Neuroscience and Biobehavioral Reviews 38 (2014) 135–159

Contents lists available at ScienceDirect

Neuroscience and Biobehavioral Reviews

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

Review

The facial motor system

Luigi Cattaneo[a,*], Giovanni Pavesi[b]

[a] Center for Mind/Brain Sciences, University of Trento, Via delle Regole 101, Mattarello, Trento 38123, Italy
[b] Department of Neuroscience, University of Parma, Via Gramsci 14, Parma 43100, Italy

ARTICLE INFO

Article history:
Received 22 May 2013
Received in revised form 18 October 2013
Accepted 2 November 2013

Keywords:
Face
Lip
Eyelids
Mouth
Voluntary movements
Facial palsy
Proprioception
Motor control
Blink

ABSTRACT

Facial movements support a variety of functions in human behavior. They participate in automatic somatic and visceral motor programs, they are essential in producing communicative displays of affective states and they are also subject to voluntary control. The multiplicity of functions of facial muscles, compared to limb muscles, is reflected in the heterogeneity of their anatomical and histological characteristics that goes well beyond the conventional classification in single facial muscles. Such parcellation in different functional muscular units is maintained throughout the central representation of facial movements from the brainstem up to the neocortex. Facial movements peculiarly lack a conventional proprioceptive feedback system, which is only in part vicariated by cutaneous or auditory afferents. Facial motor activity is the main marker of endogenous affective states and of the affective valence of external stimuli. At the cortical level, a complex network of specialized motor areas supports voluntary facial movements and, differently from upper limb movements, in such network there does not seem to be a prime actor in the primary motor cortex.

Contents

* Corresponding author at: Center for Mind/Brain Sciences (CIMeC), University of Trento, Via delle Regole, 101, I-38123 Mattarello, Trento, Italy. Tel.: +39 0461 882743; fax: +39 0461 883066.
E-mail address: luigi.cattaneo@unitn.it (L. Cattaneo).

0149-7634/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.neubiorev.2013.11.002

1. Introduction

Facial muscles are the group of skeletal muscles that originate from the 2nd pharyngeal arch and are innervated by the VII (facial) cranial nerve. They are embedded in a 2-dimensional space and form a complex interdependent system, the purpose of which is to produce changes in the superficial geometry of the face. Facial muscles contribute significantly to human behavior in a wide range of functions as, for example, feeding, speech production and communication of affective states. Here we will review the anatomy and physiology of facial muscles and their movements, focusing on two important characteristics. First, in spite of being conventionally considered as a homogeneous group, a vast heterogeneity occurs between facial muscles and even within the same muscle. Such diversity is exceptional in the human musculoskeletal system and its knowledge represents a useful key to understand the contribution of the movements of the face to a vast diversity of behavioral functions. Second, facial movements are unique and present considerable differences compared to the remaining human motor repertoire, in particular to movements of the upper limb. Some peculiarities are readily intuitive, such as the lack of joints or the lack of a visual feedback of movement trajectories. Others are less obvious and are still matter of debate, such as the absence of a muscular proprioceptive system. The central control of facial movements is complex and relies on multiple parallel systems (as for example the voluntary and the affective systems), which are segregated anatomically and functionally up to a very distal level, i.e. up to the facial nucleus. Finally, in the present work we focused exclusively on facial muscles, i.e. muscles acting on the facial skin. Three muscles innervated by the facial nerve fulfill other purposes, namely the *stapedius* muscle, involved in regulating tension of the tympanic membrane, and a pair of supra-hyoid muscles involved in the control of jaw movements, i.e. the posterior belly of the *digastricus* and the *stylo-hyoid* muscles. Their characteristics and function is beyond the topic of the present review.

2. Anatomy of facial muscles

2.1. Macroscopic anatomy

Facial muscles are conventionally classified as individual muscles, each with its own identity and function (Stranding, 2008). However, an anatomical classification of single muscles is challenging for several reasons. First, in upper limbs, the bony insertions, the joint upon which it acts, and its individual fascia of connective tissue characterize a single muscle. Facial muscles lack most, if all, of these features This is particularly evident for example in the superficial layer of perioral muscles, which are largely overlapping and can be considered, from a strictly morphological point of view, as one single muscular unit (D'Andrea and Barbaix, 2006). Second, a considerable inter-individual variability is present, especially between perioral muscles, to the point that some bundles may be non-recognizable in a significant percentage of dissections (D'Andrea and Barbaix, 2006; Pessa et al., 1998). Third, the taxonomy of facial muscles is further made difficult by the variety of nomenclature that different authors have embraced in labeling muscles of humans and other mammalian species (Diogo et al., 2008, 2009).

Fig. 1 shows a schematic representation of human facial muscles according to the most frequent nomenclature. The region around the auricular *pinna* is the location of a subgroup of facial muscles referred to as extrinsic ear muscles. They are present in all mammals (Diogo et al., 2008) but in humans only the *auricularis posterior* is found, as a small vestigial bundle of muscle fibers that by its contraction displaces backwards the *pinna* of the ear. In spite of its lesser role in human behavior and its small size, its presence seems to be constant across dissections (De Meirsman et al., 1980; Talmi et al., 1997). The forehead and the glabellar region contain a set of muscles that are strictly coupled in their action of changing the geometry of the skin of the eyebrow region. In particular the forehead contains one single flat muscle, the *frontalis* muscle. It has no bony insertions; it is attached posterior to the *occipitofrontalis* aponeurosis and anterior to the whole extent of the skin of the brows, which is lifted upwards by its contraction. In the medial-most part of the brow region, i.e. the glabella, two additional muscles are present, which move the glabellar skin medially (*corrugator supercilii* muscle) and downwards (*depressor supercilii* and *procerus* muscle) (Knize, 2000).

The *orbicularis oculi* muscle, the main function of which is closing the eyelids, covers the orbital region. It is anchored to the skull at its medial part to the medial orbital wall. Its structure is considerably preserved between mammal species (McLoon and Wirtschafter, 1991). In spite of being commonly described as a single muscle, it is actually made of 3 concentric distinct units, the (inner) pretarsal, the (intermediate) pre-septal, and the (outer) orbital, parts.

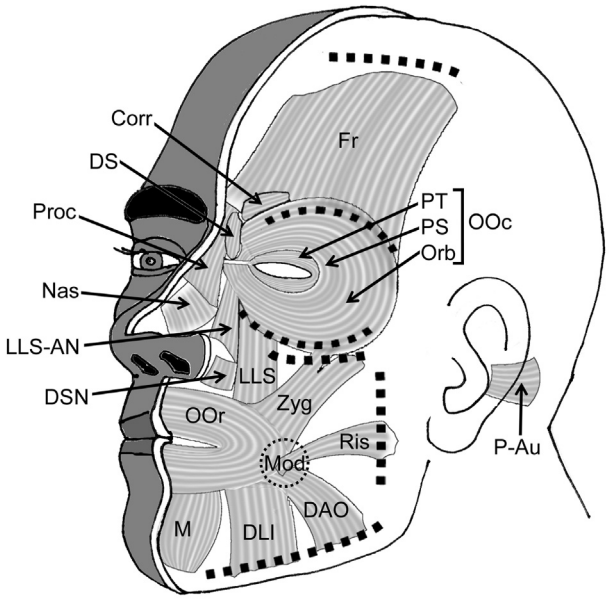

Fig. 1. Schematic representation of the facial muscular system. Corr = Corrugator; Fr = Frontalis; Proc = *procerus*; Nas = *nasalis*; DS = *depressor supercilii*; OOc = *orbicularis oculi*; PT = pretarsal; PS = preseptal; Orb = orbital; LLS-AN = *levator labii superioris alaquae nasi*; LLS = *levator labii superioris*; DSN = *depressor speti nasi*; Zyg = *zygomaticus major* and *minor*; Ris = *risorius*; M = *mentalis*; DLI = *depressor labi inferioris*; DAO = *depressor anguli oris*; P-Au = *posterior auricularis*. Bold dashed lines represent the main points of thethering of the facial skin to the skull. Mod = *modiolus*.