ABSTRACT

In this work, we focus on emotional cerebral lateralization, starting from the two main theories that have been proposed: the right hemisphere theory, which suggests that this hemisphere is dominant for processing emotions regardless of the nature of the emotional experience, and the valence hypothesis, which proposes that negative emotions such as frustration, stress, and sadness are accompanied by more activity in the right hemisphere, while positive emotions such as happiness, tenderness, and fun are reflected with more activity in the left hemisphere. In this study, we used transcranial Doppler ultrasound, which is a non-invasive tool that allows determining the lateralization of a cerebral process by measuring blood flow in the three major cerebral arteries. For this purpose, an ultrasound probe is placed on both sides of the skull in what is called the "acoustic window," where the bone is thin enough to allow sound to pass through. The objective of this study was to validate the two theories of emotional lateralization by inducing a state of happiness or sadness in 21 participants through the presentation of 15 previously validated video clips (Schaefer, Nils, Sánchez, and Philippot; 2010), while measuring hemispheric activity directly using the transcranial Doppler ultrasound device (fTCD) and indirectly through reaction to a landmark task. The results show the effectiveness of video clips with sad content in inducing an emotional state, but not for video clips with happy or tender content. There was also a significant reduction in blood flow speeed in the right middle cerebral artery during the performance of the vigilance task after emotional induction, which was significant for the negative induction group but not for the group assigned to positive mood induction. There were no significant differences in performance comparisons before and after the vigilance task in either of the groups. It is concluded then that an update of the list of video clips is necessary to generate an emotional induction, especially when the participants must be young people, like when using fTCD. Finally, the VF measurement must be carried out during the presentation of the video clips and not during the execution of the surveillance task.

Keywords: fTCD, Cerebral processing of emotions, cerebral lateralization, emotional induction.

1 EXPERIMENT

1.1 Method

1.1.1 *Participants*

Twenty-five participants were recruited in this experiment, but it was not possible to locate the signal from de AMC due to the lack of the temporal bone window for ultrasound transmission with three of them, so they were discarded. Another participant was also discarded because he did not remain still enough during the procedure and the signal was lost a few minutes before finishing, so finally the sample was 21 participants (men = 4, women = 17), all of them over 18 years old, with a mean age of 23.61 years. The participants were mostly students from the University of Ghent and some former students affiliated with the Sona system for recruiting participants for experiments at the faculty. All of them were non-native English speakers without any diagnosis of neurological disease, psychiatric disease, or neurodevelopmental disorders and were right-handed. The call through the Sona system for the recruitment of participants was made after receiving the approval of the ethics committee of the University of Ghent.

The participants were randomly divided into two groups, one for sad mood induction (1 man and 10 women) and another for happy mood induction (3 men and 7 women). Participants were informed just before starting the induction about the group to which they had been assigned.

For the group assigned to receive an induction of sadness, the experiment took 1 hour and 40 minutes. The group assigned to receive a joyful induction the average time was 1 hour and 30 minutes.

1.1.2 *Measures*

The dependent variable of this study is based on the measurement of lateralization of brain activity during mood induction. The first measurement made was the mood to corroborate if the emotional induction method was effective or not. This measurement was carried out with the Mood Assessment Scale (EVAE) at two moments, before the mood induction and after the mood induction. The EVEA test is "an instrument to assess the efficacy of mood induction procedures" (Sanz Fernández, 2001), it is used to measure transient mood states in studies that

use mood induction procedures. It contains 4 subscales: happiness, depression, anxiety, and hostility.

The second measurement, a vigilance task was programmed with the Psychopy software (Psychology software in Python) with which it was intended to indirectly measure brain activity, and directly compare the results of the performance before and during the emotional induction.

The third measurement that was carried out was the measurement of the blood flow velocity in the AMC using the functional transcranial Doppler ultrasound device (fTCD).

An ultrasound probe was placed bilaterally in the so-called "acoustic window", located above the zygomatic arch and 1 to 5 cm in front of the ear, where the skull bone is thin enough to allow sound to pass through. This technique is completely painless, considered safe, not associated with any health risk, and has been used for more than two decades to quantify hemispheric lateralization in clinical and nonclinical samples, including healthy infants. With this technique it is possible to observe which hemisphere was more active during the task. Brain activity was recorded with the Doppler device at two different moments, one before the induction of mood to take a comparison baseline. The second recording was made during induction. Immediately after each video clip, the participant had to perform the surveillance task again.

1.1.3 *Procedure*

The experiment was carried out in the psychological testing room of the department of experimental psychology at the University of Ghent. A small 5 x 5 m private cubicle was used with a table where the Doppler device was located and a laptop where the video clips would be projected and where the participant would carry out the surveillance task. The entire experiment was carried out in English, including the EVEA test, instructions, and video clips.

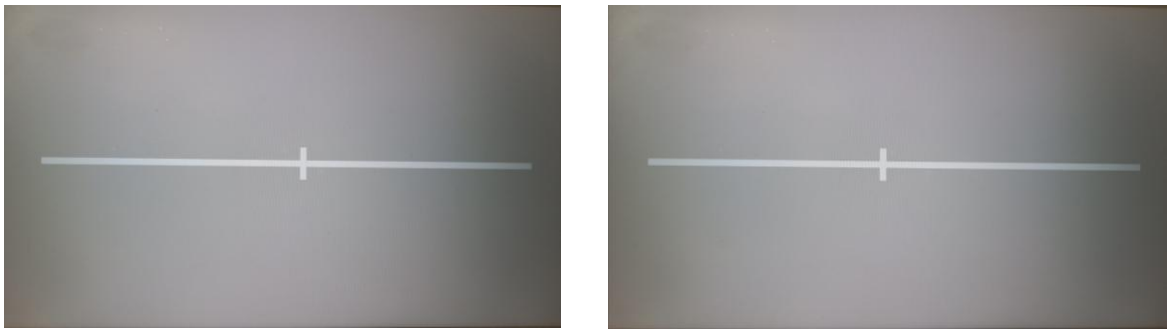
Before beginning the participant received an explanation about the nature of the experiment and what we were looking to verify, then they were asked to read and fill out the informed consent with signature and bank account number. Each participant received 20 euros for their participation. They are instructed to provide details such as name, age, dominant hand, email address, and gender for entry into the participant database where assignment to the experimental group was also indicated.

The next step was to take the EVEA Mood Test by rating sixteen statements about theirr current mood. Participants had to choose a value between 0 and 10, where 0 was not at all and

10 was a lot to statements such as “I am feeling nervous” or “I feel optimistic”. Next, a helmet was installed with the ultrasound probes of the Doppler device and the signal from the middle cerebral artery was searched for in both hemispheres. For this, a gel was used that helped to amplify the magnitude of the signal. On the computer screen of the Doppler device, it was possible to observe in the form of waves and listen to the pumping of the heart through this cerebral artery. Correctly fixing the probe is a procedure that takes at least ten minutes on each side of the skull. When the sensors were properly fixed on each side of the skull, the signal was recorded and the surveillance task began, before continuing with the presentation of the video clips.

In the vigilance task, a white horizontal line intersected by a small white vertical line appeared on the computer screen, with a dark gray background, in different parts for each trial. The horizontal line was located at the center position of the screen (0,0) and the vertical line appeared on top of the horizontal line at different positions to the right or left of the horizontal midpoint, in Image 1. You can see an example of this scheme.

Image 1



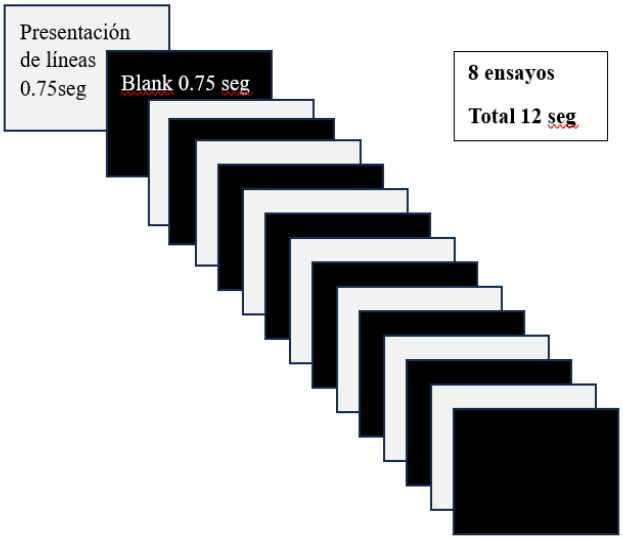
The task was performed at a pre-induction mood moment. The participants had to decide which of the sides of the horizontal line was longer depending on the position of the vertical line, right or left, and according to this decision they had to press different keys of the keyboard. Specifically, if the left side was longer they had to press the H and L keys with their index fingers at the same time, if the right side was longer they had to press the T and P keys at the same time with their middle fingers. As can be seen in Image2. The task was presented in fifteen blocks, each block containing 8 trials where the lines appeared on the screen for 0.75 seconds immediately followed by a blank period of 0.75 seconds before the presentation of the next combination of positions for the vertical line.

The landmark task was introduced in the experiment following the suggestions of the theory that a baseline of VF should be taken during a rest period or a simple mental task, such as an attention task (Hitchcock, et al. al., 2003, cited by Duschek & Schandry, 2003). An attempt was made to erase the noise of the motor activity by having the participants press two keys at the same time using the fingers of both hands and thus cancel the motor register.

Before beginning to record the session with the Doppler device, the participant was asked to perform a practice test to be sure that the instructions had been clear.

Image 2

First Practice



The instructions about how to perform the task was showed on the screen like this:

Instructions

During this task you will see on the screen a horizontal line intersected by a small vertical line. The vertical line will appear each time in different positions.
You must decide which of the two sides of the horizontal line is longer than the other one.

So:

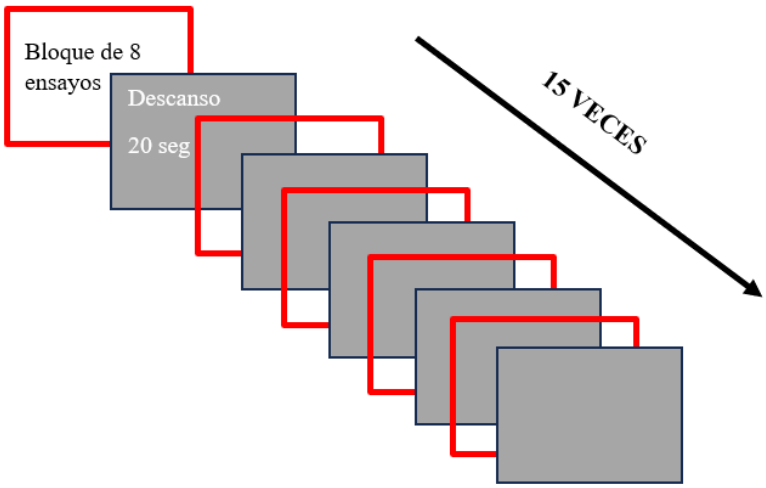
If the left side is longer than the left side you must press "H" and "L" keys.
If the right side is longer than the right side you must press "T" and "P" keys.
Please, press spacebar to start.

Instructions were also explained verbally and examples of how the task should be carried out were given when necessary.

After carrying out the initial practice of the landmark task, the baseline of the surveillance task began to be recorded. As can be seen in Image 3. Now the participant had to repeat each block of 8 trials 15 times, interspersed with a 20-second rest period.

Image 3

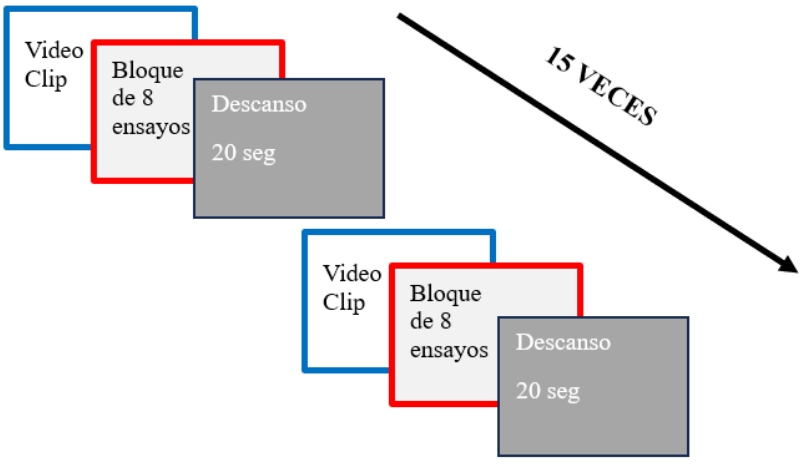
Base line landmark task



The second part of this measurement was carried out during mood induction. The participants had to watch 15 video clips and, immediately after each one, they had to solve the landmark task with 8 trials and 20-second rest period, thus completing 15 blocks again at the end of the induction. In Image 4 you can see the scheme.

Image 4

Mood induction and landmark task.



Completion of the landmark task before mood induction helped to obtain a baseline that could then be used to compare the number of correct responses when the task was performed after mood induction, as well as blood flow velocity before and during induction.

Mood induction was carried out using a list of video clips (see ANNEX 1 and 2) of famous Hollywood movies validated in previous studies by different institutions as effective for the induction of transitory mood (Schaefer et al., 2010, Culot et al.,2021, Möbius, et al, 2017). The list of videos, duration, description, and reference appear in tables 1 and 2 of the annexes. Each participant was informed about their assignment, whether it was sad or happy, just before starting to watch the video clips and each of them was asked to try to immerse themselves in the scene seeking to arouse the emotions that it proposed. The video clips were integrated into the program developed in Psychopy together with the landmark task, which allowed their automatic and randomized presentation among participants and at the same time recording the responses during the landmark task. Two versions were created, one for each group of participants.

At the end of the mood induction, the participant was asked to complete the EVEA test again according to theri current mood, and the helmet of the Doppler device was removed from the head. For the participants who were subjected to an induction of negative mood (sadness), a repair session was presented at the end in which they had to watch five video clips with happy content, the aim was to reverse the negative induction before the participant return to theri daily routine.

1.2 Results

In cases where the data were not parametric, the Friedman test for repeated measures was used, and when the data were parametric, a 2 x 2 mixed analysis of variance or ANOVA for repeated measures comparing intra-subject and inter-subject factors. An ANOVA for repeated measures was also used looking to find differences between each group individually when comparing the results before and after the mood induction.

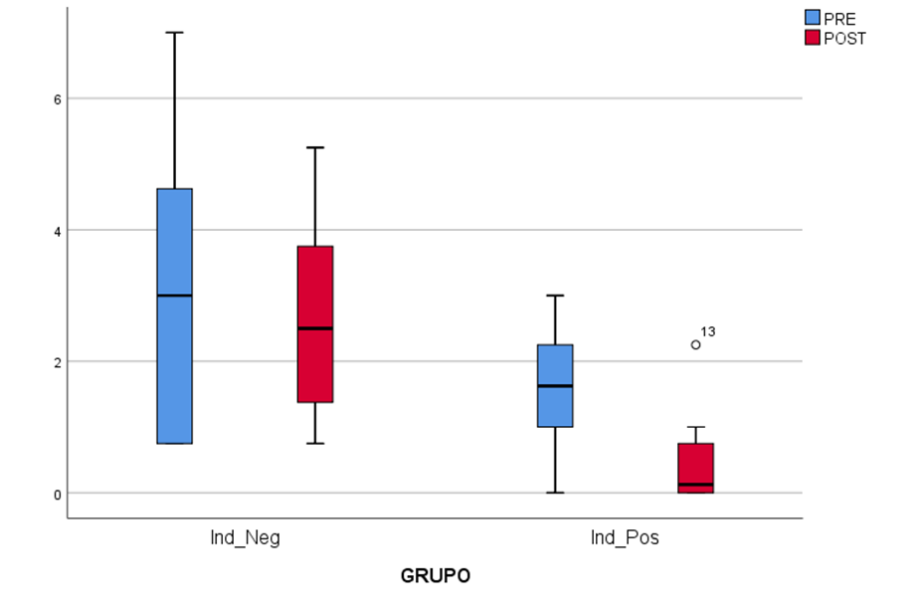
EVEA test results were compared before and after mood induction to verify the efficiency of the video clips.

With the variable anxiety, the data are parametric since they comply with the assumptions of normality and homogeneity. The results showed non-significant differences in the intra-subject effect tests (p=.067), that is, there are no significant differences between the results of the tests before (mean = 2.30, SD = 1.88) and after (mean = 1.60, SD = 1.62) of mood induction in all participants. Regarding the inter-subject results, a significant difference was found between both groups, without taking into account the independent variable "moment", F(1,19)=11,546; p<.003; η2=0.378. Graph 1 shows the difference between groups and between moments. A considerable difference can be seen in the test results in both groups before they received the induction and before knowing which group they had been assigned to. The group that was induced to a sad mood state was more anxious upon arrival in the experiment room (pre-moment) than the group that was induced to a happy mood state.

Carrying out a group-by-group statistical analysis, considering the moments, it was found through the ANOVA for repeated measures, as can be seen in Image 5. That, for the sad induction group, there was a decrease in anxiety compared to the moment pre (mean = 3.04, SD = 2.21) with post induction (mean = 2.6, SD = 1.5), but this was not significant (p<.54). For the happy induction group, a significant decrease in the anxiety variable was found, comparing the pre-induction moment with the post-induction moment F(1.09)=11,051; p<.009; η2=0.551.

Image 5

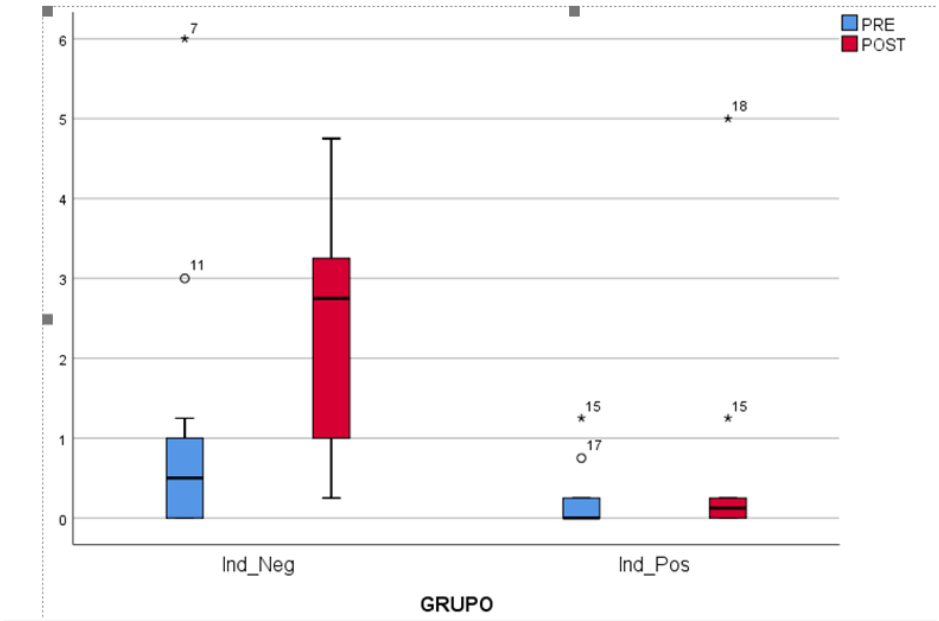
Results for anxiety group by group comparing before and after of mood induction.



For the hostility dependent variable, the data are not parametric, so the Friedman test or ANOVA was used for repeated measures of non-parametric data. As can be seen in Image 6. For the sad induction group, a significant increase (p<.035) in hostility was found, comparing the results of the test at the pre-moment (mean = 1.11, SD = 1.85) with the moment post (mean = 2.38, SD = 1.50). For the cheerful induction group there was also an increase in hostility, but this was not significant (p<. 564) comparing the pre moment (mean = 0.225, SD = 0.43) with the post moment (mean = 0.7, SD = 1.55).

Image 6

Results for hostility group by group comparing before and after mood induction.

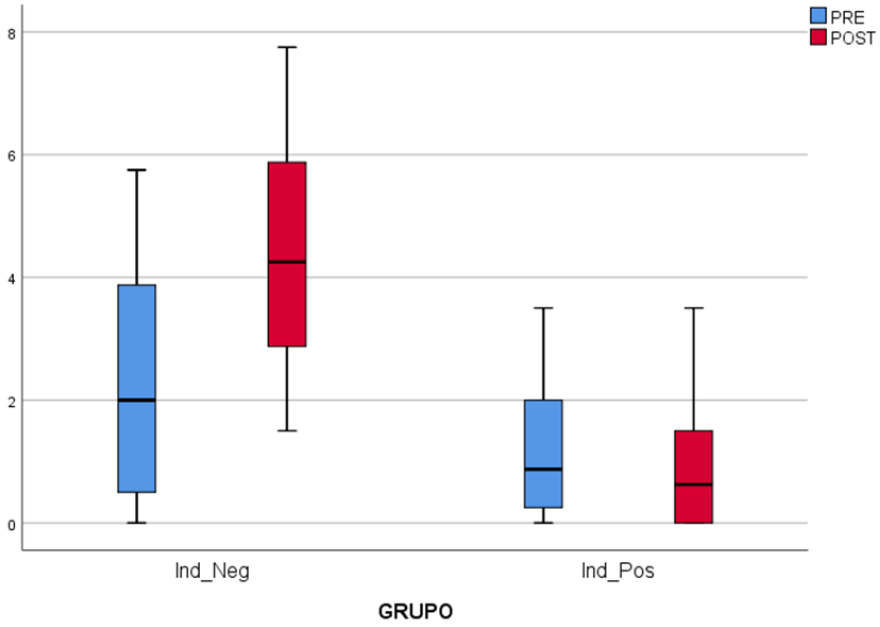


The data for the dependent variable depression are parametric. The results indicate that for the intra-subject effects test there are significant differences in the levels of depression between pre and post at a general level among the participants, F(1,19)=11,852; p<.001; η2=0.461. In the inter-subject effects test, significant differences were also found between the groups regardless of the moment, F(1,19)=10.172; p<.005; η2=0.349. Again, higher levels of depression are observed in participants in the sad induction group even before the induction and before knowing which group they would be assigned to. Repeated measures ANOVA analysis was used to compare differences between pre and post group by group. As seen in Image 7. The results found indicate that for the sad induction group the increase in depression is significant, F(1,10)=16,194; p<.002; η2=0.618, comparing the pre and post induction moments. For the

happy induction group there was a decrease in depression, comparing the pre-moment (mean = 1.2, SD = 1.26) with the post-induction moment (mean = 1.05, SD = 1.27) but this difference is not significant (p<. 217).

Image 7

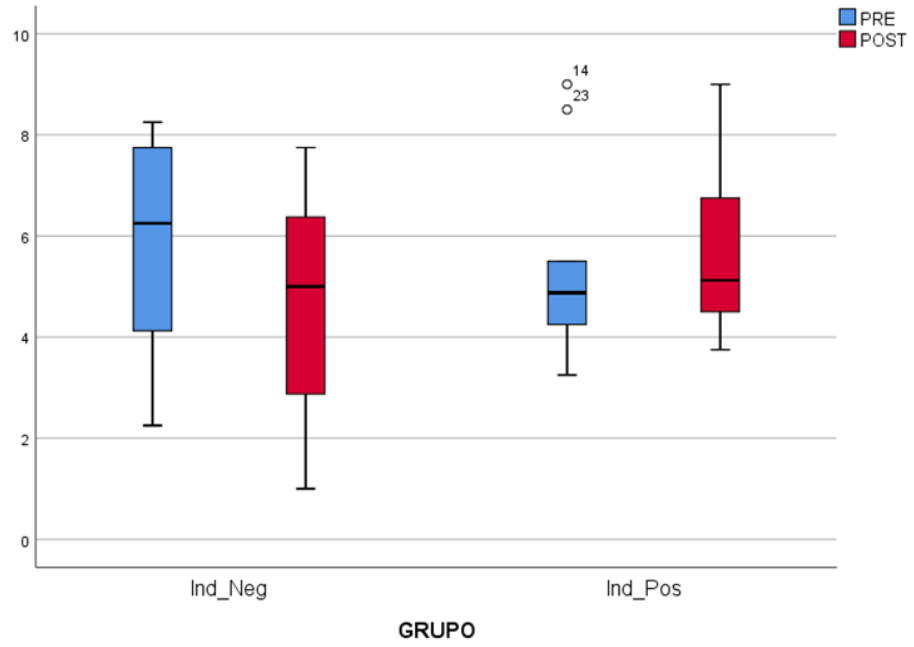
Results for depression variable comparing group by group before and after mood induction.



The data for the dependent variable happiness are parametric. The results indicate that for the intra-subject effects test there are no significant differences between the pre (mean = 5.59), SD = 1.97) and post (mean = 5.10, SD = 2.08) for all participants (p<.217). The results of the inter-subjects test comparing group vs. group regardless of moment, do not show a significant interaction either (p<.683). But when comparing considering the moment with an ANOVA for repeated measures, it was found, as can be seen in Image 8. That for the sad induction group, happiness decreased significantly, F(1,10)=14.478; p<.003; η2=0.591, while for the joyful induction group, joy did not increase significantly (p<.237) when comparing the pre-induction moment (mean = 5.35, SD = 1.90) with the post-induction moment (mean = 5 .72, SD = 1.68).

Image 8

Results for happiness variable group by group comparing before and after mood induction.

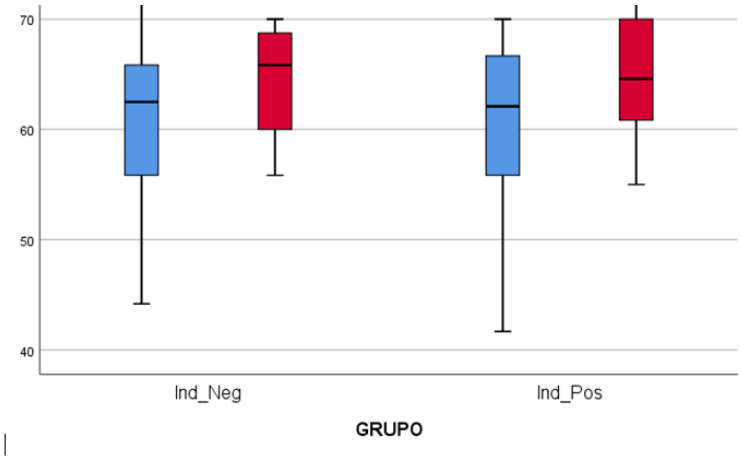


For performance measurements on the landmark task, the data is parametric. The results for the intra-subject effects test indicate that there was a significant increase in the percentage of correct answers during the test comparing the pre-induction moment (mean = 59.92%, SD = 9.08) with the post-induction moment (mean = 64.31%, SD = 5.36) for all participants, $F(1.19)=8.76$; $p<.01$; $\eta 2=0.32$, which does not confirm a cognitive alteration after receiving the induction, on the contrary, both groups improved their performance, which could be due to learning or a practice effect. Neither the effect of the groups nor the interaction for either of the two variables was statistically significant (all ps >.10).

As can be seen in Image 9. When analyzing these differences group by group having found the moment with an ANOVA for repeated measures, it was found that for the sad induction group the increase in the percentage of correct answers was significant, $F(1,10)=7.517$; $p<.021$; $\eta 2=0.429$. For the group assigned to the happy induction, the percentage of correct answers increased comparing the pre-moment (mean = 60.00, SD = 9.36) with the post-induction moment (mean = 64.64, SD = 5.58), but this increase was not significant. ($p<.112$).

Image 9

Results of performance of lanmark task.



The third measurement taken was lateralization through blood flow in the middle cerebral artery (MCA) before and during mood induction. The data are parametric and the results indicate for the within-subject effects test the changes in blood flow velocity for all participants comparing the time before (mean = -1.68, SD = 1.68) with the time during (mean = -0.98 , SD = 1.33) are not significant (p<.424). Likewise, the inter-subject effects tests do not show significant differences between the groups regardless of the time of measurement (p<.802). The ANOVA analysis for repeated measures for each of the groups indicated that, for the sad induction group, there was a significant decrease, $F(1,10)=7.207$; $p<.023$; $\eta 2=0.419$ of the blood flow velocity when comparing the pre moment (mean = -1.75, SD = 1.82) with the "during" moment (mean = -0.77, SD = 1.45). Not so for the group that was induced to joy. In this group the velocity of blood flow decreased, but not in a significant way ($p<0.543$) comparing the pre moment (mean = -1.609, SD = 1.47) with the "during" moment (mean = -1.209, SD = 1,218).

A comparison was also carried out between both groups regarding the number of times they pressed the keys to give a response in the landmark task during emotional induction. It was found that the group that received an induction of sad mood presented an average of 84.55%, that is, of 120 times that they had to choose a longer side, they gave an average of 101.45 some response. Of this percentage in answers given, this same group was correct 64.02% of the time. For the group that received an induction of happy mood, which could also be called neutral

since it did not generate any type of change in the emotional state of the participants, it was found that, in terms of the number of times they chose one side of the line longer and pressed the corresponding keys, the mean was 92.05%, that is, out of a total of 120 times in which they had to give an answer by pressing the keys, they did so an average of 109.7 times, and from this they had a mean of 64.65% of correct answers, as can be seen in Table 1.

Image 10

Measurement results of FV in AMC before and during modo induction.

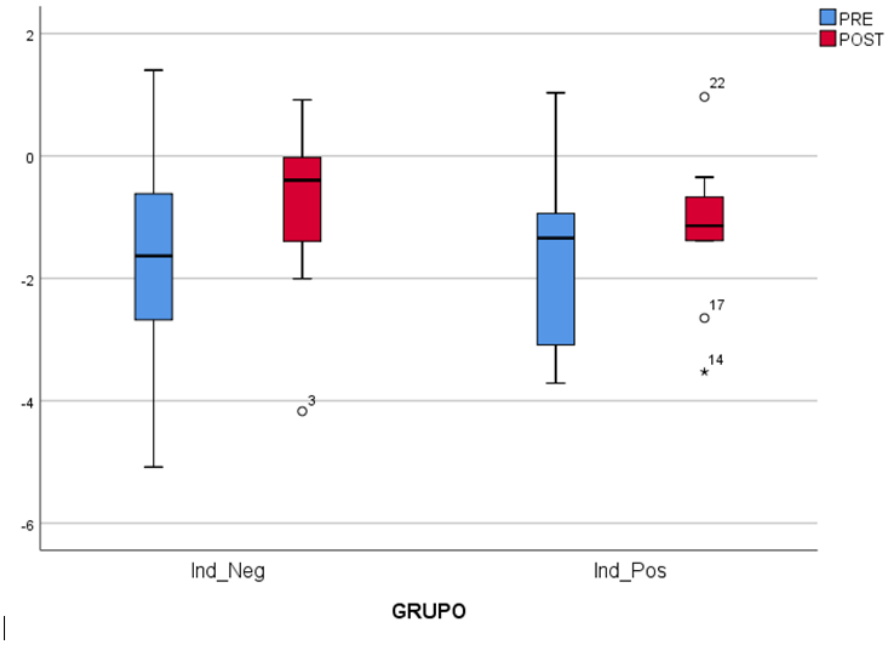


Tabla 1
Results of landmark task during modo induction.

Grupo	Total, respuestas	Respuestas dadas	%	Respuestas correctas	%	% Precisión de rptas dadas
Ind_Neg	120	96	80.00	70	58.33	72.92
Ind_Neg	120	109	90.83	79	65.83	72.48
Ind_Neg	120	88	73.33	67	55.83	76.14
Ind_Neg	120	111	92.50	83	69.17	74.77
Ind_Neg	120	106	88.33	74	61.67	69.81
Ind_Neg	120	105	87.50	84	70.00	80.00
Ind_Neg	120	71	59.17	68	56.67	95.77
Ind_Neg	120	92	76.67	82	68.33	89.13
Ind_Neg	120	111	92.50	74	61.67	66.67
Ind_Neg	120	113	94.17	84	70.00	74.34
Ind_Neg	120	114	95.00	80	66.67	70.18
Medias		101.45	84.55	76.82	64.02	76.56
Ind_Pos	120	105	87.50	66	55.00	62.86
Ind_Pos	120	114	95.00	73	60.83	64.04
Ind_Pos	120	115	95.83	84	70.00	73.04
Ind_Pos	120	110	91.67	82	68.33	74.55
Ind_Pos	120	116	96.67	79	65.83	68.10
Ind_Pos	120	115	95.83	84	70.00	73.04
Ind_Pos	120	100	83.33	73	60.83	73.00
Ind_Pos	120	103	85.83	76	63.33	73.79
Ind_Pos	120	112	93.33	87	72.50	77.68
Ind_Pos	112	107	95.54	67	59.82	62.62
Medias		109.70	92.05	77.10	64.65	70.27

1.3 Discussion

An important aim of this study was to confirm whether mood induction had been effective. As the questionnaire was in English, some participants asked what certain questions in the questionnaire referred to, so some of them possibly did not understand all the questions and simply decided to choose a number from 0 to 10 to answer, without first clarifying their meaning.

The results of the EVEA test showed that the mood induction was only effective for the group that was assigned to the sadness group, with significant differences in the mean increase in the hostility and depression scales and a significant decrease in the mean on the happiness scale of the EVEA test, comparing the moments before and after induction. For the group that was assigned to an emotional induction of joy, no significant differences appeared on the hostility, depression and joy scales when comparing the results before and after the emotional induction, so it can be said that the video clips were not effective. In this group some participants were more hostile and tired when watching the video clips. This is reflected in the increase in the mean of the hostility scale comparing the pre and post induction moment. Some mentioned that what they were seeing was not funny and they were anxious to finish soon.

Something interesting that can be seen is that in the results of the EVEA test, the participants in the sadness induction group presented from the moment prior to the induction, and without knowing which group they had been assigned to, a higher mean on the sadness, anxiety, hostility, depression and joy scales, compared with the group that would undergo a joy induction. The inter-subject effect test confirms this statement for the anxiety, hostility, and depression scales by giving significant differences in the comparison of the means between groups, but without taking the moment into account. Only for the joy variable the difference between the group means was not significant.

In general, the participants of both groups mentioned not knowing all the movies to which the video clips belong, so understanding the context in a short scene and assuming an emotion was not easy. An important factor could have been the age of the participants where the average is 23.61 years and that only four of the films on the list of sad video clips are after the year 2000 and all the films on the list of happy or tender films are earlier to the year 2000.

In both groups of participants, the anxiety scale showed a decrease that was only significant in the group assigned to receive an induction of happy mood. This could be more related to the previous nerves and the expectation about how the experiment will be and what the participant will have to do, a state that changed after the induction, reflecting greater control over this emotional state in the group assigned to the induction of happiness and tenderness (López and Talavera, 1990).

This absence of effect after the induction of the happy mood could be reinterpreted to consider this group as a "control group", since no significant differences appeared in the mood comparing the moments before and after induction, but at the same time limits the main objective of this study, since to support one of the two hypotheses of the lateralization of emotional processing in the brain we would need to corroborate whether positive emotions

generate some kind of asymmetry in the left hemisphere as suggested by the valence hypothesis or whether these types of emotions are processed in the right hemisphere, just like emotions associated with sadness.

Regarding the landmark task, it was found that both groups improved in the number of correct answers comparing the pre- and post-induction moment. This increase in the percentage of correct answers was significant for the group assigned to the sadness condition, but for the group assigned to the joy condition.

On the other hand, when comparing the number of answers given with the number of correct answers in both groups only during the emotional induction process, that is, without considering the execution of the task at the pre-induction moment, it was found that the group of participants assigned to the sadness condition obtained higher precision when comparing the results with the group assigned to the induction of happy mood. This could indicate a greater focus of attention in the sadness group.

More than 50 years ago, Easterbrook (1959), cited by von Mühlenen, et al., (2018), published a study suggesting that negative emotions focused attention. This idea has been supported by other studies such as Fredrickson and Braningan (2005), Gasper and Clore (2007), or Rowe et al. (2007), all cited by von Mühlenen, et al., (2018). These authors consider that negative emotions indicate that something is wrong and must be solved, so attention should be more focused or work locally to solve the problem, while positive emotions would indicate that everything is fine, giving rise to to a less focused attention or to a more global work, allowing the acquisition of knowledge in a more general way. Focusing on sadness, there are contradictory theories since, for example, Gable and Harmon-Jones (2010) cited by von Mühlenen et al. (2018), carried out a study where they presented sad and neutral images to a group of participants while performing a global/local letter task and found that in the participants who had observed the sad images, the reaction times to the global letter they had been faster than those of the group that observed neutral images, suggesting that sadness has an attention-widening effect, being the only negative emotion with a low motivational intensity. Von Mühlenen et al., (2018) indicate that attentional intensity is directed by the level of emotional intensity. Emotions with a high emotional intensity, such as disgust, prefix behavior directed towards a goal, so attention must be more focused to achieve those goals, while emotions with a low emotional intensity, such as sadness, appear before the achievement or failure of these goals, so attention should be broader allowing the development of cognitive processes that help consider other options.

On the other hand, studies can be found that suggest the opposite, that is, that sadness

produces a more focused or local attentional effect. For example, Gasper and Clores (2002), cited by Von Mühlenenet al. (2018), found that judgments in a shape task were made at a local level when participants had to recall sad memories and that participants who had to recall happy memories did so more globally, and Basso et al. (1996) suggest that depressed people are less likely to process globally, that is, with broad attention.

In addition, there are studies such as that of Duncan and Barret, (2007) cited by Von Mühlenen et al. (2018), which suggest that the relationship between cognitive processes and emotional processes is bidirectional, in such a way that, as well as emotions can influence cognition, cognition can also influence the processing of emotions. It is therefore considered that tasks with a global focus could facilitate the processing of positive emotions such as happiness and tasks with a local or more sustained focus, such as the vigilance task, could favor the processing of negative emotions such as sadness.

It therefore seems that in our study the results in terms of the number of correct answers, the number of answers given, and their precision would support the theory that sadness focuses attention, since the participants who received the sadness induction presented greater precision during the landmark task than the group that received an induction of joy "or neutral" for our case.

It would be interesting in the future to investigate how VF behaves in AMC in both hemispheres when an attention task is global and when it is local.

Regarding the measurement of the velocity of blood flow in the middle cerebral arteries of both hemispheres, unexpected results were found. Different studies such as that of Stoll, et al. (1999) indicate a significant increase in the VF of the AMC of the right hemisphere during the presentation of video clips with erotic or violent content. Something that was done differently in this study was that the measurements were taken not during the presentation of the video clips, but during the performance of the landmark task. The reason why the VF measurement was not taken during the presentation of the video clips is due to the idea that brain activity generated by mood induction could be confused with noise activity, for example, of thought language processes because the presentation of the videos was made in English but none of the participants had this language as their mother language, it was simply the common language that all had; or motor processes, since the participants had to remain as immobile as possible for a little over 60 minutes and this is often not 100% possible. Perhaps this idea is something to reconsider for future experiments.

The VF data during the landmark task were analyzed with the R-studio tool, version R.4.2.2, taking measurements from the 3rd to the 12th second, considering that the VF increases 5 seconds after starting the landmark task. For all participants in the group assigned to a sad mood induction, a significant decrease in FV was found, as previously mentioned. When analyzing the VF measuring from second 0, that is, from the beginning of the landmark task, to second 3, it was found that for half of the participants in this same group there had been an increase in VF comparing the moments before and during emotional induction. This could be an indication that by having a measurement closer to the time of the presentation of the videos, a behavior more consistent with the theory could have been found. (See ANNEX 3).

2 CONCLUSIONS

In conclusion, it can be stated that this study did not meet the proposed objectives on the validation of lateralization of emotional processes. By not reaching an induction of happy mood, the validation of the hypotheses on the right hemisphere and the valence hypothesis was not possible to carry out. However, having achieved an induction of sad mood, it would have been possible to verify that the FV, in the AMC, increases during the emotional induction, at least for an induction of sadness, but having taken the measurement of the FV just After the presentation of each video clip, that is, during the execution of the landmark task, and not during the presentation of the videos, the results showed a decrease in FV when comparing the baseline measurement with the measurement during the induction process, results are very different from what previous studies have suggested.

We can consider that the induction of moods through video clips is an effective and economical method to work in the laboratory, but the list of videos with which this study was carried out is too old and only served to induce a sad mood so an update could be interesting work especially when working with young people as in the case of fTCD. Another aspect that must be considered is the participant´s mother language. Presenting movie clips in the same language as the participants can help immersion in the scene and thus achieve a better mood induction. This aspect also applies to the EVEA test and thus it would guarantee that the participants know to which emotions all the statements in the questionnaire refer.

The landmark task serves to take a baseline with which to compare the speed of blood flow when an induction is being carried out, but the measurement of this indicator should have been done, in a second instance, during the presentation of the video clips since that executing

the landmark task after each of the movie fragments was a distraction that attenuated the emotional climax reached, especially regarding the sad emotional induction, resulting in a decrease in FV during the test.

The increase in the percentage of performance on the vigilance task could indicate that the participants were concerned with performing better and were not keeping the idea of emotional induction as a priority. Perhaps it would have been necessary to clarify this aspect in more detail before starting the experiment.

There was an interesting finding that had not been considered within the objectives of this study and was the result of the landmark task. Participants who received a sad mood induction performed the in-moment vigilance task during the induction more efficiently than participants who received a happy or neutral mood induction, according to our own results. This was something that seemed inconsistent, but when searching the literature on the matter, we found that this has been presented in other studies, giving rise to theories that suggest that a sad mood generates more focused attention and that a happy mood generates a global attention. Although, other studies suggest the exact opposite. Apparently, without looking for it, this study supports the theory that a sad state of mind generates more local or focused emotional processes, since sadness can suggest that something is wrong and a solution to the problem or a way out should be sought of certain situations.

Finally, human emotions are processed in the brain in a very subjective way and when seeking to carry out an emotional induction in an experimental environment, it must be considered that there are variables that can affect the process in a positive or negative way, such as language, the age of the participants and the validity of the film fragments that will be used, and many more. However, carrying out an emotional induction can open the door to many areas of research in neuropsychology, such as the affectation of cognitive processes, lateralization, resilience, the duration of the induced states and its association with psychopathologies, or the affectation of unconscious processes such as prepulse inhibition, among many others.

ANNEX 1

Video Clips List with sad content.

	Movie	Duration (min)	Emotion	Description	Referencia
1	City of angels	04:25	Sadness	Maggie (Meg Ryan) dies in Seth's (Nicolas Cage) arms.	
2	Life is beautiful	02:06	Sadness	just before the end of the war the protagonist is assassinated.	
3	Philadelphia	05:28	Sadness	Andrew (Tom Hanks) and Joe (Denzel Washington) listen to an opera aria on the stereo. Ted describes to Joe the pain and passion felt by the opera character.	
4	Schindler´s list	01:17	Sadness	In a concentration camp, thousands of dead bodies are being carried and piled by other prisoners. Suddenly, Schindler (Liam Neeson) sees a dead little girl wearing a red jacket (the whole film but this read jacket is in black and white).	Schaefer, Nils, Sánchez y Philippot (2010)
5	The dead poets society	04:25	Sadness	Todd (Ethan Hawke) commits suicide.	
6	A perfect world	04:39	Sadness	Butch (Kevin Costner) is gunned down, at the end of the movie.	
7	Campaign 2018	02:09	Sadness	A little girl grows with her puppy until his death.	
8	Dangeruous mind	02:11	Sadness	The character played by Michelle Pfeiffer tells the class that one of their classmates is dead.	
9	ET	04:57	Sadness	E.T. is going to die, surrounded by scientists.	
10	UP	04:21	Sadness	A young couple joyfully growing old together until the wife dies.	
11	The pianist	03:53	Sadness	Different scenes from the movie where a Jewish musician faces violence and war.	Catherine Culot, Carole Fantini-Hauwel and Wim Gevers (2021)
12	Schindler´s list	05:28	Sadness	Schindler must escape and everyone he saves says goodbye. He regrets not having saved more people.	
13	The Sophie´s choice	05:12	Sadness	Sophie must choose which of her children to hand over to the Nazis. They take the little girl, Sophie can do anything	Möbius M, Lacomblé L, Meyer T, Schutter DJLG, Gielkens T, Becker ES, Tendolkar I, van

					Eijndhoven P. (2017)
14	Starving polar bear	00:58	Sadness	A polar bear is starving on the ice floes	Catherine Culot, Carole Fantini-Hauwel and Wim Gevers (2021)
15	The fault in our stars	02:42	Sadness	A young girl gives the eulogy of her dead friend	

ANNEX 2

Video clips list of joy or tenderness content

	Movie	Duration (min)	Emotion	Description	Referencia
1	Forrest Gump	02:05	Tenderness	The child is introduced to Forrest. The boy goes to sit down in front of the television. Jenny – the mother – tells Forrest that this is his son. Forrest sits down close to the boy. Very moved, Jenny watches the father and the son sitting close to each other.	Schaefer, Nils, Sánchez y Philippot (2010)
2	Ghost	03:43	Tenderness	Molly (Demi Moore) and Sam (Patrick Swayze) make pottery together, in a very romantic scene.	
3	Life is beautiful 1	01:43	Tenderness	In a prisoner's camp, a father (Roberto Benigni) and a boy talk to the mother using a loudspeaker, reaching the whole camp.	
4	Life is beautiful 2	04:15	Tenderness	An American tank liberates a prison camp; the boy climbs up on the tank and finds her mother again, at the end of the movie.	
5	The dead poets society	02:45	Tenderness	By the end of the movie, all the students climb on their desks to manifest their solidarity with Mr. Keating (Robin William), who has just been fired.	
6	There is something about Mary 1	02:53	Amussement	Ted (Ben Stiller) fights with the dog.	
7	There is something about Mary 2	02:25	Amussement	Mary (Cameron Diaz) takes sperm from Ted's ear (Ben Stiller) mistaking it for hair gel.	
8	When a man loves a woman	01:41	Tenderness	Alice (Meg Ryan) promises Michael (Andy Garcia) to never acting impulsively again, and she promises to stop drinking	

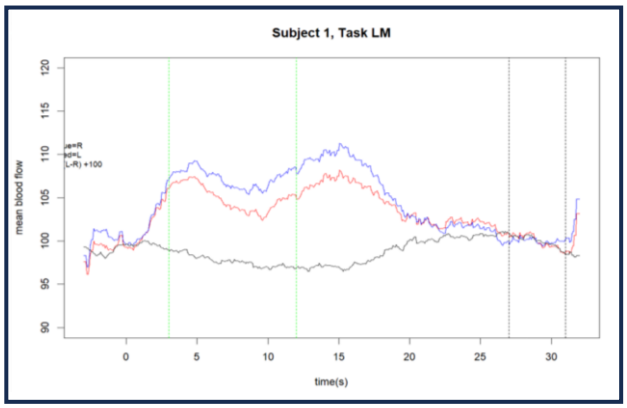
9	When Harry met Sally	02:51	Amussement	In a very well-known scene, Sally (Meg Ryan) fakes an orgasm in the restaurant, provoking Harry's (Billy Cristal) embarrassment.	
10	Benny and Jooone	02:07	Tenderness	Benny (Johnny Depp) plays the fool in a coffee shop	
11	Life is beautiful 3	03:47	Tenderness	In a prisoner's camp, the father (Roberto Benigni) translates the orders given by the soldier to the prisoners. He is not actually translating, but he is making up a translation that does not scare his son. Specifically, he is trying to make his son believe that all this is a large-scale game.	
12	The professional	02:50	Tenderness	Léon (Jean Reno) plans the escape of Mathilda (Nathalie Portman). He puts her in the ventilation circuit. She doesn't want to leave Leon. He promises that they are going to reunite later. They say goodbye to each other, and Mathilda understands that she is never going to see Leon again.	
13	A fish called Wanda	02:53	Amussement	Archie (John Cleese) gets undressed, waiting for his girlfriend. Unexpectedly, the owners of the house get into the house and discover him naked.	
14	Funy compilation	03:02	Amussement	Compilation of homemade clips with animals	Catherine Culot, Carole Fantini-Hauwel and Wim Gevers (2021)
15	Funy compilation	04:44	Amussement	Funy cats and dogs compilation	

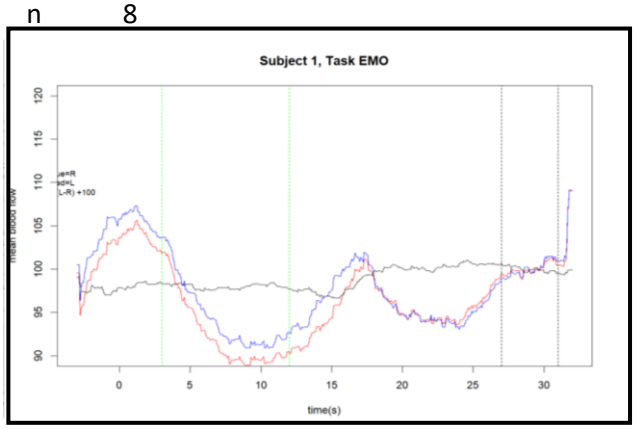
ANNEX 3

Participant 1

Measurement during performance of landmark task before mood induction (LM) and during mood induction (EMO) looking seconds 3 to 12.

n 8





Measurement during performance landmark task before mood induction (LM) and during mood induction (EMO) looking seconds 0 to 3.