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HERBERT ULLRICH, CARL N. STEPHAN

MIKHAIL MIKHAYLOVICH GERASIMOV'S AUTHENTIC APPROACH TO PLASTIC FACIAL RECONSTRUCTION

ABSTRACT: Facial reconstruction is used in paleoanthropology and the forensic sciences to predict facial appearances from dry skulls. The Russian archaeologist Mikhail Mikhaylovich Gerasimov is especially renowned for his contributions to this field; so much so, that his method defines an entire face prediction approach that delineates the theoretical and practical framework of the forensic facial reconstruction discipline. However, Gerasimov's founding method has been massively misinterpreted in the English speaking world, including the English forensic science literature. That is, Gerasimov's so-called "Russian methods" do not rely on the comprehensive construction of the facial muscles without the use of facial soft tissue thickness means as unanimously published beyond Gerasimov's manuscripts. Instead, the reverse is true: Gerasimov constructed only limited muscles – the two superficial muscles of mastication – and his method heavily depended on average soft tissue thickness values, which he twice published. While Gerasimov's hallmark Russian text, Vosstanovlenie lica po cerepu *(available since 1955), clearly delineates these methods, ongoing hesitation to abandon entrenched dogma suggests that an English synopsis is timely. To avoid continuing problems of language barriers and original text scarcity, we present and illustrate Gerasimov's authentic facial reconstruction techniques in English on the basis of two primary sources:* Vosstanovlenie lica po cerepu*; and five, two-to-three week, one-on-one training sessions with Gerasimov in the former USSR between 1959 and 1969. While this paper is not intended to replace Gerasimov's original works, it is intended to inspire proper consultation of his original manuscripts to correct entrenched misrepresentations; and provide insight on how Gerasimov implemented these recommendations at the work-bench, i.e., to elucidate his technique in addition to his method.*

KEY WORDS: Facial approximation – Facial reproduction – Plastic reconstruction – Russian method – Forensic anthropology

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INTRODUCTION

The Russian anthropologist and archaeologist Mikhail Mikhaylovich Gerasimov, 1907–1970, is internationally renowned for his method of building faces from skulls, both in paleoanthropology and in forensic anthropology (Gibson 2008, İşcan, Steyn 2013, Nature Editorial 1970, Prag, Neave 1997, Stephan 2009, Taylor 2001, Wilkinson 2004). Although he was not the first to undertake such methods, prior to him, facial reconstruction methods were thought only to produce a facial resemblance in terms of "race" (Eggeling 1913, Kollmann, Büchly 1898, Merkel 1900). In Gerasimov's view, this had little practical value as racial type could be conferred from the skull alone (Gerasimov 1971). He, therefore, sought additional performance from the methods that would justify their trouble. After 20 years of research and development, Gerasimov self-proclaimed a method called "portrait reconstruction", which was defined as "so close an approximation to the appearance of a living person…that even an unknown individual could be identified" (Gerasimov 1971: 16 or Gerassimow 1968: 30).

Despite international acclaim of these methods in the contemporary facial reconstruction literature (Gibson 2008, İşcan, Steyn 2013, Prag, Neave 1997, Taylor 2001, Wilkinson 2004), they have been monstrously misinterpreted. A prime example is the unanimously held view that Gerasimov's method required the construction of many facial muscles with little, or no, consideration of mean soft tissue depths (see e.g., Prag, Neave 1997, Starbuck, Ward 2007, Taylor 2001, Vandermeulen *et al.* 2012, Wilkinson 2004). In reality, the converse is true: Gerasimov relied heavily on average soft tissue depths, and only four muscles – the two temporalis and masseter muscles – were ever built on the skull (Gerasimov 1949, Gerasimov 1955; see also Stephan 2006, Ullrich 1958, Ullrich 1967, Ullrich, Stephan 2011).

The penetration of these major misinterpretations throughout the craniofacial identification literature is astonishing and their roots trace to the field's collective over-reliance on the secondary literature, for example, an English translation (Gerasimov 1971) of an already translated interview (Gerassimow 1968). *The Face Finder* (Gerasimov 1971) is especially misleading in places since it emphasizes an atypical case where Gerasimov worked purely by eye. Furthermore, infrequent citations are given to facial soft tissue depths in this text, which also excludes several illustrative figures – present in the original German version (Gerassimow 1968). Another heavily replied upon secondary source – the abridged English translation of *Vosstanovlenie lica po cerepu* by Tshernezky (1975), clearly subtitled as "[A] Translation with some shortages" – offers little corrective action since every three pages of Russian are reduced to one page of English.

While standard research practice could have rectified the above mentioned errors via cross-referencing among the original sources, this has not happened. Instead, errors have become ingrained in facial reconstruction's psyche as ground truths for at least the last 35 years (Stephan 2006, Stephan 2015, Ullrich 1958, Ullrich 1967, Ullrich, Stephan 2011). At the current time, these errors continue to be perpetuated, with hesitation to abandon erroneous dogma (see e.g., İşcan, Steyn 2013, Vandermeulen *et al.* 2012, Vermeulen 2012). A more detailed account of Gerasimov's protocols in English is thereby warranted, and is herein provided, based on the authors' own independent translations of *Vosstanovlenie lica po cerepu* and five, two-to-three week, one-on-one training sessions with Gerasimov in the former USSR between 1959 and 1969 (by HU).

This synopsis is not intended to replace *Vosstanovlenie lica po cerepu* (Gerasimov 1955) or rewrite Gerasimov's methods. Instead, it serves as a convenient English summary that will hopefully inspire greater consultation of Gerasimov's original work. This paper also provides insights into Gerasimov's bench-side implementation of his method, reportable as a result of HU's one-on-one training with Gerasimov. These first hand insights on Gerasimov's technique are now rare since, even at the Russian Academy of Sciences' Laboratory for Anthropological Reconstruction, students who directly studied under Gerasimov can no longer be found.

Gerasimov's Plastic Facial Reconstruction Method

Overview

Gerasimov's facial reconstruction method is a three dimensional (3D) manual technique that, in common with other 3D reconstruction methods, uses the original skull as a scaffolding for the constructed face (Gerasimov 1971). *The Face Finder* correctly indicates that only one side of the face was, at first, constructed leaving the other side of the skull visible for verification before the face was completed (Gerasimov 1971). In order to generate a final product, Gerasimov almost exclusively built two faces, sequentially, on the same skull (Gerasimov 1971). After constructing the first, he tore it down and its appearance was used (from memory) to gauge the similarity of the second constructed face and thus its accuracy. The modeling process usually took

Gerasimov 10 days, but if pressed and with only a single face "build-up", he could complete the process in a very short time (Gerasimov 1971). For example, *Ich suchte Gesichter* (Gerassimow 1968) and *The Face Finder* (Gerasimov 1971) claim a case where Gerasimov constructed one-half of a face in less than two hours.

Modeling Mastic and Instruments

Gerasimov's modeling substrate was a three-part mastic that was perfected after a six month investigation into the best material suited to the undertaking (Gerasimov 1971). As we report elsewhere, the primary ingredient was bee's wax, which gives the modeling mastic excellent detail (Ullrich, Stephan 2011). The two other ingredients were colophonium and oil based clay (plastiline). If desired, the mastic could be colored using oil-based paint. The colophonium was used to give the mastic its hardness, but its proportion can be varied to suit the needs of the practitioner. Gerasimov preferred the mastic to be hard, so its position was set only purposefully, accurately, and in a permanent manner. This stiff mastic, which gradually becomes pliable when warmed by manipulation from the hands, was the cause for finger pain following reconstruction by first-time participants – the first-timers were not prepared for such physically demanding hand routines. It is these reports of finger pain, that have led to unfounded rumors in the discipline that Gerasimov's modelling mastic was toxic (for further comment see Ullrich, Stephan 2011). A typical mix included one part colophonium, one part plastiline and five parts bee's wax.

Reconstruction Protocol

After anthropological examination of the skull to determine sex, ancestry and age; any missing or damaged teeth were modeled, in wax, before the mandible was attached to the cranium using mastic strips, placed on the lingual side of the dental arcade. The mandibular teeth were set in direct occlusion with the maxillary teeth. Although this prevented establishment of a freeway space, it ensured the mandible was correctly positioned in reference to the occlusal pattern / dental wear. When in the proper position, the mandibular condyles were in (or almost in) direct contact with the articular eminence. The resulting spaces between the glenoid fossae and the mandibular condyles were filled with wax, helping to set the mandible. Once the mandible was secure, the symmetry and robustness of the skull was assessed and noted for later representation in the constructed face.

Muscle construction

Only the large superficial masticatory muscles (i.e., the masseter and the temporalis) were modeled onto the skull. Gerasimov considered the construction of the muscles of facial expression to be dubious since their attachment to the skull was not visible (Ullrich 1958, Ullrich 1966). This explains the absence of muscles of facial expression in any illustration of Gerasimov's partially completed facial reconstructions (Stephan 2006, Ullrich, Stephan 2011). As previously mentioned, only one side of the face was constructed at first; thus, leaving the other side of the skull bare for reference. Both the masseter and temporalis muscles were determined by the

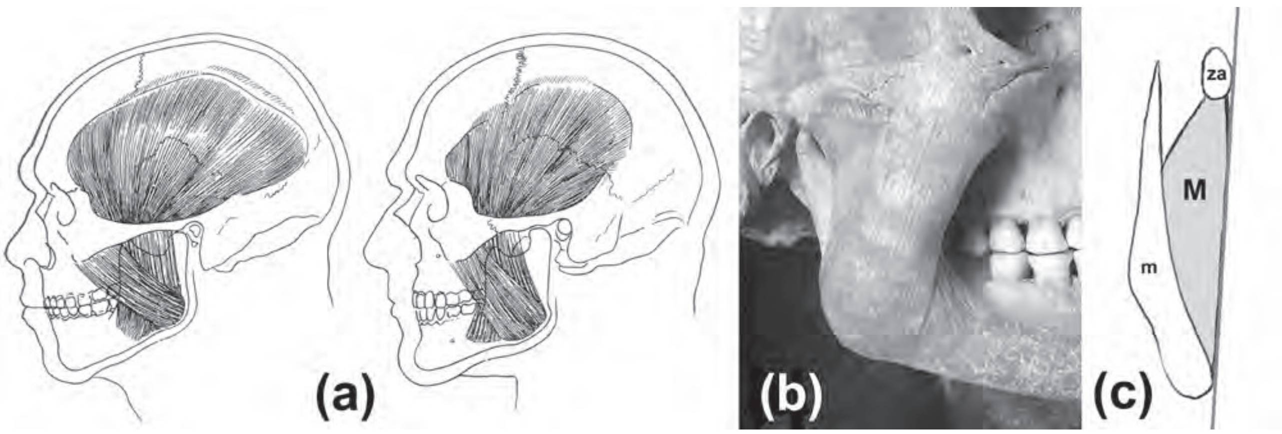

FIGURE 1: Modeling of the masseter muscle. a, Illustrations of the masseter muscle as constructed by Gerasimov (image adapted from Gerasimov 1955); b, Representation of the masseter muscle in Gerasimov's modeling mastic on a skull; c, Coronal view of the mandibular ramus indicating the determination of the masseter muscle thickness. The masseter muscle (M) does not extend past a tangent between the lateral portion of the zygomatic arch (za) and the lateral portion of the mandibular angle (m = mandible).

size of the skull and the extent of the muscles' bony attachments.

The temporalis muscle was built first, over crumpled paper placed in the infra-temporal and temporal fossa to give the constructed muscle bulk, and to save on modeling mastic. Small clumps of mastic were used in the build-up, from the superior most edge of the zygomatic arch, curving upward and becoming ever thinner, until the superior temporal line was reached. The attachment of the temporalis muscle to the coronoid process of the mandible was not undertaken. Transversely, the muscle was not constructed to be uniform but rather, it alternated from being concave anteriorly, to convex above the center of the zygomatic arch, and then concave above the root of the zygomatic arch (see Ullrich, Stephan 2011 for illustrations).

The masseter muscle was built with superficial and deep parts (*Figure 1*); the deep portion running from the posterior zygomatic arch antero-inferiorly to the corpus of the mandible. The superficial part was represented from its anterior origin on the anterior zygomatic arch to its insertion at the angle of the mandible. The shape of the muscle, relative to its long axis, was slightly convex, but not reaching beyond the bounds of a tangent touching the lateral aspect of the zygomatic arch and the region of the gonion (*Figure 1*).

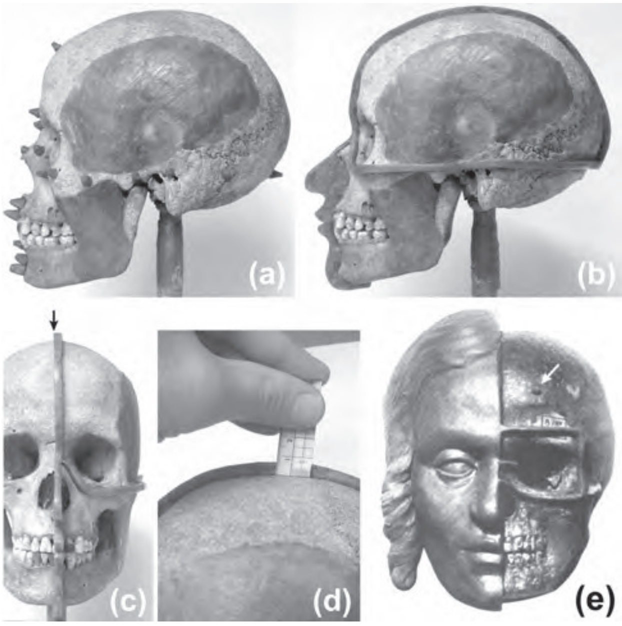

FIGURE 2: Soft tissue depth representation on the skull during plastic reconstruction. a, Representation of mean soft tissue depths in the median and Frankfurt Horizontal planes using wax pyramids as first encouraged by Gerasimov, after Kollman, Büchly (1898); b, Representation of the mean soft tissue depths using solid lines of mastic as later recommended by Gerasimov; one line essentially follows the Frankfurt Horizontal, the other the medial plane; c, Frontal view of (b) showing the profile line offset to the central vertical axis so that one edge runs directly along the median plane (black arrow); d, The use of a small ruler to check the depths of the soft tissue lines against mean values; e, One of Gerasimov's facial reconstructions illustrating the combined use of solid soft tissue depth lines and single wax pyramids (white arrow). Image (e) is reproduced from Gerassimow (1968).

Mean soft tissue depths, profile line, and face mask construction

After the masseter and temporalis muscles had been built on one side of the skull, the mean soft tissue depths were represented. Early on, Gerasimov accomplished this by constructing small mastic pyramids over the skull at various anatomical landmarks (*Figure 2*). These were then connected together by narrow mastic strips that represented soft tissue profiles. Later, he encouraged his students to skip this step, and represent the soft tissue depths using mastic strips alone (see *Figure 2*). Examples of both of these methods can be seen in Gerasimov's published work (see *Figure 2*); however, he did not typically follow either since he knew the mean depths so well that he deemed it unnecessary to represent them explicitly on the skull.

The absence of mean facial soft tissue depth markers in illustrations of Gerasimov's partially constructed faces is clearly one of the sources for the misperception of his methods. The soft tissue depth values that Gerasimov used, were derived from Gerasimov's own needle puncture and radiographic studies of fresh males and female cadavers that he published on two separate occasions (Gerasimov 1949, Gerasimov 1955). *Vosstanovlenie lica po cerepu* gives the typical range of mean values for these groups, the precise values for nine midline points, and all of the raw data (Gerasimov 1955).

Nineteen soft tissue depths were measured, and placed along two planes: "the profile line" (= the median plane) and the Frankfurt Horizontal (Gerasimov 1955). These soft tissue depths were further supplemented by five other depths at other locations (*Table 1*). To construct the profile line, a graphic construction was first made on tracing paper from a life size image of the skull in profile view (*Figure 3*). Average soft tissue depths were used for the construction of the profile and the nose shape was predicted using the two-tangent guideline and a reflection of the nasal aperture profile (see below). To represent the profile on the skull, a 5 mm wide mastic

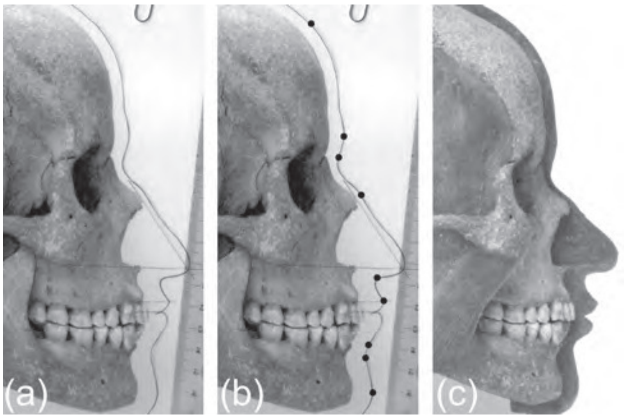

FIGURE 3: Graphic reconstruction of the facial soft tissue profile in the median plane. a, Skull and reconstructed profile line with representation of: i) the nose projection tangent; ii) height of upper vermillion border; and iii) height of the lip closure line (stomion);. b, Nine of the landmarks along the profile where average soft tissue depths were used by Gerasimov (black dots). Note here that the soft tissue depth at glabella has been reduced to accompany the reduced bony relief at this region in this individual; c, Representation of the profile line on the skull using the wax mastic, constructed by first using the 2D graphic profile reconstruction at (a) as a template.

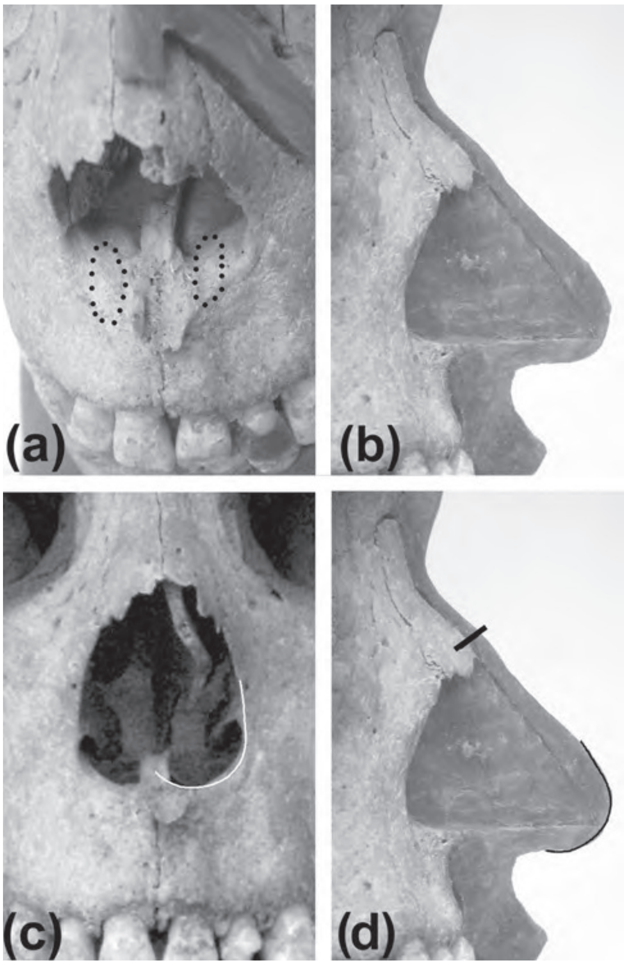

FIGURE 4: Determination of the nose projection. a, The maxillary regions used to estimate the direction of the lower nose tangent outlined on either side of the anterior nasal spine; b, Profile view of the nasal profile with the two tangents represented in the wax; c, The outline of the infero-lateral rim of the nasal aperture, which was used to approximate the outline of the tip of the nose; d, A profile view of the constructed nose indicating: i) the distal nasal bone segment used to determine the upper tangent direction indicated – note that only the end of the nasal bone distal to the black bar was used in the estimation; and ii) the lateral nasal aperture outline (black line) used to approximate the tip of the nose – this has been rotated from c to create the nose tip.

strip was constructed (*Figure 2*). Where relief of the skull was marked or absent, the soft tissue depths were either exaggerated or reduced respectively. These steps were especially considered by Gerasimov over the region of the cheeks and glabella (Gerasimov 1971, Gerassimow 1968). Gerasimov would slide a small ruler along each of the mastic strips to check their depth at appropriate locations and cross-reference to mean values (*Figure 2*).

The profile line over the nasal aperture was supported by first "blocking-in" the aperture, initially with paper and then by a covering layer of mastic (as for the temporalis muscle). The "blocking-in" should be deep enough so that the anterior portions of the crista conchalis remain exposed on each side. The nose and mouth form were modeled following the two-dimensional graphic template, which was generated prior to undertaking the 3D reconstruction. More specifically, the projection of the nose was determined by placing two tangents: one following the general direction, but the very distal end (approximately last 2 mm, but exact distance was never specified) of the nasal bones. Note here that the lateral parts of the nasal bones adjacent to the median profile may be used instead of the morphology expressed directly along the median plane). The other tangent followed the general direction of the left or right floor of the anterior part of the nasal aperture (maxillary bone) laterally adjacent to the anterior nasal spine and vomer bone (*Figure 4*). In contradiction to the popular English literature (Rynn, Wilkinson 2006, Stephan *et al.* 2003) and *The Face Finder*, the lower tangent did not necessarily follow the projection of the anterior nasal spine (Ullrich, Stephan 2011), but rather

TABLE 1: Mean facial soft tissue depths (mm) measured in a total of 71 individuals, as used by Gerasimov. Adapted from Gerasimov (1955: 105–108).

Location	Landmark	Males	Females
Points in the Median Plane	Metopion	6	5
	Glabella	8	6
	Nasion	6	6
	Rhinion	3	2
	To the side of the anterior nasal spine	11	10
	Upper lip	12	10
	Lower lip	8	9
	Mentolabial sulcus	9	8
	Pogonion	9	8
Points in the Frankfurt Horizontal Plane	Near the edge of the aperture piriformis	3	2
	Middle of the frontal process of the Maxilla	4	2
	Just under the orbit	4	3
	The most prominent point at the frontal part of the zygomatic arch	7	5
	At the zygomaticotemporalis suture	7	3
	The most prominent laterat point on the zygomatic arch	6	3
	Above the temporomandibular joint	5	4
	In the area of the ear, behind the zygomatic arch	4	3
	At the lambdoidal suture	6	4
	At the most prominet point on occipital bone	8	5
Additional Points	Over the anterior lacrimal crest	3	2
	Alongside the aperture piriformis at the height of the crista conchalis	3	2
	Adjecent to the corner of the apertura piriformis where the inferior rim turns into the lateral rim	3	3
	Lateral rim of the orbit near the malar tubercle	3	3
	Gonion	6	4

the floor of the nasal aperture. Both HU and CS find this guideline difficult to implement in practice, since the floor of the nasal cavity is often undulating, especially at its anterior extent.

The profile outline of the nose at the bridge was strictly determined by the nasal bones, the soft tissue here conforming closely to the measurement at rhinion. If the upper border of the nasal aperture was bent slightly inwards then the nasal profile, in the area of the nasal cartilages, had a wavy appearance (*Figures 3–4*). The profile outline of the dorsum and tip of the nose roughly corresponded to the lateral curve of the nasal aperture as seen in a frontal view (also see Balueva in Conant 2003; *Figure 4*). If the infero-lateral rim of the nasal aperture was rounded, then this too was mirrored in the tip of the nose. With regards to the lips, stomion was represented half way down the central incisors, and the vermillion border of the upper lip was set at the same height as the lower edge of the alveolar rim (*Figure 3*). All these features were determined relative to the Frankfurt Horizontal.

Once the profile and Frankfurt Horizontal soft tissue depth lines had been represented, interconnecting lines were added between the mean markers, forming the meshwork over the skull (*Figure 5*). These lines were not uniform in their depth, but varied according to the skull

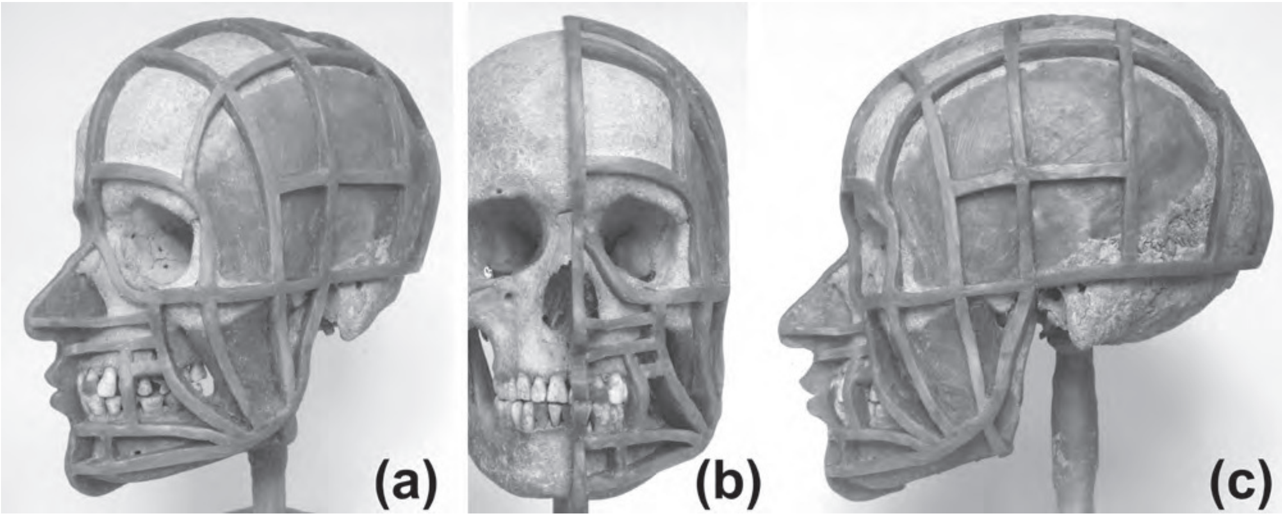

FIGURE 5*:* A skull with a completed soft tissue mesh represented, as derived from the mean tissue depth values. a, Three-quarter view; b, Frontal view; c, Profile view. Note the construction of only the temporalis and masseter muscles beneath the meshwork.

surface morphology (*Figure 5*). The lines enabled the soft tissue at various regions of the face to be visualized, whilst enabling the adjacent skull to be viewed. In this way it could be ensured that the soft tissue was constructed in accordance with the shape of the underlying bony matrix. This contrasts with the other well-known methods, such as those of Neave, Wilkinson and Gatliff (Gatliff 1984, Prag, Neave 1997, Wilkinson 2004) where wider strips or sheets of modeling substance are used to cover the skull (or skull cast) in an accelerated fashion without leaving part bare for reference.

Once the soft tissue lines were finalized, the spaces they outlined were filled using small clumps of mastic (*Figure 6* illustrates the sequence). As each space was packed, close attention was paid to the bony shape of the skull immediately below (and on the opposite side) to ensure that their contours were realistically reflected in the modeled soft tissue. Since asymmetry is often slight, two hands were used, one on the bare half of the skull and the other on the modeled soft tissue, to feel and check the accuracy of the face contours in relation to the skull (*Figure 6*). When the second half of the face was constructed, the already modelled face on the opposite side served as the reference, again using the hands to check contour compliance.

Modeling the remainder of the nose

To reconstruct the nose, the dorsum, tip, and septum were represented without the wings and the region of the upper lip was filled in. The main body of the nose was as wide as the nasal aperture, with only the wings falling beyond its limits. The soft tissue bridge closely followed the contours and relief of the nasal bones and frontal process of the maxillary bone. Once the main body had been modeled the wings were added. The wing should only be modeled as high as the crista conchalis on the corresponding side, and it should be as low as the floor of the aperture piriformis. The orientations of the nasal wings were independent of the direction of the nasal spine, but if a prenasal sulcus was present on the skull, the upper rim of the wing of the nose is directed

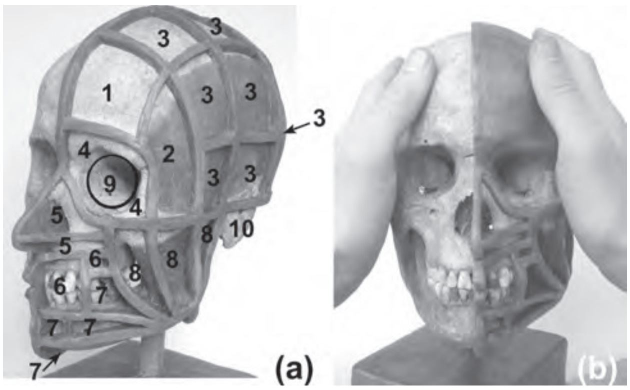

FIGURE 6: Packing the soft tissue meshwork. a, Sequence in which the spaces are filled; b, Use of the hands to simultaneously feel the skull and face to check compliance of soft tissue contours with the bone. Construction of only one half of the face enables this examination to be conducted.

anteriorly downward. If the crista conchalis fell anteriorly on the rim of the nasal aperture, then the nose was constructed to have laterally directed nostrils; if it fell posterior to the rim, then the nostrils were vertically directed. A broad nasal aperture indicated round nostrils, while a narrower nasal aperture suggested oval nostrils (no metrics were provided by Gerasimov to define constituents of 'broad' and 'narrow'). A skull with a large inter-orbital width, but a small nasal roof was taken to be indicative of a large distance between the nostrils. If the lateral rims of the nasal aperture were sharp, then the width between the outer limits of the nostrils was calculated to equal the width of the nasal aperture.

Modeling the philtrum

The philtrum ridges were centrally orientated along the long axis of the roots and the enamel of the central incisors – if they were curved, then so too were the philtrum ridges. The depth of the philtrum corresponded to the depth of the alveolar relief between the central incisors.

Modeling the nasolabial fold and the cheeks

The nasolabial groove started at the upper margins of the wings of the nose, just above the crista conchalis. The nasolabial groove was made to run through the deepest point of the canine fossa in the direction of the lower second molar. The greater the relief of the canine fossa (i.e., the deeper it is), together with wide zygomatic bones, then the shallower the nasolabial groove.

If the cheekbones were rounded and weakly formed then the cheeks were full. If the zygomas were angular, then the cheeks were flat. Slim zygomatic bones with a strong profile, indicated thinner soft tissue at the cheeks; wide, but flat, zygomatic bones in the profile view indicated greater soft tissue thickness at the cheeks.

Modeling the remainder of the mouth

The mouth was determined by the configuration of the alveolar region of the maxilla, width of the zygomatic bones, form of the teeth, prognathism and type of occlusion. The width of the mouth stretched between the upper second premolars. The soft tissue thickness of the upper lip was 7–8 mm in the median plane, 3 mm over the first premolar and 12 mm over the second premolar. The orientation of the lip closure line followed the line of tooth occlusion, even though it was set above it (i.e., at the height of the mid-portion of the enamel of the central incisors).

If there was large prognathism, the lips were constructed to be thick and the philtrum deep. Large incisors were also taken to indicate thick lips, with the red lip part being equal to the height of the enamel of the central incisors plus 1.5 mm. With weak prognathism and average sized teeth, a more feminine lip form was constructed. If the central incisor was broad with a small lateral incisor, the upper lip was strongly curved. If both incisors were broad, the upper lip was only weakly curved. If the labiomental sulcus was deep with a projecting chin, then the lower lip was constructed to be thick.

Modeling the chin

The soft tissue of the chin followed the profile outline of the bone. If the angle of the ramus was close to 90 degrees, then the chin was prominent. Also, if the anterior aspect of the mandible was squared then the thickness of the chin was marked and made "plump".

Modeling the eye

The eyeball was not constructed as a solid sphere, rather the back of the orbit was packed with paper and only a convex disc used to represent the anterior portion of the globe. Note here that Gerasimov used prosthetic eyeballs for his forensic reconstructions, but not for his paleoanthropological cases. The projection of the eye was set 1–2 mm in front of a tangent that connects the anterior borders of the supra- and infra-orbital margins in their mid-plane. However, if the orbital form was of the "closed type" (heavier rims with a long orbit) then the eye was more deeply set. If the orbital form was of the "open type", light rims with a short obit length and with a triangular appearance in profile, then the eyeball was more prominent/projecting.

Positioning of the eyeball within the coronal plane was grossly obtained by the position of the palpebral fissure, which ran in the direction from the middle of the lacrimal groove to the malar tubercle. The endocanthus was placed 2–3 mm lateral to the medial orbital wall, while the ectocanthion was placed 2.5 mm medial to the lateral orbital wall. If the supra-orbital margin was round, then the upper eyelid was thick. The sharper the supra-orbital margin, then the thinner the eyelid. Similar rules applied to the lower orbital rim/lid, where a sharp margin indicated a weak eyelid. The upper eyelid was constructed to cover (or overhang) the superior one-quarter of the iris in the frontal view. If the supraciliary ridges and adjacent bony relief was marked/massive with low set orbits, then a crease over the upper eyelid was represented. In young females, even if the eye was deep within the orbit (i.e., of the "closed type"), the upper eyelid and crease were always represented to be "full".

Specific positioning of the eyeball in the coronal plane was achieved by defining three skull types based on the angle formed between the Frankfurt Horizontal and a line passing through both the maxillofrontal and zygomaxillary sutures. If the angle was > 135 degrees (horizontal type) then "free room" was present between the eyeball and both sides of the orbit. If the angle was < 119 degrees (steep type) then free room was represented in the superior and medial corner of the orbit and between the eyeball and the infra-orbital wall. The distribution of the free room between the orbital walls and the eyeball was also thought to influence the configuration of the eyelids. Free room in the superior medial angle was linked to thin and deeply sunken eyelids. Free room in the lower outer part of the orbit was connected with a "baggy" appearance of the lower eyelid. Free room on both sides of the orbit pointed to an overhanging and folded upper eyelid.

Modeling the ear

The ear was first modeled separately to the head and then attached. The height of the ear was approximately equal to the distance between glabella and subnasale, which Gerasimov later revised to include the addition of two millimeters (Ullrich, Stephan 2011). The ear dimensions reflected the proportions of the face, i.e., if the face was long and narrow then so too were the ears. The width of the ear equaled half its height, plus 2–3 mm. The ear was inclined to the same angle as the general direction of the ramus of the mandible and it was placed, so that the external auditory meatus was positioned about 1/3rd of the way up the vertical height of the ear. A broad funnel-shaped external auditory meatus indicated a large ear. The occipital border of the mastoid process was taken to indicate the shape of postero-inferior edge of the ear, which followed the same relative line. A large supramastoid crest and outwardly directed mastoid processes indicated a protruding ear. A weak supramastoid crest and a deeply placed porion indicated a flat ear. If the opening of the external auditory meatus could be seen in the frontal view then the tragus was small and flat. If the opening of the external auditory meatus lay deep in the temporal bone and only its rim-edge was visible from the frontal view, then the tragus was represented to be large and projecting.

Modeling the hair and the eyebrows

In good quality specimens where the skull vault had been subject to little wear/erosion, smooth surfaces indicated places of hair absence, while weak pitting was taken to indicate places of hair presence. The hairline (across the forehead) was represented approximately two times the distance from supraglabella to metopion and was placed to start where any pitting was evident. The eyebrow was constructed so that its course corresponded to the shape of the superior edge of the orbit.

CONCLUDING COMMENTS

Vosstanovlenie lica po cerepu provides a detailed account of Gerasimov's methods, which should be consulted in preference to *The Face Finder* or other secondary sources. Herein we provide a brief synopsis of Gerasimov's methods in English in the hope that they inspire the redress of deeply entrenched, but clearly mistaken views.

Gerasimov's so-called "Russian" methods were inspired from German centric methods, which also heavily relied on facial soft tissue thicknesses (see e.g., His 1895, Kollmann, Büchly 1898, Merkel 1900, Welcker 1883), as acknowledged by Gerasimov in his texts. Consequently, Gerasimov's methods do not represent entirely novel firsthand inventions, nor are they categorically distinct from "American" methods that also drew heavily from German soft tissue depth approaches in similar fashion (see Stewart 1982; Stephan 2015). Furthermore, it should be acknowledged that Gerasimov was not the first to build the muscles of mastication in facial reconstruction – that accolade goes to morphologist Paul Richer of France who implemented that action at least 11 years prior to Gerasimov's first self-reported attempt at facial reconstruction (Gerasimov 1971, Gerassimow 1968, Special Cable to the New York Times 1913; Weber 1922, Shorto 2008 or for review Ullrich, Stephan 2011).

Gerasimov's prime contributions to face prediction were the introduction of numerous soft tissue prediction rules, a specialized modelling mastic, and the popularization of portrait reconstruction. Despite wide spread use of Gerasimov's face prediction guidelines in more contemporary methods, it should be recognized that many of these rules are not without weaknesses. A major one being their repeatability, which Gerasimov himself acknowledges as problematic (Gerasimov 1971, Gerassimow 1968). Many of Gerasimov's guidelines concern size of facial features, but his instructions provide little direction in regard to their magnitudes. The globe is said, for example, to be more deeply placed with orbits of the "closed type", but how deeply the eyeball should actually be placed goes unreported. Gerasimov also noted that the face would "evolve" during the reconstruction process since the practitioner needs to retouch some of the already constructed facial features to ensure conformance with the holistic appearance of the face. Thus, in working from the above mentioned procedures there is significant opportunity for wide divergence in interpretations of Gerasimov's implementation.

Several contemporary studies have suggested that some of Gerasimov's guidelines contain errors that could otherwise be minimized (see e.g., Guyomarc'h *et al.* 2013, Stephan 2002) and some prediction rules, such as the prediction of the hairline from pitting in the frontal bone, seem anatomically tenuous. Irrespectively, several of Gerasimov's other soft tissue prediction guidelines have been shown to perform more accurately than published alternatives (Gatliff 1984, Prag, Neave 1997, Taylor 2001, Wilkinson 2004). For example, by placing the globe 1–2 mm in front of a tangent connecting the infra and supra orbital margins, Gerasimov's method underestimates eyeball projection by 2 mm less than so-called "American" and "British" methods (Stephan 2002). By constructing the mouth as wide as the premolars, Gerasimov's prediction guideline also more accurately predicts mouth width than the underestimates provided by the contemporary guideline that uses the distance between the canines (Stephan, Henneberg 2003). From this basis, it is clear that Gerasimov's methods should be awarded higher esteem than other manual face prediction techniques, but they should be recognized for their warranted value, not pedestaled above the realities posed by face prediction from bare skull morphology.

REFERENCES

CONANT E., 2003: Man of 1,000 faces. *Archaeology Magazine* 56, 4: 48.

EGGELING H. V., 1913: Die Leistungsfahigkeit physiognomischer Rekonstruktionsversuche auf Grundlage des Schadels. *Archiv für Anthropologie* 12: 44–47.

GATLIFF B. P., 1984: Facial sculpture on the skull for identification. *The American Journal of Forensic Medicine and Pathology* 5, 4: 327–332.

GERASIMOV M. M., 1949: *Osnovy vostanovleniia litsa po cherepo,* Izdat. Akademii Nauk SSSR, Moskva.

GERASIMOV M. M., 1955: *Vosstanovlenie lica po cerepu,* Izdat. Akademii Nauk SSSR, Moskva.

GERASIMOV M. M., 1971: *The face finder; translated from the German by Alan Houghton Brodrick*. Hutchinson & Co., London.

GERASSIMOW M. M., 1968: *Ich suchte Gesichter*. C. Bertelsmann Verlag, Gutersloh.

GIBSON L., 2008: *Forensic art essentials*. Elsevier, Burlington.

GUYOMARC'H P., SANTOS F., DUTAILLY B., COQUEUGNIOT H., 2013: Facial soft tissue depths in French adults: variability, specificity and estimation. *Forensic Science International* 231, 1–3: 411.e1–411.e10.

HIS W., 1895: Anatomische Forschungen über Johann Sebastian Bach's Gebeine und Antlitz nebst Bemerkungen über dessen Bilder. *Abhandlungen der mathematisch-physikalischen Klasse der Königlichen Sachsischen Gesellschaft der Wissenschaften* 22: 379–420.

İŞCAN M. Y., STEYN M., 2013: *The human skeleton in forensic medicine*. Charles C Thomas, Springfield.

KOLLMANN J., BÜCHLY W., 1898: Die Persistenz der Rassen und die Reconstruction der Physiognomie prahistorischer Schädel. *Archiv für Anthropologie* 25: 329–359.

MERKEL F., 1900: Reconstruction der büste eines Bewohners des Leinegaues. *Archiv für Anthropologie* 26: 449–457.

NATURE EDITORIAL, 1970: Dr M. M. Gerasimov. *Nature* 228, 5266: 98–98.

PRAG J. NEAVE R., 1997: *Making faces: using forensic and archaeological evidence*. British Museum Press, London.

RYNN C., WILKINSON C. M., 2006: Appraisal of traditional and recently proposed relationships between the hard and soft dimensions of the nose in profile. *American Journal of Physical Anthropology* 130: 364–373.

SHORTO R., 2008: *Descartes' bones: a skeletal history of the conflict between faith and reason*. Doubleday, New York.

SPECIAL CABLE TO THE NEW YORK TIMES, 1913: Sketch identifies skull of Descartes. *The New York Times* January 26: C4.

STARBUCK J. M., WARD R. E., 2007: The affect of tissue depth variation on craniofacial reconstructions. *Forensic Science International* 172, 2–3: 130–136.

STEPHAN C. N., 2002: Facial approximation: falsification of globe projection guideline by exophthalmometry literature. *Journal of Forensic Sciences* 47, 4: 1–6.

STEPHAN C. N., 2006: Beyond the sphere of the English facial approximation literature: ramifications of German papers on Western method concepts. *Journal of Forensic Sciences* 51, 4: 736–739.

STEPHAN C. N., 2009: Craniofacial identification: techniques of facial approximation and craniofacial superimposition. In: S. Blau, D. H. Ubelaker (Eds.): *Handbook of forensic anthropology and archaeology.* Pp. 304–321. Left Coast Press, Walnut Creek.

STEPHAN C. N., 2015: Facial approximation – from facial reconstruction synonym to face prediction paradigm. *Journal of Forensic Sciences* 60, 3: 166–571.

STEPHAN C. N., HENNEBERG M., 2001: Building faces from dry skulls: are they recognized above chance rates? *Journal of Forensic Sciences* 46, 3: 432–440.

STEPHAN C. N., HENNEBERG M., 2003: Predicting mouth width from inter-canine width – a 75% rule. *Journal of Forensic Sciences* 48, 4: 725–727.

STEPHAN C. N., HENNEBERG M., SAMPSON W., 2003: Predicting nose projection and pronasale position in facial approximation: a test of published methods and proposal of new guidelines. *American Journal of Physical Anthropology* 122: 240–250.

STEWART T. D., 1982: Pioneer contributions of Harris Hawthorne Wilder, Ph.D., to forensic sciences. *Journal of Forensic Sciences* 27, 4: 754–762.

TAYLOR K. T., 2001: *Forensic art and illustration*. CRC Press, Boca Raton.
TSHERNEZKY W., 1975: *The reconstruction of face on the base of structure of skull: Translation with some shortages by W. Tshernezky.* Unpublished manuscript.
ULLRICH H., 1958: Die methodischen Grundlagen des plastischen Rekonstruktionsverfahrens nach Gerasimov. *Zeitschrift fur Morphologie und Anthropologie* 49, 2: 245–258.
ULLRICH H., 1966: Kritische Bemerkungen zur plastischen Rekonstruktionsmethode nach Gerasimov auf Grund personlicher Erfahrugen. *Ethnographisch-archäologische Zeitschrift* 7: 111–123.
ULLRICH H., 1967: Plastische Gesichtsrekonstructionen urgeschichtlicher Menschen nach der Methode von Gerasimov. *Neue Museumskunde.* VEB Deutsche Verlag der Wisenschaften, Kothen.
ULLRICH H., STEPHAN C. N., 2011: On Gerasimov's plastic facial reconstruction technique: new insights to facilitate repeatability. *Journal of Forensic Sciences* 56, 2: 470–474.
VANDERMEULEN D., CLAES P., DE GREEF S., WILLEMS G., CLEMENT J., SUETENS P., 2012: Automated facial reconstruction. In: C. M. Wilkinson, C. Rynn (Eds.): *Craniofacial identification.* Pp. 203–221. Cambridge University Press, Cambridge.
VERMEULEN L., 2012: Manual forensic facial reconstruction. In: C. M. Wilkinson, C. Rynn (Eds.): *Craniofacial identification.* Pp. 184–192. Cambridge University Press, Cambridge.
WEBER F. F., 1922: First face rebuilding. *The New York Times* May 9: 15.
WELCKER H., 1883: *Schiller's Schädel und Todtenmaske, nebst Mittheilungen über Schädel und Todtenmaske kant's*. Viehweg F and Son, Braunschweig.
WILKINSON C., 2004: *Forensic facial reconstruction*. Cambridge University Press, Cambridge.

Herbert Ullrich
Medizinhistorisches Museum der Charité,
Humboldt-Universität zu Berlin,
Charitéplatz 1,
D-10117 Berlin
Germany
E-mail: herbert.ullrich@freenet.de

Carl N. Stephan
Laboratory for Human Craniofacial and Skeletal Identification,
School of Biomedical Sciences,
The University of Queensland,
Brisbane
Australia 4072
E-mail: c.stephan@uq.edu.au