Chin win story

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We habitually stroke our chin pondering over the questions of life, universe and beyond, but did you ever realize that the chin – a bony projection on the forward-most portion of the lower border of the mandible is a unique signature of humans. No other ape or even the Neanderthal, our nearest evolutionary relative, has chin as prominent as ours. Hence it is an important anatomical feature which describes humans in the fossil records. The discussion on the ontogeny of the chin dates back to more than 200 years ago, when Blumenbach (1775) identified the 'chin' as being among the most fundamental features that he considered uniquely human[1].

In common parlance, the chin is an aesthetic ornament and yardstick to one's behaviour – large chins are routinely associated with masculinity; the 'chinless wonder' describes one who is feeble, ineffectual and unmanly; last but not the least, prominent chin is an artistic ideal. But for evolutionary anthropologists, who believe nature is nothing, if not conservative with respect to evolution of the human body, the reason behind the origin of the chin has long been a source of debate and yet a consensus remains elusive.

To date several hypothesis have been proposed and debated by scientists to explain why humans have a prominent chin. Was it due to: (i) an adaptation to masticatory stress; (ii) humans developing articulate speech; (iii) evolution of bipedalism, or (iv) as sexual ornamentation? Some others have proposed that the chin is a spandrel, a selected by-product of the evolutionary process operating elsewhere in the mandible or face. Also a debate is on that the chin is a spandrel, produced as a result of genetic drift and not of selection elsewhere in the mandible.

In spite of extensive research into the evolutionary origins of the chin, a consensus remains elusive, partly because this feature has been considered as a singularity. Singularities are unique evolutionary events, and therefore do not comply to simple comparative approaches, a standard norm used in studies of evolutionary biology. To overcome this limitation, three recently published articles[2–4] have used quantitative techniques, which throw some light on the origin of the chin – a cladistic apomorphy. The articles argue that the chin has evolved for a reason.

Pampush[2] evaluates the shifts in evolutionary rates of the mandibular symphisis (which is the midline joint between the left and right lower jaws). This is a powerful approach to understand whether the chin represents an exceptionally derived morphological condition, and if this condition can be interpreted as the product of natural selection or a result of genetic drift. The author proposes that if selection worked to produce a trait of an organism, the evolutionary rate associated with generating the trait of that particular organism would be higher when compared to the rate associated with genetic drift producing the same trait. Alternatively, if genetic drift produced a particular trait, the evolutionary rate associated with emergence of the trait should correspond to the evolutionary rates of other homologous traits throughout the clade of the organism.

Quantitative measures of chin projection, namely chin index and chin angle were collected from midsagittal sections of computerized tomography (CT) scans from 123 primate taxa. Chin index is defined as the ratio of chin length to mandible length. Chin angle is defined as the angle between the occlusal plane and the line passing between the uppermost border of the midsagittal symphysis and the lowermost border of the symphysis. Evolutionary rates associated with these measures to get significant phylogenetic signal. The evolutionary rate was far higher along the Homo tip (~77 times greater than the rate of evolution in primates) than elsewhere in the primate phylogeny.

The results of this study suggest two novel concepts regarding the origin of the chin. First, when assessed as a trait in the phylogenetic tree and not as a discrete character, the chin is shown to be derived as an exceptional trait. Second, the results further suggest that natural selection has been operational in producing the human chin and negate the role of genetic drift. However, the current study is insufficient to conclude whether the chin is an adaptation or a spandrel evolved due to natural selection operating elsewhere in the mandible or face.

This question to a certain extent was addressed by Holton *et al.*[3], whose study shows that our chin is not an adaptive solution to masticatory stress. During mastication (chewing), the mandible (lower jaw bone) is subjected to mechanical stresses, which play a significant role in shaping the mandibular symphyseal morphology. Studies indicate that modern human mandible with a chin is better at resisting masticatory stress compared non-chinned model. Thus, it is possible that an increase in chin prominence increases resistance to stress encountered during mastication. If prominence of the chin is a response to symphyseal bending loads during development, then it could be predicted that increased bending resistance will be associated with ontogenetic increase in chin projection. Conversely, reduced chin projection early in the development should correspond to a decrease in relative bending resistance. To elucidate this hypothesis, the researchers examined X-rays of the chin and jaws of 37 people who had been regularly X-rayed from the age of three to their mid-20s. Using mathematical models, they calculated the mechanical stress that was placed on the jaw during the act of chewing. These authors observed that the age of the people and the strength of the jaw are inversely correlated, thus arguing that chin does not strengthen your jaw or aid in chewing. Therefore, Holton *et al.*[3] fielded the hypothesis that the emergence of the chin in modern humans is a result of simple geometrical change. As our faces became smaller with evolution from archaic to present-day humans, in anthropological terms referred to as 'craniofacial feminization' (Figure 1), the chin became a bony prominence at the bottom of our face. Craniofacial feminization refers to the retraction and diminution of the facial skeleton of present-day humans compared to 'archaic' humans, which itself is a phenotypic indicator of reduced aggressiveness. Thus chin is a spandrel, a selected by-product of the evolutionary process operating elsewhere in the mandible or face.

So what evolutionary process produced craniofacial reduction/feminization

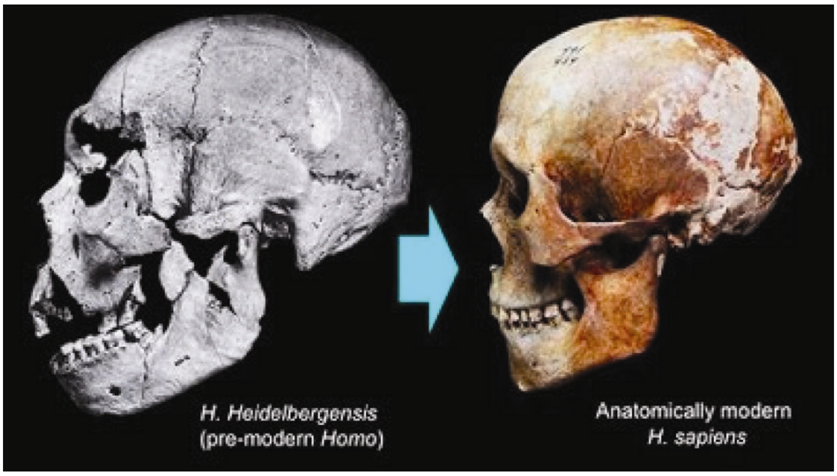

Figure 1. Craniofacial feminization (reduction in average brow ridge projection and shortening of the upper facial skeleton) in *Homo sapiens*. The 110–90 ka-year-old male specimen Skhul 5 (left) compared to that of a recent African male (right). (Courtesy: Cieri *et al.*[4]).

in the *Homo sapiens*? This question was addressed by Cieri *et al.*[4] who proposed that craniofacial feminization resulted due to emergence of 'behavioural modernity' or 'fully symbolic *sapiens* behaviour'[5].

Behavioural modernity is a distinctive human trait which involves innovation, planning and cultural creativity. It has been reported that behavioural modernity has evolved in the last 200,000 years of human evolution and has become persistent sometime after 80,000 years ago. This epoch in evolution witnessed rapid development of new technologies, including sophisticated pyrotechnology, and possibly watercraft, and is referred to as cumulative technological evolution (CTE), or 'cultural ratcheting'. Interestingly, this period of rapid technological innovation coincides with the earliest evidence of symbolic behaviour and abstract thought which emerged in the middle of Middle Stone Age (MSA/ Middle Palaeolithic (MP)) and steadily increased to late Stone Age (LSA)/Upper Palaeolithic (UP)). As behavioural modernity requires both innovation and transmission, this attribute can only express in the realm of less aggressive human temperment, increased cooperation and social tolerance. It is well documented that androgen, specifically testosterone, plays a significant role in moderating social tolerance and also has an effect on the craniofacial growth and development. So, it is possible to argue that selection against the antisocial behavioural traits associated with high androgen reactivity would be expected to cause a reduction in average androgen levels or receptor density, and result in craniofacial feminization in a population over time.

To test this hypothesis, that a major change in temperament occurred around the time of establishment of behavioural modernity, the authors sought to quantify relative changes in craniofacial morphology among anatomically modern human crania from the Middle Pleistocene to historic times. They examined measures of brow ridge projection, facial shape and endocranial volume in three temporal samples of modern human crania. These samples included a pre-80 ka BP MSA/ MP-associated group, LSA/UP-associated group and a global sample of Recent (Holocene) humans. The results indicated that there was a consistent reduction in brow ridge projection, facial shape and endocranial volume in the human faces from MSA/MP to LSA/UP and then to the modern humans. Thus, once aggressive hominids had to self-domesticate to imbibe behavioural modernity and take a positive stake in the evolution of present day humans.

Hence craniofacial feminization and the emergence of the human chin, serve as an indicator of changes in testosterone reactivity and thereby changes in social tolerance. Many researchers have argued that it is too simplistic to propose a linear model, which claims that to imbibe behavioural modernity, testosterone had to be underplayed and this led to craniofacial feminization and emergence of the chin. But for now, evidence indicates that as we evolved from being mere *Homo sapiens* to humans, along with thought and intellect, we developed the chin. So next time you tend to get hostile and mean, remember that evolution has taken millions of years to select you against these traits and the proof is your own chin.

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