Effects of Beta and Delta/Theta Binaural Beats on Stroop Test

Research Project for Research Methodologies in Humanities and Science and Cognitive Science & Psychology

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Background

- When two pure tones of slightly different frequency are presented separately to each ear, the listener perceives a third single tone with amplitude variations at a frequency that equals the difference between the two tones, this perceptual illusion is known as **binaural auditory beat** *(Oster, 1973)*.

- There are anecdotal reports that suggest that the binaural beat can **entrain EEG activity** *(Jan Schnupp, 2011)* and may affect the arousal levels, although few studies have been published *(Tina L.Huang, C.Charyton, 2008)*,*(D.S.Foster,1990)*. Few studies explore how BB's affect performance on attention tasks *(Lane et al, 1998),(Wahbeh et al, 2008),(Crespo et al, 2012)*.

- There is a need for double-blind, well-designed studies in order to establish a solid foundation for these sounds, as most of the documented benefits come from **self-reported cases** that could be affected by placebo effect and also from authors related to **commercial companies** *(Charyton, 2008).*

Experimental Study

- The aim in our research was to explore the potential of BB's in a particular field: tasks that require focus and concentration (**Stroop Effect**).

- In this study we compare the effect of different binaural stimulation in **delta/theta** and **beta** frequency ranges, 20 participants were exposed to ~15 min + ~15 min binaural beat stimulation.

-**Hypothesis: "**Exposure to binaural auditory beats in the EEG beta frequency ranges in comparison to delta/theta frequency ranges improves significantly performance in stroop test."

- The effects were obtained with qualitative stroop application. Results suggest **no significant statistical improvement** in 15 min stimulation.

Methods - Materials & equipment

- Sound Room (La Nau): soundproof
- Stereo Headphones and microphone
- Binaural beats (double blinded):
  - Delta/theta: at 1.5 Hz and 4 Hz + pink noise as background
  - Beta: at 16 Hz and 24 Hz + pink noise as background

Subject perception: BB non perceptible, 2 sounds alike

- iPad

Methods - Experiment design

- Within subjects.
- 21 participants (1 removed): 11 male, 9 female. Mean age 28.1 years old.
- Counterbalance: Randomized sound sequence: 10 AB, 10 BA.

Methods - Procedures

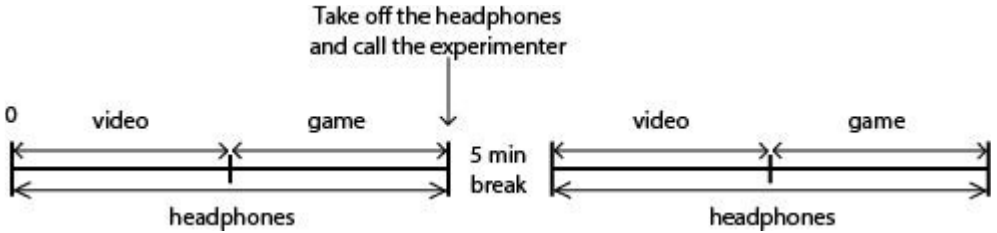
Experiment:

- Part I

  Ishihara Test (9’)

- Part II

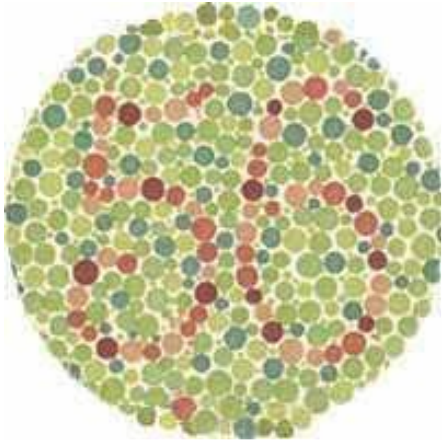
  Stroop Test (~ 6’ depending on performance)



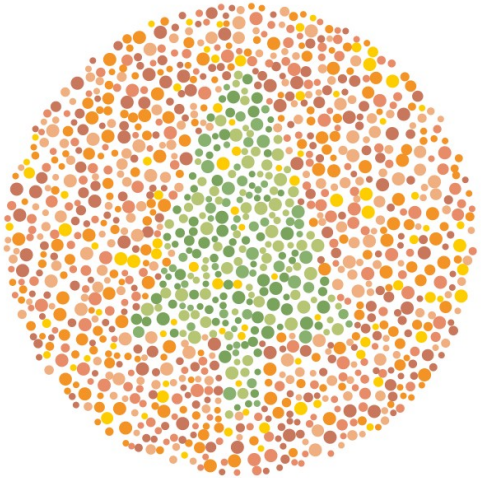
Methods - Procedures - Part I

Ishihara test

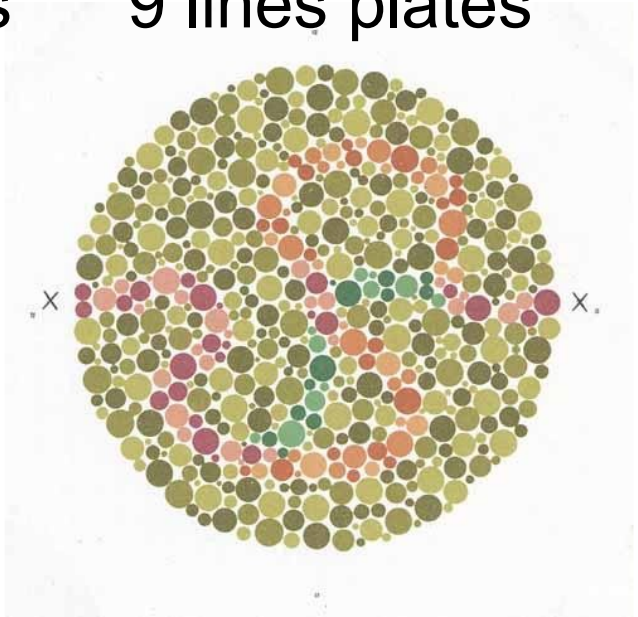
17 numbers plates



6 shapes plates



9 lines plates



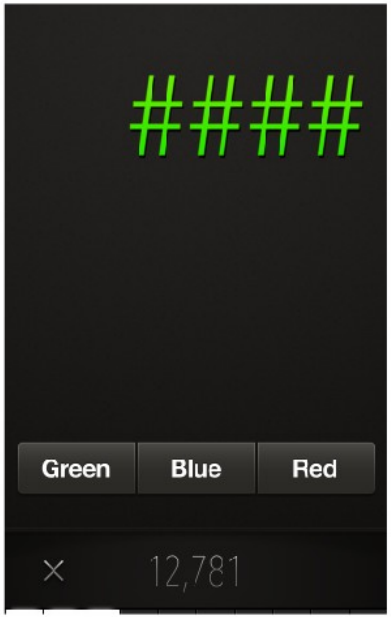
Methods - Procedures - Stroop Test App

App for research purposes

(screen for Minimal Hepatic Encephalopathy. *Bajaj et al., 2013)*

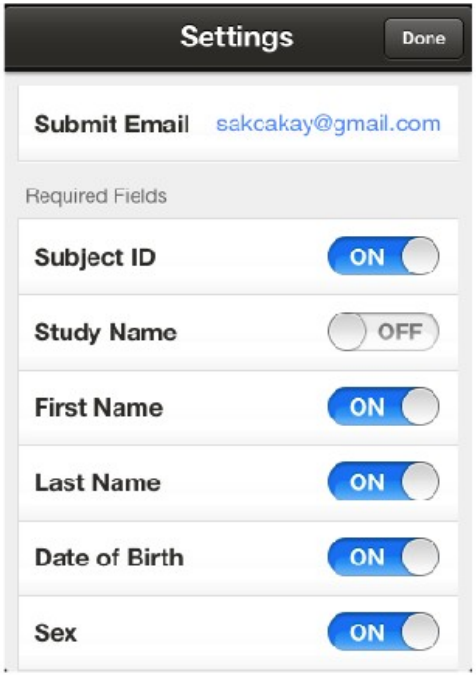
Stroop Off and

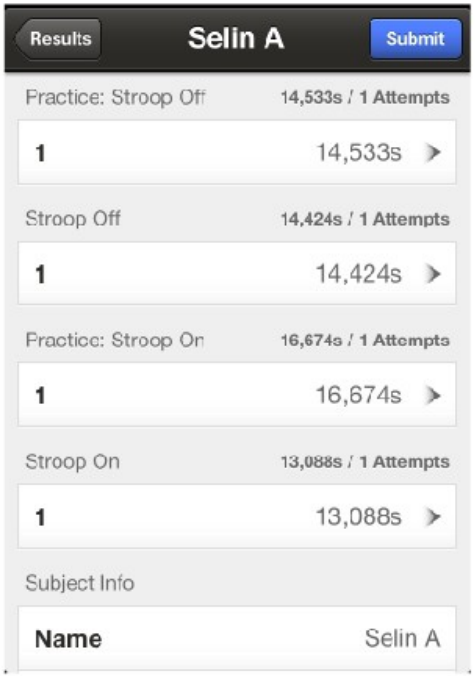
Stroop On State



Methods - Procedures - Stroop Test App

Settings and Results of Application





Methods - Procedures - Stroop Test App

Stroop Output

Output	Definition
OFFTIME	Time required to complete 5 correct runs in the “Off State”
ONTIME	Time required to complete 5 correct runs in the “On State”
TRIALS OFF	Number of trials it took the subject to get 2 correct runs in the “Off State”
TRIALS ON	Number of trials it took the subject to get 2 correct runs in the “On State”
OFFTIME + ONTIME	Sum of Offtime and Ontime
ONTIME - OFFTIME	Ontime substracted by Offtime

Results

- Two-way repeated measures ANOVA
- Mean reaction time for a single item
- Factors:
  - Stroop level (neutral, incongruent)
  - Binaural beat frequencies (beta, delta/theta)

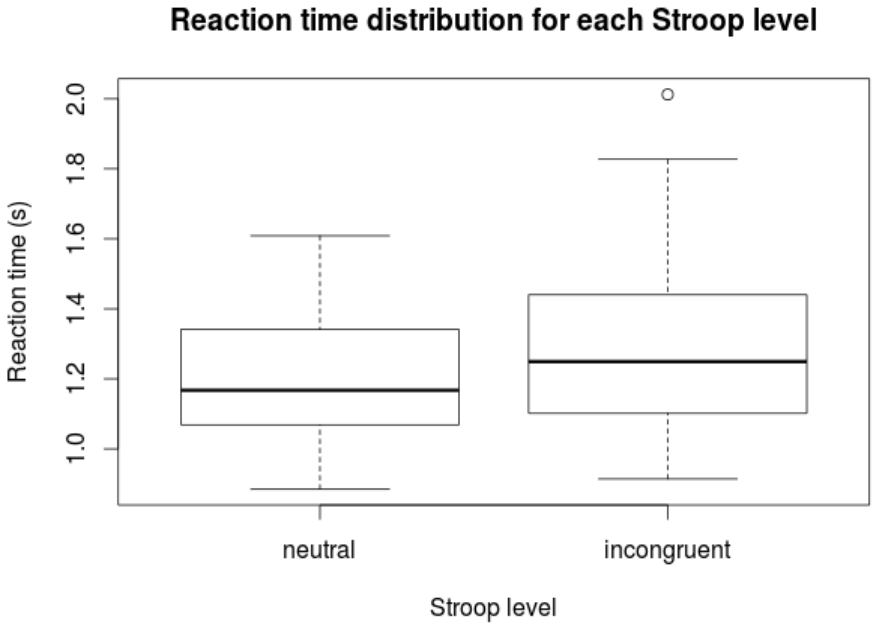
Results (mean reaction time)

- Neutral (off)

M=1.20, *SD*=0.18

- Incongruent (on)

M=1.29, *SD*=0.25



ANOVA

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Residuals	19	3.06	0.16		
sound	1	0.02	0.02	1.75	0.2015
Residuals1	19	0.24	0.01		
level	1	0.18	0.18	14.89	0.0011
Residuals2	19	0.23	0.01		
sound:level	1	0.00	0.00	0.68	0.4182
Residuals	19	0.05	0.00		

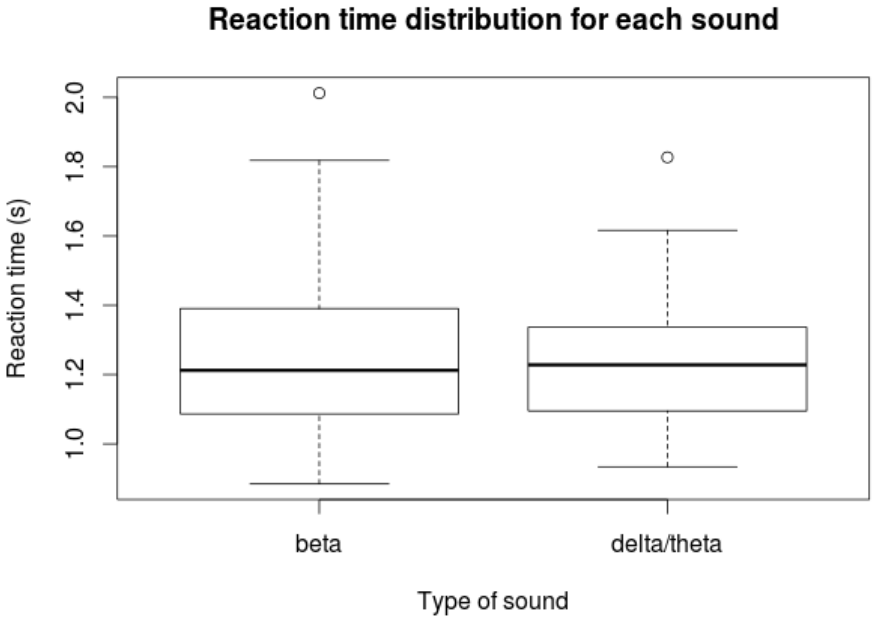
Results (mean reaction time)

- Beta

M=1.26, *SD*=0.24

- Delta/Theta

M=1.23, *SD*=0.20



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sound:level	1	0.00	0.00	0.68	0.4182
Residuals	19	0.05	0.00		

Results

- Accuracy (%)
  - 100*(5+5)/(TRIALS OFF+TRIALS ON)
- Total time
  - OFFTIME+ONTIME

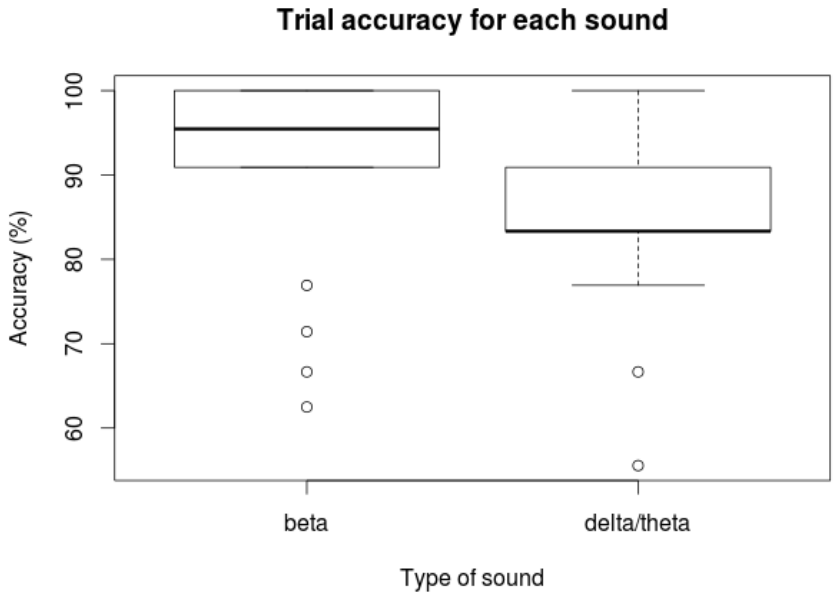
Results (accuracy)

- Beta

M=91.15, *SD*=12.13

- Delta/Theta

M=85.32, *SD*=11.22



ANOVA

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Residuals	19	2652.89	139.63		
sound	1	339.90	339.90	2.55	0.1270
Residuals1	19	2535.70	133.46		

Results (total time)

- Beta

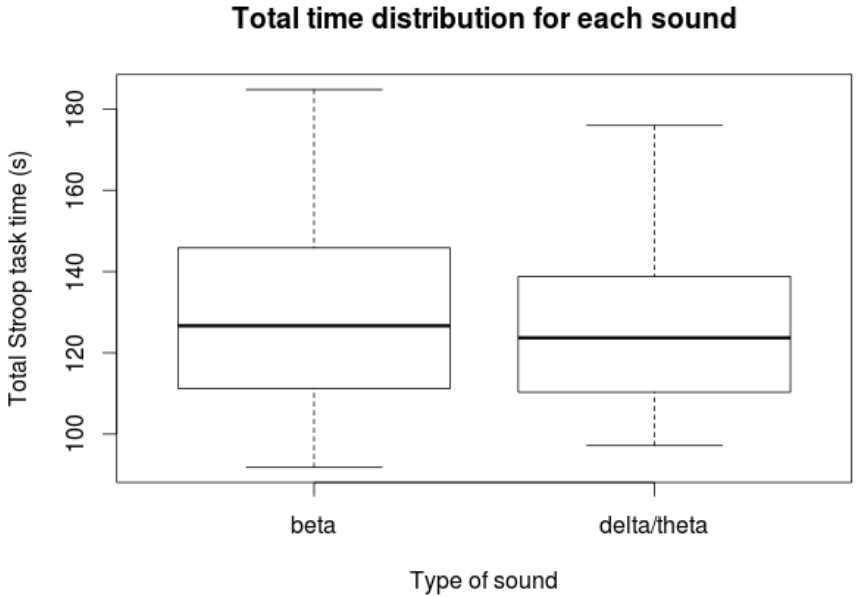
M=130.58, *SD*=25.21

- Delta/Theta

M=128.05, *SD*=21.44

ANOVA

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Residuals	19	19440.58	1023.19		
sound	1	63.69	63.69	0.88	0.3600
Residuals1	19	1375.51	72.40		



Discussion

Hypothesis: "Exposure to binaural auditory beats in the EEG beta frequency ranges in comparison to delta/theta frequency ranges improves significantly performance in stroop test"

Conclusion:

- No statistically significant difference found between the two conditions ($p>0.05$)
- Results provide no evidence for improvements in cognitive function after exposure to beta binaural beats (mean time 15' 09") in contrast to theta/delta binaural beats (mean time 15' 03") in a small sample of 20 healthy adults.
- Stroop effect was observed

Discussion

Limitations:

•Experiment duration may not be sufficient for entrainment

Improvements:

•Increase exposure time to BB

•Sessions in separate days

•More sessions

•Increase sample size

•Within subjects vs between groups

+ avoid learning curve

- natural variance (big sample needed)

References

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