EEG Beta Range Dynamics and Emotional Judgments of Face and Voices

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Abstract: The purpose of this study is to clarify multi-modal brain processing related to human emotional judgment. This study aimed to induce a controlled perturbation in the emotional system of the brain by multi-modal stimuli, and to investigate whether such emotional stimuli could induce reproducible and consistent changes in the brain dynamics. As we were especially interested in the temporal dynamics of the brain responses, we studied EEG signals. We exposed twelve subjects to auditory, visual, or combined audio-visual stimuli. Audio stimuli consisted of voice recordings of the Japanese word 'arigato' (thank you) pronounced with three different intonations (Angry - A, Happy - H or Neutral - N). Visual stimuli consisted of faces of women expressing the same emotional valences (A, H or N). Audio-visual stimuli were composed using either congruent combinations of faces and voices (*e.g.* H x H) or non-congruent (*e.g.* A x H). The data was collected with a 32-channel Biosemi EEG system. We report here significant changes in EEG power and topographies between those conditions. The obtained results demonstrate that EEG could be used as a tool to investigate emotional valence and discriminate various emotions.

1 INTRODUCTION

Judgment is the operation of the mind by which knowledge of the values and relations of things is obtained. Judgment is important for decision making, and involves both cognitive and infra-cognitive processes. In social cognition, judging the emotion of another human being is important to interpret communications. For instance, patients with emotional judgment disorders, such as patients suffering from major depression (Griamm et al., 2008), can have serious social impairments. Our purpose is to investigate the neurodynamics of human emotional judgments.

Human communication is based both on face and voice perception, therefore facial expression and tone of voice is important to understand emotions. Such multi-modal brain processes are difficult to investigate. Anatomically, a huge literature emphasizes the role of sub-cortical areas in emotion processing (see *e.g.* Ledoux, 2000). This explains the preponderance of fMRI studies in brain science literature, as this imaging technique provides information about sub-cortical activities. However, these sub-cortical areas do not work independently one from another, and consequently emotion processing necessarily involves large-scale networks of neural assemblies, in cortico-subcortical transient interactions, where the time evolution of the network is a key factor (Tsuchiya and Adolfs, 2007). Therefore, EEG could provide crucial information about emotional processes. For this reason, in a previous pilot study, we investigated the effects of voice and face emotional judgments on EEG signals, on two subjects (Hiyoshi-Taniguchi, et al., 2011). Here we extend those results with 12 subjects.

The purpose of our study was to induce a controlled perturbation in the emotional system of the brain by multi-modal stimuli, and to control if such stimuli could induce reproducible changes in EEG signal. We used a combination of photos and voices with congruent or non congruent emotional

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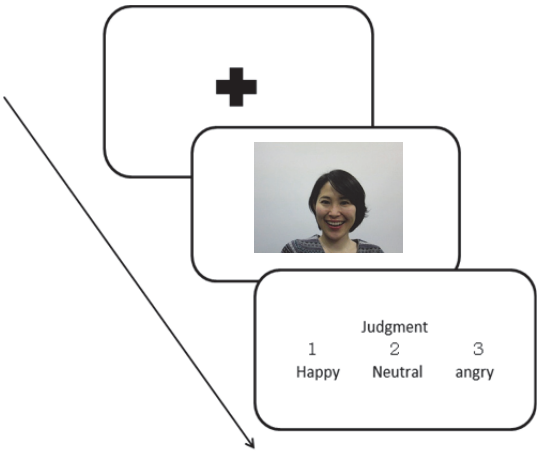
valence. Through the investigation of this 'abnormal' perceptual condition, we intend to reveal the mechanisms of normal emotional judgment (how one can distinguish the valence of emotions in a given stimulus). The use of three different valence stimuli (neutral, angry, happy) will be compared.

2 METHOD

We recruited 12 subjects for this study. All subjects were young (age =21.9 ± 0.31) healthy adults, without prior history of any neurological or psychiatric disorders. All subjects were screened to be right handed using the Edinburgh handedness test. 10 subjects were female, 2 were male.

We exposed these subjects to auditory, visual, or combined audio-visual stimuli. Stimuli were presented for 2 sec, the subjects was asked to answer afterwards within a 3 sec window, and then had 5 sec of rest (one trial = 10 sec). Audio stimuli consisted of voice recordings of the word '*arigato*' (thank you) pronounced with three different intonations (Angry - A, Happy - H or Neutral - N). Visual stimuli consisted of faces of women expressing the same emotional valences (A, H or N). Audio-visual stimuli were composed using either congruent combinations of faces and voices (*e.g.* HxH) or non-congruent (*e.g.* AxH):



3 RESULT

For multimodal stimuli, the common pattern between emotional conditions (both in HxH vs. NxN and in AxA vs. NxN) is observed, with a general increase of the EEG power in peripheral areas, for beta range.

In the non-congruent condition, specific effects are observed (Figure 1):

- when comparing a congruent stimulus with a non-congruent stimulus with a visual difference (HxH vs. AxH), one can observe a distinct pattern: a longitudinal shift of power in the alpha range (increased in the frontal area, decreased in the occipital area). The same shift is obtained in the beta range, but only for the HxH vs. AxH condition.
- when comparing a congruent stimulus with a non-congruent stimulus with an auditory difference (HxH vs. HxA), another distinct pattern is visible: a longitudinal shift of power in the beta range (increased in the frontal area, decreased in the occipital area).

Finally, in all the non-congruent conditions, an increase of activity is observed in the theta range, in a right centro-temporal location (C_4, CP_4).

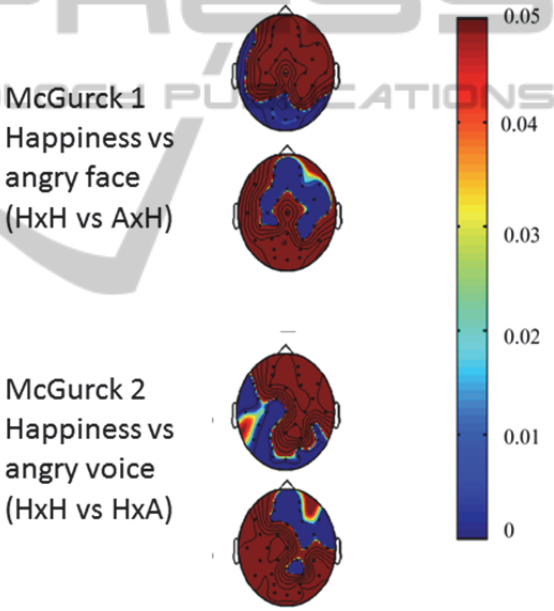


Figure 1: Illustration of the difference between HxH and AxH and HxA conditions in the beta (12-25) ranges.

4 DISCUSSION

We first off all analyzed congruent emotional judgment. Emotional judgment is known to be associated with neural correlates in the left and right dorso-lateral prefrontal cortex (Nakamura, et al., 1999; Ochsner, et al., 2002; Lange, et al., 2003; Keightley, et al., 2003; Northoff, et al., 2004; Grimm, et al., 2006). We indeed observed in the congruent condition strong activations in the prefrontal channels, especially in the alpha and beta

ranges. From our result, we observe an angry-visual and happy-auditory preferential association. This effect might be due to a well-known reaction of preparation to danger (the Colavita visual dominance effect, see *e.g.* van Damme, et al., 2009): perception of angry emotion means a potential danger, which would place the subject in a preferential visual dominance mode. Threatening facial expression also induces avoidance behaviour, visible in eye-tracking (Rigoulot and Pell, 2012). These effects might be correlates of the EEG occipital area alpha range increase.

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