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Some notes on the role of the hand-arm system (HAS) in the ecology of human communication

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1. Introduction

The hand-arm system (hence HAS) of modern humans is a biomechanically extremely effective system of grasping and manipulation that humans have developed in the course of human evolution and which they have been using for the benefit of their well being. Biologically, it is a very complex system of bones, muscles, ligaments, and nerves organized into bilateral hand-arm complexes which are characterized by a large number of degrees of freedom and which thus allow for a generation of a very flexible set of behaviours. The system may be represented in the following way:

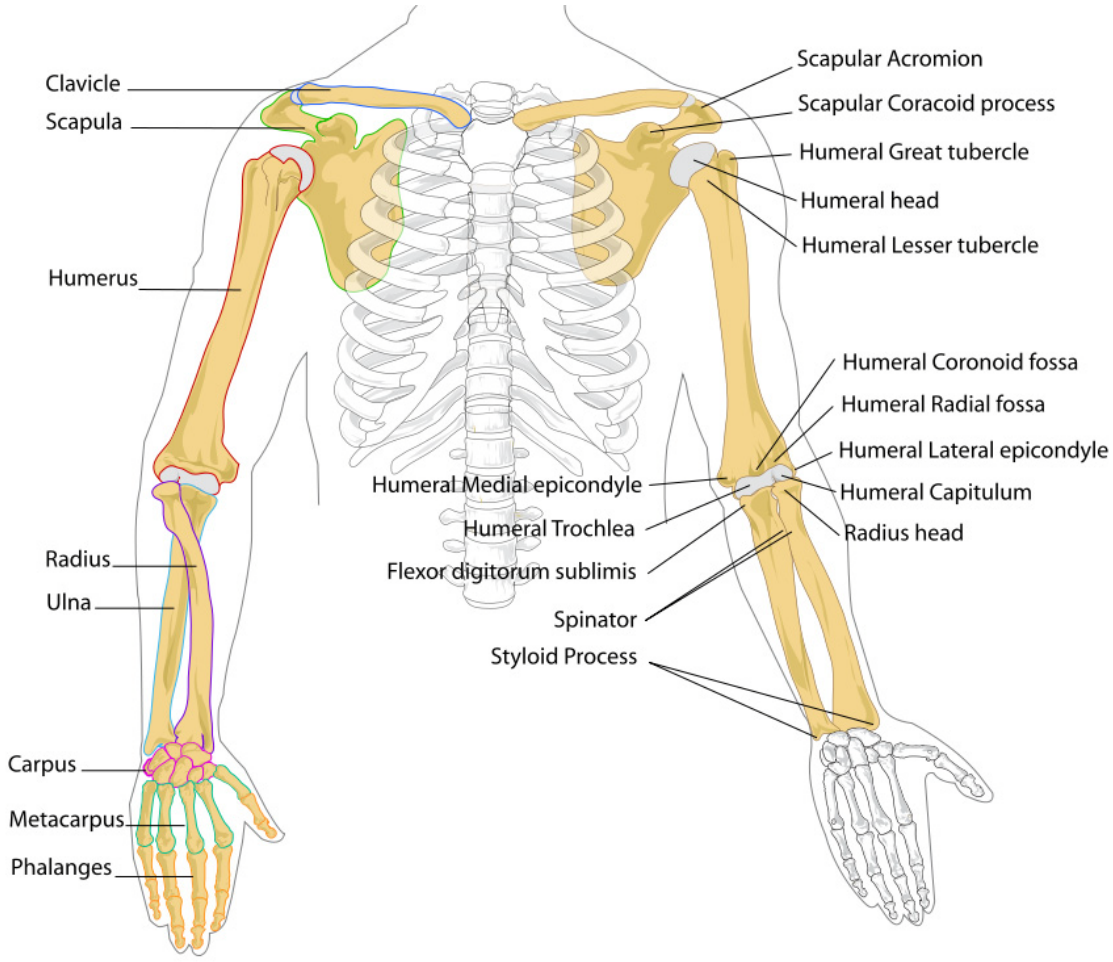


Fig. Nr 1

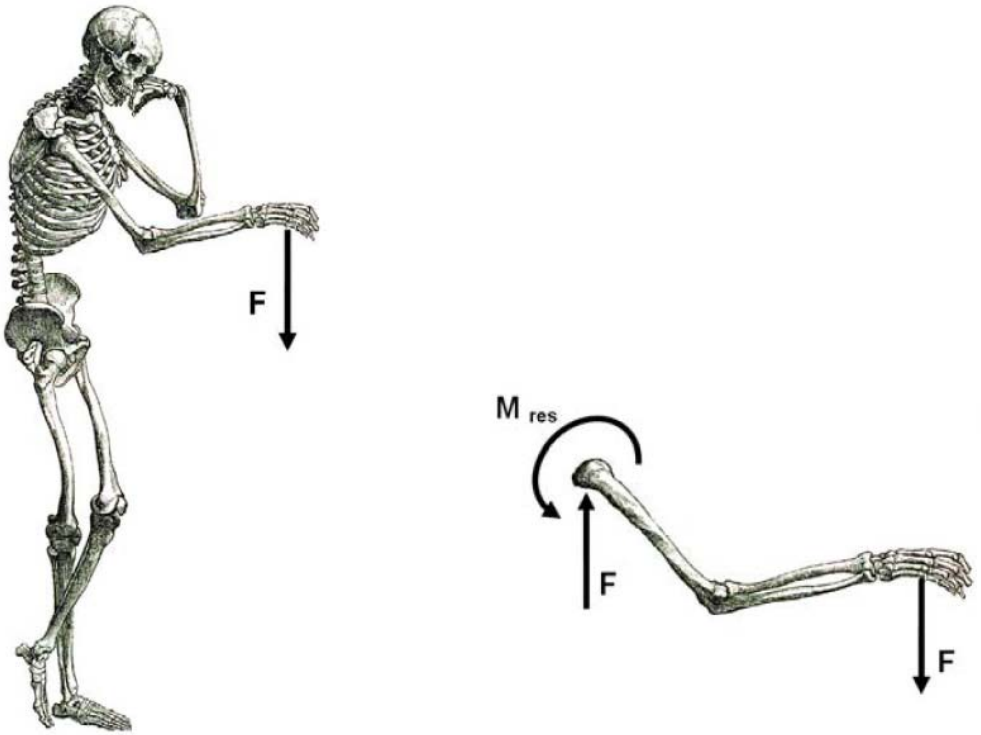
(source: human arm bones diagram.svg)

In turn, a single hand-arm device may be represented in the following way:

Fig. Nr 2
(the fingers-hand-arm complex)

The HAS may thus be defined as a device which, while being set at manipulating synergistically the individual degrees of freedom, is capable of performing a rich array of spatial tasks, such as those mentioned below, relative to the world coordinate system and under the general conditions of kinematics which allow for an inherent mechanical flexibility of the HAS while being involved in generating variable gestural complexes. It should also be remembered that this is realized while the HAS acts under the general constraints of both global load placed on the entire HAS and local stresses operating within the particular

elements of the HAS. The interdependence of the constraints is shown in the diagram below (Fig. Nr. 3):



(a) (b)

Fig. Nr 3

(source: Panzer et al., 2008)

where the left part of the diagram (a) represents global load placed on the hand, and the right part (b) shows the resultant stress on the shoulder joint, with M indicating the so-called ‘torque’ (i.e. the power output of an engine, in this case the HAS, and the tendency of a force to rotate an object about an axis, see e.g. Kane and Levinson, 1985).

It should be emphasized at this point that the human hand-arm system, or more precisely, the fingers-hand-arm complex, is a novel evolutionary trait compared to other animal (sub-human) limbs, for in the course of human evolution it has been freed from participating in direct locomotion in favour of the uniquely human bipedal gait (as shown in Fig. Nr 4 below). This latter development has had far reaching social-cultural-mental consequences for the human species (see, e.g. Wilson, 1998), as it has allowed for an unprecedented development of technology and intra-species communication in “a complex world full of obstacles” (Miller et al., 2005:56), where the HAS has been generally

participating by way of “a combination of bending moments and torsion moments, thus pointing into an arbitrary direction” (Panzer et al., 2008:5).

Fig. Nr 4

(the uniquely human bipedal gait, with the HAS freed from locomotion)

The freed upper two-limb complex has in the course of time been made noticeably shorter than in the closest ancestors which is clearly visible in the diagram below (see Fig. Nr 5). This is due to the liberation of the human HAS from direct locomotion (also known as ‘brachiation’, especially used by the lesser apes such as gibbons, but also by our direct cousins on the evolutionary tree, the great apes, see, e.g. Rice and Moloney, 2005; Stanford et

al., 2006). This evolutionary tendency may be expressed in the following way: the shorter the front limbs become, the freer they happen to be and the more likely it is that they will be given tasks other than locomotion (e.g. prehension and gestural communication).

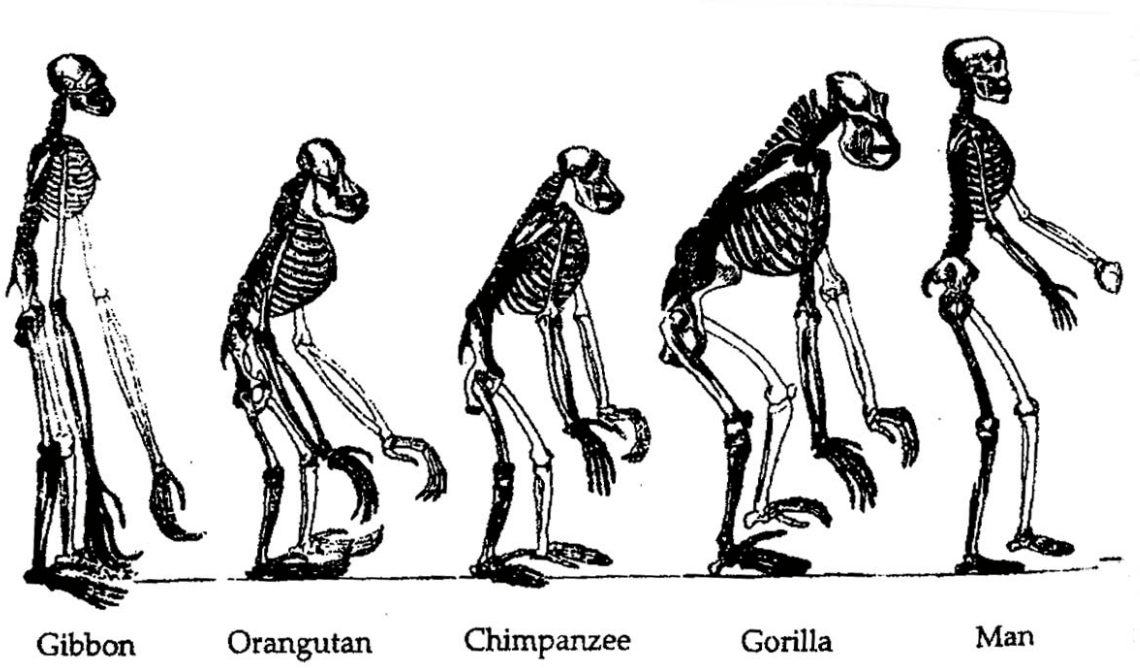


Fig. Nr 5

(source: www.biology2-ths.wikispaces.com/Human+Evolution)

As a result, the HAS has been adapted by the genus *Homo sapiens* to a very rich multitude of manual behaviours which may be grouped into:

(a) those which are generated by the HAS understood as a haptic ('sandhi') device which is generally involved in the touch and grasp tasks,

(b) those which are generated by the HAS understood as a spatial device and which is generally involved in communication (especially in non-verbal gestural communication)

(c) those behaviours which are hybrid in nature, that is, those which require the use of the HAS understood as a combined haptic-spatial device.

One may thus postulate that the HAS operates in two major modes:

- **the contact-bound mode** in which various touch-grasp tasks (such as touching, holding, pulling, pushing, striking, lifting, etc.) are being performed, and
- **the contact-free mode** in which a diversified number of spatially structured gestures (such as waving, circling, lifting, stretching, binding, etc.) are being performed for the purpose of both dyadic and group communication.

Subsequently, one may also postulate the presence of different kinds of sociality founded by the above mentioned modes of operation of the HAS. Namely, the contact-bound mode suggests a haptic type of sociality which, generally, is involved in the prolongation of the body via contact with different kinds of objects and their surfaces. The haptic sociality, therefore, appears to be more physical and material in nature and it results in such major operations as: the prolongation of the body (e.g. by a tool), support, removal, annihilation, etc. On the other hand, the contact-free mode suggests a more spatially and iconically-symbolically oriented sociality, whereby the free HAS is capable of performing a complex number of manipulations in space due to the maximum degree of flexibility (i.e. maximum number of degrees of freedom) and in liaison with the more iconic-symbolic aspects of the semiosphere (see e.g. Puppel, 2008; Puppel and Puppel, 2008). It is the second type of sociality which is of importance to the present paper.

2. The relevance of the contact-free mode of the HAS for human communication

The relevance of the HAS, especially in its contact-free mode of operation, is more than obvious and it has been the subject of intense studies in the area of non-verbal communication. Such a demonstrably vivid interdisciplinary interest, which can only be compared to the equally ample research on the semiotic and linguistic aspects of communication, has resulted in the formulation of useful typologies concentrating on the richness of spatially structured gestures in human communication (see, e.g. Efron, 1941; Ekman and Friesen, 1969; Argyle, 1975; Argyle and Trower, 1979; Morris et al., 1979; Kendon, 1997; McNeill, 2005).

In terms of the actual modalities involved, the contact-free mode of operations of the HAS involves the visual-tactile modality, whereas the linguistic code is typically expressed by most human communicators by the vocal-auditory modality. Both modalities interact closely in human communication, such that in normal communication practice, one cannot exist without the other (see, e.g. Mehrabian, 1972). That is why the use of the notion ‘human communicator’ seems more appropriate than the conservative, traditional, and somewhat

misleading notion of the ‘speaker’ (used predominantly in XXth century literature on human communication) with reference to verbal vs. non-verbal interaction. The impossibility of separating either modality from the other in acts of human communication presents, in fact, a strong argument in favour of combining the two modalities into what may be termed a ‘double modality communicative design’ in which both modalities are most naturally intertwined and which strengthen each other in the universally replicable interpersonal communication ecology. The design is shown below in the following diagram (Fig. Nr 6):

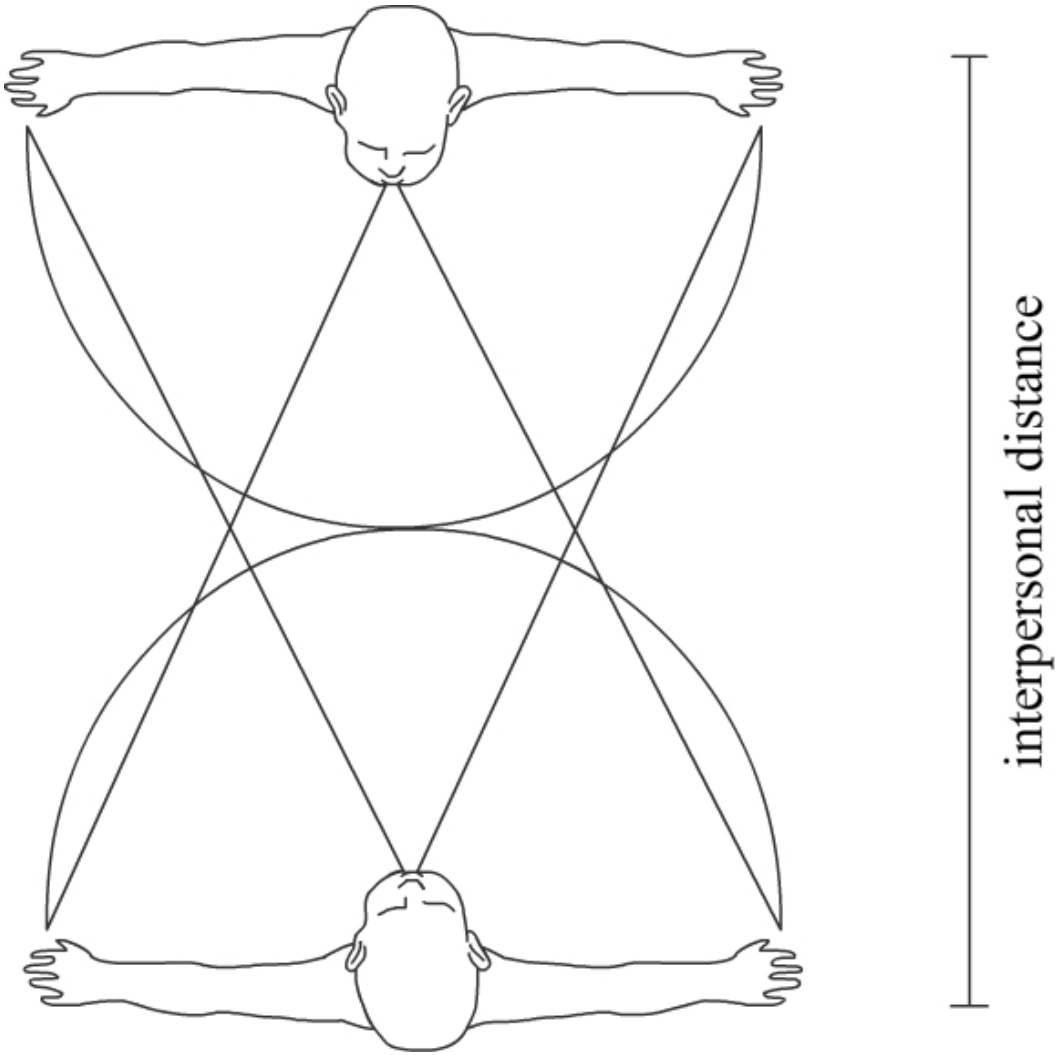


Fig. Nr 6

3. Conclusions

It follows from the above brief discussion and the above diagram that the universally available and replicable interpersonal communication ecological design, formed by the complex of the locomotion-free HAS and the vocal-auditory modality, represents a particularly rich communicative device capable of expressing a very diversified plethora of sound-gesture complexes. This may be due to the well-known combinatorial design of the phonological sub-code, on the one hand, and to increased combinatorial design of the HAS, on the other, both working synergistically in various communicative tasks.

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