The auditory-visual integration of anger is impaired in alcoholism: An event-related potentials study.

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Aims

In everyday life, sensory events are not experienced in isolation. Indeed, human beings are constantly confronted with multiple stimuli, which are integrated into a unitary perception of the environment. Crossmodal interactions, at behavioral and cerebral levels, are therefore crucial for daily adaptive behaviors, particularly for emotional processing. Nevertheless, while unimodal (auditory or visual) impairments in the processing of emotions have been repeatedly described at a behavioral level in alcoholism (e.g. Monnot et al., 2001; Townshend & Duka, 2003), the crossmodal (auditory-visual) processing of emotional stimuli has not yet been explored.

This study used an emotion-detection task based on emotional facial expression and emotional prosody, with recording of event-related potentials (ERPs) to:

(1) describe the electrophysiological correlates of unimodal (visual and auditory) impairments in emotional processing among alcoholic individuals;

(2) determine whether this deficit is general or "emotion-specific";

(3) explore potential deterioration in the specific crossmodal integration processes in alcoholism.

Methods

Subjects :

- 15 inpatients (five women), diagnosed with alcohol dependence according to DSM-IV criteria and recruited during the third week of their detoxification treatment.
- 15 volunteers matched for age, gender and education level.

Stimuli :

- 12 Visual stimuli (V): Emotional Facial Expression, namely 4 faces (2 males) X 3 emotions (angry, happy, neutral).
- 12 Auditory stimuli (A): Audiotapes enunciating a semantically neutral word ("paper") with an emotional prosody, namely 4 voices (2 males) X 3 emotions (angry, happy, neutral)
- 12 Auditory-Visual (crossmodal) stimuli (AV), based on the combination of a visual and an auditory stimulus (congruent for emotion and gender).

Task :

- Emotion-detection task in which participants were confronted with faces and voices, presented separately (unimodal conditions) or simultaneously (crossmodal condition).
- As illustrated in Figure 1, each trial consisted in: (1) a fixation cross for 300 msec; (2) the stimulus (face, voice, or both) for 700 msec; (3) a black screen for a random duration of between 800 and 1300 msec. From the stimulus onset, participants had 1500 msec to answer.
- Two emotions per block (e.g. anger – happiness). At the beginning of each block, participants were told which pair of emotions will be presented and had to decide in each trial which emotion was displayed by pressing the button corresponding to that emotion (e.g. "anger").
- 15 blocks (each defined by 60 stimuli) for a total of 900 stimuli [100 per experimental condition, 3 modalities (A,V,AV) X 3 emotions (anger, happiness, neutral)].

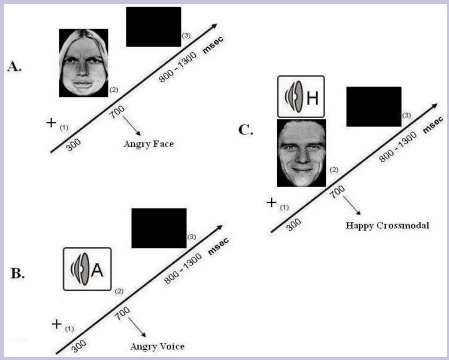

Fig1. Illustration of the experimental design, with the successive arrival of (1) a fixation cross, (2) the stimulus and (3) an inter-stimuli black screen. The three categories of stimuli are illustrated in an Anger-Happiness block: (A) visual, (B) auditory, and (C) crossmodal.

Recording and data analysis

32 electrodes quick cap (Quick-Cap, Neuromedical Supplies®, Neurosoft, Inc.)
Standard 10-20 system with additional intermediate positions (linked mastoid physical reference)
EEG amplified by battery-operated A.N.T.® amplifiers. Gain of 30,000; band pass of 0.3-30 Hz
Continuous recording, sampling rate 512 Hz (Eeprobe, A.N.T. ®)
Artifacts manually removed
Epochs beginning 200 ms prior to stimulus onset and continuing for 1000 ms.
Recalculation to obtain common average reference recordings
By participant : individual peak amplitudes and maximum peak latencies for the ERP's evoked by stimuli, for each wave of interest (P100, N170-N2, P3b)
Electrodes : Oz, O1, O2, T5, T6 for P100 ; T5, T6 for N170-N2 ; Pz, P3, P4 for P3b.
Statistical analysis: ANOVA, paired sample t-tests, Pearson's correlations
Source reconstruction based on the SWLoreta Method.

Results

Behavioral data

Control measures

Alcoholics had higher scores than controls for depression, anxiety state and trait and alexithymia, but these differences did not influence the experimental results (no significant Pearson's correlations with behavioral and ERP's data).

Behavioral data

Performance: Alcoholic individuals made more errors than control subjects, but only for visual stimuli.

Reaction times: Alcoholic individuals were globally slower than controls to perform the task.

Electrophysiological data

P100 : No significant differences between groups neither in amplitude nor in latency.

N170-N2: - *Latencies* : Alcoholics had longer latencies than controls, particularly for auditory stimuli.
- *Amplitudes*: Alcoholics had lower amplitudes than controls, particularly for auditory and auditory-visual stimuli.

P3b: - *Latencies* : Alcoholics had longer latencies than controls, regardless of the modality or emotion.
- *Amplitudes*: Alcoholics had lower amplitudes than controls, regardless of the modality or emotion

Crossmodal interactions analysis

- Crossmodal interactions were isolated in each group on the basis of the subtraction of the unimodal conditions (auditory and visual) from the bi-modal one (auditory-visual): **AV – (A+V)**
- These significant crossmodal activities index the electrophysiological components specifically associated to integrative processing.
- A group comparison of the subtraction waves obtained in each emotional condition was then computed. Significant differences between groups for crossmodal activities are shown in Table 1. These differences are particularly present for anger.

Source location (Figure 2)

- In order to test the anatomical correlates of the results obtained in the ERP data, a source analysis was computed for both groups.
- For anger and happiness, neural generators were identified in the occipital and temporal regions for both groups. Nevertheless, an additional generator located in the frontal region was observed for the anger stimuli among controls, but not alcoholics.

Time interval, ms	Electrode	*t* value*	*p* value†
Anger			
130–160	Fz	2.60	0.02
110–160	F4	2.22	0.04
130–160	Pz	2.23	0.04
120–160	P3	2.19	0.05
120–150	T5	2.16	0.05
110–150	T6	2.35	0.03
090–140	Oz	2.50	0.03
490–690	F4	2.20	0.05
510–660	Pz	2.31	0.04
570–670	P3	2.17	0.05
510–650	P4	2.46	0.03
Happiness			
210–290	F4	2.60	0.02
220–280	T6	2.23	0.04
210–270	O1	2.53	0.02
600–760	F4	2.33	0.04
Neutral			
380–800	Pz	2.47	0.03
330–800	P4	2.18	0.05

F = frontal; P = parietal; T = temporal; O = occipital.
Note: Each line is associated with a significant difference between groups concerning the cross-modal activities (audio-visual – [audio + visual]).
*The *t* value of the *t* tests comparing the cross-modal activities between groups during this time interval.
†The *p* value of the *t* tests comparing the cross-modal activities between groups during this time interval.

Table 1. Significant differences between groups for the subtraction waves in each emotional condition.

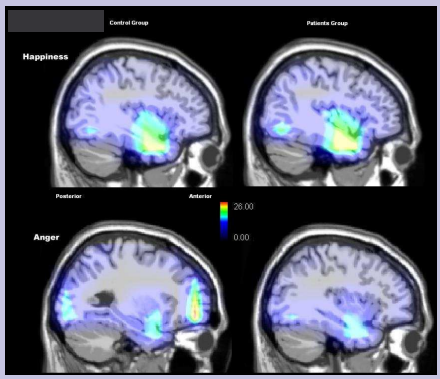

Fig 2. Source reconstruction analysis of the cerebral generators in the control (left) and alcoholic (right) groups, for happiness (above) and anger (below) subtraction waves. Observe the absence of frontal activation in the alcoholic group as compared to controls, but only in the anger condition.

Summary of the results

- At the behavioral level, alcoholics made **more errors** and had globally **longer RTs in all the conditions**.
- At the ERP level, alcoholics had no deficit on P100, but presented a **N170-N2** and **P3b impairment**.
- At the crossmodal interactions and source location level, alcoholics showed **impaired crossmodal processing for anger,** indexed by a **frontal activity reduction**.

Discussion

At the behavioral level, our data confirmed the impaired performance of alcoholics in identifying complex emotional stimuli, and suggested that this deficit is greater for visual stimuli than for auditory and auditory-visual stimuli.

At the ERP level, main results are:

- *The observation of a N170 deficit*: The impairment in emotional processing seen in alcoholism starts at the perceptive level, specifically at the face and voice processing stage of the cognitive stream.
- *The generalization of the P3b deficit*: Many studies showed impaired P3b in alcoholism with simple stimuli, but the present study generalized this observation to complex emotional visual and auditory stimuli (namely faces and voices), and provided the first observation of a P3b impairment for crossmodal stimuli.
- *The description of a specific deficit for anger in alcoholism during crossmodal processing*: (1) For neutral stimuli, alcoholics did not have significant impairment, showing that crossmodal processing appears preserved for non- emotional stimuli; (2) For happiness, alcoholics had only late crossmodal processing impairment (250-300 ms); (3) For anger, alcoholics had early impairment in crossmodal processing (as soon as 90-160 ms), particularly at frontal sites, where control subjects had marked activity between 100 and 150ms, while no activity was detected in the alcoholic group.

Conclusion

- This study mainly showed that early crossmodal processing is impaired specifically for anger in alcoholism. This result could explain the hiatus between clinical observations (showing high difficulties to manage anger in alcoholism) and previous experimental studies (showing no massive deficits for anger processing). Indeed, this difference could be due to the fact that previous studies used artificial and unimodal stimuli (mainly EFE).
- On the basis of more ecological multimodal stimuli, the present study described, at the ERP level, the specific crossmodal deficit for anger in chronic alcoholism that has been repeatedly described at clinical level. These results may encourage future studies to use more ecological stimuli (notably faces and voices) in the exploration of emotional impairments in alcoholism.

Reference

Maurage et al. (2008). Journal of Psychiatry and Neuroscience, 33(2), 111-122.