Neuroscience Letters 544 (2013) 10–14

Contents lists available at SciVerse ScienceDirect

Neuroscience Letters

journal homepage: www.elsevier.com/locate/neulet

Effects of viewing affective pictures on sEMG activity of masticatory and postural muscles

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HIGHLIGHTS

- The results show that emotions are not able to influence the activity of masticatory and postural muscles.
- The statistically significant results seem to be randomly distributed.
- Further studies are required.

ARTICLE INFO

Article history:
Received 2 December 2011
Received in revised form 13 February 2013
Accepted 25 February 2013

Keywords:
Emotion
sEMG
Postural muscles
Masticatory system

ABSTRACT

Recently there has been an upsurge of interest in the question to what extent the human motor control system is influenced by the emotional state of the actor. The aim of this study was to evaluate whether emotional inputs modify the activity of masticatory and postural muscles. Twenty healthy young adults viewed affective pictures, while surface electromyography (sEMG) of masticatory and postural muscles was recorded to investigate the coupling between emotional reactions and body muscular activity. One hundred and twenty pictures, chosen from the International Affective Picture System (IAPS), divided in two blocks of six sets, were presented to the subjects. sEMG data were statistically analyzed (RM ANOVA on Ranks). Root Mean Square (RMS) amplitudes, comparing the subsequent sets (Neutral, Unpleasant, Neutral, Pleasant) with the first and the last Baseline set, changed significantly only randomly. The results show that emotional inputs seems not influence the activity of masticatory and postural muscles, recorded by sEMG.

1. Introduction

Looking at pictures with emotional content and intensity effects different physiological systems [2]. As an example, Bradley et al. [3] demonstrated that the specific thematic content of pleasant (e.g., erotic vs adventure) or aversive picture stimuli (e.g., threat vs victim) can specifically modulate the physiological response. Also, it is known from the theory of emotions that unpleasant stimuli generally prime withdrawal reactions, whereas pleasant stimuli prime approach actions. Many studies analyzed the electromyography (EMG) activity of facial muscles in response to viewing pleasant and unpleasant photographs. For example, Zhou observed that the intensity of facial EMG activity on the left side of the face is stronger than the right side of the face during the process of emotional expression [19]. Rymarczyk demonstrated that subjects react spontaneously and rapidly to happy faces with increased EMG activity of zygomaticus major and decreased activity of the corrugator supercilii showing changes in response to dynamic stimuli greater than those to static ones in both muscles. In contrast, angry faces evoked no alteration of EMG activity in zygomaticus muscles and only small changes in the corrugator muscle EMG, and there were found no difference between the responses to static and dynamic stimuli [15]. However, such results are relative only to mimic muscles, while masticatory or body posture responses have been often neglected, which in turn should also be observed as neuro-physiologically and anatomically linked to them [13,14]. The aim of this study is therefore to evaluate whether pictures with emotional content may modify the surface electromyography (sEMG) of the stomatognathic and postural systems, providing evidence of functional links among emotional reactions, posture and masticatory functionality.

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http://dx.doi.org/10.1016/j.neulet.2013.02.053

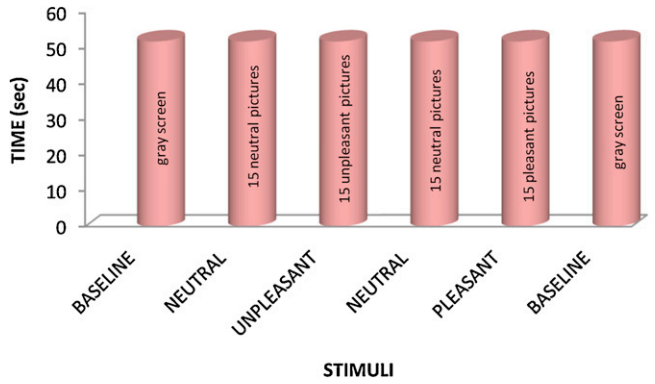

Fig. 1. The sequence of six sets (Baseline, Neutral, Unpleasant, Neutral, Pleasant, Baseline) for each block.

2. Materials and methods

Twenty male healthy volunteers without visual or hearing impairments (mean age 25.6 years; range 19–34 years) participated in this study. All the subjects were right handed, as determined by self-report [8]. Exclusion criterion was the presence of any musculoskeletal diseases, potentially related to gnathologic or postural disorders (fibromyalgia, myofascial pain, temporomandibular disorders, low back pain, scoliosis, hip pain, trochanteric bursitis, previous orthodontic or gnathologic treatment, etc.). With reference to the skeletal pattern and dental occlusion, all the subjects were characterized by a skeletal and dental Class I. In the week before the evaluation, the subjects were asked to avoid heavy physical activity [1]. The following muscles, mainly implied in postural control and masticatory function, were bilaterally individuated [9]: masseter (MST), anterior temporalis (AT), sternocleidomastoid (SCM), upper trapezius (UT), quadratum lumborum (QL), and gastrocnemius (G). Prior to the experiment, the subjects skin was cleaned up using an alcohol soaked pad to improve skin electrodes impedance; for sEMG registration, disposable electrodes (DUO F3010 bipolar-10 mm, AgCl, lithium chloride gel, unit distance 22 mm, LTT FIAB Vicchio, Firenze, Italy) were applied onto muscle bellies, according to Cram [6]. To ensure the repeatability in the placement of the subject, the participant was placed on two force platforms in standing posture, and feet position was standardized according to D'Attilio [7]. A total of 120 pictures (30 pleasant, 30 unpleasant, 60 neutral) from the International Affective Picture System (IAPS) [19] were selected. The pleasant images included family scenes and erotic scenes; the unpleasant pictures included scenes of attack by humans or animals and scenes of mutilation; the neutral images included pictures of faces and household objects. Images with mean valence and emotional arousal ratings were selected [5].

As shown in Fig. 1, the experimental paradigm included two blocks (six sets, in sequence Baseline, Neutral, Unpleasant, Neutral, Pleasant, Baseline, for each block). Each block started with a 51.2 s baseline measurement, during which no pictures were displayed. Next, 4 sets of images were shown. Each set consisted of 15 pictures that were presented in succession. Each image was shown for 3 s, and was preceded by a 0.44 s lasting grey screen. So, the duration of each set was 51.2 s. At the end of each block, a further rest measurement (51.2 s) was carried out without presenting any picture but the background. The presentation of each set was preceded by a 20 s time interval, necessary to reset the sEMG equipment. The recording time of sEMG instrument (51.2 s) was calibrated on the recording time of a posture-stabilometric equipment, contemporarily used. The posture-stabilometric data will be analyzed and discussed separately in our another study. The pictures were displayed on a photo projector, 3 m away from the subject, in a darkened room, to obtain clear and vivid images. Participants were instructed to make themselves comfortable, with their arms by their sides, and to gaze at the projector screen at the height of their eyes. Subjects were asked to swallow before each set of pictures to acquire a physiological occlusal condition of Rest Position. To avoid possible fatigue while maintaining the orthostatic posture, the participant was allowed to observe 2 min of rest between the blocks. sEMG was performed by using a Key Win 2.0 surface electromyography (Biotronic, Italy), and the registrations were triggered with the presentation of each picture set. For each set, the Root Mean Square (RMS, μV) of the different muscles was automatically calculated by the system [17]. At the end of the test, the subjects were asked to judge valence and arousal of the pictures according to the IAPS visual analogical scale; mental state of the participants was also scored by the Italian version of Spielberger's state trait anxiety inventory [18].

The local Ethics Committee approved the study. All participants signed an informed consent form prior of being enrolled in the study.

2.1. Statistical analysis

2.1.1. Studies on method error

To avoid inter-operator errors the sEMG recordings were acquired by the same operator (D.R.). In order to assess intra-operator errors due to the positioning of electrodes, the sEMG recordings were acquired twice, and changes in the calculated RMS values between the first and the second measurement were evaluated with the Wilcoxon Signed Rank test.

2.1.2. Data analysis

The statistical analysis was performed to compare differences in RMS values of the muscles across the experimental sets (Baseline, Neutral, Negative and Positive) in each block.

The Wilcoxon Signed Rank test was performed to compare the first and the last Baseline set in each block; at a later stage, each subsequent set (Neutral, Unpleasant, Neutral, Pleasant) was compared to the first and the last baseline for each block [11]. $P < 0.05$ was assumed as statistical significant threshold.

RMS amplitudes were then used to calculate the Symmetry Percentage (SP) for each muscle pair [4]. SP between two homologous muscles was calculated according to the following formula: SP = ((greater RMS − smaller RMS)/greater RMS) × 100.

If this value was >20%, the pair of muscles evaluated was considered asymmetric (AM; asymmetric muscle) [4]. SP values of each muscular couple evaluated during each set were compared through a one-way ANOVA on Ranks for repeated measures ($P < 0.05$) [11].

3. Results

None of the subjects scored out of normality values at the STAI test and the overall rating for picture arousal and valence did not differ from the pre-defined IAPS reference values.

The Wilcoxon Signed Rank test applied to assess intra-operator errors due to the positioning of electrodes, did not reveal statistical differences among sEMG recordings acquired twice, confirming the reproducibility of sEMG data on the studied sample ($P < 0.05$).

The Wilcoxon Signed Rank test applied to compare the first and the last Baseline Set showed statistical differences (Table 1) for the Right Anterior Temporalis in block I ($P = 0.03$) and block II ($P = 0.01$), Left Upper Trapezius in block I ($P = 0.02$), Left Quadratum Lumborum in block I ($P = 0.04$) and block II ($P = 0.002$).

In the first block (Table 2), comparing the sequent sets (Neutral, Unpleasant, Neutral, Pleasant) with the first and the last Baseline

Table 1
Wilcoxon Signed test ($P < 0.05$) between the first and the last baseline set for each muscle.

Wilcoxon Signed Rank test		
Muscle	I block 1stB vs 2ndB P (<0.05)	II block 1stB vs 2ndB P (<0.05)
RAT	0.03*	0.01*
LAT	0.3	0.9
RMST	0.5	0.3
LMST	0.4	0.1
RSCM	0.1	0.7
LSCM	0.8	1
RUT	0.1	0.4
LUT	0.2	0.02*
RQL	0.6	0.9
LQL	0.04*	0.002*
RG	0.3	0.8
LG	0.7	0.6

* Means statistically significant.

Set, RMS amplitudes changed significantly for the following muscles:

- Right Anterior Temporalis: First Baseline Set vs Second Neutral Set, $P = 0.03$.
- Right Anterior Temporalis: First Baseline Set vs Pleasant Set, $P = 0.03$.
- Right Anterior Temporalis: Second Baseline Set vs Unpleasant Set, $P = 0.02$.
- Left Anterior Temporalis: Second Baseline Set vs First Neutral Set, $P = 0.02$.
- Left Upper Trapezius: First Baseline Set vs Pleasant Set, $P = 0.02$.
- Left Quadratum Lumborum: Second Baseline Set vs First Neutral Set, $P = 0.02$.
- Left Quadratum Lumborum: Second Baseline Set vs Pleasant Set, $P = 0.02$.

In the second block (Table 3), comparing the sequent sets (Neutral, Pleasant, Neutral, Unpleasant) with the first and the last Baseline Set, RMS amplitudes changed significantly for the following muscles:

- Right Anterior Temporalis: First Baseline Set vs Pleasant Set, $P = 0.03$.
- Right Anterior Temporalis: Second Baseline Set vs First Neutral Set, $P = 0.002$.
- Right Anterior Temporalis: Second Baseline Set vs Unpleasant Set, $P = 0.01$.
- Right Anterior Temporalis: Second Baseline Set vs Second Neutral Set, $P = 0.02$.
- Right Anterior Temporalis: Second Baseline Set vs Pleasant Set, $P = 0.008$.
- Left Masseter: First Baseline Set vs First Neutral Set, $P = 0.03$.
- Left Sternocleidomastoid: Second Baseline Set vs First Neutral Set, $P = 0.04$.
- Left Sternocleidomastoid: Second Baseline Set vs Second Neutral Set, $P = 0.04$.
- Left Sternocleidomastoid: Second Baseline Set vs Pleasant Set, $P = 0.02$.
- Right Upper Trapezius: First Baseline Set vs Second Neutral Set, $P = 0.04$.
- Left Upper Trapezius: First Baseline Set vs Pleasant Set, $P = 0.03$.
- Left Upper Trapezius: First Baseline Set vs Unpleasant Set, $P = 0.02$.
- Left Quadratum Lumborum: First Baseline Set vs Unpleasant Set, $P = 0.04$.
- Left Quadratum Lumborum: Second Baseline Set vs First Neutral Set, $P = 0.01$.

In Table 4, the Symmetry Percentage for each pair of muscle for the different stimuli is reported. In bold, the values indicating the asymmetry of muscular function are reported.

No statistical differences in SP values between pleasant, unpleasant and neutral stimuli were observed.

4. Discussion

In our study, we observed that emotional stimuli seem to be unable to modify significantly the muscular activity of the stomatognathic and postural systems, recorded by sEMG.

The Wilcoxon Signed test applied to compare the first and the last Baseline Set showed statistical differences, randomly distributed, in both block I and II. In accordance with this evidence, the Baseline Sets are not comparable. Consequently, it is not possible to consider the first and the last set of each block as records of basic muscular activity.

The tendency of the RMS values during the last Baseline Set to differ from the first one could be due to fatigue. Subjects required to maintain the same position for the extended period of each block could experience muscular fatigue. This hypothesis seems to be confirmed by literature [12,16]. Statistical analysis did not reveal significant difference between pleasant, unpleasant, and neutral pictures, compared to the first and the last Baseline records, during both I and II blocks.

Table 2
Wilcoxon Signed test ($P < 0.05$) to compare the first and the last baseline sets to the sequent experimental sets for each muscle in the first block.

Wilcoxon Signed test								
Muscle	I block							
	1stB vs 1stN	1stB vs U	1stB vs 2ndN	1stB vs P	2ndB vs 1stN	2ndB vs U	2ndB vs 2ndN	2ndB vs P
RAT	0.1	0.1	0.03*	0.03*	0.1	0.02*	0.4	0.4
LAT	0.9	0.9	0.1	1	0.02*	0.09*	0.4	0.2
RMST	0.8	0.8	1	0.7	0.9	0.7	0.7	1
LMST	1	1	0.5	0.7	0.6	0.6	1	0.8
RSCM	0.2	0.3	0.3	0.8	1	0.6	0.5	0.07
LSCM	0.5	0.7	0.2	0.3	0.2	0.6	0.5	0.2
RUT	0.3	0.7	0.4	0.08	0.4	0.6	0.5	1
LUT	0.1	0.1	0.05	0.02*	0.4	0.3	0.7	0.3
RQL	0.6	1	0.6	0.9	0.4	0.6	0.5	1
LQL	0.8	0.4	0.	0.1	0.02*	0.1	0.06	0.02*
RG	1	0.3	0.3	0.1	0.6	0.6	0.4	0.2
LG	0.3	0.4	0.7	0.8	0.5	0.4	0.2	0.2

* Means statistically significant.

Table 3
Wilcoxon Signed test ($P < 0.05$) to compare the first and the last baseline sets to the sequent experimental sets for each muscle in the second block.

Wilcoxon Signed test								
Muscle	II block							
	1stB vs 1stN	1stB vs U	1stB vs 2ndN	1stB vs P	2ndB vs 1stN	2ndB vs U	2ndB vs 2ndN	2ndB vs P
RAT	0.9	0.8	0.05	0.03*	0.002*	0.01*	0.02*	0.008*
LAT	0.6	0.2	0.9	0.1	0.2	0.7	0.4	0.1
RMST	0.1	0.6	1	0.4	0.1	0.5	0.5	0.2
LMST	0.03*	0.3	0.4	0.07*	0.1	0.3	0.8	0.4
RSCM	0.3	0.3	0.9	0.5	0.4	0.4	0.9	0.1
LSCM	0.2	0.3	0.4	0.5	0.04*	0.06	0.04*	0.02*
RUT	0.3	0.1	0.04*	0.1	0.8	0.6	1	0.4
LUT	0.9	1	0.7	0.03*	0.02*	0.09	0.2	0.4
RQL	1	1	0.6	0.07	0.8	0.9	0.4	0.2
LQL	0.06	0.04*	0.2	0.1	0.01*	0.6	0.3	0.6
RG	0.6	0.6	0.4	0.2	0.2	0.6	0.2	0.5
LG	0.2	0.1	0.2	0.4	0.2	0.3	1	0.5

* Means statistically significant.

Table 4
Symmetry Percentage (SP) of homologous muscles.

Muscle	I sequence						II sequence					
	B	N	U	N	P	B	B	N	U	N	P	B
AT	**0.7**	**0.67**	**0.67**	**0.62**	**0.62**	**0.62**	**0.66**	**0.65**	**0.63**	**0.3**	0.1	0.13
MST	0.05	0.04	0.13	0.03	0.02	0.07	0.14	0.15	0.13	0.08	0.001	0.14
SCM	0.12	0.15	0.1	0.03	0.05	0.04	0.06	0.12	**0.29**	0.12	**0.33**	**0.34**
UP	**0.2**	0.18	0.15	**0.33**	0.009	0.09	0.05	0.11	0.08	**0.24**	**0.34**	**0.43**
QL	0.03	0.03	0.03	0.07	**0.26**	0.13	**0.42**	**0.4**	**0.35**	**0.41**	**0.41**	**0.26**
G	0.03	0.12	0.15	0.04	0.01	0.04	0.14	0.05	0.03	0.12	0.03	0.22

Rat, right anterior temporalis; Lat, left anterior temporalis; Rmst, right masseter; Lmst, left masseter; Rscm, right sternocleidomastoid; Lscm, left sternocleidomastoid; Rut, right upper trapezius; Lut, left upper trapezius; Rql, right quadratum lumborum; Lql, left quadratum lumborum; Rg, right gastrocnemius; Lg, left gastrocnemius; B, baseline; N, neutral; U, unpleasant; P, pleasant.

The statistical differences observed seem to be randomly distributed; it is not possible to evidence a tendency of the muscle activity to chance specifically during sets. The statistically significant differences, evidenced by Wilcoxon Signed Rank test, interest several muscles in different sets, without any recognizable trend of modification of the muscle activity due to emotional stimuli. The results seem to be related to chance. This evidence suggests that variations of the muscular activity due to emotional inputs could not be revealed with sEMG. This lack of significance could be related to the anatomical position of the muscles analyzed. Literature reports evidence of muscular effects of emotional stimuli of mimic muscles rather than of positional and masticatory muscles. Deschamps et al. showed that the presentation of angry faces was associated with corrugator activation and zygomaticus relaxation, happy faces with an increase in zygomaticus and a decrease in corrugator activation, fearful faces with frontalis activation, and sad faces with a combination of corrugator and frontalis activation [9]. Probably the masticatory and postural muscles are too deep anatomically to evidence statistically significant variations to emotions, when analyzed by sEMG. Probably different recording instruments could be more effective to reveal postural and stomatognathic responses to emotions as posturo-stabilometric platforms or thermography.

Literature seems to confirm this hypothesis [10].

In conclusion, this reading of the results need further confirmations to better evaluate the effects of emotional stimuli on the muscular activity of postural and stomatognathic systems.

5. Conclusion

Viewing emotion eliciting images seems not to have statistically significant effects on body muscular response of masticatory and postural systems. Further studies are needed to better highlight, understand and validate these early evidences.

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