The influence of motivation on attention and conscious visual perception.

An examination with lateralized EEG power spectra.

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Content

Abstract

The goal of this study was to examine the influence of motivation on attention and conscious visual perception. Motivation was manipulated by the possibility of a monetary reward that depended on performance. To examine attention and conscious visual perception a combination of a Posner cueing paradigm with backward masking was used. In total 23 participants participated. Electroencephalogram (EEG) measurements were used to examine attention by α-activity. Lateralized power spectra (LPS) were used to analyse the EEG measurements by comparing α-activity for the ipsilateral and contralateral hemispheres. It was expected that participants in the motivation group would perform better than participants in the control group due to a better allocation of attention. Analysis of the data showed that extrinsic motivation did not have a positive influence on conscious visual perception. Analysis of the EEG measurements showed that participants actively directed their attention, but extrinsic motivation did not have an influence on endogenous attention. A recommendation for future research could be to increase self-efficacy of participants by enabling more participants to win money.

Samenvatting

Het doel van deze studie was om de invloed van motivatie op aandacht en bewuste visuele perceptie te onderzoeken. Motivatie werd gemanipuleerd door de mogelijkheid om geld te winnen afhankelijk van de prestatie. Om aandacht en bewuste visuele perceptie te onderzoeken werd gebruik gemaakt van een Posner cueing paradigm gecombineerd met backward masking. In totaal werkten 23 participanten mee aan dit onderzoek. Elektro-encefalogram (EEG) metingen werden gebruikt om aandacht te meten door middel van α-activiteit. Lateralized power spectra (LPS) werden gebruikt om de EEG metingen te analyseren door het vergelijken van α-activiteit voor de ipsilaterale en contralaterale hemisferen. Verwacht werd dat de participanten in de motivatie groep betere scores behaalden dan de participanten in de controle groep door het beter richten van aandacht. Analyse van de data liet zien dat motivatie niet een positieve invloed had op bewuste visuele perceptie. Analyses van de EEG metingen lieten zien dat participanten actief aandacht richtten tijdens de taak, maar extrinsieke motivatie had geen invloed op de endogene aandacht. Een aanbeveling voor toekomstig onderzoek zou kunnen zijn om de self-efficacy van de participanten te verhogen door het voor meer participanten mogelijk te maken om geld te winnen.

Introduction

In this paper the influence of motivation on attention and its role for conscious visual perception will be examined. Attention and conscious visual perception seem to be influenced by motivation.

The next paragraph will give a brief overview of the used definitions of attention, conscious visual perception and motivation and the relation between these concepts. This paper will then describe two methods for the examination of attention and conscious visual perception. Hereafter, this paper will justify the use of EEG measurements and useful methods to analyse these EEG measurements.

Attention, conscious visual perception and motivation

A way to describe visual attention is as the concept of a spotlight that can be directed independent of to where the eyes are fixated (Posner, Snyder & Davidson, 1980). This spotlight can be influenced by exogenous or endogenous factors. Attention is a limited cognitive resource and facilitates processing of the stimuli in the visual field where attention is directed to. The perception of visual stimuli is therefore measurably influenced by consciously directing one's attention (Posner, Snyder & Davidson, 1980). Top-down selective attention enhances, as noted before, the processing of relevant stimuli but also suppresses the processing of irrelevant or disturbing stimuli (Banerjee, Frey, Molholm & Foxe, 2015). It also has been argued that external and internal noise can be reduced by attention, which inhibits distraction (Klimesch, 2011). Therefore, actively directing attention to a stimulus triggers enhancement and suppression, which increases the ability to report the presence of the stimulus (Deheane et al, 2006). This means that conscious visual perception is positively influenced by actively allocating attention. The relation between attention and conscious awareness was also described by Lamme (2003). He argues that many sensory inputs reach the brain, but to be consciously aware of them attentive selection has to be carried out. This makes it possible to report about these sensory inputs, which means that you are consciously aware of these inputs.

As noted by Posner (1980), attention is influenced by exogenous or endogenous factors. These endogenous factors could be inner goals and wishes (Jonides, 1980). Another example of endogenous attention is when a person attends to a specific spatial location via verbal instructions or via the high chance of appearance of the stimulus at this point (Chica & Lupiáñez, 2009).

Research shows that endogenous attention is influenced by intrinsic motivation (Banerjee, Frey, Molholm & Foxe, 2015). Intrinsic motivation comes from the person itself, and can be described as an endogenous factor. Research of Banerjee et al. (2015) showed that participants performed better on a visuospatial task when the targets were more interesting. Intrinsic motivation thus influences endogenous attention. Alongside intrinsic motivation, extrinsic motivation also has an influence on the allocation of attention. Extrinsic motivation can be described as doing something because of a pleasant or a separable outcome. Examples of this type of motivation are reward or punishment (Ryan & Deci, 2000). Research of Failing & Theeuwes (2016) showed that stimuli associated with monetary pay-out became more salient, probably because of a dopamine release. This release made it more likely that the salient stimuli would attract attention (Failing & Theeuwes, 2016). This means that extrinsic motivation has an influence on exogenous attention.

Above mentioned studies of Banerjee et al. (2015) and Failing & Theeuwes (2016) imply that motivation has an influence on attention. According to research of Deheane et al. (2006) and Lamme (2003), attention has an influence on conscious visual awareness. Therefore, it can be argued that motivation enhances conscious visual perception.

Backward masking and Posner Cueing paradigm

A useful method to influence conscious visual perception is backward masking (Breitmeyer, 2014). This method prevents an afterimage to occur by replacing stimuli by junk material. This means that the stimuli have been detected by actively directing attention to the stimuli (Mathewson, Gratton, Fabiani, Beck & Ro, 2009; Kaltwasser, et al., 2014). This implies that attention is an important factor in the effectiveness in masking. As a result, it could be argued that attention plays an important factor in conscious visual perception (Boyer & Ro, 2007).

Another important paradigm since the 1980s to examine attentional processes is the Posner cueing paradigm (Posner, 1980). In this paradigm participants have to fixate their eyes on a point. Attention is focused on the left or right of this point, dependent on which side the cue pointed to. These cues were followed by a target stimulus, which was shown for different short milliseconds. Participants had to respond to these stimuli (Posner, 1980). As a result of the short appearance of the stimuli, participants had to actively focus attention. Therefore, this paradigm has frequently been used to examine endogenous attention (Jonides, 1981).

The combination of the Posner cueing paradigm and backward masking thus provides a way to examine endogenous attention and visual awareness. This combination of the

paradigm and masking can give more insight in this relation between consciousness and attention.

EEG measurements

In combination with the Posner cueing paradigm, EEG measurements are often used to examine the neural mechanisms that underlie the allocation of attention. This can be done by looking at activity in the α-band. Activity in this frequency band is related to attention. This activity reflects suppression and selection (Klimesch, 2012). Enhanced α-band activity in parietal cortical areas ipsilateral to the attended side of the visual field is caused by shifting attention to the cue (Cosmelli et al., 2011).

A method used to analyse EEG data are the lateralized power spectra (LPS). This method was first proposed by Van der Lubbe & Utzerath (2013) and offers a number of advantages over the use of earlier used methods such as event-related potentials (ERP). The method is based on wavelet analyses conducted on the raw EEG and measures both evoked and induced activity (Hermann et al., 2005). Induced activity is of special interest because attention is likely not directed at the same moment on every trial. This implies that the oscillations are not visible after performing an averaging procedure (Hermann et al., 2005).

Another advantage is the use of a double-subtraction in the computation of LPS, thus combining measurements for the left and right cue locations. This way of computing the LPS corrects for hemispherical differences and reveals changes in the allocation of attention (Van der Lubbe & Utzerath, 2013). This means that the use of LPS can give more insight in the reaction of the brain on the stimulus and gives more information about changes in attention allocation. Together with a focus on the α-band differences in attention allocation and differences in different brain areas can be examined.

Research question

As noted earlier, in this paper the influence of motivation on attention and its role for conscious visual perception will be examined. Although research on endogenous attention has been done frequently and Posner (1980) stressed that exogenous factors have influence on attention, no research has been done to assess the relation between endogenous attention and extrinsic motivation. This raises the question if a relation between extrinsic motivation and endogenous attention exists. Considering that no research has been done to examine this relation and the relationship between attention and conscious visual perception, it is therefore of interest to examine the influence of extrinsic motivation on endogenous attention and

indirectly on conscious visual perception. To examine if extrinsic motivation has an influence on endogenous attention, participants in this paper will receive a reward when they perform fast and accurately in the experiment. To examine endogenous attention and conscious visual perception a combination of backward masking with the Posner cueing paradigm will be used. To analyse the underlying mechanisms of attention, EEG measurements will be used. These measures can give more insight in suppression and selection of attention during a visuospatial task. Because LPS offers some advantages for analysing the EEG data, this method will be used to examine changes of activity in the α-band.

As noted earlier, an indicator for attention is increased α-activity ipsilateral of where the stimulus appeared. This is due to suppression and selection of attention (Klimesch, 2012). Research of Deheane et al. (2006) and Lamme (2003) showed that attention does have a positive influence on conscious visual perception. This results in a higher percentage of correct answers. Based on research of Banerjee et al. (2015) and Failing & Theeuwes (2016) it can be implied that motivation enhances attention and therefore conscious visual perception. People with more extrinsic motivation are more efficiently in the allocation in attention. This will be expected to be expressed in more alpha power ipsilateral than contralateral (Cosmelli et al., 2011). Therefore, conscious visual perception is positively influenced by extrinsic motivation. For that reason, it will be expected that people with a higher extrinsic motivation have the ability to detect stimuli with a lower stimulus onset asynchrony (SOA) than people who are less motivated. This will be expected to result in a lower average reaction time and higher percentage correct answers for the participants who are more extrinsically motivated than participants who are less extrinsically motivated.

Method

Participants

Twenty three participants, mainly students from the University of Twente, with normal or corrected-to-normal vision and with no history of neurological disease participated in the experiment. Handedness with use of Annett's Handedness Inventory, color-blindness, eye dominance, and visual acuity with use of the Freiburg visual acuity test was assessed (Annett, 1970; Ishihara, 1976; Bach, 1996). Criterion for the color-blindness test was that the participants had to pass the test. For the Freiburg visual acuity test a criterion of an average score of both eyes above 1 was set. The handedness test resulted in 19 right-handed participants, 3 left-handed, and 1 ambidextrous participant. Eye dominance resulted in 90.9% left eye dominance and 49.1% right eye dominance under all participants. In total 14

participants were female (M = 20.7, SD = 1,5, ranging from 18 to 23 years), and 9 participants were male (M = 23, SD = 5.6, ranging from 19 to 37 years). The participants were randomly assigned to either the motivation or control group. The employed procedures were approved by the local ethics committee at the Faculty of Behavioral Sciences of the University of Twente.

Task and procedure

Motivation was influenced by dividing the participants in two groups. The motivation group received a reward, the control group not. The best participant in the motivation group won €30, -, the second best €20, - and the third won €10, -. Participants were before the experiment instructed to answer as accurately and fast as possible. Especially for the motivation group, emphasis was put on answering as accurately as possible.

For the experiment a variation of the Posner cueing task (Posner, 1980) was used. The default display consisted of a central white fixation point with a diameter of 0.3 cm on a black background and two open circles on the left and the right side of the screen. The distance between the fixation point and the open circles was 7.5 cm and the distance between the circles was 15.3 cm. This first default screen was shown for 700 ms. To mark the beginning of a trial, the fixation point was slightly enlarged to 0.5 cm for 200 ms. Participants were instructed to direct their eyes towards the fixation point. After the fixation display was shown for 600 ms, another display with two triangle-shaped cues (one blue, other yellow), pointing outwards to the left or the right side of the screen, was shown. This was displayed for 600 ms. Whether the left or right triangle was blue or yellow was randomly determined and either one of the two colours functioned as the side to where attention had to be focused. Both colours were counterbalanced over the participants. After showing the cue, the fixation display was shown for another 800 ms. After these 800 ms, a target was presented in the left or right circle for 500 ms. A mask was shown for 500 ms after the appearance of the target. After the mask, the fixation display was shown for another 900 ms. A schematic representation of the sequence in a trial can be found below in figure 1.

The targets were striped black-and-white, either horizontally or vertically. When a horizontally striped target appeared the participants were asked to press the left CTRL-button, a vertically striped target required a push on the right CTRL-button. The participants were instructed to press one of the two buttons when they had difficulties to determine which stimulus had appeared. The responses had to be made as fast and accurately as possible. When

a faulty response was given, a red dot was shown at the end of the trial. This delayed the trial with 500 ms.

The task consisted of 896 trials, which were divided into eight blocks of 112 trials. In each block of trials the SOAs of the target were: 7 ms, 14 ms, 21 ms, 28 ms, 35 ms, 42 ms, 49 ms, 63 ms, 83 ms, 111 ms, 139 ms, 174 ms, 208 ms, 278 ms. These 14 different SOAs were shown eight times per block and it was randomly determined in which order they appeared. Between the different blocks with trials the participants had a pause of 1 minute, the text shown on the screen was: "1 minuut rust". When a new block started a text with which block started was displayed for 5000 ms on the screen. At the end of the experiment a display with the text "Einde van het experiment" was shown for 3000 ms. In total, execution of the task took approximately 90 minutes.

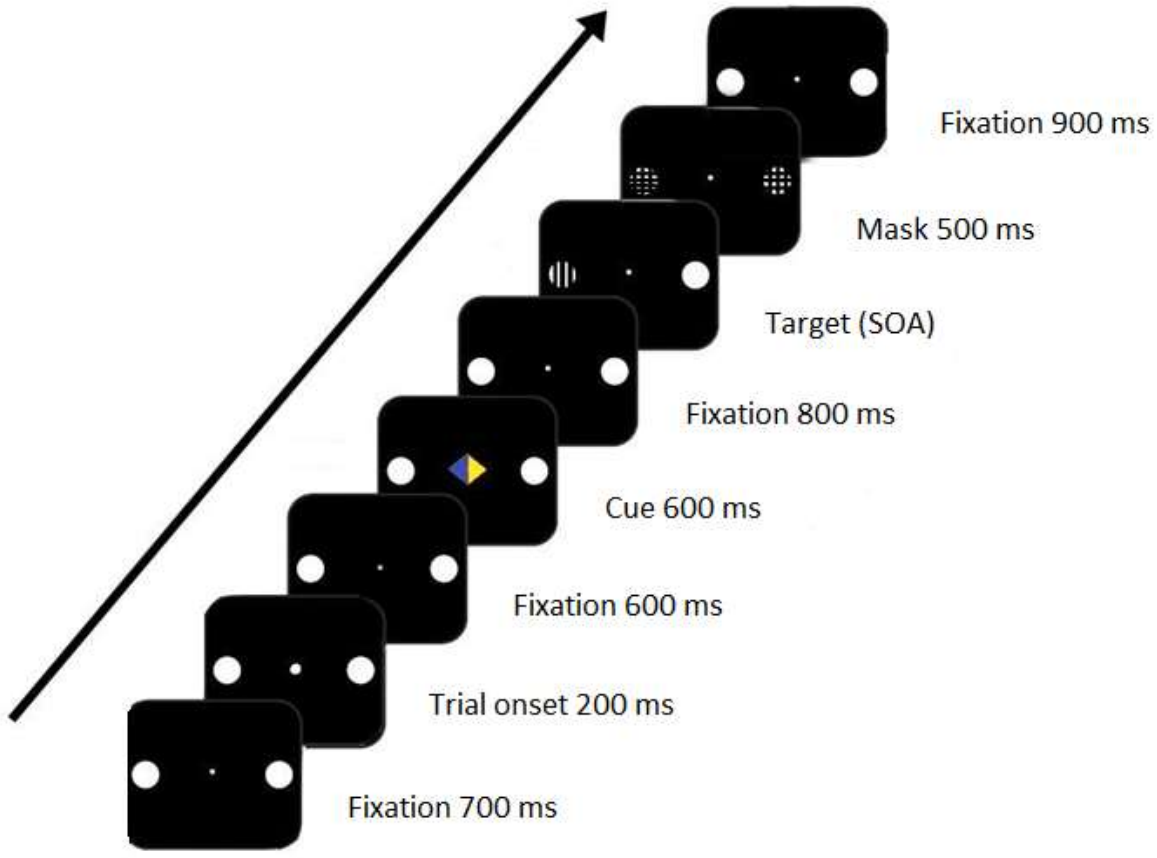

Figure 1. Schematic representations of the sequence of events in a trial.

Apparatus and EEG recordings

Participants sat on an office chair with their eyes at approximately 45 cm above the table, in a darkened room at approximately 85 cm in front of a 24 inch screen. The stimuli were

displayed using Presentation software (Neurobehavioral Systems, Inc., 2012) installed on a separate computer. The used keyboard for the CTRL buttons was a QWERTY keyboard.

Active Ag/AgCl electrodes were placed at 32 locations in an elastic cap (Braincap, Brainproducts GmbH) at the following positions: AF7, AFz, AF8, F7, F3, Fz, F4, F8, FC5, FC1, FC2, FC6, T7, T8, C3, Cz, C4, CP1, CP2, P7, P3, Pz, P4, P8, PO7, PO3, POz, PO4, PO8, O1, Oz, O2. These positions are marked red in figure 2 below. The horizontal and vertical electro-oculogram (hEOG and vEOG) were recorded by placing electrodes above and below the left eye and at the outer canthi of both eyes. A ground electrode for the hEOG was placed above the right eye. The EOG were recorded together with the EEG. With use of electrode gel and standard procedures to improve conductivity, the resistance could be kept below 10 kΩ. A 64 channels ActiCHamp amplifier (Brain Products GmbH) was used to amplify the EEG and EOG. The EEG, EOG, and task related events such as responses and stimulus onset were recorded together with BrainVision Recorder (Brain Products GmbH), installed on the separate computer. Signals were sampled at a rate of 500 Hz with the following filters: low cut off filter = 0.016 Hz, high cut off filter = 32 H, notch filter = 50 Hz, and time constant of 10

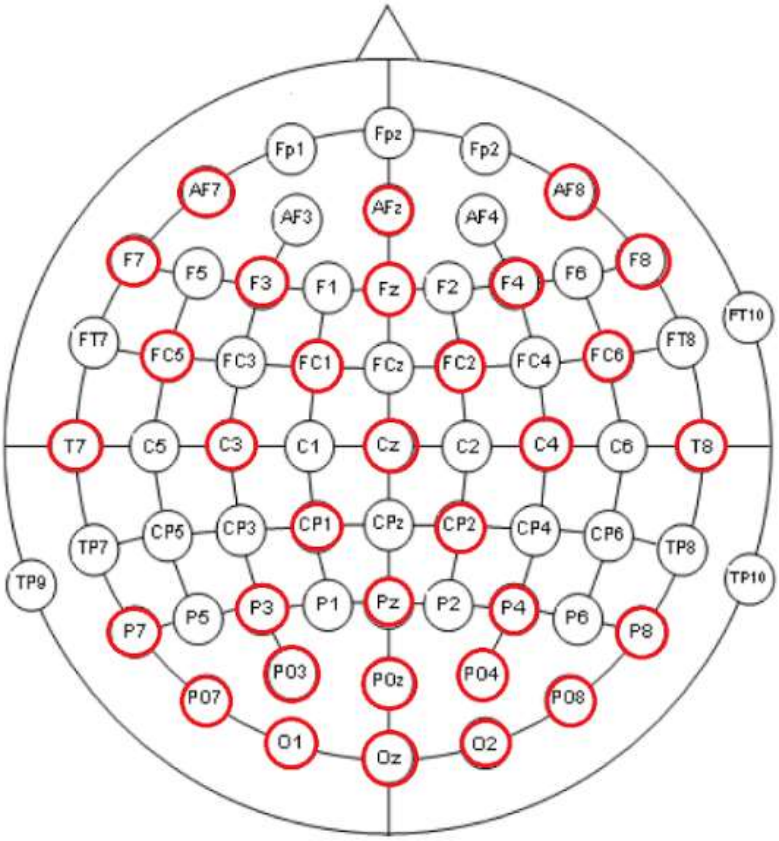

Figure 2. Schematic representation of the used electrodes.

Data processing and analysis

Data processing was carried out with Brain Vision Analyzer 2.1 (Brain Products GmbH, 2012). The data were first partitioned in segments from -1000 to 3400 ms relative to cue onset. Amplitudes on the hEOG and vEOG channels exceeding +/- 40 µV marked horizontal and vertical eye movements. Trials in which eye movements were detected in the cue-target interval were excluded from further analyses. This was to avoid behavioural measures which may be due to overt rather than covert orienting. In the cue-target interval all EEG-segments with artefacts were removed. The criteria used were: a gradient criterion of 100 µV, min-max criterion of +/-150 µV and a low activity criterion of 1 µV. To correct EEG for eye movements, a regression coefficient was measured between EOG and EEG.

The resulting data was used to determine the reaction time (RT) and proportion of correct answers (PC). To check for the influence of motivation on these factors a repeated measures ANOVA was carried out. All statistical analyses were done using IBM SPSS Statistics version 21 (IBM Corporation). Next to RT and PC the 75% correct answers per SOA was calculated. This was done by setting off the RT per participant against the different SOAs. To check for differences between the groups an independent samples t-test was carried out.

Alongside RT and PC a Complex Morlet wavelet analysis was carried out on the trials on all raw EEG channels. The relevant frequency bands for the analysis were α_1 and α_2 with a central frequency of 8,9/11,7 Hz and with upper and lower border at 7,2/9,4 Hz and 10,7/14,00 Hz. On basis of these values, LPS were computed for all four relevant electrode pairs (P7/8, PO7/8, PO3/4, O1/2) depending on the direction of the cue. These were averaged after wavelet analysis across the trials to get one value per participant for each 100 ms time window in the cue-target interval. The LPS were calculated according to this formula (Van der Lubbe & Utzerath, 2013):

$$\mathrm{LPS}(\omega_p)_t = ((\left(\text{left cues } \frac{(\omega_p(\mathrm{PO7}) - \omega_p(\mathrm{PO8}))}{(\omega_p(\mathrm{PO7}) + \omega_p(\mathrm{PO8}))}\right) + \left(right\ cues\ \frac{(\omega_p(\mathrm{PO8}) - \omega_p(\mathrm{PO7}))}{(\omega_p(\mathrm{PO8}) + \omega_p(\mathrm{PO7}))}\right))/2$$

Values in the resulting LPS vary between -1 and +1. A negative value indicates higher relative α power in the contralateral hemisphere to the cued side than ipsilateral. Positive values indicate the opposite pattern, higher power values above the ipsilateral side of the cue than above the contralateral side. A value of zero indicates that there are no hemispherical differences (Van der Lubbe & Utzerath, 2013).

On all results a two-tailed t-test was performed between 0 and 1400 ms after cue onset. These t-tests were performed to determine per cue condition whether activity deviated from

zero. Due to the high amount of the to-be-performed t-tests, a Bonferoni-correction was made to account for the heightened risk of Type-I errors. The formula for this correction is: $p<\sqrt{\alpha} \div ((time\ windows-1)\times eletrode\ pairs)$, which was used by Van der Lubbe in earlier work (Van der Lubbe, Bundt, & Abrahamse, 2014). The chosen significance level was α = 0.05 and the measurements were taken in 14 time windows for 4 electrode pairs in two alpha bands. The significance criterion for the analysis was p = 0.026 for two successive time windows.

Results

Behavioral measures

The next paragraphs give an overview of the analyses of the reaction time and percentage correct answers. In the next two paragraphs the results of the analyses of the reaction time will be discussed. To determine if differences between the motivation and control group were present in the performance of the task, a repeated measures ANOVA was used to analyse the 14 different SOAs for the motivation and control group. Figure 3 shows for the two groups the percentage correct answers per SOA. This figure suggests that the motivation group had more answers correct than the control group for the first 7 SOAs (14, 21, 28, 35, 42, 49, 63 ms). The 5 SOAs hereafter (83, 11, 139, 173 ms) it appears that the control group had a higher mean percentage correct answers. The mean percentage correct for the motivation group was 76.58% and for the control group 75.86%. The repeated measures ANOVA showed that the differences between the groups were not significant ($F(1, 22) = 1.4$, $p = 0.246$). This means that participants in the motivation group did not gave more correct answers than the participants in the control group.

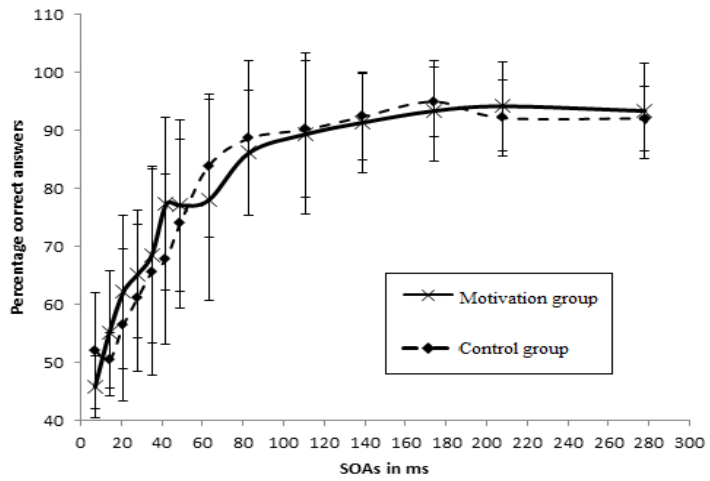

Figure 3. Percentage correct answers in percent per different SOA in milliseconds for the motivation and control group.

Also the 75 % percentage correct answers per SOA between the motivational and control group was examined. It appears that the average SOA per 75% correct answers was reached earlier for the control group (M = 47.40, SD = 15.53) than for the motivational group (M = 52.18, SD = 29.12). According to Figure 4 below, it seems that the results for the motivation group are more spread out than the results of the control group. The found differences were found to be not significant (t(22) = 0.961, p = 0.347). This means that participants in the control group did not reach 75% correct answers at a lower SOA than participants in the motivation group and that the results for the motivation group were not more dispersed than for the control group.

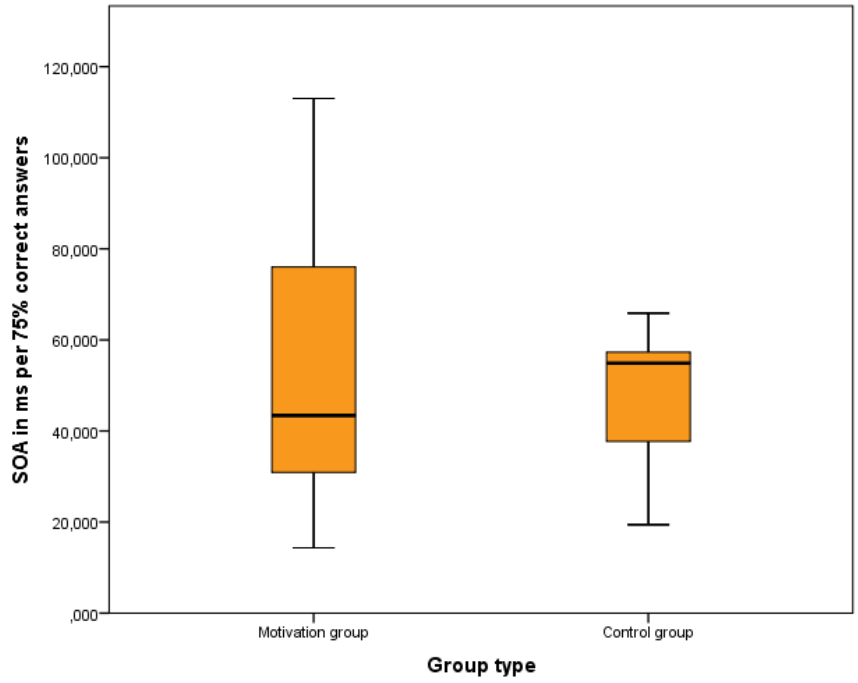

Figure 4. A boxplot of the dispersion of the data divided in motivation and control group.

To check for the influence of motivation on the reaction times, also a repeated measures ANOVA was carried out for the 14 different SOAs. Figure 5 below shows the mean reaction times for the motivation and control group per SOA. As a result, it appears that the control group had a lower reaction per the trial than the motivation group. The mean reaction time for the control group was a mean reaction time of 899.3 ms with a standard deviation of 55.9 and the motivation group had a mean of 955.6 ms with a standard deviation of 58.3. The repeated measures ANOVA showed that the differences between the groups were not significant ($F(1, 22) = 1.2$, $p = 0.322$). This means that the participants in the control group did not respond faster in the task than the participants in the motivation group.

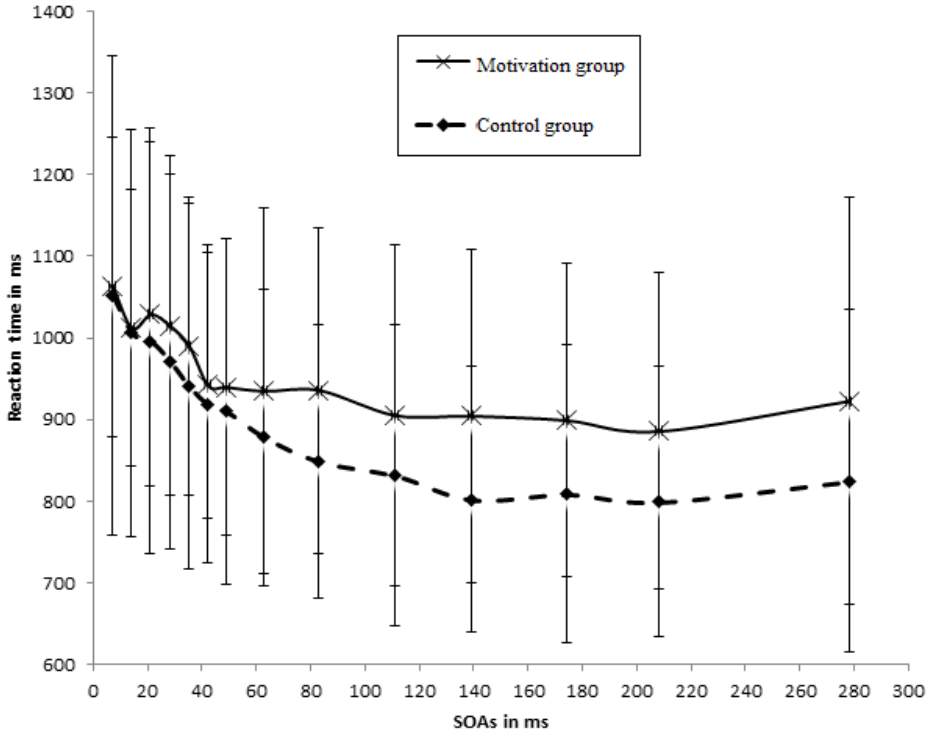

Figure 5. Reaction time in milliseconds per SOA in milliseconds for the motivation and control group.

According to the results of the percentage correct answers per SOA, reaction time per SOA and 75% correct per SOA it can be concluded that participants with a higher extrinsic motivation did not give more correct answers or did not respond faster in the task. Data for the motivation group was not more dispersed than for the control group.

EEG measures

To test for ipsi-contralateral differences in the two alpha band lateralizations one-sample t-tests were performed. In the results of these analyses a distinction between α_1 and α_2 bands was made. The effects for the electrode pairs are shown below in Figure 6 and 7 per α-band. Because effects are described as ipsi-contralateral differences, P8 describes activity of the P7 and P8 electrode pair, PO4 of the PO3 and PO4 electrodes, PO8 of PO7 and PO8, and O2 of the O1 and O2 electrodes. The results of these analyses will be displayed below, starting with the α_1 band. After this, the results of independent samples t-test will be displayed to test for the ipsi-contralateral differences between the motivational and control groups.

Table 1 indicates the results of the one sample t-tests for the α_1 band. The results are shown per relevant electrode and in the time windows of 400 – 800 ms, 800 – 100 ms and 1000 – 1400 ms with the lowest and highest *p* values in these windows. Except for electrode pair PO4, the highest p values are found in the time window of 800 – 1000 ms. This means that in this time window ipsi- and contralateral differences are less significant than for differences in the other time windows. Therefore, the differences in α-activity in both hemispheres for these electrode pairs are less present as compared to the other relevant time windows. This can also be found in figure 6 below. In this graph a negative peak can be found around 800 -1000 ms. The LPS values here are less positive compared to the preceding and the following values. This negative peak can also be seen in the topographical representation in figure 6 in the pictures of 800 – 900 ms and 900 – 100 ms. This negative peak for these time windows indicate a decrease of α-activity in the ipsilateral hemisphere, compared to the contralateral hemisphere, as a result of the appearance of the fixation point between the cue and target. From 1100 ms an increase of α-activity can be found which lasts to the next cue onset at 1400 ms. This increase can be related to the appearance of the target (SOA), as shown above on page 8 in Figure 1.

Table 1. *Observed effects for the alpha 1 frequency band per time window and electrode with the lowest and highest p values.*

Band	Electrode	Window in ms	< p <
Alpha 1	P8	400 - 800	.001 < .011
		800 - 1000	.016 < .032
		1000 - 1400	.001 < .008
	PO4	400 - 800	.004 < .007
		800 - 1000	.000 < .005
		1000 - 1400	.000 < .001
	PO8	400 - 800	.000 < .002
		800 - 1000	.006 < .010
		1000 - 1400	.000 < .002
	O2	400 - 800	.000 < .006
		800 - 1000	.019 < .026
		1000 - 1400	.000 < .013

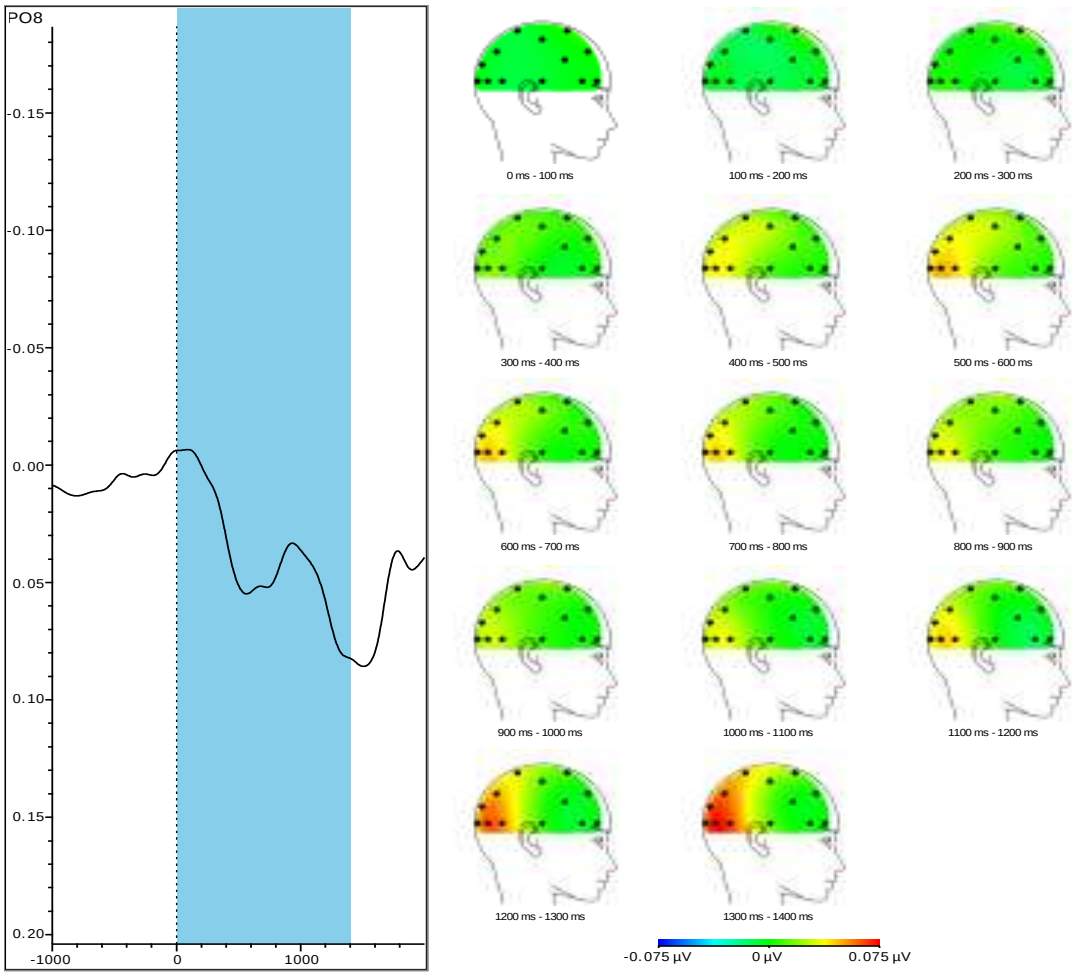

Figure 6. Topographical representation and graph of ipsilateral LPS deviations in the α_1 band for the cue condition averaged across groups.

For the α_2 band, the results of the analyses are displayed in table 2. These analyses showed that only that the ipsi- and contralateral differences for the O1/O2 electrode pairs for α_2 were not significant in the time window from 800 till 1000 ms ($.041 < p < .080$). This means that there are no differences found in ipsi- and contralateral α activity in the time window between 800 and 1000 ms for the O1 and O2 electrodes. For the other electrodes, the found differences were significant but the level of significance for the time interval of 800 -100 ms was again higher except for electrode pair PO4. Given the time interval of 800 – 1000 ms, it can be suggested that a decrease of α-activity in the ipsilateral hemisphere, compared to the contralateral hemisphere, is related to the reappearance of the fixation point.

Different from the results of the α_1 band, the p value for the time window 1000 – 1400 ms was for all electrode pairs .000. This means that the results that are found here are significant and that is thus can be argued that there is more activity ipsi- than contralateral in the hemispheres. As a consequence, it can be said that for target appearance there is more ipsilateral α-activity than contralateral. These effects can also be found in figure 7 below.

A less significant effect for the electrodes P8 and PO8 in time window 800 – 1000 ms was found. For O2 differences in ipsi- and contralateral activity for the time window of 800 – 100 ms were not significant. In the graph, in Figure 7, a peak can be found around 800 -1000 ms, as is also seen in the results of the α_1 band. The LPS values here are less positive compared to the preceding and the following values. This decrease can also be seen in the topographical representation in the pictures (figure 7) of 800 – 900 ms and 900 – 100 ms. Given this time interval, this decrease can be related to the appearance of the fixation point. As seen in the results of the analyses for the α_2 band, here also an increase of activity can be seen from 1100 to 1400 ms. As a consequence, it can be argued that for target appearance there is more ipsilateral α-activity than contralateral. A difference compared to the results of the α_1 band is that the α activity for the α_2 band in time windows 400 – 800 ms is less present than in the α_1 band.

Table 2. *Observed effects for the alpha 2 frequency band per time window and electrode with the lowest and highest p values.*

Band	Electrode	Window in ms	< p <
Alpha 2	P8	400 – 800	.000 < .002
		800 - 1000	.006 < .032
		1000 - 1400	.000
	PO4	400 - 800	.007 < .013
		800 - 1000	.001 < 0.10
		1000 - 1400	.000
	PO8	400 - 800	.000 < .002
		800 - 1000	.006 < .016
		1000 - 1400	.000
	O2	400 - 800	.005 < .024
		800 - 1000	0.41 < 0.80
		1000 - 1400	.000

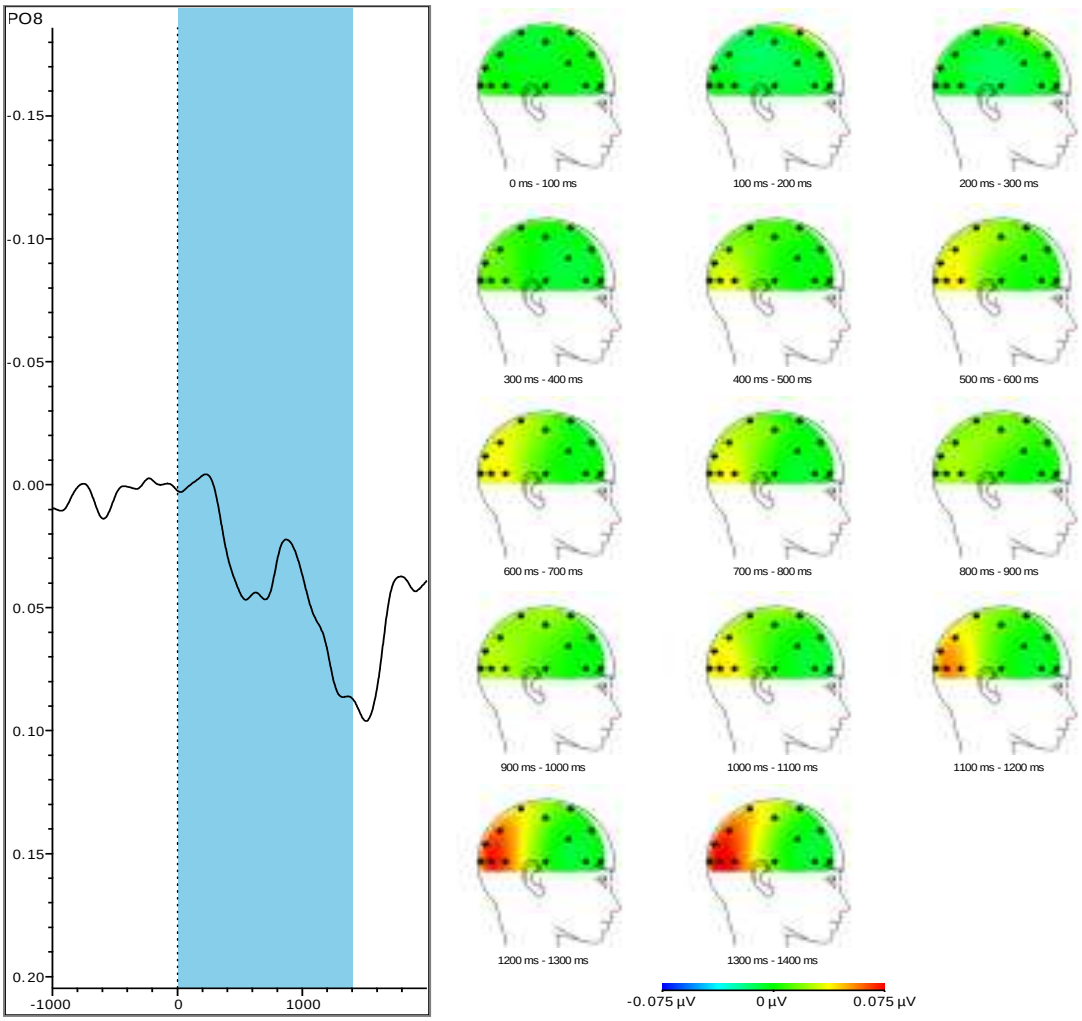

Figure 7. Topographical representation and graph of ipsilateral LPS deviations in the α_2 band for the cue condition averaged across groups.

To examine the ipsi-contralateral differences for the motivational and control groups, a one way ANOVA analysis was carried out. Also for these analyses a distinction was made between the α_1 and α_2 bands. The results of these analyses will be described below.

Figure 8 indicates the LPS values for the α_1 band per electrode. The dashed line in this figure represents the motivation group and the solid line per electrode represents the control group. The LPS values for the motivation group here seem to be less positive, which indicates that these participants showed less alpha activity. The results of the ANOVA showed per time window that for the α_1 band the differences between the two groups were not significant. These outcomes are displayed in Table 3 in Appendix A. All outcomes were above the significance level of $p = 0.026$. This means that the differences displayed above in Figure 8 can be attributed to coincidence. The control group did not show more alpha activity in the α_1 band during the experiment.

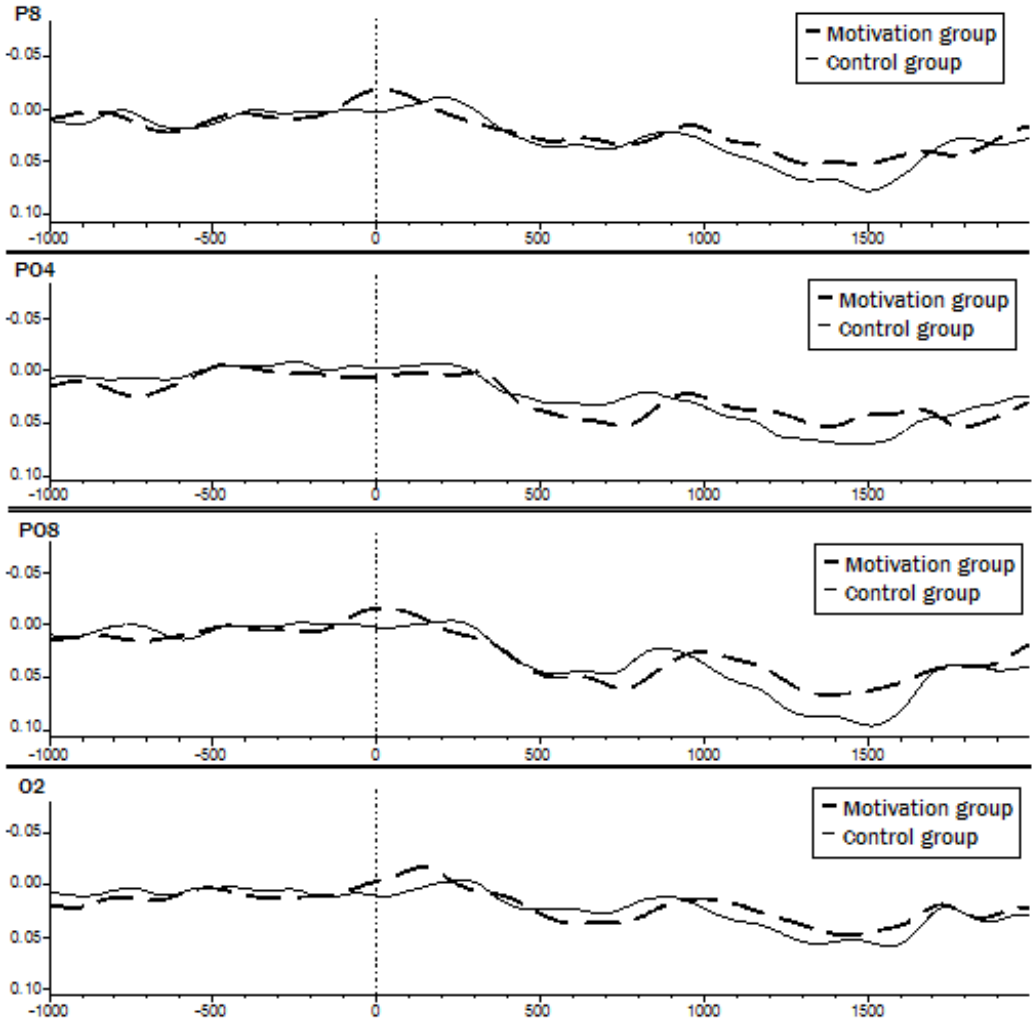

Figure 8. LPS values for the α_1 band per electrode for the motivation and control group.

Figure 9 displays the LPS values for the α_2 band per electrode. The dashed line in this figure represents the motivation group and the solid line per electrode represents the control group. The LPS values for the motivation group for every electrode pair seem to be less positive, which indicates that these participants showed less alpha activity. Nevertheless, the results of the ANOVA showed per time window that for the α_2 band the differences between the two groups were not significant. These outcomes are displayed in Table 4 in Appendix B. The significance level of $p = 0.026$ was not crossed. This means that the control group did not show more alpha activity in the α_2 band during the experiment.

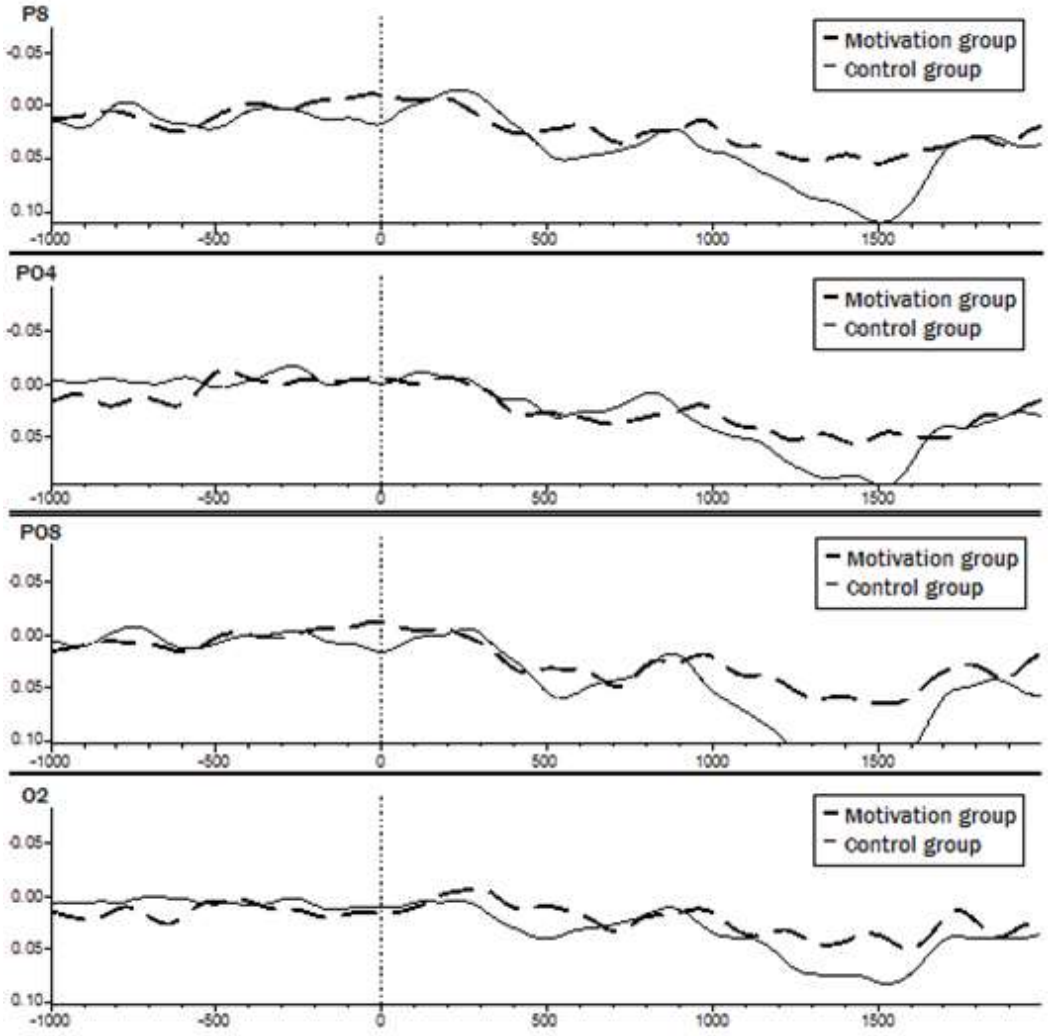

Figure 9. LPS values for the α_2 band per electrode for the motivation and control group.

According to the results of the EEG measurements it can be concluded that alpha activity is increased for both groups during the cue-target interval. A peak in alpha activity can be found for in the time window 1000-1400 ms, which can be due to the appearance of the target. No differences were found with the ANOVA analysis between the groups.

Discussion

As mentioned in the introduction, the goal of this study was to examine the influence of extrinsic motivation on endogenous attention and on conscious visual perception. It was expected to find that participants with a higher extrinsic motivation would be able to detect stimuli with a lower SOA than participants with a lower extrinsic motivation. Further, it was expected to find that participants in the motivation group showed more alpha power ipsilateral than contralateral than participants in the control group.

The behavioural data of our experiment suggests that the participant's ability to detect stimuli with different SOAs was not influenced by extrinsic motivation. The differences in performance of the task in reaction time and percentage correct answers between the motivation and control group were not significant. Also the differences between the motivation and control group at which SOA they reached 75% correct answers were not significant. This means that the differences in dispersion of the data are also not significant. These results of the behavioural data imply that the participants with a higher extrinsic motivation did not perform better or faster at a visuospatial task. Therefore, it can be said that extrinsic motivation does not have a positive influence on the conscious visual perception. This would indicate that extrinsic motivation did not have an influence on endogenous attention, because attention facilitates the process of conscious visual perception of stimuli (Posner et al., 1980; Banerjee er al., 2015; Klimesch, 2011; Deheane et al., 2006; Lamme, 2003). The influence of extrinsic motivation on endogenous attention will be discussed below in the next paragraphs.

As noted above, results of the behavioural measurements imply that extrinsic motivation did not have an influence of endogenous attention. Analysis of the EEG data implied that participants in the experiment did suppress and select attention actively, because more α-activity was found ipsilateral to the attended side of the visual field than contralateral (Klimesch, 2012). However, results of the analyses showed that extrinsic motivation did not have an influence on attention. Participants in the motivation group did not show more α-activity in the ipsilateral hemisphere, compared to the contralateral hemisphere, when executing the task. This means that the participants in the motivation group did not suppress other functions more than the control group. Especially increased α-activity in the ipsilateral side than contralateral to which attention was directed, indicates selection of attention (Cosmelli et al., 2011). Also selection of stimuli was not found to be more for the motivational group than for the control group, because no differences were found in α-activity between the ipsilateral and contralateral side.

In the results of the LPS a negative peak of α-activity was found for the time window of 800 – 1000 ms. During this time window the fixation point reappeared between the cue and the target during the task. This means that it can be suggested that the negative peak is related to the reappearance of the fixation point. Ipsi- and contralateral differences for O2 electrode in the α_2 band were found to not be significant in the negative peak. Reappearance of the fixation point caused no differences in α-activity for the ipsi- and the contralateral sides. According to Klimesch (2012) and Cosmelli et al. (2012) these negative peaks suggest that during the reappearance of the fixation point attention was not actively directed. To prevent this negative peak to occur in follow-up research, the fixation point between the cue and target can be removed. This would mean that the cue will directly be followed by the target and no negative peak in α-activity will occur.

Analysis of the behavioural and EEG measurements showed that extrinsic motivation did not have an influence on endogenous attention or conscious visual perception. A possible explanation for these outcomes can be due to low self-efficacy of the participants. Self-efficacy is a motivational construct and defined by Bandura (1986) as the belief that one is capable of successfully performing a particular task. Only three out of 12 participants could win money and participants reportedly said that the experiment was really difficult. This could mean that participants believed they had not the necessary capabilities to perform the task successfully and had a low self-efficacy (Bandura, 1986). Research of Greene & Miller (1996) and Ryan & Deci (2000) showed that beliefs about ability are positively related to performance. This implies that if participants thought they could not be one of the three best participants, they would not win the reward and performed less. A recommendation for future research is to improve the experiment by increasing the self-efficacy of the participants. This can be done by giving more participants a chance to win money. For the participants it is easier to win something and they need less exceptional capabilities to win money.

As noted in the introduction no research has been done to the influence of extrinsic motivation on endogenous attention. Since this is the first time research has been done to examine this relation, these results give the opportunity to fill this gap. Because this is the first time this relation has been examined, it is still recommended to do future research on this topic.

According to the results of the behavioural measurements it can be concluded that extrinsic motivation did not have an influence on conscious visual perception. Differences in reaction time and percentage correct answers were not significant. Analysis of the EEG data showed that attention was actively directed during the execution of the task. No differences

were found between the motivation and control group, which implies that extrinsic motivation did not have an influence on endogenous attention.

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Appendix A

Table 3. *Results of the One way ANOVA for the alpha1 band with F values and significance levels per electrode and per time window in milliseconds.*

	Time window									
	400 - 500	500 - 600	600 - 700	700 - 800	800 - 900	900 - 1000	1000 - 1100	1100 - 1200	1200 - 1300	1300 - 1400
					P8					
F	.783	.967	.448	.030	.076	.536	.268	.182	.320	.472
α	.386	.337	.511	.865	.785	.472	.610	.674	.577	.500
					PO4					
F	.003	.115	.537	1.399	.309	1.255	.003	.005	.825	.319
α	.958	.738	.472	.250	.584	.275	.959	.947	.374	.578
					PO8					
F	.251	.132	.006	.272	.146	.217	.852	.753	.809	.688
α	.621	.720	.939	.607	.706	.646	.367	.395	.379	.416
					O2					
F	.2001	.115	.022	.205	.056	.063	.136	.145	.763	.691
α	.172	.697	.883	.656	.816	.805	.716	.707	.392	.415

Note. Used degrees of freedom are df(1,22).

Appendix B

Table 4. *Results of the One way ANOVA for the alpha2 band with F values and significance levels per electrode and per time window in milliseconds.*

	Time window									
	400 - 500	500 - 600	600 - 700	700 - 800	800 - 900	900 - 1000	1000 - 1100	1100 - 1200	1200 - 1300	1300 - 1400
					P8					
F	.813	4.888	1.730	.122	.001	.965	.699	.780	.811	1.522
α	.377	.038	.203	.730	.975	.337	.412	.387	.378	.231
					PO4					
F	.158	.017	.074	.699	.666	.945	.749	.363	.785	1.562
α	.695	.898	.789	.413	.424	.342	.396	.553	.386	.225
					PO8					
F	.350	2.415	.243	.001	.005	.672	2.655	3.122	2.681	2.770
α	.561	.135	.627	.978	.944	.422	.118	.092	.116	.111
					O2					
F	.4.293	1.995	.179	.028	.029	.575	.624	.267	1.805	1.213
α	.051	.173	.676	.870	.866	.457	.438	.611	.193	.283

Note. Used degrees of freedom are df(1,22).