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IS IT POSSIBLE TO RECOGNIZE EMOTIONS/ FEELINGS?

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ABSTRACT

It is true that emotions are the most important psychological functions in humans and are on the top of the hierarchical tree of the homeostasis.

As a potent mental activity, emotions significantly influence various aspects of human functioning such as decision-making, perception, attention and memory.

For scientific but also for practical reasons, the main question is: how to register and measure emotions?

The aim of this article is to summarize the main known methods for measuring the emotions/feelings published in Medline basis.

Different methodologies are presented in order to measure emotions such as: Face recognition,

Bodily maps of emotions, Evaluation of autonomic nervous system activity, EEG, and especially fMRI and PET scan. Data are used from PubMed bases.

Keywords: emotions, body, brain, imaging

INTRODUCTION

I am convinced that emotions are the most important psychological functions in humans. They are on the top of the hierarchical tree of the homeostasis (Damasio, 2004) [1]. In everyday language we often use the terms emotions and feelings as synonyms. This shows how closely emotions are connected with feelings. As a potent mental activity, emotions significantly influence various aspects of human functioning such as decision-making, perception, attention and memory. Numerous mental diseases, including autism, hyperactivity, melancholy and addictions are also linked to emotions. Therefore, the rapid and accurate recognition of emotions is of great importance for cognitive behavioural research, the diagnosis and treatment of emotion-related diseased as well as for human–computer interaction, recommendation systems etc.

For neuroscience, emotions are the complex reactions of the body to certain stimuli. This emotional reaction occurs automatically and unconsciously. Feelings occur after we become aware in our brain of such physical changes; only then we can experience the exact feeling.

The brain is constantly receiving signals from the body, registering what is going on inside of us. It then processes the signals in neural maps, which then compiles it in the so-called somatosensory centres. Feelings occur when the maps are read, and it becomes apparent that emotional changes have been recorded. An organism can possess feelings only when it can create a representation of the body's functions and the related changes that occur in the brain. Thus, the organism can perceive them. Without this mechanism there would be no consciousness. Current technological achievements make it unclear that emotions could ever develop in a machine (AI), or whether we really want to construct machines with feelings.

The notion that afferent visceral signals are essential for the unique experiences of distinct emotions remains a key unresolved question at the heart of emotional neuroscience (Cacioppo et al., 2000; Rainville et al., 2006) [2,3].

The Somatic Marker Hypothesis suggests that emotions and feelings create "somatic markers" which act as signals guiding behaviour towards beneficial outcomes. Deficiencies in these markers can lead to impaired decision-making and inappropriate social behaviour, as seen in patients with certain brain conditions. Demonstration that both sympathetic and parasympathetic nervous systems possess exquisite organ-specific regulation has countered this argument and contributed to a revival of somatic theories (Damasio, 1994, 1999) [4,5]. Similarly, emotion-specific patterns of neural activity have been demonstrated in association with discrete feeling states (Damasio et al., 2000, 2003) [6,7]. As consequence, emotions are often felt in the body, and somatosensory feedback has been proposed to trigger conscious emotional experiences.

Emotions are ubiquitous in development and have been studied from structural, functional and dynamic perspectives. Emotions involve subjective experiences, physiological patterns, and behavioural responses. Structurally, emotions have traditionally been classified into basic emotions (fear, disgust, anger, surprise, happiness, and sadness) and complex emotions (e.g., shame, guilt, pride) that reportedly require more self-reflection and self-evaluation. Additionally, to the six main emotions, Russell's titter-wake scale defines emotions quantitatively by three dimensions, Valence, Arousal, and Dominance for emotion recognition (Fang A et al., 2024) [8].

Emotional development includes experiencing and learning about socioemotional events as well as individual difference in emerging emotional regulatory abilities, while emotion regulation is defined as the ability to respond and adapt to emotional experiences in an age-appropriate manner.

Many types of research are performed to understand the areas of the brain that are responsible for emotional response, emotional learning and memory, the way how emotions modulate memory, and the influence of emotion on attention and perception. It is proven that the amygdala is involved in fear and other emotional activities. The sensory input signals are received by the amygdala and these signals stop at the end of the lateral nucleus (LA). If there is any damage in the LA, it leads to fear conditioning, and lesions could cause changes in cognitive functions too.

The Need-Informational Theory of Emotions states that there are different neural pathways for motivations, emotions, and intuition. Some circuitries are involved in positive and negative emotional responses. The amygdala-neocortical circuitry explicitly shows the immediate consciousness of the implicit processing of emotions and the explicit processing of thoughts that are semantically based and are managed by the hippocampal-neocortical circuitry. The right hemisphere of the brain is responsible for regulating negative emotions, while the left hemisphere is responsible for regulating positive emotions. The amygdala, which is more involved in fear sensitization, may lead to several phobias due to the increased sensitization-associated amygdala activity and these are proven through animal studies. This shows that there is a direct connection between emotions with learning and memory consolidation.

For scientific but also for practical reasons, the main question is: how does one recognize and measure emotions? The aim of this article is to summarize the main known methods for measuring the emotions/feelings published in Medline basis.

1) Facial expression

The facial expressions of seven common emotions, also known as "micro-expressions," tell us how we are feeling inside. Our body language, facial expressions, and tone of voice say more than what we actually say to other people. The research on facial expressions and emotions is related to Charles Darwin. He suggested that just the universality of facial expressions supports the theory of evolution. There is strong evidence to support the opinion that these facial expressions reveal our true emotions. However, they do not last very long. "Micro-expressions" can last for a fraction of a second, but if you catch them, you are likely to have more insight into how a person is feeling. Main emotions related to facial expression are surprise, fear, disgust, hate, anger, sadness and happiness. The ability to quickly and accurately encode and respond to emotional faces is crucial for social interactions, and it is possible that dysfunctional emotion encoding contributes to emotional-behavioural problems.

Emotion encoding can be conceptualized as a sensory-cognitive ability that partly draws on intelligence and in particular on perceptual abilities (Jaksic C, Schlegel K., 2020) [9], highlighting the importance of accounting for general cognitive abilities. As follows, emotion recognition can be performed through different modalities such as facial expression, speech, gait, physiological signals, etc. Although some modalities like facial expressions might lead to significant and considerable results, they cannot be used for all people, like those who are disabled and are not able to move their head and muscle. In this context, people with Myotonic dystrophy, Neuromuscular diseases, Parkinson, strokes etc. are able to recognize emotions via face expressions. Making quick inferences about the personality of others appears to have evolutionary roots and is considered an adaptive process in that it assists us in everyday decisions (Lenzoni S. et al, 2020; García I. et al, 2024; Johnson C. et al, 2020) [10,11,12]. Figure 1 shows main emotional facial expression in humans.

2) Bodily maps of emotions

Emotions are often felt in the body, and somatosensory feedback has been proposed to trigger conscious emotional experiences. The use of the maps of bodily sensations are associated with different emotions using a unique topographical self-report method. In practice, clients are asked to colour the bodily regions whose activity they felt increasing or decreasing while viewing different stimulus. Different emotions were consistently associated with statistically separable bodily sensation maps. Emotions are represented in the somatosensory system as culturally universal categorical somatotopic maps. Perception of these emotion-triggered bodily changes may play a key role in generating consciously felt emotions (i.e. feelings). Figure 2 presents bodily sensation maps.

On a practical level, BSMs may be a useful tool to improve the specificity and efficiency of communicating and visualizing feelings. People typically have difficulty in assessing, discerning, and describing their own emotions. Instead of describing their feelings verbally or transferring their feelings into an abstract value on a scale,

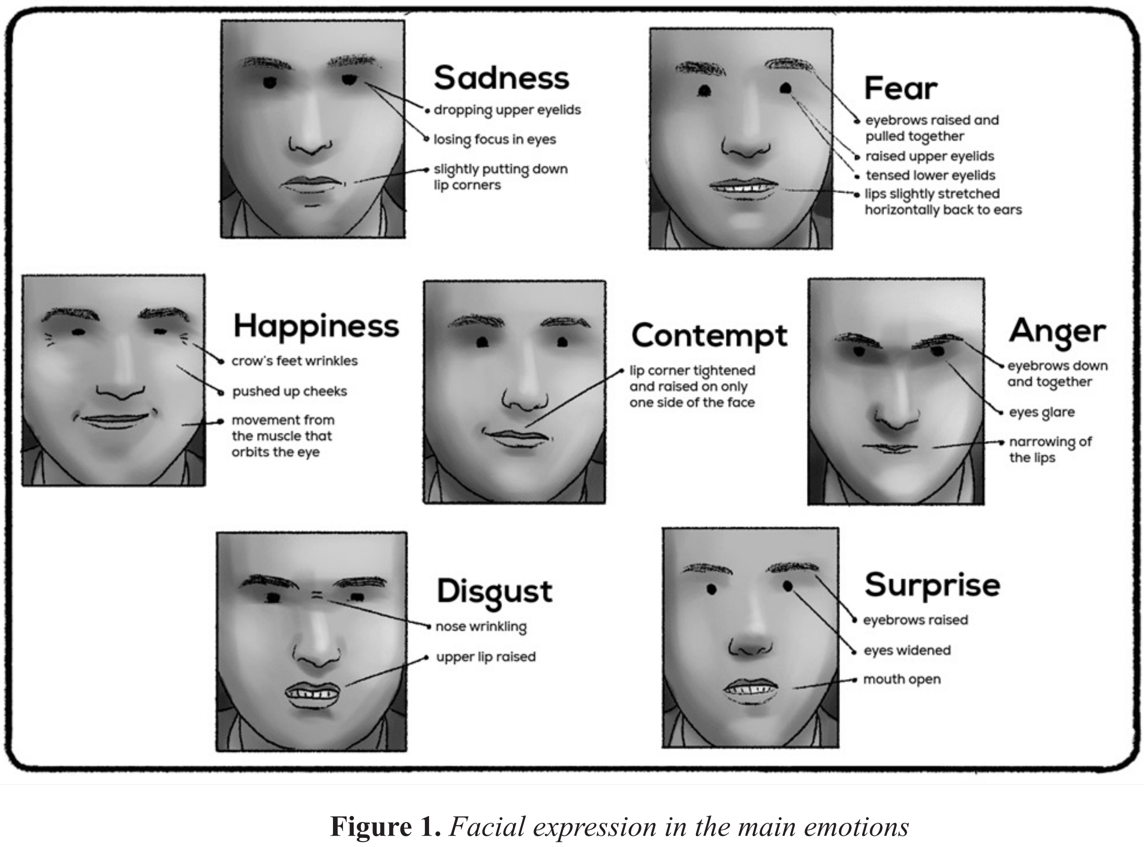

Figure 1. *Facial expression in the main emotions (Retrieved from https://practicalpie.com/facial-expressions-of-emotions/)*

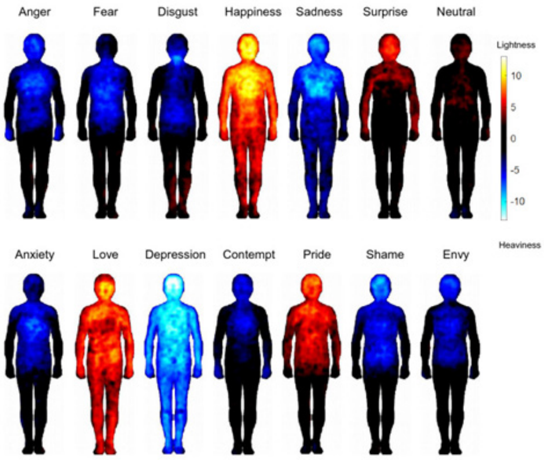

Figure 2. *Bodily sensation maps (BSMs) of basic emotions including a neutral state (upper panel) and non-basic emotions (lower panel). Retrieved from* https://practicalpie.com/facial-expressions-of-emotions [13].

[The warm colours show body regions with an increased sensation of bodily lightness, and the cold colours show regions with an increased sensation of bodily heaviness when participants displaced themselves into the different emotional states. The colour bar indicates the t-statistic range $p < .05$, FDR correction].

people can just "paint" a BSM to represent how their body feels.

However, activity-based BSM tools cover only a limited spectrum of bodily sensations. This limitation becomes evident for example when comparing the BSM for anger and pride: These two BSMs look quite similar (both show a selective activation in the upper body, although there is a fundamental difference in the quality of the feeling associated with these emotions. This example highlights that a sensation of activation is unspecific in terms of valence (it can be a pleasant or an unpleasant activation). Following the circumplex model of affect, only the combination of activity and valence-related BSMs allows for a comprehensive assessment of emotions.

3) Measure autonomic nervous system (ANS) activity

Studies related to the various measures of autonomic nervous system (ANS) activity have been used historically to inform professionals about the development of emotions.

The brain and heart are connected via the autonomic nervous system (ANS), and both indirectly influence each other's behaviour. The connection of the sympathetic nervous system (SNS) and parasympathetic nervous system (PNS) is part of the ANS.

Several physiological signals such as respiration (RSP), galvanic skin response (GSR), electromyograph (EMG), electrocardiogram (ECG) and electroencephalogram (EEG) are used for emotion recognition studies, as they can better reflect real emotional states due to their almost impervious nature to artificial interference.

In this context, different **electrocardiography (ECG)** methodologies are used to examine emotion development during infancy and early childhood (the age range across studies was from 5 months to 8 years). ECGs are one of the most widely used biosensors in emotion recognition because of their quality and the information on human emotions contained in the signals. Following ECG signal preprocessing, a large number of random convolutional kernels were used to transform the signals, and the resulting features are utilized to classify the various emotion states (Hasnul MA. et al., 2021) [14].

Additionally, emotion recognition systems, such as classical ECG recording, are currently an important technology that enables affective computing. There are a lot of ways to build an emotion recognition system using various techniques and algorithms. It is proven that the physiological approach towards emotion recognition has become a better alternative to facial expressions, gestures, and vocal traits.

The centres of the ANS's control over the heart rhythm are located at the medulla oblongata. Without any external factor, both centres provide a minuscule amount of stimulation to the cardiac muscle and cause it to have an autonomic tune. However, upon excitation, the cardioaccelerator releases the neurotransmitter norepinephrine and causes the heart rate (HR) to increase drastically. This process occurs throughout the SNS, as well as at the sinoatrial (SA) node, and is commonly known as the "fight or flight" response. As for the decrease in the HR, the cardioinhibitory centres release the neurotransmitter acetylcholine (Ach) to the PNS.

Galvanic skin response (GSR), also known as electrodermal activity (EDA) or skin conductance, measures electrical changes in the skin caused by sweat gland activity in the palms and fingers. It can provide important information about the body's level of physiological arousal, or activation and excitement, in response to stimuli. GSR is related to activity of autonomous nervous system, and consequently the emotional state. Galvanic skin response is usually measured with pain-free sensors placed on the body, often on the hands, feet, and/or fingers. Certain wearable devices, such as specially designed gloves and watches, may also be used to measure changes in skin conductance. Data about the galvanic skin response is also sometimes used in virtual reality (VR)–based therapy. I have a great deal of experience using EDA in my research on stress-related disorders in children (Pop-Jordanova) [15-21].

Respiratory sinus arrhythmia (RSA) functioning is an indicator of parasympathetic vagal control and has been linked with self-regulation of emotions (Porges, 2003) [22]. Moreover, cognition may play an important role in physiological recovery from negatively emotion-laden events as well.

Heart Rate (HR) acceleration and deceleration patterns are also meaningful measures of fear responses and attentional focus, respectively. Lower HR and quicker startle responses when dangerous objects were paired with fearful voices.

The final measure examined was **cortisol reactivity**. Cortisol levels are collected through cheek swabs but have limitations because they are an indirect measure of physiological functioning of emotions. In addition, cortisol levels take time to change and are subject to age-related circadian rhythms, so it can be difficult to determine whether the measurements are reflective of the effects of the specific emotion stimulus.

4) Eye-tracking is another non-invasive measure that has been used to study infant and child development. This method has been used in several important studies of emotional development (Peltola MJ, et al., 2015)[22] and the risk for autism spectrum disorders (Wagner JB, et al, 2013) [23].

Eye tracking is the process of measuring either the point of gaze (where one is looking) or the motion of an eye relative to the head. An eye tracker is a device for measuring eye positions and eye movement. Eye trackers are used in research on the visual system, in psychology, in psycholinguistics, marketing, as an input device for human-computer interaction, and in product design. In addition, eye trackers are increasingly being used for assistive and rehabilitative applications such as controlling wheelchairs, robotic arms, and prostheses. Recently, eye tracking has been examined as a tool for the early detection of autism spectrum disorder. There are several methods for measuring eye movement, with the most popular variant using video images to extract eye position. Other methods use search coils or are based on the electrooculogram.

5) EEG is a more preferable method since it is cost effective, non-invasive and simple to record and it also has very high spatial and temporal resolution. As mentioned before, emotions are controlled by the central nervous system (CNS) and EEG directly measures the activity of the brain which is responsible for emotion regulation. As it is known, our brain plays the role of a modulation system for emotions and by analysing EEG we are more likely to investigate these modulatory emotion circuits which are totally unknown for us. (Morteza Zangeneh Soroush et al, 2020) [24].

EEG is generated by a highly complex system (i.e. brain) which indicates the nonlinear, non-stationary and chaotic behaviour of this physiological signal.

While EEG signals have demonstrated commendable accuracy in emotion recognition, they still have some limitations. For example, the computational complexity and processing time of these methods tend to increase proportionally with the number of physiological signals used. Moreover, EEG signal acquisition devices, due to their limited mobility, are not easily adaptable for real-life applications. In contrast, ECG signals offer a more practical alternative. Compared to the scalp placement of EEG electrodes, ECG recording is less obtrusive, more comfortable and generally more accepted by users for continuous monitoring. Additionally, the ECG recording equipment is generally simpler, less expensive and more portable than EEG signal. This makes ECG more suitable for real-world applications outside clinical or laboratory settings. As a result, using ECG signals for emotion recognition presents a feasible solution.

6) Sigh (breathe out heavily)

Several historic authors (William Shakespeare) and musicians (Johann Sebastian Bach) have used the sigh as a metaphor for emotions, suggesting that a sigh has a psychological meaning. In addition, laypersons generally associate sighs with emotional states (Danvers et al., 2021; Teigen, K. 2008) [25,26]. At the same time, increasingly popular relaxation, stress and pain management techniques, such as yoga, mindfulness and meditation, often include instructions to take a deep breath, or to sigh. These lay assumptions and breathing practices suggest that sighs are functional in both the expression and management of emotional states. Despite these general beliefs, scientific research investigating the psychological functions is lacking.

The association between anxiety disorders and frequent sighing has been well established in laboratory studies; persons with panic disorder, post-traumatic stress disorder and chronic anxiety, sigh more frequently than healthy controls during quiet sitting. The sigh is not only an important regulator of respiration (e.g. blood gases and lung compliance), but also an often overlooked contributor to the homeostatic regulation of psychological states, including stress, emotions (e.g. anxiety), and perceived symptoms and sensations (e.g. pain, dyspnoea, nausea). Additionally, sighs may be implicated in the regulation of behavioural and emotional states. Furthermore, a bidirectional relationship between sighs and emotions may exist.

In addition to sighs characterizing negative emotional states, sighs are particularly associated with a specific positive emotional state: relief.

Altogether, it seems that sighs serve important psychological functions that are supported by neurobiological mechanisms. While an increasing body of evidence suggests that a sigh may act as a psychophysiological reset button that contributes to psychophysiological flexibility, more research is needed to better understand the psychological functions of sighs.

7) Functional infrared thermal imaging (fITI)

Thermal infrared imaging (fITI) is considered a promising methodology in the emotional field. Driven by sympathetic nerves, observations of affective nature derive from muscular activity subcutaneous blood flow as well as perspiration patterns in specific body parts (Kosonogov V. 2017) [27].

Thermal infrared imaging enables cutaneous temperature recordings to be measured noninvasively, ecologically, and contact free. The autonomic nervous system (ANS) is at the forefront of biological heat displays, controlling unconscious heart rate, breathing, tissue metabolism, perspiration, respiration, and cutaneous blood perfusion, providing grounds for observations of emotional inference to be made. Thus, thermal infrared imaging (also referred to as functional infrared imaging (fITI), enables the characterization of the competing subdivisions of the ANS.

Neuroimaging techniques

The associations of the brain regions about emotions-cognitive functions can be visualized with various imaging tools such as positron emission tomography (PET) and functional magnetic resonance imaging (fMRI). As mentioned before, the electrical stimulus and dynamics in the brain regions in response to emotional tasks and cognitive functions can be measured with the use of an electroencephalogram (EEG). Thus, with the use of different imaging and spectroscopy techniques, the interactions of different brain regions associated with emotions and cognition concerning the stimuli can be observed.

Neuroimaging techniques are involved in the study of the changing regions of the brain due to varied emotions and, consequently, some treatment strategies are based on the changes observed. Some feedback mechanisms in the brain are associated with changes in different emotions.

Different emotions result from differential activation patterns within a shared neural circuitry, mostly consisting of midline regions, motor areas and subcortical regions. The more similar the neural underpinnings of these emotions, the more similarly they also are experienced. It was suggested that the relative engagement of different parts of this system defines the current emotional state. Figure 3 shows the cumulative sum of maps across emotions vs. neutral condition in activation and deactivation states.

The amygdala is the most important brain region for emotions. In this context, figure 4 shows the interaction between the amygdala and different emotional states obtained with fMRI.

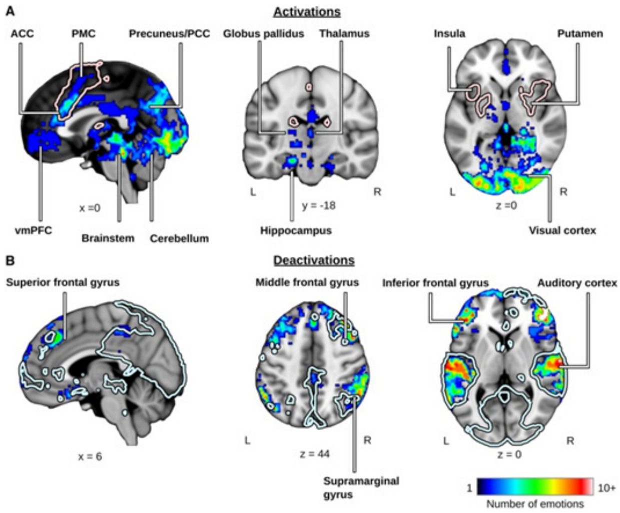

Figure 3. *Cumulative activation map showing the cumulative sum of binarized t maps (P < 0.05, cluster-corrected) across each emotion vs. neutral condition.*

Outline shows results for all emotions contrasted against the neutral condition (P < 0.05, cluster-corrected). (B) Cumulative deactivation map showing the cumulative sum of binarized t maps (P < 0.05, cluster-corrected) across neutral vs. each emotion. (Saarimäki H. et all. 2018) [28]

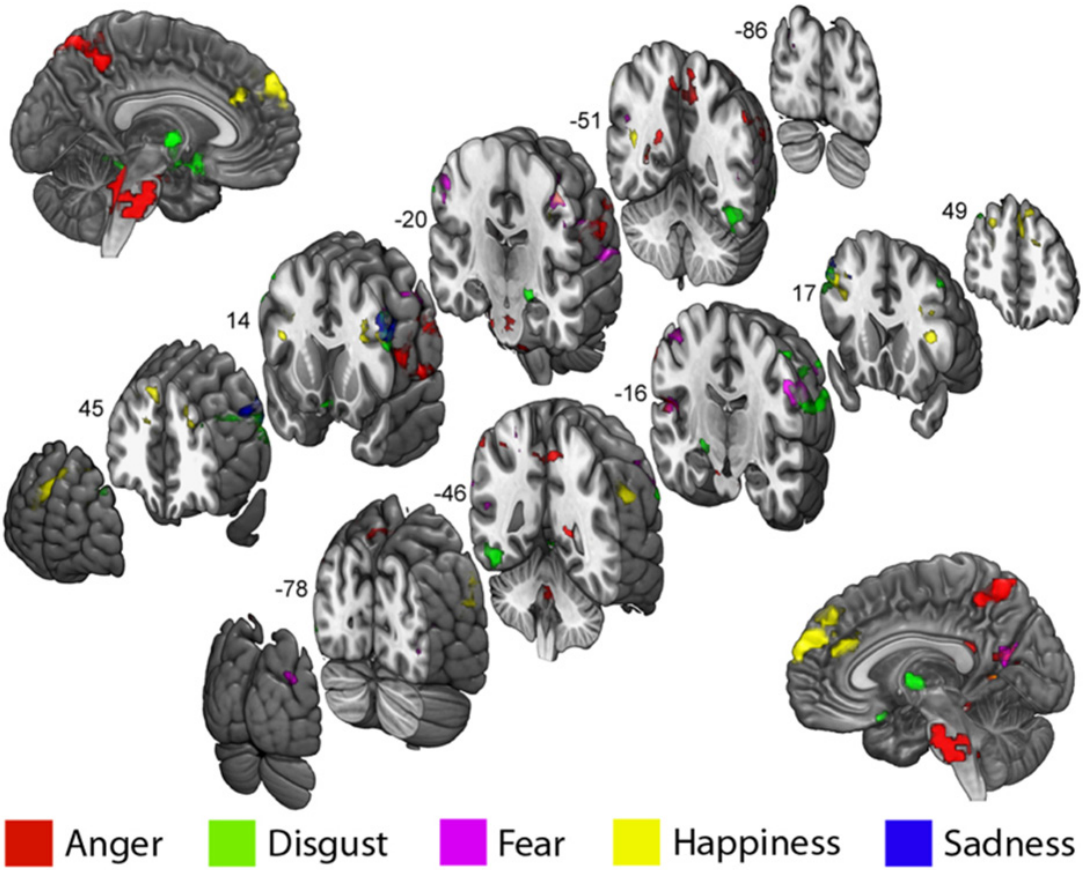

Figure 4. *Brain areas showing significant emotion-dependent functional interactions with the amygdala for the contrast of each emotion with the neutral expression condition separately*

(Sci Rep. 2017 Mar 27; 7:45260) [29]

How emotions are represented in the nervous system is a crucial and still unsolved problem in the affective neuroscience. Many studies strive to find the localization of basic emotions in the brain but have failed. Thus, many psychologists suspect the specific neural loci of basic emotions, but instead, some have proposed that there are specific neural structures for the core affects, such as arousal and hedonic value.

A variety of different fMRI paradigms have been used to probe emotion processing in order to understand its neural underpinnings in healthy subjects and to study the effects that development, psychopathology or therapeutic interventions exert on it.

Meta-analyses of fMRI research on emotion processing have robustly implicated several brain regions, namely, the amygdala, the anterior insula, the pregenual and subgenual anterior cingulate cortices (ACC) as well as the dorsal ACC (dACC), the dorsomedial prefrontal cortex (dmPFC), the dorsolateral PFC (dlPFC), the parahippocampus, the orbitofrontal cortex and visual and auditory cortices.

The active recall of emotional autobiographical episodes, compared with the recall of neutral episodes, was associated with the activity of a wide frontotemporal network, bilaterally including the pre-SMA (supplementary motor area), the amygdala, and the hippocampus. Further activations were found at the level of the left middle temporal gyrus, the left thalamus, the left amygdala, and the right cerebellum. Figure 5 presents brain activity evoked by emotional recall.

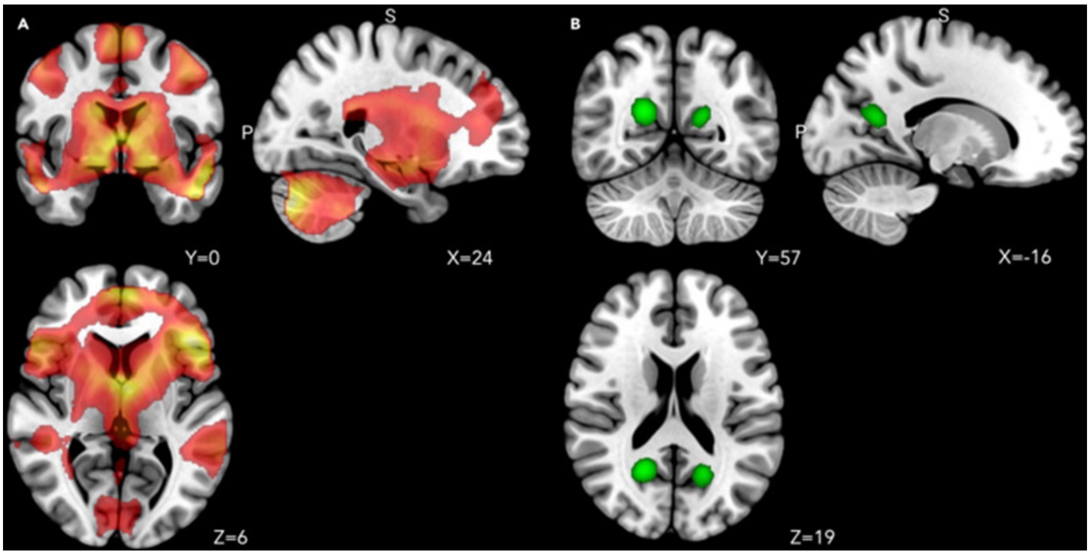

Figure 5. *Brain activity evoked by the emotional recall task*

(A) Brain regions that resulted significantly active for the contrast "Emotional episodes > Neutral episodes." (B) Brain regions that resulted significantly active for the contrast "Neutral episodes > Emotional episodes." (Retrieved from Internet pictures)

In general, it can be concluded that very large part of the brain is activated when emotional recall is present. It means that the localisation of unique emotion is practically impossible.

In order to obtain more a precise localisation of the neural correlates of responses to emotionally valanced olfactory, visual, and auditory stimuli positron emission tomography (PET) scans were used (Royet JP. et al., 2000) [30]. Positron emission tomography is a functional imaging technique that uses radioactive substances known as radiotracers to visualize and measure changes in metabolic processes, and in other physiological activities including blood flow, regional chemical composition, and absorption. I mention in this article the focused analyses of emotional versus neutral conditions using PET scan which revealed a significant regional cerebral blood flow (rCBF) increased in the hypothalamus for visual stimuli, the right and left hippocampus for visual and olfactory stimuli, and the left hippocampus for auditory stimuli. Because the hippocampal region was found to be activated in all the three modalities, this study suggest that such an activation could reflect a gating process through which highly arousing stimuli preferentially gain access to hippocampal mnemonic processes. The cited study indicates a strong lateralization of cerebral areas participating in emotion, with the OFC, the temporal pole, and the frontal gyrus clearly presenting an rCBF increase in the left side. The right OFC was also activated but with a weakly significant level. (Fig. 6)

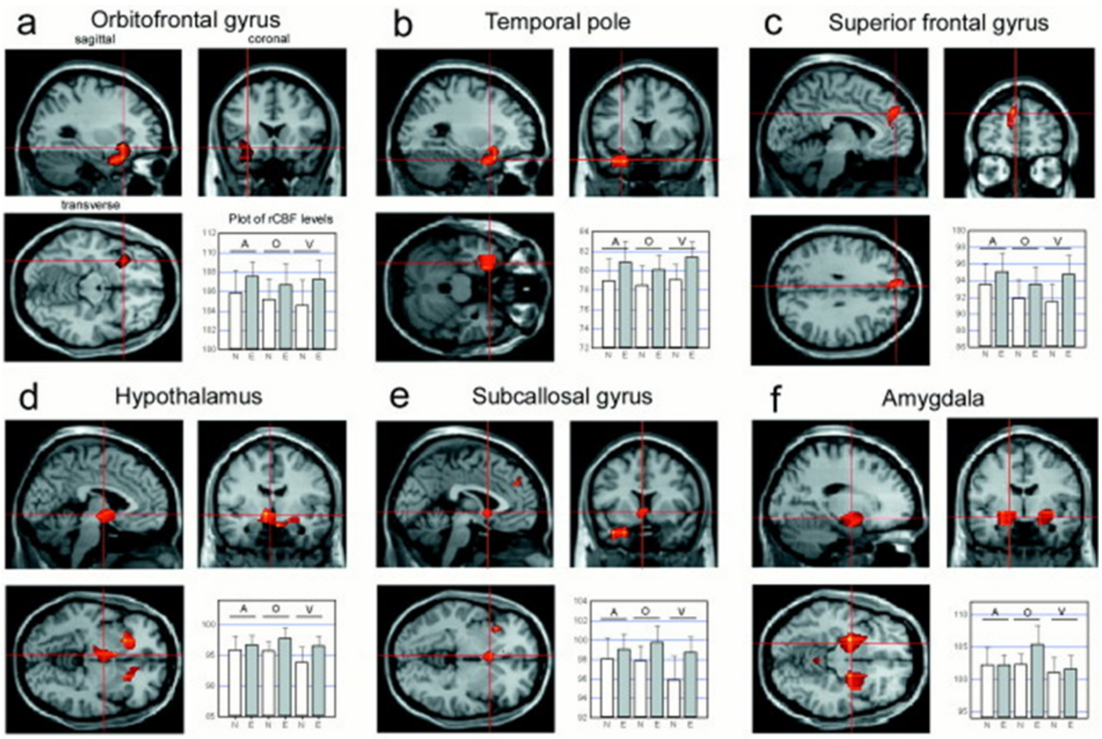

Figure 6. *Sagittal, coronal, and transverse sections through the z maps on an anatomically normalized standard brain with areas activated in the three modalities in the emotional minus neutral conditions: in (a) the left inferior frontal gyrus, (b) the left temporal pole, (c) the left superior frontal gyrus; in olfaction and vision in (d) the hypothalamus and (e) the subcallosal gyrus; and (f) in olfaction in the emotional minus no-stimulation control conditions in both amygdalae. For each area activated, the plots show rCBF levels in the six activation conditions for this coordinate (J Neurosci. 2000 Oct 15;20(20):7752–7759.)*

CONCLUSION

Emotions can be denoted as a mental state because of neurophysiological changes.

Emotions are related to mood, personality, temperament, and consciousness.

Emotions are ubiquitous in development and have been studied from structural, functional and dynamic perspectives. As the most important psychological processes, emotions involve subjective experiences, physiological patterns, and behavioural responses.

This article highlights different methods used to record and measure emotional states in humans.

The field is being pushed in new directions by work on emotion recording, especially in the field of the AI technologies.

All mentioned methods are more precise if compared with subjective evaluations through psychological test and questionnaires.

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Резиме

ДАЛИ Е МОЖНО ПРЕПОЗНАВАЊЕ НА ЕМОЦИИТЕ/ЧУВСТВАТА?

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Точно е дека емоциите се најважните психички функции кај луѓето и се на врвот на хиерархиското дрво на хомеостазата.

Како моќна ментална активност, емоциите значително влијаат на различни аспекти на човековото функционирање, какви што се: донесувањето одлуки, перцепцијата, вниманието и меморијата.

Од научни, но и од практични причини, главното прашање е: како да се регистрираат и како да се измерат емоциите?

Целта на оваа статија е да ги сумира главните познати методи за мерење на емоциите/чувствата објавени во базата Medline.

Презентирани се различни методологии со цел да се измерат емоциите, какви што се: препознавањето лице, телесните мапи на емоциите, евалуацијата на активноста на автономниот нервен систем, ЕЕГ и, особено, fMRI и ПЕТ-скен. Податоците се користени од базите PubMed.

Клучни зборови: емоции, тело, мозок, слики