NEURODYNAMICS OF EMOTIONAL JUDGMENTS IN THE HUMAN BRAIN

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Abstract: The purpose of this study is to clarify multi-modal brain processing related to human emotions. 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 EEG signals.

We exposed two 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 EEG system and analysis was performed by computing the topographic distributions of EEG signals in the theta, alpha and beta frequency ranges.

We compared the conditions stimuli (A or H) vs. control (N), and congruent vs. non-congruent. Topographic maps of EEG power differed between those conditions on both subjects. The obtained results suggest that EEG could be used as a tool to investigate emotional valence and discriminate various emotions.

1 INTRODUCTION

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. The brain is a complex machine, and unfortunately no optimal method exists to understand fully its mechanisms – especially when one intends to use non-invasive measurements. In order to understand the mechanisms of emotion, one has to ask first where these mechanisms would be expected to be located inside the brain. Anatomically, a huge literature emphasizes the role of sub-cortical areas in emotion processing. However, these 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).

There is considerable evidence that multisensory stimuli presented in spatial or temporal proximity are bound by the brain into a unique perceptual gestalt (Van den Stock, et al., 2008). What would happen if subjects were exposed to contradictory visual and auditory stimuli? Such contradiction is termed as a "McGurk effect" (McGurk and MacDonald, 1976, see Figure 1) – the visual and auditory stimuli do not carry the same message. Subjects confronted to these emotional stimuli, and asked to provide feedbacks on their internal perceptions while their neural activities are recorded, are confronted to the difficulty of binding contradictory emotional features.

2 AIM

The purpose of our pilot study was to induce a controlled perturbation in the emotional system of

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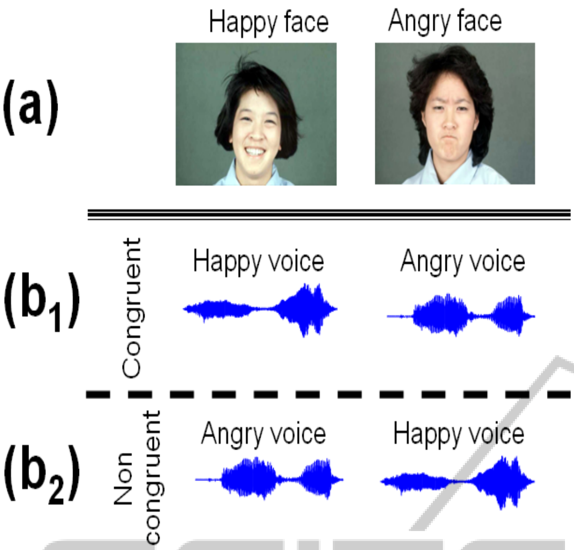

Figure 1: McGurk effect. Visual stimuli (a) are combined with audio stimuli (b). Subjects will expect congruent stimuli (b_1), where visual and auditory clues are concordant (e.g. happy face and happy voice). Non-congruent stimuli (b_2), where visual and auditory clues are discordant (e.g. happy face and angry voice), will induce distortions in either the visual or auditory perception (this distortion is termed as a "McGurk effect".

the brain by multi-modal stimuli, and to control if such stimuli could induce reproducible changes in EEG signal. 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 different valence stimuli (neutral, aggressive, appeasing, etc.) will be compared.

3 METHOD

We exposed two right handed, male 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), taken from the JACfee and JACNeuf Japanese-Caucasian photo databases (Biehl et al. 1997). Audio-visual stimuli were composed using either congruent combinations of faces and voices (*e.g.* HxH) or non-congruent (*e.g.* AxH). The experiment consisted in three different sessions:

- In the first session, the subjects were exposed to visual stimuli only. Their task was to judge if the face was neutral, angry, or happy. 60 stimuli were presented in a pre-decided random order, and so that two consecutive emotions were always different.
- In the second session, the subjects were exposed to visual stimuli only. Their task was to judge if the voice was neutral, angry, or happy. 60 stimuli were presented in a pre-decided random order, and so that two consecutive emotions were always different.
- In the third session, the subjects were exposed to the combined audio-visual stimuli. Their task was to judge if the percept was neutral, angry, or happy. 60 stimuli were presented in a pre-decided random order, and so that two consecutive emotions were always different, and so that the same number of trials occurred for all possible pairs of stimuli.

In each of the three sessions, the task of the subjects was to judge if the face was neutral, angry, or happy, and to provide this response with a keyboard.

The data was collected with a 64-channel Biosemi EEG system with active electrodes in a shielded room. Sampling rate was fixed at 1024 Hz, notch filter at 50 Hz and analog bandpass filter between 0.5 and 100 Hz. The topographic distributions of EEG signals (relative power) in the theta (4-8 Hz), apha (8-12 Hz) and beta (12-25 Hz) ranges was afterwards computed using the Welch periodogram method (Welch, 1967) on the trials of the third session.

4 RESULT

We compared the conditions stimuli (A or H) vs. control (N), and congruent vs. non-congruent. Topographic maps of EEG power differed between those conditions on both subjects. Generally, the difference is maximized for HxH vs. HxA (Figure 2), in other words, the non-congruent stimuli are "more different" than the neutral stimuli. Significant changes are observed in the alpha range in the frontal and right temporal areas; and in the left parietal area in the theta range (Figure 2, Figure 3). These changes are specific to the McGurk effect

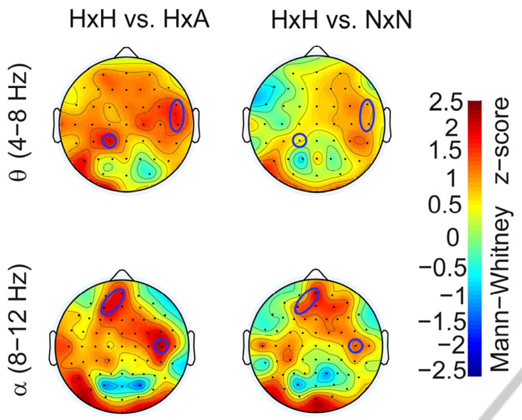

Figure 2: Illustration of the difference between HxH and HxA conditions (Mann-Whiteny z-score) in the theta (4-8 Hz) and alpha (8-12 Hz) ranges.

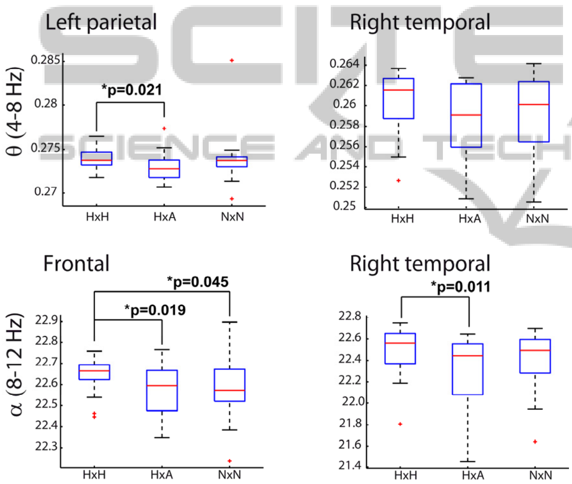

Figure 3: Boxplot of theta (4-8 Hz) relative power in the left parietal and riught temporal area, and alpha (8-12 Hz) relative power in the frontal and right temporal areas (blue ellipses of figure 2) for each condition.

(congruent vs. non-congruent), they are not observed on the HxH vs. control topographic map.

5 DISCUSSION

It was shown recently that the emotions elicited, and the EEG topographies observed in emotion studies, are influenced by the task given to the subject in the experiment (Grandjean and Scherer, 2008). Therefore, our results are not general observations of emotional mechanisms, and should be considered in the context of the experimental task (emotional judgment). One could model emotional experience as a confluence of two dimensions, valence and arousal (Feldman Barrett, et al., 2007). Many current theories of emotion now place the appraisal component of emotion at the forefront in defining and studying emotional experience. However, most contemporary psychologists who study emotion accept a working definition acknowledging that emotion is not just appraisal but a complex multifaceted experience with the following components:

- Cognitive appraisal (Scherer, 1999). Only events are judged or appraised to have significance for our goals, concerns, values, needs, preferences, or well-being elicit emotion. This is the cognitive aspect of emotional valence.
- Subjective feelings. The appraisal is accompanied by feelings that are good or bad, pleasant or unpleasant, calm or aroused. This is a more perceptual aspect of emotional valence.
- Physiological arousal (*e.g.* Schachter and Singer, 1962).. Emotions are accompanied by autonomic nervous system activity.
- Expressive behaviours (Ekman and Friesen, 1978; Martin et al., 1988). Emotion is communicated through facial and bodily expressions, postural and voice changes.
- Action tendencies. Emotions carry behavioural intentions, and the readiness to act in certain ways.

We investigated emotional judgement, *i.e.* cognitive appraisal of emotional stimuli. Our exploratory experiment indicates that EEG could be used as a tool to investigate emotional valence. The main effect observed is that the Mc Gurk effect (non congruent stimuli) seems to enhance the difference of brain EEG topography, as compared to more classical emotional stimuli. Additional data will be collected to confirm our first observations.

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