal gyrus were activated on the left (**Table S37**).

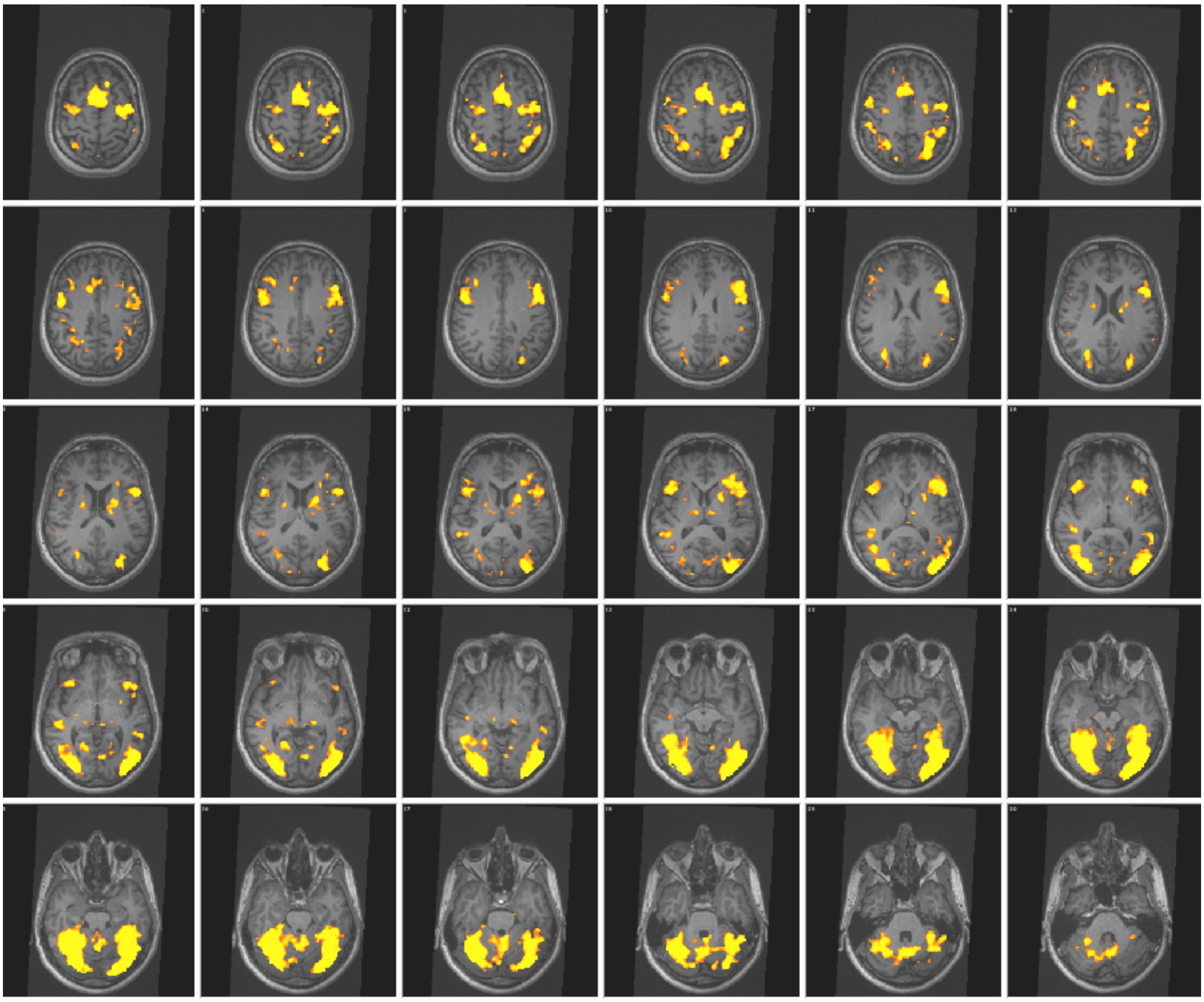


Figure 30: *Cortical activation Brand3, young participants.*
Displayed in axial view, radiological convention. Comparison with the baseline shown by a p-value of p<1.175e-09.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Inferior parietal lobule	40	n/a	n/a	1973	8.77
Inferior parietal lobule	40	2474	8.52	2041	9.28
Putamen	n/a	1357	7.93	1933	8.68
Anterior Insula	n/a	2355	9.17	2354	9.48
Cingulate gyrus	24	2110	9.85	1588	9.35
Middle temporal gyrus	21	1974	8.69	1369	7.05

Table 18: *Different regions of cortical activation, Brand3 young vs baseline.*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area, p-value p<1.175e-09.

Middle-aged subjects:

The middle-aged participants exhibited activation in the areas of the precuneus (PCu), the caudate nucleus (NC) and the putamen exclusively on the left hemisphere. The anterior insula was activated predominantly on the right, the middle temporal gyrus, however, on both hemispheres (**Figure 31**, **Table 19**). The difference in activation between the middle-aged participants on the one hand and the young and elderly ones on the other was that the middle-aged participants versus the young showed no relevant activation, nor did the middle-aged participants versus the elderly.

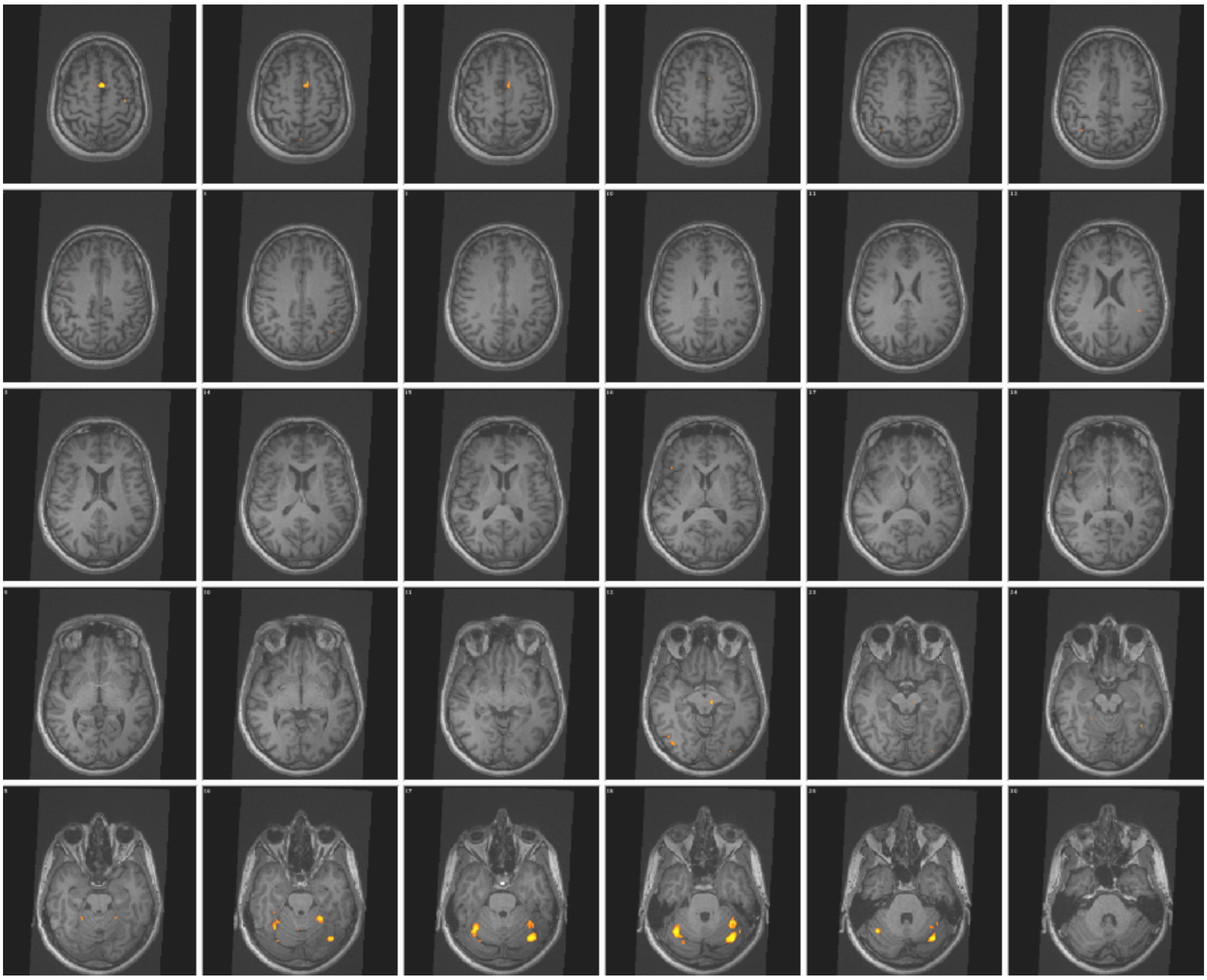


Figure 31: *Cortical activation Brand3, middle aged participants.*
Displayed in axial view, radiological convention. Comparison with the baseline shown by a p-value of p<1.175e-09.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Caudate nucleus	n/a	n/a	n/a	137	4.84
Putamen	n/a	n/a	n/a	66	4.93
Precuneus	7	n/a	n/a	396	5.17
Middle temporal gyrus	21	171	5.11	88	4.94
Anterior Insula	n/a	1161	5.07	411	5.01

Table 19: *Different regions of cortical activation and number of voxesl, Brand3 middle vs baseline.*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area, p-value p<1.175e-09.

Elderly subjects:

The elderly participants in general showed considerable activation, so a higher p-value had to be chosen. It should be taken into consideration that the pictures and the determination of voxel were made with the high p-value, too. The middle temporal gyrus (GTm) showed activation on both hemispheres. The cingulate gyrus (GC) and the caudate nucleus (NC) were activated only on the right hemisphere. The putamen was activated only on the left, while the anterior insula showed activation predominantly on the right hemisphere. The precuneus (PCu) was activated rather on the left than on the right hemisphere (**Figure 32**, **Table 20**).

When measured, the difference in activation between the elderly participants on the one hand and the young and middle-aged participants on the other proved to be the following: the elderly participants versus the young showed activation only in the cingulate gyrus of the right hemisphere (**Table S36**). The elderly versus the middle-aged participants were activated only in the middle temporal gyrus, and this mostly on the left hemisphere (**Table S35**).

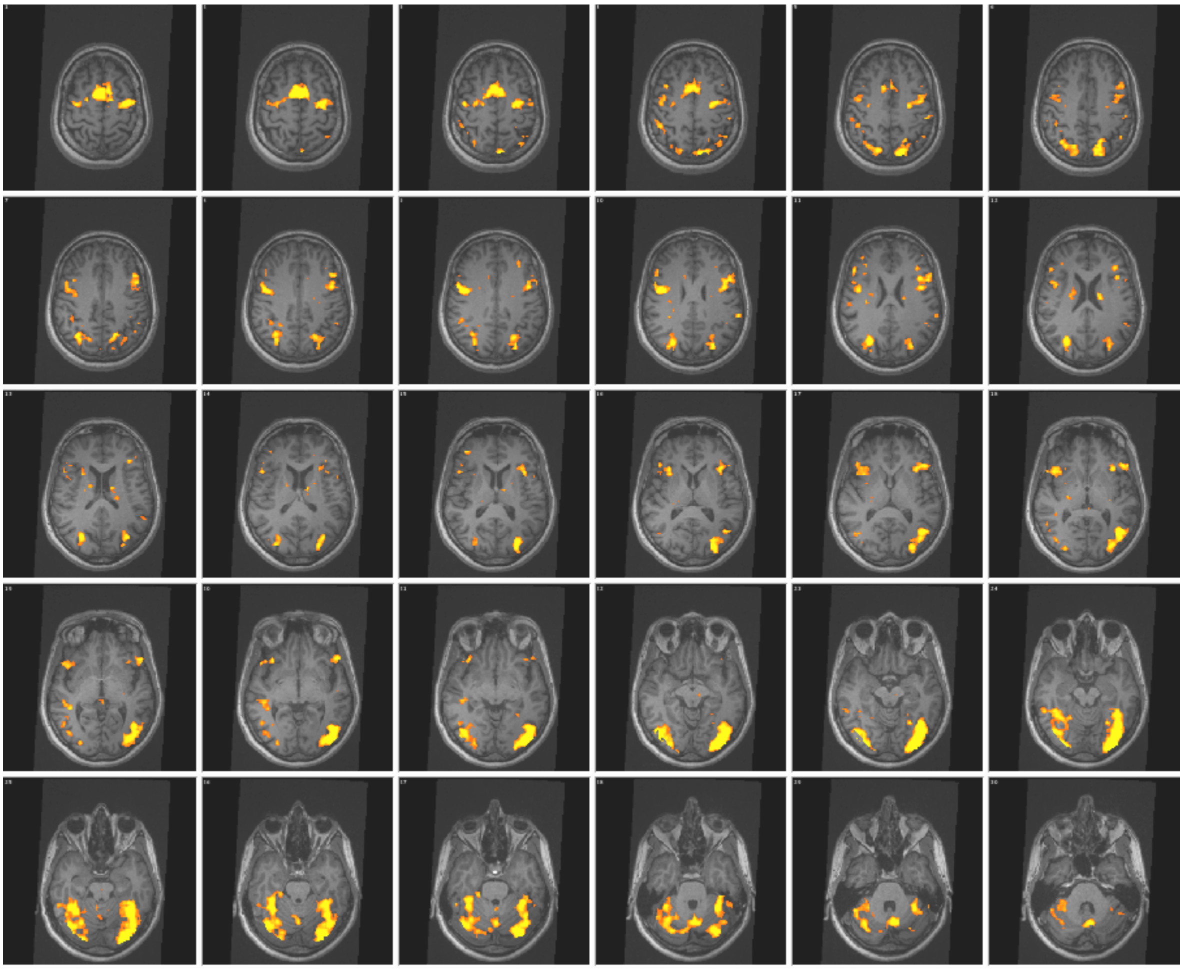


Figure 32: *Cortical activation Brand3, elderly participants.*
Displayed in axial view, radiological convention. Comparison with the baseline shown by a p-value of $p<1.175e-09$.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Precuneus	7	1338	8.73	1834	9.34
Putamen	n/a	n/a	n/a	400	7.59
Anterior Insula	n/a	2225	8.56	1221	8.61
Caudate nucleus	n/a	862	8.00	n/a	n/a
Cingulate gyrus	24	409	7.58	n/a	n/a
Middle temporal gyrus	21	921	8.29	n/a	n/a
Middle temporal gyrus	39	1030	8.06	2294	9.89

Table 20: *Different regions of cortical activation, Brand3 elderly vs baseline.*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area, p-value $p<1.175e-09$.

<u>*Summary discrimination age class:*</u>

The general conclusion drawn from the activation patterns of the three news magazines was that the young participants' activation prevailed on the left hemisphere, the middle-aged participants activation could be measured on both the right and the left hemispheres in equal shares, while the elderly participants' activation was registered on the right hemisphere, which was highest among all age groups. It became obvious that according to the subjects' age the activation patterns changed the hemisphere and that the area of activation increased or decreased.

4.2.3 Gender

The participants were subdivided in gender classes too, and the distinctive features between them regarding the different news magazines were measured. The thirty-one participants consisted of sixteen women, fourteen men and one man who, as explained above, had to be excluded because of movement artefacts.

<u>*Gender **Brand1**:*</u>

Male subjects:

The male participants showed activation in the areas of the anterior insula, the precuneus (PCu), the middle temporal gyrus (GTm) and parietal lobule predominantly on the right hemisphere. The cuneus was activated only on the left hemisphere. The caudate nucleus (NC) and the cingulate gyrus (GC) were activated exclusively on the right hemisphere. On the whole, large voxels of signal increase were measured (**Figure 33**, **Table 21**).

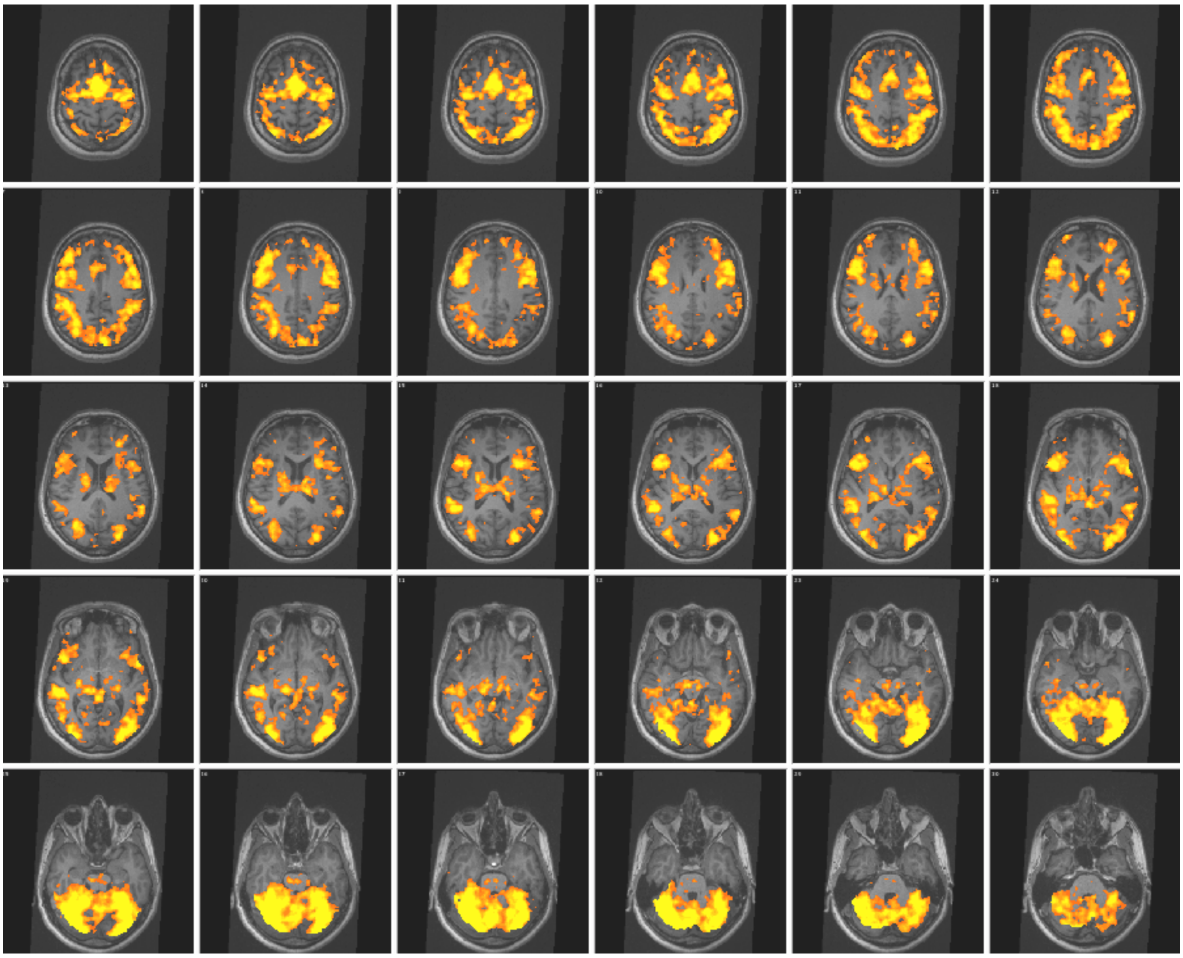


Figure 33: *Cortical activations Brand1, male participants.*
Displayed in axial view, radiological convention. Comparison with the baseline shown by a FDR of q: 0.001.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Caudate nucleus	n/a	259	4.25	n/a	n/a
Cingulate gyrus	24	272	4.34	n/a	n/a
Precuneus	7	392	4.50	286	4.70
Inferior parietal lobule	40	1913	4.90	1535	4.71
Middle temporal gyrus	21	1365	4.78	627	4.53
Anterior Insula	44	1900	4.80	622	4.50
Cuneus	19	n/a	n/a	720	4.53

Table 21: *Different regions of cortical activation and number of voxels, Brand1 male vs baseline.*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area, FDR = q: 0.001.

Female subjects:

The female participants displayed activation in the precuneus (PCu) on the right hemisphere. The anterior insula, the middle temporal gyrus and the parietal cortex were activated much more on the left hemisphere than on the right (**Figure 34**, **Table 22**).

When the difference in response between the male participants and the female participants was measured, the male versus the female participants showed activation only in the cingulate gyrus on the right hemisphere. In general, there were less conspicuous activation patterns (Table S63). The female versus the male participants showed no relevant activation at all.

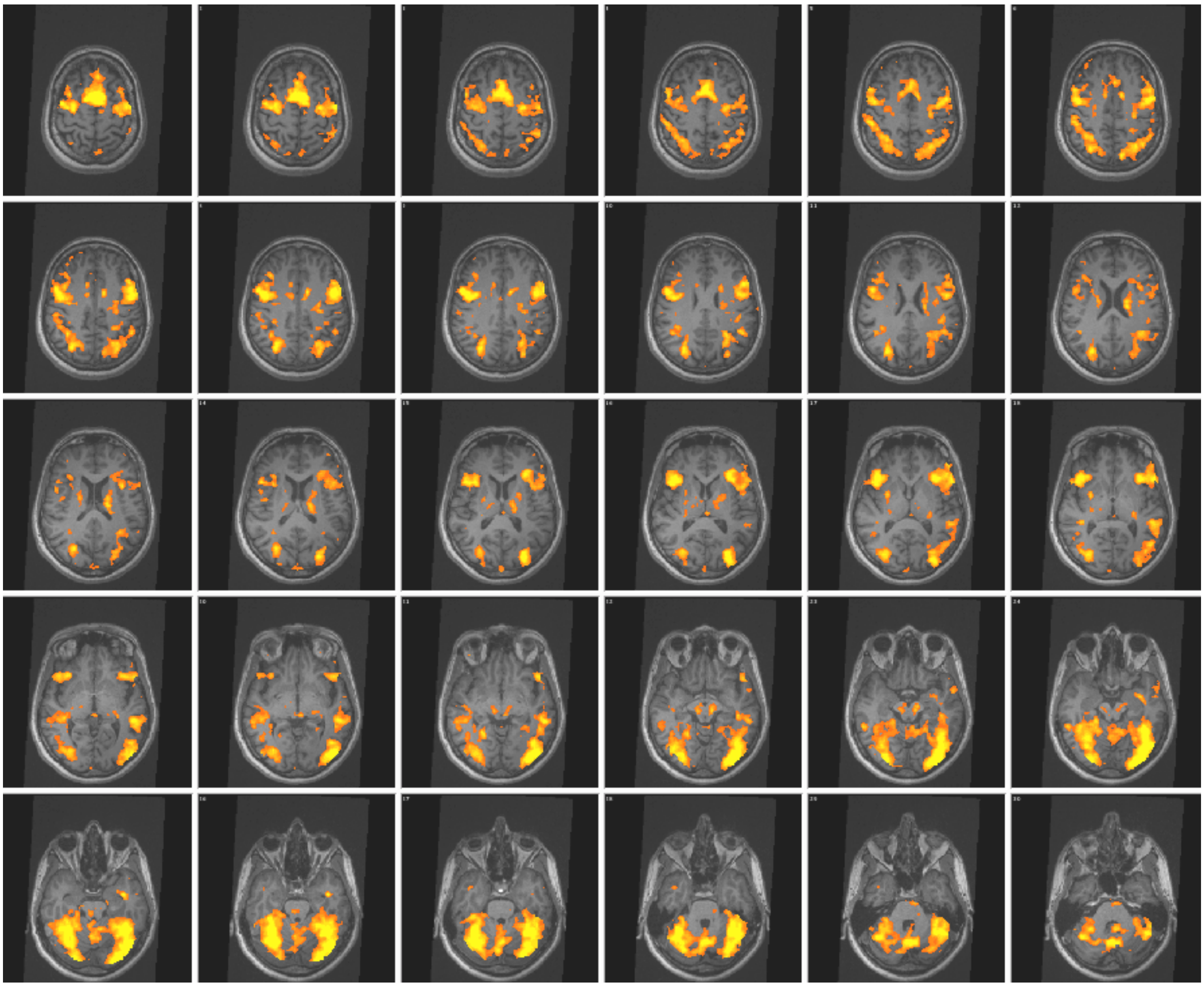


Figure 34: *Cortical activations Brand1, female participants.*
Displayed in axial view, radiological convention. Comparison with the baseline shown by a FDR of q: 0.001.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Middle temporal gyrus	21	66	4.63	582	4.63
Anterior Insula	44	1180	4.90	1750	4.89
Precuneus	19	781	4.75	n/a	n/a

Table 22: *Different regions of cortical activation and number of voxels, Brand1 female vs baseline.*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area, FDR = q: 0.001.

Gender ***Brand2:***

Male subjects:

The male participants showed activation in the precuneus (PCu) on both hemispheres. The anterior insula was activated much more on the right than on the left hemisphere and the middle temporal gyrus showed activation only on the right hemisphere. The cuneus was activated only on the left hemisphere (**Figure 35**, **Table 23**).

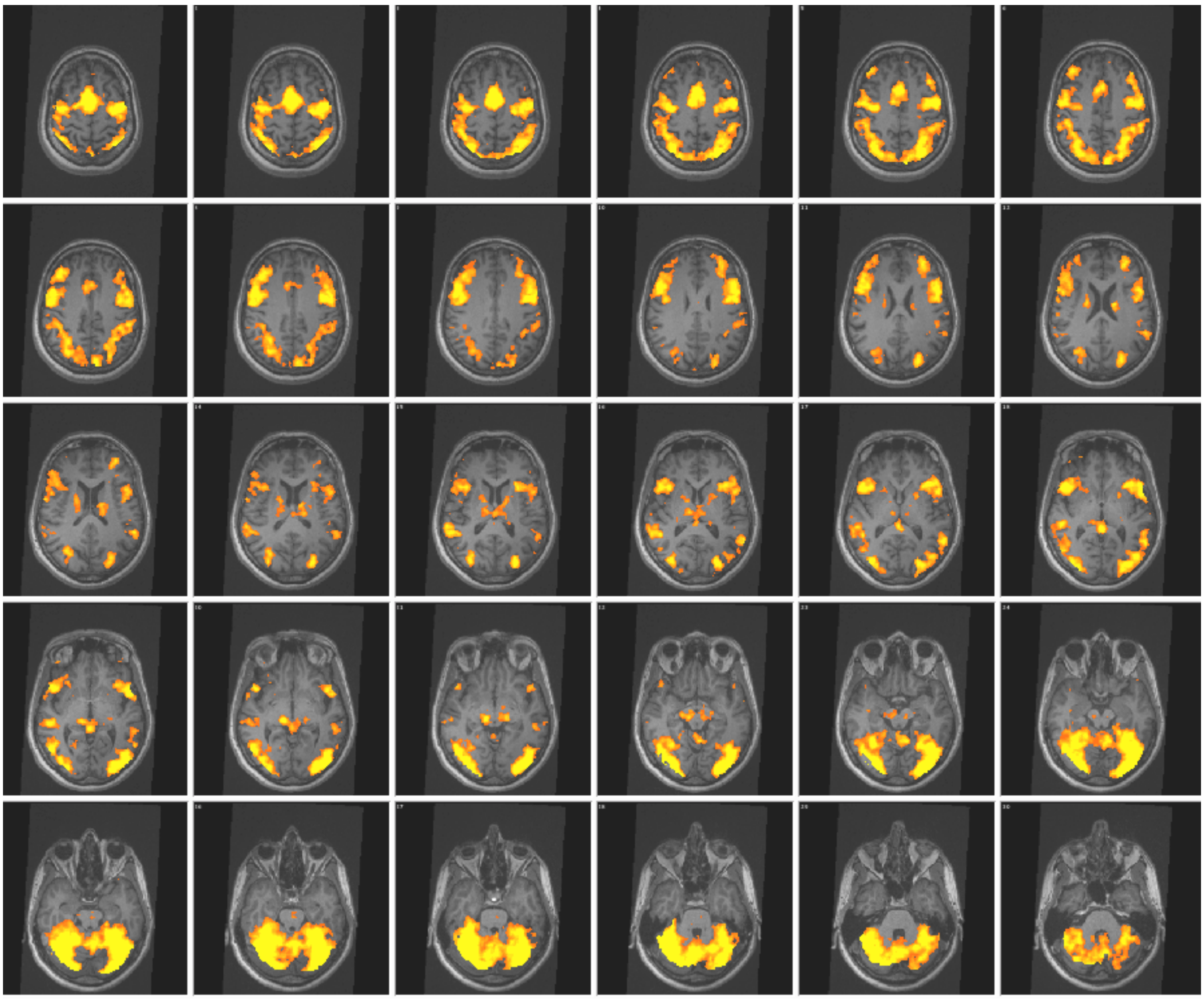


Figure 35: *Cortical activations Brand2, male participants.*
Displayed in axial view, radiological convention. Comparison with the baseline shown by a FDR of q: 0.001.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Precuneus	19	1978	4.90	1854	4.83
Middle temporal gyrus	21	1517	5.11	n/a	n/a
Anterior Insula	45	1393	4.77	1051	4.61
Cuneus	19	n/a	n/a	524	4.63

Table 23: *Different regions of activation and number of voxels, Brand2 male vs baseline.*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area, FDR = q: 0.001.

Female subjects:

The female participants showed activation in the middle temporal gyrus and the anterior insula. They showed more activation on the left hemisphere than on the right (**Figure 36**, **Table 24**).

When the differences in activation patterns between the male participants and the female participants were measured, the male versus the female participants showed activation in the precuneus (PCu) and the cuneus only on the left hemisphere. The cingulate gyrus was activated only on the right hemisphere. In general, there were a lot of activation patterns (**Table S34**). The female versus the male participants displayed no relevant activation.

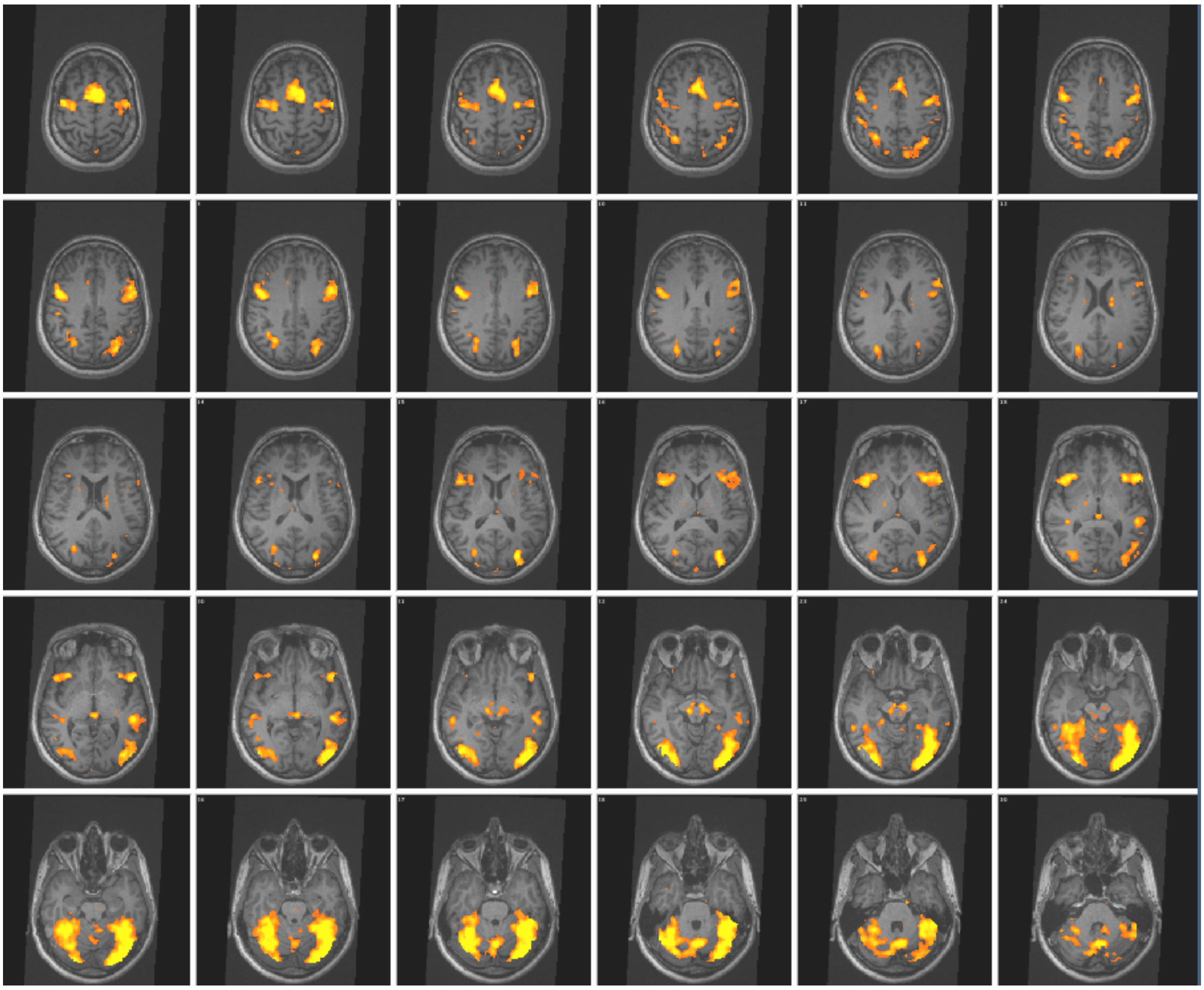


Figure 36: *Cortical activations Brand2, female participants.*
Displayed in axial view, radiological convention. Comparison with the baseline shown by a FDR of q: 0.001.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Superior frontal gyrus (pars medialis)	6	n/a	n/a	2550	5.13
Middle temporal gyrus	21	n/a	n/a	212	4.74
Anterior Insula	n/a	251	4.47	537	4.67

Table 24: *Different regions of cortical activation and number of voxels, Brand2 female vs baseline.*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area, FDR = q: 0.001.

Gender ***Brand3:***

Male subjects:

The male participants showed activation in the caudate nucleus only on the right hemisphere. That anterior insula region was activated on both hemispheres, but the middle temporal gyrus (GTm) mainly on the right. Likewise the precuneus (PCu) was concerned, more activation could be observed on the right hemisphere than on the left. The cuneus and the putamen were activated only on the left hemisphere. In general large voxels were measured and so a higher p-value had to be chosen. It should be taken into consideration that the pictures and the determination of voxel, too, were taken with the high p-value (**Figure 37**, **Table 25**).

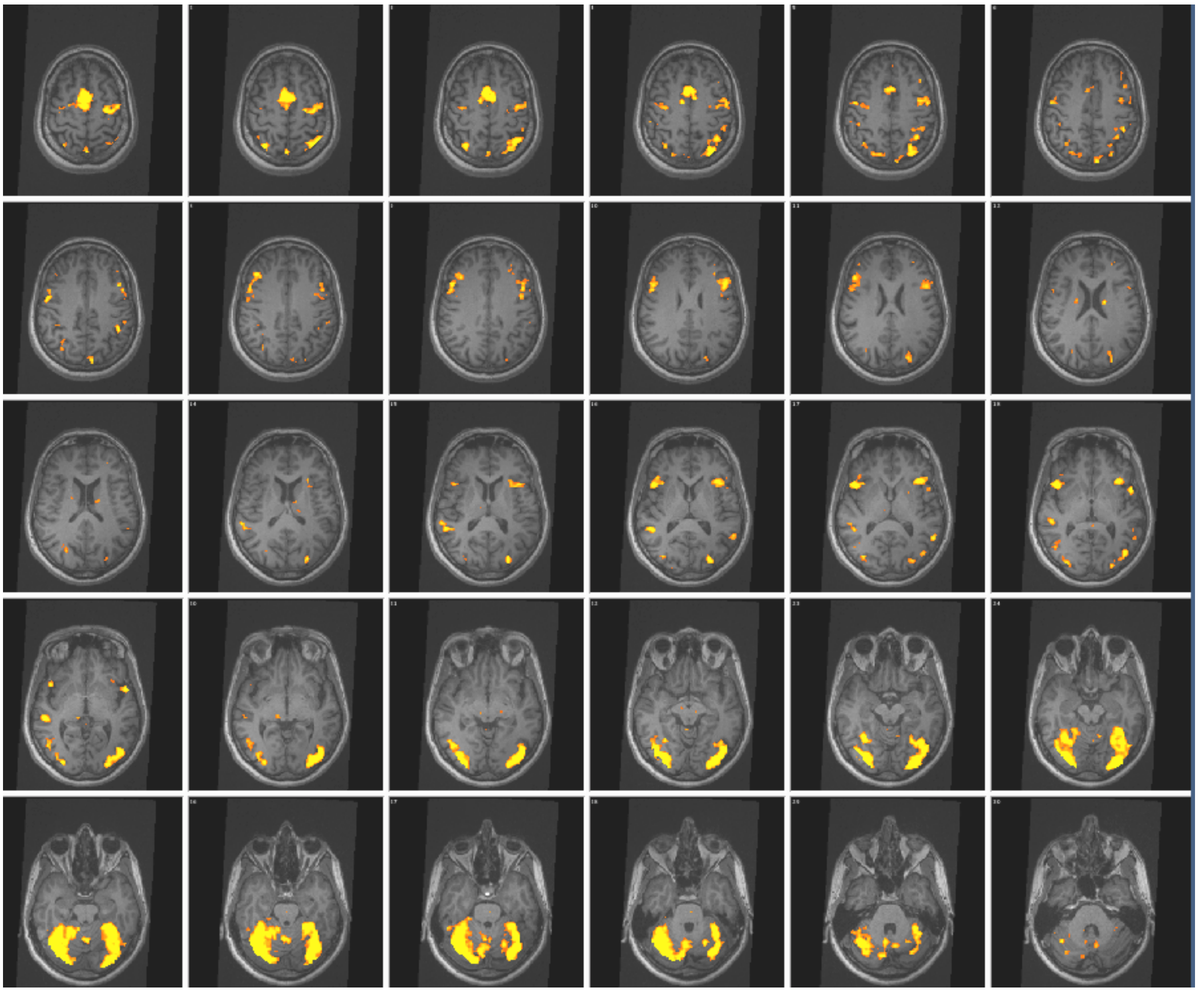


Figure 37: *Cortical activations Brand3, male participants.*
Displayed in axial view, radiological convention. Comparison with the baseline shown by a p-value of p<1.175e-09.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Cuneus	n/a	n/a	n/a	1261	8.03
Putamen	n/a	n/a	n/a	221	7.49
Anterior Insula	n/a	2322	7.49	2371	8.67
Caudate nucleus	n/a	563	7.66	n/a	n/a
Middle temporal gyrus	21	1590	8.23	881	8.08

Table 25: *Different regions of cortical activation, Brand3 male vs baseline*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area, p-value p<1.175e-09.

Female subjects:

The precuneus of the female participants, however, reacted on the left hemisphere. The anterior insula region was activated predominantly on the left hemisphere. The putamen, the cingulate gyrus and the middle temporal gyrus reacted to the stimuli on both hemispheres (**Figure 38**, **Table 26**).

A comparison of the activation pattern of the male participants with that of the female participants produced the following results: The male versus the female participants showed activation in the cuneus and cingulate gyrus only on the left hemisphere (**Table S32**). The female versus the male participants displayed activation only in the middle temporal gyrus (GTm) predominantly on the left hemisphere.

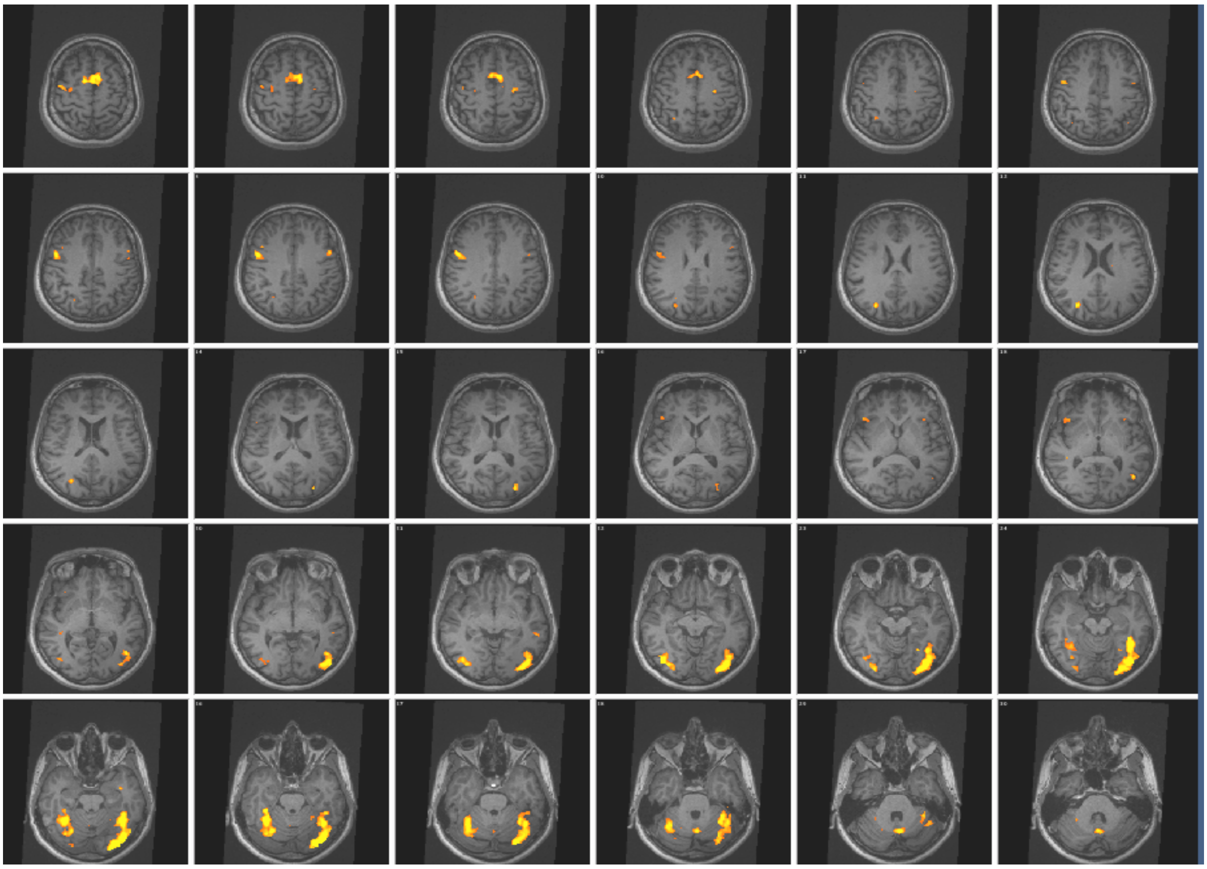


Figure 38: *Cortical activation Brand3, female participants.*
Displayed in axial view, radiological convention. Comparison with the baseline shown by a FDR of q: 0.001.

Anatomical region		Right		Left	
	BA	No.voxel	t-value	No.voxel	t-value
Precuneus	19	n/a	n/a	1371	4.42
Middle temporal gyrus	21	4580	4.81	2926	4.93
Middle temporal gyrus	21	346	4.30	1206	5.32
Putamen	n/a	2851	4.59	3002	4.73
Cingulate gyrus	24	944	4.18	950	4.18
Anterior Insula	n/a	251	4.47	537	4.67

Table 26: *Different regions of cortical activation and number of voxels, Brand3 female vs baseline.*
n/a means not applicable, No.Voxel = number of voxels, BA= Brodmann area, FDR = q: 0.001.

Summary discrimination gender:

Finally the conclusion has to be drawn that the male participants reacted mainly on the right hemisphere while performing the Brand1 and Brand2 tasks. They showed bilateral activation while performing the Brand3 tasks. By contrast, the female participants were activated on the left hemisphere while looking at Brand1, Brand2 and Brand3. All in all the male participants showed rather more general activation whereas the female displayed smaller activation patterns. On this occasion it has to be recorded the fact that Brand2 again showed the lowest activation and Brand3 the highest, independent of gender.

4.3 Correlation with Questionnaires

4.3.1 Brand1 vs. Brand2 vs. Brand3

The results of the test for the news magazines **Brand1, Brand2** and **Brand3** can be summed up as follows:

First the reading behaviour was analysed. The question posed was, how often the news magazines were read (each edition, every two to three editions or more rarely). The analysis revealed no significance between the individual magazines. The imagination of the three news magazines was significantly clearer for Brand2 as distinct from Brand3 and Brand1. Brand1 took the last place. All in all the imagination of the three news magazines was very clear. Their attractiveness was significantly positive for Brand2. Brand1 and Brand3 are on the same

level but behind the position of Brand2. The contents of the news magazines in general were evaluated on a three point scale:
Brand2 was evaluated best, Brand1 got the second score and Brand3 the least response. The difference between each of the news magazines was significant.
Analysing the data, the conclusion was that Brand2 got the best score overall in the questionnaires and that Brand1 and Brand3 both achieved mediocre results, but that Brand1 got a slightly better assessment in the questions referring to contents than Brand3, whereas Brand3 obtained better results for image than Brand1. When the response data and the questionnaires were compared there was a significant correlation (**Table 27**).

Reading behaviour	*Brand1*	*Brand2*	*Brand3*
Each	3	2	1
Every 2/3	9	12	6
Rarely	19	17	24
Altogether	31	31	31
Imagination	*Brand1*	*Brand2*	*Brand3*
Clear	18	29	22
Unclear	3	1	0
Others	10	1	9
Altogether	31	31	31
Attractiveness	*Brand1*	*Brand2*	*Brand3*
Attractive	13	17	13
Not attractive	7	1	5
Others	11	13	13
Altogether	31	31	31
Contents	*Brand1*	*Brand2*	*Brand3*
Accurate	236	294	165
Not accurate	130	54	152
Others	161	179	210
Altogether	527	527	527

Table 27: *Summary of the results of the questionnaire concerning the different brands.*

4.3.2 Age Class

As far as the reading behaviour was concerned no significant difference was found between the three news magazines Brand1, Brand2 and Brand3 as a consequence of the different age classes. All three news magazines were read rather seldom by each of the age classes.

With regard to imagination the three age classes on the whole responded equally, except that Brand1 got highly significant results both from elderly and young adults ($p = 0.004$). The elderly participants had a significantly clearer imagination of Brand1 as the young

participants, who saw Brand1 in the last rank, just as the middle-aged subjects did. The ranking was: Brand2 first, then Brand3 and in the last place Brand1.
As far as the attractiveness of the news magazines is concerned, a significant difference between the three age classes became evident. In the opinion of the middle-aged participants (6/10) Brand1 was attractive, but not so for the young ones (p = 0.05). Generally Brand2 obtained good results for its attractiveness, especially the young participants judged it positively (9/11). Thus there was a considerable margin between the judgment of the young and the middle-aged adults (p= 0.05) and between that one of the young and the elderly ones (p = 0.05). The assessment of Brand2 showed a significant difference between the elderly and the young participants (p = 0.05). The elderly adults preferred Brand3 more often than the young adults did and ranked it first.

The evaluation of the contents of the three news magazines showed a significant difference between the three age classes. The young and middle-aged adults judged Brand1 negatively in significant contrast to the elderly participants, who evaluated the contents of Brand1 positively. The young participant's positive judgment of the news magazine Brand2 can be distinguished clearly from that of the middle-aged and especially that of the elderly participants, who voted against it in tendency. The outturn of the evaluation of the news magazine Brand3 demonstrated significantly that the elderly participants opted more decidedly for Brand3 as opposed to the young participants, who evaluated it more negatively. The middle-aged probationers rated Brand3 lowest (**Table 28**).

Brand1	young	middle	elderly
Accurate	55	64	108
Not accurate	64	46	20
Others	68	60	42
Altogether	187	170	170
Brand2	young	middle	elderly
Accurate	121	87	87
Not accurate	18	11	25
Others	48	72	58
Altogether	187	170	170
Brand3	young	middle	elderly
Accurate	57	31	77
Not accurate	55	63	34
Others	75	76	59
Altogether	187	170	170

Table 28: *Evaluation of the contents of the three brands by the different age classes.*

Table 29 shows the general ranking of the three news magazines in the different age classes. The reading behaviour wasn't listed, because it showed no difference at all, as described above.

Age	**young**	**middle**	**elderly**
Imagination			
Brand1	3	3	1
Brand2	1	1	1
Brand3	2	2	1
Attractiveness			
Brand1	2	1	2
Brand2	1	2	3
Brand3	2	3	1
Contents			
Brand1	2	2	1
Brand2	1	1	2
Brand3	2	3	3

Table 29: *General ranking of the three brands in the different age classes.*
The numbers 1-3 mean the first place, second place and third place.

Concluding the analysis it can be summed up to the effect that the news magazine Brand2 was ranked first in the opinion of the young participants in imagination, attractiveness and contents. The middle-aged participants placed Brand2 first regarding imagination and contents, while they ranked Brand1 first for attractiveness. The elderly participants placed Brand3 first for attractiveness (Brand2 was only last in this category) and Brand1 first for contents.

4.3.3 Gender

There was no significant difference between the male and female participants in the evaluation of the news magazines.

The female and male participants have the same reading behaviour. Both groups read the three news magazines rather seldom.

Further, the imagination concept of the news magazines showed the same results for both male and female participants. The table reveals a clear brand image for Brand2 and a rather fuzzy brand image for Brand3. Brand1 takes the third and last place in the opinion of both male and female probationers for the imagination ranking. There was the same not so favourable brand image result in the opinion of the young and the middle-aged participants.

Concerning attractiveness the news magazines got the same ranking from both gender groups. Brand2 led ahead of Brand1 and Brand3, which shared the same place.

Relating to contents a clear ranking for the news magazines was obtained. The female and male participants saw Brand2 in first place, Brand1 in second and Brand3 in last place.

Table 30 shows the general ranking of the three news magazines. As there was no difference in reading behaviour, this category is not listed, as described above.

Gender	**male**	**female**
Imagination		
Brand1	3	3
Brand2	1	1
Brand3	2	2
Attractiveness		
Brand1	2	2
Brand2	1	1
Brand3	2	2
Contents		
Brand1	2	2
Brand2l	1	1
Brand3	3	3

Table 30: *General ranking of the three brands in the different gender groups.*
The numbers 1-3 mean the first place, second place and third place.

On the whole, a ranking of the three news magazines was observed: Brand2 took the lead, Brand1 the second and Brand3 the last place, but a difference can be stated in ranking among the four main topical groups of the questionnaire.

As the questions of the response data only comprised the questionnaire issues “attractiveness” and “contents” of the news magazines, only the results of the response data concerning these topical groups could be compared and summed up in a general way. The results showed that there were correlations between the response data and the questionnaires as well as between the age classes and the gender classes.

5 Discussion

5.1 Differences in Cortical Activation between Brand 1, 2 and 3

The three news magazines Brand1, Brand2 and Brand3 are well-known brands in Germany. The print media was examined and the three news magazines were compared with each other. First the difference in their general cortical activation was measured without the discrimination of gender and age classes. It can be concluded that on the whole Brand1 and Brand3 activated rather the right hemisphere than the left. In contrast to that Brand2 stimulated the left hemisphere more than the right. On the whole Brand3 triggered off the highest activation and Brand2 the lowest in comparison with the others.

The scans of all participants showed that brand perception is a highly complex process and doesn't take place in one distinct area but in a network of brain areas. Moreover, there was activation in defined regions, which will be described in the following.

The anterior insula was one of the important regions activated and was stimulated by all the three magazines and almost during every single one of the measurements. In this respect the change of lateralization between the separate news magazines was conspicuous. For the interpretation of the different lateralization the "valence-hypothesis" was used, which postulates that the left brain hemisphere is specialized on positive emotion and the right brain hemisphere on negative emotion (28). Considering that in general Brand2 activated predominantly the left hemisphere and Brand1 and Brand3 activated prevailingly the right hemisphere at all, everything indicated that Brand2 was perceived much more positively than the other two magazines. On the whole, the analysis of the response data and the questionnaire both lead to the same result: The news magazine Brand2 was evaluated best, followed by Brand1. Brand3 was ranked last.

In addition to that, an understanding of the different functions of the anterior insula is needed for the interpretation of the results in combination with the above-mentioned hypothesis. One of the important results of a previous study about brand strength was that the anterior insula is a region in which brand strength is depictable. In this respect strong and weak brands (well known and unknown makes of car) were compared, with the result that the left anterior insula was activated during the presentation of strong brands while the right anterior insula was activated during the presentation of weak brands (26). If this interpretation is transferred to the results of the present study, it can be concluded that because of its left side activation of the anterior insula, Brand2 represents a strong brand. Furthermore, this can be underlined on the assumption that the left hemisphere stands for positive emotional perception (see above), for in order to become a strong brand a product has perceived positively and with little effort in the mind of the consumer. The situation was different for Brand1 and Brand3. Both didn't come off well in the examination (questionnaire and response data) and the fMRI showed a dominant right side activation of the anterior insula. So it must be concluded that if the interpretation above is taken into account, Brand1 and Brand3 were perceived as weaker brands than was Brand2.

Alan G. Sanfey and colleagues showed clear results of different activation of the anterior insula by investigating the neural basis of economic decision-making in the ultimatum game (29). In this game two players split a sum of money; one player proposes a division and the other player can either accept or reject this. The decision between good or bad offer showed activation in the right anterior insula, the bad offer showing the highest activation. The corresponding process in the present study was the decision of preference between the three magazines and their evaluation. Brand1 and Brand3 highly activated the anterior insula on the right side, Brand3, however, clearly showing higher activation. This can be interpreted to the effect that Brand1 and Brand3 were both a worse offer in tendency and needed more place, i.e. higher activation, for a decision. One important point is that Brand3 by a wide margin caused the highest general activation, which has to be interpreted as worst brand perception in the comparison of the three magazines, provided that high activation means unfavourable and low activation favourable perception. So Brand2 was the better and more effortless choice because of its left and lower dominant activation, which could be named effortless processing. The weighing of the different brands against one another appeared to be an important process. So what does this mean for the economist? The region of the anterior insula reflects the social behaviour of trust, altruism and fairness which is a prerequisite for the achievement of economic growth (30). If the anterior insula shows the highest activation (in this study generated by the magazines Brand1 or Brand3) when confronted with an unfair offer, this means for the economists in charge of the marketing of a defined the product that they have to change it in order to generate a more positive attitude towards the product, thereby influencing and enhancing the willingness to buy it.

The anterior insula is a crucial region with many different functions. One of these is its role for word processing and word production (31). This accounts for the activation of the anterior insula by all three magazines, because the participants have to read the questions under each title page. The anterior insula is equally involved in complex functions such as working memory and selective visual attention (31). This function was important for the study because

the tasks demand selective visual attention from the participants. This attention existed during all measurements, showing that the results were accessible and meaningful.
Of course the anterior insula serves many functions and is connected to almost all brain areas (31). In order not to lose track of the essentials, the interpretation will focus on the above mentioned functions.

Another influential region was the middle temporal gyrus (GTm). In this region the three magazines prompted different lateralizations of activation again, Brand1 and Brand3 being represented on the right and Brand2 predominantly on the left hemisphere. The middle temporal gyrus is responsible for semantic processing, which means the way words can be read and their meaning understood (32). In the study the participants had to understand the different questions in combination with the different covers. The activation in the middle temporal gyrus may be indicating that they understood the task. It was in this region, however, that Brand2 had the lowest activation in comparison with the other two. This stands for an easier comprehension and immediate response to the task. Here Brand2 once again underlined its brand strength.
A study from *Bartolo and colleagues* showed the left side activation of the middle temporal gyrus during the presentation of a nonverbal task (33). It was the aim of the study to show humour comprehension and appreciation with the fMRI. The participants had to compare funny and not funny cartoons. Likewise, in the present study the participants had to understand the pictures shown in correlation with the task set. Thus the left hemisphere activation again showed the better visual perception and comprehension of Brand2.
The processing of brand image takes place in the temporal gyrus as well. Imagery can be defined as manipulative sensory information that comes not from the sense, but from memory. In their review, *Robert Cabeza and Lars Nyberg* described the imaging cognition among other things (34). The brand image of the news magazines was the focus of the present study because the participant had to imagine the different news magazines and had to evaluate these. The right temporal activation was related to more complex visual imagery. This means that Brand1 and Brand3 need this complex visual imagery because of their right temporal hemispheric activation and because of their weaker brand perception. The left temporal hemispheric activation of Brand2 can be regarded as due to its simple visual imagery (35). Besides, the imagery of the three news magazines was an explicit question of the questionnaire, the result being that the imagination of Brand2 was much clearer than the brand

image of the other two - one more point for the brand strength of Brand2 in comparison with Brand3 and Brand1.

A further region of interest for the analysis, the cingulate gyrus, is known to be involved in a form of attention that serves to regulate both the cognitive and the emotional processing (36, 37). Especially the anterior part of the cingulate gyrus (aGC), which was mostly activated during the study, assists the cognitive and motor control and plays a key role in cognitive, motor and emotional processes (38). On the whole, the anterior cingulated cortex was activated more by Brand1 and Brand3, Brand3 again showing the most activation in this region.

In decision making, which is based on reward, a strong activation in the anterior cingulated cortex could be noted (38, 39). As Brand1 and Brand3 produced more activation in the anterior cingulated cortex, it can be deduced that the assessment of the three new magazines was more difficult for Brand3 and Brand1. These seemed to provoke more conflicts between emotional and cognitive offers. The participants therefore needed more effort for their decision between Brand1 and Brand3 in comparison with Brand2.

Other studies proved that the anterior cingulated cortex shows activation in tasks with focussed attention and answer selection (34) and is activated during cognitive conflicts between emotional and cognitive offers (40). Attention during the task was a precondition for our study and so it was not surprising that all participants generated activation in this region. Because of their higher cortical activation there, it seems that Brand1, and above all Brand3 needed more attention and answer selection than Brand2.

It can be assumed that the anterior cingulated cortex has a self-regulating function and plays a crucial role in error control (41). Because of its lower activation in this region, it seems that Brand2 needed no error control and no focussed attention any more. This may reflect the fact that Brand2 is better anchored in mind.

A region of great interest is the precuneus. It is part of a neural network essential for self-consciousness and crucial for the awareness of the environment. This explains its significance for the study and is reflected by the question of how did the participants stand up for the different brands and what was their awareness of them? The activation of the precuneus cannot solve these questions in general but sheds some light on the matter. The precuneus was generally activated during the presentation, which showed that to a certain extent the participants had some brand awareness of all three magazines (they are all reasonably strong brands). But what qualities does this brand awareness have? The precuneus plays a key role in a wide spectrum of highly integrative tasks, for example visual spatial imagery and episodic memory and is important for memory of pictorial information (42, 43, 44). So the brand awareness of the precuneus is rather more a pictorial one, which explains the considerable activation during the task, because the participants had to evaluate the cover of the news magazines. Fact of the matter was that Brand3 showed the highest activation again, followed by Brand1. The lowest activation in comparison with the other two was produced by Brand2. This activation pattern can be interpreted as follows: Brand3 and Brand1 cause a brand awareness which is mainly based on pictorial perception. These two magazines back their contents in a pictorial way, set off the text by a lot of coloured pictures. The news magazine Brand2 is aligned more with academic and investigative journalism. It does without the support of lots of pictures. This explains that the associative activity in looking at the covers during the task prompted the region of the precuneus in different ways.

The ventral striatum belongs to the basalganglia and consists of caudate nucleus, putamen and nucleus accumbens. The area of the basaganglia plays an important role in quite a number of positive emotions, such as happiness, [gains support from multiple in vivo investigations of addictive substances and behaviours (45, 46, 47, 48)] and enjoyable activities, for example playing a video game (49). The ventral striatum is moreover activated during feelings of pleasure for example from reward after gain of money (50, 51). Activation in the basal ganglia, including the ventral striatum and putamen, has been observed in response to happy faces (36, 52, 53, 54), pleasant pictures (55, 56, 57), and happiness-induced recall (58, 59). A lot of information about the basalganglia and other regions can be gathered from the review of *Phan and colleagues* (60).

In the present study the basalganglia, especially the putamen and the caudate nucleus, played a significant part, mainly in the discrimination of the three magazines. It could be observed that Brand2 produced hardly any activation at all but that Brand1 and Brand3 activated the putamen much more, with Brand3 again showing the highest activation. What can be drawn from these observations? All three magazines caused activation in the putamen and the caudate nucleus, which means that all of them were connected with positive emotions (see above: pleasant pictures, happy faces). Brand2, Brand1 and Brand3 are magazines which were read willingly. In this context the lowest activation generated by Brand2 won’t be interpreted as negative result, like Brand2 is the magazine which is read with the least pleasure, as we still need more detailed information about the function the basalganglia have in processing the data. As described above, another function of the putamen and the caudate nucleus is the reward function. Thus Brand2 with its lowest activation of this region meant that the feeling of reward it engendered was least in comparison to Brand1 and Brand3, which engendered the most outstanding feeling of reward. These results were interpreted as follows: Important in this context is that the three news magazines use different images and have a different way of presenting their contents. Brand2 with its strict layout concept and clear headlines promises to be more academic and serious in tendency. But the feeling of reward is triggered by easy comprehension and perception. The covers of Brand1 and Brand3 already signal that they deal more with more social and popular topics. These two magazines try to entertain and to inform their readers on society and politics with mixed articles which are pepped up with coloured pictures. This triggers the participants' reward feelings and explains the higher activation of the basalganglia by Brand1 and Brand3. Here another target of neuromarketing is affected because both investing money, in the present case buying a magazine, and gaining something in return, which in the present study means finding pleasure in reading the magazine, might correlate with the activation of the rewarding system (30).

But not all the articles on the subject described the function of the basalganglia as involved in the feelings of reward and happiness. To complete the picture we have to add that some studies observed an activation of the basalganglia during the presentation of disgusting pictures or odours. The activation seen in the basalganglia in response to disgust may represent a state of preparedness triggered by a warning stimulus to process emotionally salient information (61). These points of view do not contradict our result, because we interpreted the activation of the putamen and the caudate nucleus as a warning stimulus which told the reader to make a precise distinction and assessment of the reports. Brand2 with its low activation would then be the choice which gives solid and trustful information. The reports of Brand1 and Brand3 are examined more critically because of their not so obvious demands on seriousness.

Another significant region is the frontal gyrus. This region plays a cardinal role for the realisation of higher cognitive functions. It is also an essential part of a network which carries out executive functions such as the modulation of attention, problem-solving and strategic planning. It is a predominant right fronto-parietal network, which shows activation during sustained attention (62). But the frontal gyrus doesn't only take part in executive functions. It is also important for the encoding and retrieval of the autobiographical long-term memory (63).

For the present study the fronto-parietal network played an important role, because the attention of the participants during the task was a precondition for the success of the study.

Without being attentive the participants couldn't have solved the task adequately. The right fronto-parietal network was activated especially by Brand1 and Brand3 which means that they required attention for solving the task. For this part of the brain that can be interpreted as Brand1's and Brand3's demanding perception of the task. On the other hand we can say that Brand2, which didn't create any right dominant fronto-parietal activation patterns, once again demonstrated its effortless processing.

On the whole, the analysis of the response data, the questionnaire and the fMRI lead to the same result: Contents-, brand image-, and attractiveness-questions as well as spontaneous evaluation by pressing the button resulted in the first place for Brand2, the second for Brand1 and the last for Brand3. This means that, in correlation with the cortical activation, the news magazine Brand2 is a well-established brand which is strongly anchored in the participants' minds. The other two news magazines aren't as accepted when judged by reading conditions and the evaluation of their contents. Brand2 is assessed as trustful and more serious.

5.2 Age Class

The general conclusion drawn from the activation patterns generated by the three news magazines was that the young participants have more activation on the left brain hemisphere; the middle-aged subjects have activation on the right and on the left hemispheres in equal shares, whereas the elderly participants showed predominant activation on the right hemisphere.

On the whole the brain activation seems to increase with the age with reference to all important affected brain regions. The activation patterns could be seen changing accordingly from the left hemisphere with the lowest activation patterns (young participants) over bilateral activation (middle-aged participants) to mostly right side brain activation (the elderly participants) with the highest activation patterns.

A leading significant result for the interpretation was the change in lateralization in function of age class. A clue is rendered by the valence-hypothesis (see above), which states that the left hemisphere principally reacts to positive emotions and the right brain hemisphere is aroused predominantly by negative emotions (64). The younger participants for the most part showed left hemisphere activation, which stands for their positive emotional assimilation of the task. They assimilated more emotionally than the elderly participants, who displayed right brain hemisphere activation. It can also be said that elderly people judge in a down-to-earth way because of their lifetime-experience. Another hypothesis was that "normal" thought processes need more brain activation in one's old age. Elderly people have "to add" the right hemisphere to get the same output as young people with their left dominant activation patterns only (65). For the same output more brain regions were needed. Another study of a partner research team at the institute of clinical Radiology of the Ludwig-Maximilians-Universitiy Munich obtained similar results when testing patients suffering from Alzheimer Dementia. The result of this study was that the brain of an Alzheimer patient compensated the failure of determined brain regions by consulting other brain regions in the right hemisphere (66). It is clear that these results are only valid for adult people, but, in referring to other studies that describe the brain activation of younger people (67, 68), we can compare the brain activation during the aging process.

The fact of the changing lateralization of activation patterns within the different age classes had to be explained and if it was rather the same for all three news magazines. Isn't there any difference in the evaluation of the magazines across the different age classes? In the chapter above the results of the three magazines in general are laid out, they reflect the different hemispheric lateralization of the three magazines (Brand2 = left side activation; Brand1 and Brand3 = right side activation). So these general results have to be brought in line with the results of the age classes.

First a detailed description of the age class results of the three news magazines is required:

Reading the news magazine Brand1 the young participants show significant activation on both sides but more on the left hemisphere. This can be interpreted as emotional processing (see above). A lot of activation can be detected in the inferior frontal gyrus. This means additional attention, which is needed by the young participants for reading Brand1 and is also an indicator for the weaker brand perception.
The middle-aged participants show a lot of activation in the precuneus region during the reading of Brand1. That means that Brand1 is perceived very pictorially by the middle-aged. The middle temporal gyrus is also activated on the right side, an indication of complex visual imagery needed for the task by the middle aged participants, which means a weaker brand status of Brand1. All in all Brand1 activated the middle temporal gyrus of the middle-aged

bilaterally once again which can be explained by the recruiting of more brain regions during the aging process.
The elderly participants show the highest activation patterns of the three age classes while reading the news magazine Brand1. What probably accounts for the hypothesis that an originally active brain region loses its effectiveness in the course of the aging process and further brain regions have to be included for the processing. Another hypothesis holds that elderly people think in a more down-to-earth manner and answer the task more rationally. Both hypotheses can be put forward to account for the predominantly right hemisphere activation pattern of the elderly participants during the reading of the news magazine Brand1.

Brand2 is responsible for the bilateral, more left-dominant activation patterns with the young participants which means a rather emotional processing (see above). The precuneus region is activated more on the left hemisphere. In comparison with the other news magazines this region shows its least activation by Brand2 which can be explained by a demanding academic and investigative journalism without a lot of pictures to ensure and back up the quality of the contents. This activation underlines the self-consciousness of the young participants while reading the magazine. The anterior insula region shows activation more on the left hemisphere and in comparison with Brand1 and Brand3 this region is activated less by Brand2. This stands for the effortless processing of this brand, as explained above. Moreover activation can be observed in the region of the middle temporal gyrus only on the left side. It is interpreted as an indicator of the simple imagery (see above) of Brand2 as set against the complex visual imagery of Brand1 and Brand3. The middle-aged participants exhibit a both-sided activation pattern in contrast to the young participants in general. This accounts for the tendency that with the age increasing you have to recruit more brain regions for the same output. There are no special regions to discuss, because there are no brain regions activated which were not activated by other magazines or other age classes as well. Brand2 is processed with the highest activation pattern by the elderly participants. The characteristic activation is mainly on the right hemisphere. Responsible for this phenomenon is the generally unemotional view of things by the elderly participants. They require more effort to solve the task and have to recruit more brain regions to get the same results as the younger ones.

The young participants show a high, more left-sided activation pattern while reading and answering the Brand3-task. The activation was the highest in comparison with Brand1 and Brand2 and could be interpreted as a sign of a worse brand processing. One difference to the other news magazines was that there was a high activation in the reward centres putamen and caudate nucleus. This can be explained as follows: While reading the news magazine Brand3, the reward centres were activated because of the very pictorial and simple layout. Activation in further brain regions could have been observed. This is an indicator of the poor identification of the news magazine Brand3. The readers don't know how to evaluate the magazine. They have no defined notion on it. Another matter is the left-side activation of the young adults. This can be interpreted as emotional reaction to the task according to the valence-hypothesis. Young adults generally judge with more emotion. The middle-aged participants display a both-sided and high activation in all important brain regions. Like with Brand1 and Brand2, the bilateral activation of the middle-aged by Brand3 is interpreted as less emotional evaluation and stands for the additional recruiting of brain regions because of the increasing ineffectiveness of the aging brain. Here again, the activation of the putamen is remarkable and diffuse from that aroused by the other brands. In addition the elderly participants display activation in the putamen. In both cases this indicates the general rewarding functions of Brand3 (explanation see above). The elderly participants show a mainly right-sided and very high activation pattern corresponding to their unemotional view of things. The increasing brain activation caused by Brand3 can be accounted for two facts: the weak and therefore demanding brand processing of the task on the one hand and the increasing ineffectiveness of the elderly brain on the other.

The news magazine Brand3 generated by far the highest activation of the three magazines. Each age class showed so high activation patterns that a differentiation between the different brain regions was difficult. But this underlined that Brand3 was the weakest of the three according to our interpretation that the higher the activation the lower the brand strength.

In summary, two central characteristics are conspicuous in the comparison of the three age classes:

Firstly there is the change of lateralization within the different age classes. The activation changes from the left hemisphere and emotional evaluation by the younger adults to the right hemisphere and more unemotional down-to-earth view of things by the elderly adults. Secondly an increase in brain activation across the different age classes can be noticed because of the necessary support of further brain areas. These findings shift the focus of attention from of the differentiation of the three news magazines to the processing of visual stimuli in connection with brand perception as dependent on the participants' age. In fact, there do not exist many studies with the explicit aim to find out the difference in brain activation between the different age groups. In the present study we shed light on a topic which is worth further exploration.

5.3 Gender

A short survey of comparison of the gender:
In general we can see that the male participants are stimulated on the right brain hemisphere while watching the news magazines Brand1 and Brand2. They display activation on both sides but more on the right one when faced with the news magazine Brand3. The female participants are activated mainly on the left hemisphere while watching brands 1, 2 and 3.

The same difference in lateralization is described by *Bell and colleagues* (69). One attempt at explaining for the difference in varying lateralization between males and females is based on the functional differences of the blood flow between the genders during cognitive tasks in Bell's study. Other studies referred to the gender-related characteristics in various activation patterns as word processing, visual stimulation, spatial navigation and working memory (70). Such distinctive features suggest that the sexes use specific strategies in solving specific problems and that the difference may result from the functional brain difference of gender. But could we conclude that the different experimental results between women and men are caused by the different functional construction of their brains only? It could be postulated that the right brain hemisphere is responsible for rational thinking and less emotional perception while the left hemisphere is in control of emotional processing. In contrast to that "the right hemisphere hypothesis" holds that the right hemisphere dominates the left hemisphere in all the emotion processing (64). As far as the gender results are concerned the conclusiveness of the different approaches will be discussed in the following.

First the description and discussion of the way men solve the task:
A clear result is that men display much more brain activation during the task than women. This result could mean that the processing of the task is more demanding for them. They need more brain effort to solve the same task as women, a conclusion that was underpinned by other studies, too (71). In addition, we have interpreted high brain activation as demanding thinking process throughout the study. The predominance of the right hemisphere (or rather

symmetric activation by Brand3) with the male participants can be interpreted like this: the left brain side is activated mainly in an emotional response or thinking while the right side is stimulated rather by negative emotions and rational response. According to this hypothesis men think in a more rational and less emotional way during the task. As referred above there exist studies and interpretations of lateralization which claim exactly the opposite. For the gender difference in lateralization, however, the valence-hypothesis seems more plausible and correlates with the activation of another important brain region:

This very interesting brain region, the cuneus, is activated only by men and only on the left hemisphere and that during the whole task (i.e. for all three news magazines). Here the visual concept building for usefulness and feasibility takes place (34). In the context of the present study this signifies that men judge according to this concept. This means that men judge a brand in terms of usefulness rather than in terms of niceness and liking and underlines at the same time the statement that men think in a more unemotional and objective way.

In general we see no specific gender difference in the acceptancy of the three news magazines brand 1, 2 and 3. For all of them, bilateral activation patterns could be observed with a predominance of the right hemisphere for the male participants.

Looking at the results for the female participants, we can interpret them in the following way:

In contrast to the right side activation patterns of the male participants the female participants display an unilateral activation pattern on the left. The same kind of activation pattern was observed by *Speck and colleagues* (72) during a working memory task. For the interpretation of the different lateralization with women the same hypothesis should be used as for men (28). According to this hypothesis the female left side activation can be interpreted as a more emotional approach to the task. This means that women solve problems and tasks in a more emotional way than men. In construction of objects females engage predominantly the left hemisphere whereas with men the activation is bilateral (73). Another way of explaining the distinct lateralization is the functional difference of blood flow between men and women (see above).

A further outcome of the study is the difference in quantity of activation. Women generally being less activated than the men. This can be interpreted as more effortless processing because females do not need so much effort of the brain to solve the same problems as males.

Throughout the study we see no specific difference in the way the three news magazines are perceived by the genders. For all the three brands no activation patterns could be detected on the left hemisphere of the female participants.

The different lateralization of the genders was the main issue of the interpretation. It is clear that the different brain regions, which have been discussed in the general part of the presentation, were activated both with the males and females during the task, but the only difference (apart from the cuneus) was located in the specific hemisphere activation. In this context, the results of the questionnaire and the response data cannot account for the different brain activation because the questions were not precise enough with regard to usefulness or emotion.

Limitations of the validity of the study:
It should be mentioned that in comparison with clinical studies in the present study only a limited number of subjects was examined. Therefore, the results cannot be extended to a larger population and generalized without reserve, but in comparison to other fMRI studies, the group strength was rather a big one. One limitation of the study was the problem of social acceptability in answering the questionnaire, but this is a general limitation of questionnaires and had to be accepted. As during the task a new cover was presented to the subjects every 3 seconds to get their spontaneous reaction, it may have happened that the impression of the different brands melted into one another, but it should be emphasized once more that the change of the different covers was as long as possible, but as short as necessary to get spontaneous reactions.

5.4 Prospects

The human brain with its complex functions and structures is a field of research for many unsolved questions. With functional MRI the scientists want to decipher the mystery of the brain and how it works. The role of neuroimaging studies for marketing research is important and continually growing, because you can depict spontaneous reaction of the brain while it is working. That is why marketing research has adopted it for analysing the consumer's buying behaviour and brand image of a product. The present study proved that the brain work is performed in a network of different brain areas reacting to stimuli and activated and participating in the solution of different tasks. One important result was that the brain works differently across the age classes and that there is a difference in function between the gender classes especially as far as lateralization is concerned. This is a field for further, more detailed analysis in order to understand the difference in brain perception.

But is it possible at all to decipher the brain and in doing so the human mind? “If the brain was constructed so easily that humans could understand it, humans were too stupid to understand it” (74) said *Bernard Lown*, a respected scientist and he is not the only one to hold this opinion. It is a generally accepted fact that one of the greatest mysteries of humanity is the human being itself, but why not try and get a little closer to unveiling the mystery? In this approach, functional MRI may help science to get closer to an understanding of the human brain step by step than ever before.

6 Conclusion

The three news magazines we have examined (Brand1, Brand2 and Brand3) are well-known brands in Germany. The aim of the study was to find out if there is a difference in the brand perception of the three news magazines in general and if so, if there is any connection with gender or age, i.e. if the difference is gender or age specific. So we investigated the print media and compared the three news magazines with each other.
First the difference in general was measured without any discrimination of gender or age: We observed that Brand1 and Brand3 caused activation rather on the right hemisphere than on the left. In contrast to that Brand2 engendered activation more on the left hemisphere than on the right. On the whole Brand3 stimulated the strongest activation and Brand2 had the lowest activation in comparison with the other two.
The scans of all participants prove that brand perception takes place in a network of brain areas, but the distinctly different activation of the anterior insula has special importance for the interpretation, because of its function for brand perception. As a whole the results were interpreted in the following way:
Brand2, unlike Brand1 and Brand3, underlines its brand strength both in the scans and in the questionnaire, unlike Brand1 and Brand3. This is indicated by the change in lateralization and the lower activation caused by Brand2.

The general conclusion of the specific activation patterns of the three brands shows that the young participants have more activation on the left hemisphere; the middle-aged participants have activation in equal shares on the right and on the left brain hemispheres, while the elderly participants show activation predominantly on the right hemisphere. The activation "wanders" from the left-sided emotional evaluation by the younger adults to the right-sided, unemotional, down-to-earth view of things by the elderly adults.
On the whole, brain activation increases with the age. The young participants show the least activation and the elderly participants the highest activation with reference to all important brain regions. The brain activation increases throughout the three age classes probably because of the increasing ineffectiveness of the older brain.

If we evaluate the results of the study in the light of the genders we have to establish that the male participants showed a predominant stimulation of the right hemisphere while watching the news magazines Brand1 and Brand2. They had activation on both sides but more on the right one while watching the news magazine Brand3. The predominance of the right hemisphere (or rather symmetric activation by Brand3) of the male participants could be interpreted like this: men think more rationally and less emotionally during the task. A clear result of the study is that men show much more brain activation during the task than women. This result could mean that the processing of the input is more demanding for men. Their brain responds more intensely when the same task is set for them as the women's brain.

The female participants responded mostly on the left hemisphere while watching all three brands. We interpreted the female predominantly left-sided activation as a more emotional evaluation of the task. Accordingly it can be concluded that women solve problems and tasks more emotionally than men. Another result is that women show less activation in general. This can be interpreted as rather effortless processing in contrast to men. On the whole, the different lateralization of the genders was the main issue of the interpretation of the prresent findings.

Finally it should be emphasized that all comparable studies urgently ought to aim at gender and age dependent analysis to minimise systemic errors by combining the cohorts. In our opinion additional studies regarding age and gender with focus on the interdependence on working memory, emotional processing and attention are essential to detect the network components and their significance.

7 List of Figures

8 List of Tables

9 Bibliography

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Appendix

Chi2	p-value	with Yates	Fisher-Test
Brand1 positive > Brand2 positive	0.00351	0.004	0.004
Brand1 positive > Brand3 positive	0.00001	0.00001	0.00001
Brand3 positive > Brand2 positive	0	0	0
Brand1 negative > Brand2 negative	0.0004	0.0005	0.0005
Brand1 negative > Brand3 negative	0.4	0.4	0.4
Brand3negative > Brand1 negative	0.00001	0.00001	0.00001

Table S31 *Summary of the response data in general*
pos= stongly agree and agree, neg= moderately agree and agree not

Chi2		p-value	with Yates	Fisher-Test
young>middle	agree	0.1	0.11	0.11
young>elderly		0.005	0.006	0.006
elderly>middle		0.3	0.34	0.3
young>middle	not agree	0.06	0.06	0.06
young>elderly		0.00001	0.00002	0.00002
elderly>middle		0.02	0.03	0.03

Table S32 *Evaluation among the different age classes of Brand1*
Agree means strongly agree and agree; not agree means moderately agree and not agree

Chi2		p-value	with Yates	Fisher-Test
young>middle	agree	0.3	0.3	0.3
young>elderly		0.005	0.006	0.005
elderly>middle		0.1	0.1	0.1
young>middle	not agree	0.08	0.9	0.8
young>elderly		0.04	0.04	0.04
elderly>middle		0.9	0.9	0.9

Table S33 *Evaluation among the different age classes of Brand3*
Agree means strongly agree and agree; not agree means moderately agree and not agree

Chi2		p-value	with Yates	Fisher-Test
male>female	agree	0.003	0.003	0.003
male>female	not agree	0.0003	0.0004	0.0004

Table S34 *Evaluation of the different gender classes of Brand1*
Agree means strongly agree and agree; not agree means moderately agree and not agree

Chi2		p-value	with Yates	Fisher-Test
male>female	agree	0.0007	0.0009	0.0008
male>female	not agree	0.00002	0.00002	0.00002

Table S35 *Male and female assessments of Brand2*
Agree means strongly agree and agree; not agree means moderately agree and not agree

Loc	x	y	z	BA	voxel	*t* value	min	max
Left								
gfd	0	4	54	6	7672	6.83	3.99	11.13
lpi	-37	-57	40	40	5508	5.23	3.99	7.45
gfi	-50	7	31	44	5568	5.7	3.99	8.45
ant.ins	-34	20	6	45	7598	5.03	3.99	8.32
gtm	-50	-34	-1	21	3595	5.04	3.99	7.64
pu	-22	-4	10	n/a	1631	4.64	3.99	6.41
Right								
lpi	30	-52	40	40	5822	5.36	3.99	7.72
gfi	47	7	28	44	9095	5.47	3.99	9.14
ant.ins	38	20	9	45	8511	5.37	3.99	9.14
gtm	48	-29	-2	21	3871	4.91	3.99	7.16

Table S36 *Coordinates of different activated cortical regions and the number of voxel, Brand1*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	voxel	*t* value	min	Max
Left								
gfd	-1	4	55	6	7438	6.37	4.1	11.12
gprc	-35	-11	57	6	4743	5.32	4.1	7.38
lpi	-28	-62	44	7	4648	5.16	4.1	7.68
gprc	-45	4	34	6	5544	5.53	4.1	7.66
ant.ins	-34	22	3	45	4408	5.29	4.1	8.37
nc	-17	-7	20	n/a	703	4.76	4.1	6.19
gtm	-55	-40	1	21	803	4.78	4.1	6.61
Right								
gprc	35	-11	57	6	5444	5.25	4.1	8.16
gprc	43	4	35	6	5042	5.58	4.1	8.59
ant.ins	46	18	9	45	3907	5.53	4.1	5.53
gtm	52	-30	-2	21	727	4.75	4.1	6.35

Table S37 *Coordinates of different activated cortical regions and the number of voxel, Brand2*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	voxel	*t* value	min	max
Left								
gfd	-3	7	57	6	7863	7.74	3.84	12.72
gprc	-29	-13	53	6	7535	6.21	3.84	9.63
gfi	-45	12	32	44	7566	6.36	3.84	9.54
lpi	-29	-68	43	40	6255	6.04	3.84	8.7
ant.ins	-37	22	7	45	6451	5.97	3.84	19.12
gtm	-54	-34	0	21	5328	5.32	3.84	8.84
Right								
gprc	30	-14	56	6	6484	5.96	3.84	9.3
gfi	38	3	32	44	6658	6.35	3.84	9.91
lpi	31	-58	41	40	6255	6.04	3.84	8.7
ant.ins	39	22	9	45	7264	6.3	3.84	10.36
gtm	47	-28	0	21	6246	5.29	4.84	9.14

Table S38 *Coordinates of different activated cortical regions and the number of voxel, Brand3*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	voxel	*t* value	min	max
Left								
gts	-14	26	48	8	524	4.2	3.93	5.13
gc	-18	38	16	32	1037	4.28	3.93	5.53
gc	-19	-53	18	30	1237	4.43	3.93	5.92
Right								
gc	12	22	39	32	1066	4.45	3.94	6.37
gc	21	38	16	32	1744	4.58	3.93	6.49
gts	36	-56	0	21	1049	4.40	3.93	5.50
gl	11	-48	-7	18	n/a	n/a	n/a	n/a
gc	27	-50	18	30	624	5.26	3.93	5.27

Table S39 *Comparison of different cortical activations Brand3 vs Brand2, number of voxels and coordinates*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	voxel	*t* value	min	Max
Left								
gfd	-2	2	58	6	3126	4.95	4.24	7.27
pcu	-26	-64	43	19	175	4.41	4.24	4.83
gc	-3	14	48	32	1399	5.00	4.24	6.54
gfm	-31	26	46	8	343	4.72	4.24	5.69
gfi	-47	11	31	44	2076	4.87	4.24	6.68
gts	-50	-48	23	22	1410	4.84	4.24	6.39
gts	-35	-45	23	22	334	4.78	4.24	7.03
gtm	-52	-55	15	39	1319	4.79	4.24	6.30
ant.ins	-33	27	9	n/a	2289	5.22	2.24	8.02
gtm	-52	-37	2	21	1783	4.95	4.24	7.42
Right								
gfd	10	1	58	6	1150	5.15	4.24	7.43
pcu	23	-60	43	19	845	4.68	4.24	6.29
gc	3	14	48	32	1109	5.10	4.24	6.39
gfi	50	12	31	44	840	4.82	4.24	6.56
gts	40	-46	23	22	523	4.65	4.24	6.28
gts	49	-40	15	22	637	4.66	4.24	5.65
ant.ins	35	25	6	n/a	1530	4.93	4.24	6.98

Table S40 *Coordinates of different activated cortical regions and the number of voxels, Brand1 young vs baseline*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	voxel	*t* value	min	max
Left								
gfd	-5	3	54	6	5180	5.97	3.95	10.37
pcu	-3	-68	49	7	711	5.18	3.95	8.19
lpi	-34	-37	36	40	1820	5.09	3.95	7.94
gfi	-47	14	25	45	912	4.82	3.95	7.06
gts	-41	-27	22	22	1266	4.81	3.95	6.94
pu	-18	-2	9	n/a	969	4.74	3.95	7.24
gtm	-47	-34	9	21	417	4.69	3.96	6.83
ant.ins	-35	22	6	n/a	2580	5.03	3.95	8.03
Right								
pcu	7	-67	50	7	1294	4.70	3.95	7.34
pcu	5	-66	36	7	1461	5.22	3.95	7.86
gprc	47	0	36	6	1749	5.03	3.95	7.74
gfm	43	28	36	9	1906	5.37	3.96	8.11
lpi	44	-33	36	40	2033	5.46	3.95	9.18
gfi	45	12	25	45	1858	5.28	3.96	7.92
gfm	31	59	22	10	739	4.51	3.96	5.60
nc	19	-2	22	n/a	1006	4.76	3.95	7.06
pu	25	0	9	n/a	1194	4.81	3.96	7.06
gtm	54	-37	9	21	1173	4.83	3.95	6.61
ant.ins	39	22	6	n/a	4340	5.60	3.95	9.15
gtm	52	-27	-3	21	1918	5.01	3.96	7.25

Table S41 *Coordinates of different activated cortical regions and the number of voxel, Brand1 middle-aged vs baseline*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	voxel	*t* value	min	max
Left								
gprc	-37	-10	53	4	2346	6.08	3.06	9.39
gc	-4	9	45	32	1958	6.78	3.96	11.96
pcu	-4	-73	45	7	718	6.14	3.96	9.26
gfm	-45	15	39	9	2316	5.94	3.97	10.09
gts	-57	-43	18	22	1835	5.47	3.96	8.21
ant.ins	-37	24	3	n/a	1966	5.04	3.06	8.33
p u	-24	-6	11	n/a	324	4.66	3.96	6.52
Right								
gfd	5	0	53	6	2113	6.70	3.97	13.47
lpi	36	-31	53	40	448	4.79	3.96	7.14
gprc	30	-9	53	4	2345	5.16	3.96	8.43
gc	5	11	45	32	795	5.83	3.97	10.00
pcu	8	-71	45	7	817	5.59	3.96	8.84
gfm	33	14	39	9	1174	4.98	3.96	8.14
ant.ins	38	23	3	n/a	2371	5.13	3.96	8.46
gtm	47	-33	3	21	2122	4.89	3.96	7.37
pu	22	-4	11	n/a	201	4.33	3.97	5.28

Table S42 *Coordinates of different activated cortical regions and the number of voxel, Brand1 elderly vs baseline*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	voxel	*t* value	min	max
Left								
gfd	-3	4	56	6	3259	6.24	4.00	11.40
gprc	-37	-8	56	4	2384	5.55	4.00	8.84
pcu	-30	-56	43	7	2908	5.29	3.99	8.37
lpi	-42	-34	41	40	1095	4.42	4.00	5.52
gfm	-38	25	41	8	505	4.82	4.00	7.60
gprc	-45	9	32	6	4765	5.79	4.00	9.00
pu	-20	4	12	n/a	1491	4.7	4.00	6.67
ant ins	-40	22	5	n/a	4344	5.61	4.00	9.15
gtm	-53	-50	5	21	1478	4.73	4.00	6.78
gtm	-52	-32	1	21	1170	4.47	4.00	5.86
Right								
gfd	9	5	56	6	1532	5.77	4.00	10.0
gprc	39	-7	56	4	1799	5.23	4.00	7.88
pcu	24	-55	43	7	1869	5.40	3.99	9.16
lpi	45	-29	41	40	1260	5.04	4.00	7.46
gfm	33	43	41	8	590	4.65	4.00	6.07
gprc	50	9	32	6	3529	5.76	4.00	8.76
nc	17	5	20	n/a	399	4.41	4.00	5.92
ant ins	43	20	5	n/a	3239	5.58	4.00	8.49
gtm	48	-28	1	21	580	4.81	4.00	7.24

Table S43 *Coordinates of different activated cortical regions and the number of voxel, Brand2 young vs baseline*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	voxel	*t* value	min	max
Left								
gprc	-33	-16	57	4	1110	4.81	4.31	6.22
gc	-1	9	46	32	1885	5.43	4.31	8.12
lpi	-32	-56	46	40	1280	4.92	4.31	6.83
gprc	-43	-2	39	6	1294	4.97	4.31	7.06
ant ins	-33	20	6	n/a	327	4.72	4.31	5.82
Right								
gprc	35	-12	57	4	2264	5.18	4.31	7.73
lpi	34	-56	46	40	1821	4.78	4.31	6.22
gfi	47	11	31	44	1786	5.02	4.31	8.03
ant ins	45	20	3	n/a	1950	5.04	4.31	7.87
gtm	46	-46	7	21	130	4.78	4.31	6.03
gtm	46	-57	-2	21	1177	5.05	4.31	7.42
pcu	6	-70	37	7	106	4.56	4.31	5.02

Table S44 *Coordinates of different activated cortical regions and the number of voxel, Brand2 middle-aged vs baseline*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	voxel	*t* value	min	max

Left								
gprc	-33	-7	50	4	3626	5.84	4.09	9.26
pcu	-7	-72	50	7	1578	6.31	4.09	10.43
pcu	-16	-72	40	19	1435	6.26	4.09	11.23
gc	-2	21	40	32	1589	6.06	4.09	11.14
gfi	-43	9	32	44	4214	5.65	4.09	9.40
gfm	-34	37	31	9	515	4.58	4.09	6.35
gtm	-27	-68	20	19	1763	5.28	4.09	9.88
gts	-58	-44	20	22	1178	5.12	4.09	7.41
gfm	-44	37	17	46	963	4.93	4.09	7.11
ant ins	-37	23	4	n/a	2484	5.35	4.09	9.29
Right								
gprc	37	-8	50	4	2893	5.01	4.09	7.26
lpi	42	-41	47	40	2014	5.16	4.09	7.63
pcu	18	-71	40	19	2520	5.52	4.10	8.12
gc	4	21	40	32	377	5.42	4.09	10.04
gfi	43	6	32	44	3410	5.69	4.09	9.59
gsm	38	-44	32	40	1573	5.04	4.09	8.01
gfm	33	33	31	9	198	4.39	4.09	5.62
gtm	27	-66	20	19	2240	5.35	4.09	9.01
nc	12	-1	17	n/a	259	4.48	4.09	6.36
gfi	46	25	17	45	2225	4.87	4.09	7.18
ant ins	41	18	4	n/a	3443	5.12	4.09	8.51
gtm	44	-32	-2	21	873	4.62	4.09	6.36
gtm	51	-60	-2	21	1567	5.2	4.09	9.96

Table S45 *Coordinates of different activated cortical regions and the number of voxel, Brand2 elderly vs baseline*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	**x**	**y**	**z**	**BA**	**voxel**	***t* value**	**min**	**max**

Left								
gc	-4	16	41	24	1588	9.35	7.05	14.79
Lpi	-29	-64	41	40	1973	8.77	7.05	11.42
lpi	-31	-52	41	40	2041	9.28	7.05	12.13
gprc	-41	2	36	6	n/a	n/a	n/a	n/a
gtm	-30	-71	23	39	n/a	n/a	n/a	n/a
pu	-22	2	14	n/a	1933	8.68	7.05	12.14
Ant ins	-34	27	8	n/a	2354	9.48	7.05	14.74
gtm	-52	-53	4	21	1369	8.16	7.05	10.87
Right								
gc	9	17	41	24	2110	9.85	7.05	15.51
lpi	26	-52	41	40	2474	8.52	7.05	12.54
gtm	26	-69	23	39	n/a	n/a	n/a	n/a
pu	22	0	14	n/a	1357	7.93	7.05	12.58
Ant ins	40	18	8	n/a	2355	9.17	7.05	12.58
gtm	38	-59	4	21	1974	8.69	7.05	12.49
gtm	50	-28	-2	221	1349	8.48	7.05	11.65

Table S46 *Coordinates of different activated cortical regions and the number of voxel, Brand3 young vs baseline*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, p-value p<1.175e-09

Loc	x	y	z	BA	voxel	*t* value	min	max
Left								
gfd	-3	2	55	6	1536	5.38	4.56	7.22

gfd	-10	-15	55	6	505	5.17	4.56	7.03
gprc	-33	-19	55	4	559	5.15	4.56	6.59
pcu	-1	-65	55	7	396	5.17	4.56	6.42
lpi	-40	-54	42	40	481	4.95	4.56	5.85
gts	-41	-29	22	22	179	4.97	4.56	5.82
gts	-49	-20	16	22	128	5.10	4.57	6.60
nc	-18	-19	16	n/a	137	4.84	4.57	5.67
pu	-18	-4	10	n/a	66	4.93	4.56	6.15
ant ins	-35	21	6	n/a	411	5.01	4.56	6.09
gts	-50	9	0	22	128	5.03	4.57	5.98
gtm	-55	-38	0	21	88	4.94	4.56	5.78
Right								
gfd	10	0	55	6	553	5.01	4.56	6.28
gprc	26	-10	55	4	438	5.12	4.56	6.49
gprc	45	5	35	6	469	5.01	4.56	6.61
lpi	30	-49	31	40	336	4.80	4.57	5.49
gfi	41	10	27	44	381	4.98	4.56	5.77
gts	46	-27	22	22	73	4.88	4.56	5.88
ant ins	39	22	6	n/a	1161	5.07	4.56	6.79
gtm	35	-56	0	37	171	5.11	4.56	6.03

Table S47 *Coordinates of different activated cortical regions and the number of voxel, Brand3 middle-aged vs baseline*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, p-value p<1.175e-09

Loc	**x**	**y**	**z**	**BA**	**voxel**	***t* value**	**min**	**max**
Left								

pcu	-11	-72	45	7	1834	9.34	7.02	12.48
pu	-22	3	13	n/a	400	7.59	7.02	10.87
Ant ins	-33	23	4	n/a	1221	8.61	7.02	11.61
gtm	-45	-65	4	39	2294	9.89	7.02	16.62
Right								
pcu	17	-70	45	7	1338	8.73	7.03	12.52
lpi	43	-38	45	40	n/a	n/a	n/a	n/a
gc	7	14	33	24	409	7.58	7.02	9.09
nc	14	-1	19	n/a	862	8.00	7.02	10.53
Ant ins	35	23	4	n/a	862	8.00	7.02	12.36
gtm	43	-66	4	39	1030	8.06	7.02	10.90
gtm	41	-29	-6	21	921	8.29	7.02	10.32

Table S48 *Coordinates of different activated cortical regions and the number of voxel, Brand3 elderly vs baseline*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, p-value p<1.175e-09

Loc	**x**	**y**	**z**	**BA**	**Voxel**	***t* value**	**min**	**max**
Left								
gprc	-35	-13	51	4	584	4.84	4.02	7.57
lpi	-47	-33	41	40	1535	4.71	4.02	6.65
pcu	-7	-51	43	7	286	4.7	4.02	6.57
gfm	-39	31	35	9	574	4.61	4.02	6.16
gfi	-48	15	24	46	1029	4.54	4.02	5.85
cu	-8	-77	37	19	720	4.53	4.02	5.91
ant ins	-29	16	11	44	622	4.5	4.02	6.03
gtm	-56	-47	11	39	446	4.487	4.02	5.66
gtm	-55	-40	2	21	627	4.53	4.02	5.78
Right								
gfd	2	2	56	6	2206	5.50	4.02	8.44

lpi	42	-32	39	40	1913	4.9	4.02	7.24
gfs	-10	27	55	8	431	4.27	4.02	6.8
pcu	19	-52	43	7	392	4.5	4.02	5.9
gfm	39	31	35	9	1213	4.93	4.02	7.55
gfi	45	17	24	46	1658	4.73	4.02	7.11
gtm	40	-51	25	39	430	4.42	4.02	6.08
gtm	29	-67	19	39	744	4.34	4.02	5.64
gc	9	17	34	24	272	4.34	4.02	5.18
nc	15	-10	18	n/a	259	4.25	4.02	5.07
gtm	30	-66	18	39	630	4.34	4.02	5.64
gts	43	-47	16	22	227	4.3	4.02	5.24
ant ins	44	18	11	44	1900	4.8	4.02	7.87
put	22	-1	11	n/a	457	4.5	4.02	6.65
gts	50	-41	11	22	2206	4.76	4.02	6.98
gtm	47	-45	2	21	1365	4.78	4.02	6.98
gtm	52	-29	-1	21	2788	4.98	4.02	7.6

Table S49 *Coordinates of different activated cortical regions and the number of voxel, Brand1 male vs baseline* n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	Voxel	*t* value	min	max
Left								
gfd	-5	4	57	6	3450	5.05	4.30	6.91
gfi	-47	7	33	44	2216	4.9	4.30	6.96
gtm	-36	-48	21	39	800	4.84	4.30	6.35
ant ins	-32	26	9	44	1750	4.89	4.30	6.51
gtm	-53	-37	2	21	582	4.63	4.30	5.76
Right								
gfd	11	1	57	6	1103	4.8	4.30	5.95

gfm	31	12	57	6	445	4.9	4.30	6.09
gfi	-47	7	33	44	1794	4.84	4.30	6.39
pcu	26	-64	33	19	781	4.75	4.30	5.87
gtm	41	-44	21	39	66	4.63	4.30	5.42
ant ins	38	21	9	44	1180	4.9	4.30	6.60

Table S50 *Coordinates of different activated cortical regions and the number of voxel, Brand1 female vs baseline*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	Voxel	*t* value	min	Max
Left								
gprc	-36	-8	55	4	3033	4.86	4.10	6.60
gfd	-4	0	54	6	569	5.72	4.11	9.19
lpi	-45	-41	49	40	38	4.22	4.10	4.50
pcu	-26	-65	43	19	1854	4.83	4.1	7.1
cu	-8	-78	36	19	524	4.63	4.1	6.3
gfm	-46	4	29	9	2362	4.79	4.10	6.51
gfm	-32	45	25	9	529	4.49	4.10	5.88
ant ins	-37	21	4	45	1051	4.61	4.10	5.98
Right								
gprc	34	-10	54	4	2267	4.94	4.10	7.29
gfd	4	0	54	6	729	6.80	4.96	9.11
lpi	40	-43	49	40	1435	4.78	4.10	6.45
pcu	29	-60	43	19	1978	4.9	4.1	6.7
gfm	36	37	36	9	883	4.46	4.10	5.42
gfm	47	13	34	9	2310	4.98	4.10	7.46
gts	59	-40	11	22	315	4.48	4.11	5.36
ant ins	45	16	2	45	1393	4.77	4.10	6.86
gtm	50	-59	-2	21	1517	5.11	4.1	7.26

Table S51 *Coordinates of different activated cortical regions and the number of voxel, Brand2 male vs baseline*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	Voxel	*t* value	min	max
Left								

gfd	-2	2	58	6	2550	5.13	4.22	7.13
ant ins	-48	22	4	n/a	537	4.67	4.22	5.50
gtm	-50	-33	0	21	212	4.74	4.22	6.07
Right								
gprc	43	4	35	6	473	4.76	4.22	6.15
ant ins	43	19	4	n/a	251	4.47	4.22	5.13

Table S52 *Coordinates of different activated cortical regions and the number of voxel, Brand2 female vs baseline*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	Voxel	*t* value	min	max
Left								
gfs	-10	24	50	8	707	6.07	5.11	8.20
pcu	-1	-66	50	7	692	6.8	5.12	9.56
pcu	-8	-78	41	7	n/a	n/a	n/a	n/a
gc	-2	14	42	32	n/a	n/a	n/a	n/a
gfd	-6	43	42	8	n/a	n/a	n/a	n/a
lpi	-33	-48	42	40	n/a	n/a	n/a	n/a
gprc	-53	5	37	4	n/a	n/a	n/a	n/a
pu	-21	4	12	n/a	221	7.49	7.08	8.49
antins	-38	20	9	n/a	2371	8.47	7.08	12.58
cu	-7	-80	36	n/a	1261	8.03	7.08	10.42
gtm	-57	-51	7	21	881	8.08	7.08	9.82
Right								
pcu	1	-66	50	7	692	6.8	5.12	9.56
pcu	15	-71	41	7	n/a	n/a	n/a	n/a
gc	6	13	42	32	n/a	n/a	n/a	n/a
gprc	46	1	37	4	n/a	n/a	n/a	n/a
gfm	36	30	31	9	n/a	n/a	n/a	n/a
nc	17	-2	22	n/a	563	7.66	7.08	10.19
ant ins	41	18	4	n/a	2322	8.67	7.08	12.58
gtm	48	-39	9	21	1304	8.37	7.08	11.44
gtm	51	-59	1	21	1590	8.23	7.08	11.33

Table S53 *Coordinates of different activated cortical regions and the number of voxel, Brand3 male vs baseline*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, p-value p<1.175e-09

Loc	x	y	z	BA	voxel	*t* value	min	max
Left								
gfd	-6	6	55	6	5511	6.05	3.79	9.16

gprc	-31	-8	55	4	4026	5.21	3.79	9.14
pcu	-3	-68	51	19	1371	4.42	3.79	5.71
gc	-1	-4	30	24	950	4.18	3.79	5.18
pu	-20	-1	11	n/a	3002	4.73	3.79	7.51
ant ins	-33	24	7	n/a	4000	4.95	3.79	7.11
gtm	-52	-37	0	21	2926	4.93	3.79	7.50
gtm	-37	-3	-20	21	1206	5.32	3.79	9.02
Right								
gfd	10	8	55	6	4886	5.50	3.79	9.46
gprc	30	-7	55	4	4591	5.51	3.79	7.97
gc	5	-4	30	24	944	4.18	3.79	5.18
pu	23	0	11	n/a	2851	4.59	3.79	6.92
ant ins	42	23	7	n/a	3739	4.94	3.79	7.11
gtm	47	-38	0	21	4580	4.81	3.79	7.97
gtm	39	0	-20	21	346	4.30	3.79	5.87

Table S54 *Coordinates of different activated cortical regions and the number of voxel, Brand3 female vs baseline*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Reading behavior	**Brand1**	**Brand2**	**Brand3**
each	3	2	1
each 2/3	9	12	6
seldom	19	17	24
altogether	31	31	31

Table S55 *Analysis of the reading behaviour of the three brands*

Imagination	**Brand1**	**Brand2**	**Brand3**
Clear	18	29	22
Unclear	3	1	0
Rest	10	1	9
Altogether	31	31	31
Chi2	*p-value*	*with Yates*	*Fisher-Test*
B1 clear>B2 clear	0,001	0,003	0,002
B1 clear>B3 clear	0,29	0,43	0,43
B3 clear>B2 clear	0,02	0,05	0,04

Table 56 *Analysis of the imagination of the three brands*

Attractiveness	**Brand1**	**Brand2**	**Brand3**
attractive	13	17	13
not attractive	7	1	5
rest	11	13	13

altogether	31	31	31
Chi2	*p-value*	*with Yates*	*Fisher-Test*
B1 attr.>B2 attr.	0,3	0,45	0,45
B1 attr.>B3 attr.	1	1	1
B3 attr.>B2 attr.	0,3	0,45	0,45
B1 not attr.>B2 not attr.	0,02	0,06	0,05
B1 not attr.>B3 not attr.	0,52	0,75	0,75
B3 not attr.>B2 not attr.	0,08	0,19	0,19

Table S57 *Analysis of the attractiveness of the three brands*

Contents		**Brand1**	**Brand2**	**Brand3**
Accurate		236	294	165
not accurate		130	54	152
Rest		161	179	210
altogether		527	527	527
Chi2		*p-value*	*with Yates*	*Fisher-Test*
B1>B2	accurate	0,00035	0,00045	0,00044
B1>B3	accurate	0,00001	0,00001	0,00001
B3>B2	accurate	0,000001	0,000001	0,000001
B1>B2	not accurate	0,000001	0,000001	0,000001
B1>B3	not accurate	0,016	0,019	0,019
B3>B2	not accurate	0,000001	0,000001	0,000001

Table S58 *Analysis of the contents of the three brands.*

Brand1		Young	middle	elderly
Accurate		55	64	108
not accurate		64	46	20
Rest		68	60	42
altogether		187	170	170
Chi2		*p-Wert*	*with Yates*	*Fisher-Test*
young>middle	accurate	0,09	0,12	0,11
young>elderly	accurate	0,000001	0,000001	0,000001
elderly>middle	accurate	0,000001	0,000001	0,000001
young>middle	not accurate	0,14	0,18	0,17
young>elderly	not accurate	0,000001	0,000001	0,000001
elderly>middle	not accurate	0,0004	0,0006	0,0005

Table S59 *Evaluation of the contents of Brand1 among the age classes*

Brand2	Young	middle	elderly
Accurate	121	87	87
not accurate	18	11	25
Rest	48	72	58

Altogether		187	170	170
Chi2		*p-Wert*	*with Yates*	*Fisher-Test*
young>middle	accurate	0,01	0,01	0,01
young>elderly	accurate	0,01	0,01	0,01
elderly>middle	accurate	1	1	1
young>middle	not accurate	0,27	0,37	0,33
young>elderly	not accurate	0,14	0,19	0,15
elderly>middle	not accurate	0,014	0,02	0,02

Table S60 *Evaluation of the contents of Brand2 among the age classes*

Brand3		Young	middle	elderly
Accurate		57	31	77
not accurate		55	63	34
Rest		75	76	59
Altogether		187	170	170
Chi2		*p-Wert*	*with Yates*	*Fisher-Test*
young>middle	accurate	0,007	0,01	0,009
young>elderly	accurate	0,004	0,005	0,004
elderly>middle	accurate	0,000001	0,000001	0,000001
young>middle	not accurate	0,13	0,15	0,14
young>elderly	not accurate	0,04	0,05	0,05
elderly>middle	not accurate	0,0005	0,0008	0,0007

Table S61 *Evaluation of the contents of Brand3 among the age classes*

Loc	**x**	**y**	**z**	**BA**	**Voxel**	***t* value**	**min**	**max**
Left								
gprc	-19	-35	57	4	157	4.40	3.93	5.67
lps	-22	-54	57	7	534	4.6	3.92	6.49
gfm	-23	35	46	8	194	4.49	3.92	6.05
gc	-9	-25	43	31	229	4.33	3.92	5.24
cu	-7	-80	35	19	413	4.40	3.92	5.33
cu	-2	-73	23	18	228	4.39	3.92	5.67
gc	-3	48	21	30	357	4.45	3.92	5.83
Right								
gts	57	-33	14	22	175	4.35	3.92	5.59
gsm	44	-59	32	39	386	4.44	3.92	5.42

Table S62 *Coordinates of different activated cortical regions and the number of voxel, Brand3 male vs female*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	**x**	**y**	**z**	**BA**	**Voxel**	***t* value**	**min**	**max**
Left								
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Right								
gc	8	30	-6	24	143	5.21	4.88	6.06

Table S63 *Coordinates of different activated cortical regions and the number of voxel, Brand1 male vs female* n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	Voxel	*t* value	min	max
Left								
cu	-8	-77	33	19	178	4.17	3.87	5.07
gfm	-25	29	32	9	1365	4.68	3.86	7.56
gts	-50	8	-2	22	369	4.64	3.86	6.60
pcu	-7	-57	34	7	100	4.16	3.86	5.00
Right								
gc	7	-4	46	24	225	4.29	3.86	5.34
gc	21	20	41	32	290	4.48	3.86	5.62
lpi	52	-37	41	40	755	4.74	3.87	6.64
gfm	26	46	19	46	652	4.35	3.86	6.69
gfi	49	37	19	45	528	4.42	3.86	6.69
gts	58	-33	13	22	314	4.41	3.86	5.66

Table S64 *Coordinates of different activated cortical regions and the number of voxel, Brand2 male vs female* n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	Voxel	*t* value	min	max
Left								
gtm	-33	-76	21	19	541	4.41	4.03	5.90
gfi	-38	31	22	45	152	4.45	4.03	5.82
gtm	-41	-60	7	21	851	5.03	4.03	7.58
gtm	-59	-27	-15	21	349	5.13	4.03	7.74
Right								
gfi	46	30	22	45	91	4.54	4.03	5.91
gtm	38	-66	7	21	199	4.45	4.03	6.10

Table S65 *Coordinates of different activated cortical regions and the number of voxel, Brand3 elderly vs middle* n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	Voxel	*t* value	min	max
Left								
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Right								
gc	10	-39	25	23	270	4.65	3.94	6.37
gtm	37	-72	23	39	147	4.45	3.94	5.96

Table S66 *Coordinates of different activated cortical regions and the number of voxel, Brand3 elderly vs young* n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	**x**	**y**	**z**	**BA**	**Voxel**	***t* value**	**min**	**max**
Left								
Ant ins	-26	29	10	n/a	118	4.64	3.94	6.38
gtm	-37	-40	4	21	170	4.56	3.94	6.00
Right								
gc	10	20	39	32	203	4.54	3.93	6.02
pcu	18	-47	34	7	106	4.44	3.93	5.74
gfm	42	47	28	9	605	4.45	3.93	5.69
nc	13	10	16	n/a	197	4.23	3.94	5.49

Table S67*Coordinates of different activated cortical regions and the number of voxel, Brand3 young vs elderly* n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	**x**	**y**	**z**	**BA**	**Voxel**	***t* value**	**min**	**max**
Left								
gc	-1	20	43	32	534	3.82	3.37	5.03
gtm	-36	-77	20	19	2372	4.75	3.37	7.04
Ant ins	-24	25	11	n/a	923	3.85	3.37	5.15
pu	-25	12	6	n/a	415	4.02	3.37	5.66
Right								
gc	10	21	43	32	2286	4.99	3.37	8.56
pcu	20	-52	40	7	1004	4.17	3.37	8.03
nc	13	10	15	n/a	845	3.86	3.37	5.26
gtm	42	-39	6	21	651	3.85	3.37	5.65
gtm	46	-47	-9	21	2503	4.94	3.37	9.73

Table S68*Coordinates of different activated cortical regions and the number of voxel, Brand3 young vs middle* n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	**x**	**y**	**z**	**BA**	**Voxel**	***t* value**	**min**	**max**
Left								
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Right								
lpi	53	-35	49	40	165	5.19	4.27	6.42
pcu	25	-72	40	19	232	4.71	4.27	5.64
gsm	39	-44	34	40	252	4.95	4.27	7.02
Ant ins	38	20	-5	n/a	80	4.77	4.27	5.86
gfi	45	23	-13	47	331	4.71	4.26	5.86

Table S69 *Coordinates of different activated cortical regions and the number of voxel, Brand2 elderly vs young*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	Voxel	*t* value	min	max
Left								
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Right								
lpi	51	-44	41	40	344	5.12	4.37	7.06
gts	53	-3	6	22	95	4.91	4.37	6.30
gtm	65	-17	-3	21	178	4.73	4.37	5.43

Table S70*Coordinates of different activated cortical regions and the number of voxel, Brand2 middle vs young*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	Voxel	*t* value	min	max
Left								
gtm	-10	-86	-1	18	135	4.62	4.26	5.32
Right								
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table S71*Coordinates of different activated cortical regions and the number of voxel, Brand2 young vs elderly*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	Voxel	*t* value	min	max
Left								
gtm	-47	-37	-14	21	864	5.11	4.37	6.87
Right								
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table S4*Coordinates of different activated cortical regions and the number of voxel, Brand2 young vs middle*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	x	y	z	BA	Voxel	*t* value	min	max
Left								
lpi	-29	-48	45	40	190	4.01	3.67	4.67

gtm	-50	-48	22	19	210	4.28	3.67	6.07
Ant ins	-38	25	7	n/a	158	3.95	3.67	4.65
gc	-9	-29	33	31	n/a	n/a	n/a	n/a
pcu	-26	-52	52	7	n/a	n/a	n/a	n/a
Right								
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table S72*Coordinates of different activated cortical regions and the number of voxel, Brand1 young vs middle*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.

Loc	**x**	**y**	**z**	**BA**	**Voxel**	***t* value**	**min**	**max**
Left								
gtm	-36	0	-20	21	303	4.5	3.92	5.91
Right								
gtm	42	1	-20	21	60	4.47	3.93	5.85

Table S73 *Coordinates of different activated cortical regions and the number of voxel, Brand3 female vs male*
n/a means not applicable, No.Voxel = number of voxel, BA= Brodmann area, FDR = q: 0.001.