FACES IN THE MIRROR: APPLYING GEOMETRIC MORPHOMETRICS TO 18TH CENTURY PORTRAITS DEPICTING THE SAME SITTER

ALEXEY ZOTOV AND SUSAN HAYES

ABSTRACT | This research constitutes an experimental case study to see if geometric morphometrics (statistical shape analysis) can help elucidate authenticity, likeness and artistic style in historical portraits depicting the same sitter. Specifically, we take this approach to identify which of a highly diverse range of original and derivative 18th century portraits depicting the Russian military commander, Generalissimo Alexander Vasilyevich Suvorov, show greater agreement with both the iconographic studies undertaken by 19th and 20th century Russian art historians, and the relatively reliable fluctuating asymmetries evident in Suvorov's death mask. Our findings are that geometric morphometrics is able to identify the extent to which the depictions of the facial features vary, with the results indicating that the derivative works have tended to alter Suvorov's head pose, there are inconsistencies in the representation of 2D perspective due to a strict adherence to artistic conventions of the period, and that some of the portraits considered derivative are more likely to be primary. Furthermore, an original oil painting by the Austrian Imperial Royal Court painter, Josef Kreutzinger (1757-1829), which was rapidly reproduced and widely dispersed across Western Europe and North America, has evidence of presenting the famously mirror-averse Suvorov in mirror-reverse. We have found, therefore, that geometric morphometrics may have a deep, as well as broad, applicability to the direct concerns of art historians.

Introduction

An ongoing issue within art history is the notion of establishing 'authenticity' in pre-photographic portrait depictions of historical figures.[1] Traditionally, this has been dependent on iconography: painstaking research identifying which portraits of a sitter have evidence of a life sitting, and are therefore primary, not derivative, works. How successful these portraits were in capturing a sitter's likeness, and the role of artistic convention in producing this likeness, is less clearly achievable through this approach. Instead, a portrait's authenticity is inferred from the evidence of likeness assessments by the sitter, their lifetime contemporaries, and the informed opinions of the iconographers themselves. When a death mask is available, iconographic studies can include visual comparisons of the mask to the portrait depictions.

However, even with photographic portrait likenesses such visual assessments can be highly error-prone,[2] and a death mask is not synonymous with a person's face in life.[3]

With this in mind, our study applies geometric morphometrics, a statistical method of biological shape analysis that has previously analyzed likeness in contemporary portraits,[4,5,6] to a diverse collection of 18th century portraits depicting Generalissimo Alexander Vasilyevich Suvorov (1730[?]-1800). Our main aims are to see if this approach can: (i) complement the iconographic studies undertaken by Russian art historians, (ii) identify the extent to which the portraits—both original and derivative—include both the historical evidence of Suvorov's likeness and the more reliable facial characteristics evident in Suvorov's death mask, and, (iii) suggest which stylistic conventions of the period likely shaped the artists' depictions of Suvorov's facial features.

Historical and iconographic context

A contemporary of Horatio Nelson (1758-1805) and George Washington (1732-1799), Alexander Suvorov was a military commander in the service of Catherine the Great and her son, Paul I. Unusually for his time, Suvorov prioritized the welfare of the troops over the officers under his command. Still one of Russia's most popular national heroes[8] and often compared to the younger Napoleon Bonaparte (1769-1821), Suvorov's reversal of gains made during the French Revolutionary Wars in Europe led to his international prominence, and, as with Suvorov's military contemporaries, derivative portraits abound. Suvorov was, however, a reluctant sitter, and furthermore, so averse to his own appearance that all mirrors were required to be covered or removed from his presence.[9] At the height of his military career, therefore, the demand for an image of Suvorov would have been well in excess of supply.[10]

Although most of the lifetime depictions of Suvorov were only produced within the five-year period 1795-1800, their diversity left the 19th century art historians, Stremoukhov and Simanski, at a loss to understand how each could claim to portray the same face.[11] Stremoukhov and Simanski's iconography involved categorizing Suvorov's portraits by their similarity to the works of three artists with the strongest evidence of having attained a life sitting:[12]

- Bechon type: multiple miniatures by the French-Polish miniaturist, Karol (Charles) Bechon (Warsaw, 1795);
- Kreutzinger type: three or more portraits by the Austrian Imperial Royal Court painter and engraver, Josef Kreutzinger (Vienna, 1799);
- Schmidt type: a portrait undertaken shortly before Suvorov's death by the German portrait artist and pastelist, Johann Heinrich Schmidt (Prague, 1800), thought lost for ff100 years until discovered in Russia in 1898.[13]

In 1963, the art historian Pomarnatsky largely followed this approach, but included the following:

- Astrakhan type: Unknown artist (Astrakhan, c. 1775-1785), thought to be the youngest depiction of Suvorov as an adult (44-53 years).[14]

Portraits under analysis

Our search of online collections resulted in 16 high-resolution digital images of portraits undertaken during Suvorov's lifetime. These are listed in Table 1, together with the iconographies of Stremoukhov and Simanski,

and Pomarnatsky, supplemented by the iconographic and historiographic works of Rovinsky,[15] Voensky et al.,[16] Lopatin,[17] and Zamostyanov[18] (for image sources and current provenance, refer Supplementary Materials Table SM1). Of the 16 works, 13 are reproduced in Figure 1 and the remaining represented by digital tracings. While there are degrees of difference, it can be seen that all but Schmidt portray Suvorov facing in the same direction. A further commonality is that most of the artists were Western European, and that during this historical period the practice of portraiture within the St Petersburg Imperial Academy was also dominated by the Western European style.[19]

Evidence of likeness

Lifetime descriptions include Suvorov himself, who, while claiming to have been attractive in his youth,[53] did not consider his appearance to be appropriately heroic.[54] The Russian Academician Thibault described Suvorov in his early 40s as diminutive, robust, and lean.[55] Ivan Sergeyev, who served with Suvorov, notes that his hair turned gray at a relatively young age,[56] and, together with other contemporaries, recalls Suvorov's forehead as deeply, and expressively, lined.[57] Similarly, Denis Davydov, who was presented to Suvorov in c.1793, described Suvorov's face as wrinkled and lean, adding that Suvorov's eyebrows were typically raised above slightly drooping eyelids.[58] Peter Bagration, who attended to Suvorov shortly before his death, thought Suvorov's eyes large and kindly.[59] The British academic W. Lyon Blease describes Suvorov as "short, thin, and ugly"[60] and includes a translation of Gabrielle Guilloche-Dubokage's account of Suvorov in his late 50s: "[h]e was not tall, he had a big mouth, his face was not altogether pleasant; but his glance was fiery, quick and unusually penetrating."[61] Guilloche-Dubokage's description likely indicates Suvorov's mouth was wide. The derogatory association of being—as opposed to having—a 'big mouth' only emerged in 1889, and in North America.[62]

Historical records also include likeness assessments of some portraits. At the time of its completion, Colonel de Pieri told Suvorov he thought the Astrakhan portrait most resembled a mutual acquaintance,[63] while Count Rostopchin, who served under Suvorov, considered Walker's 1799 mezzotint to be accurate.[64] Davydov preferred a reproduction of one of the lifetime portraits by Kreutzinger,[65] however—given a lifetime copper engraving of one of Kreutzinger's portraits by the Hungarian printmaker, Johann Josef Neidl,[66] was rapidly reinterpreted 37 times following its initial appearance in 1799[67]—it is not clear which reproduction this was. Portraits with an inferred likeness include the work by an unknown artist from the collection of Stepan Apraksin, a military associate and admirer of Suvorov known to prioritize likeness in portraits over artistic merit;[68] a Bechon miniature that Suvorov gifted to Monsieur Grimm, now lost, but was the

Figure 1. Facial diversity in the 16 lifetime portraits of Suvorov under analysis. The images are ordered by iconographic type (refer Table 1) and labeled by the attributed artist, where known; *primary type; ^evidence of likeness assessment from Suvorov's contemporaries. The images are adapted (cropped, resized, greyscale) from: (a) Voensky et al.,[20] (b) Rovinsky,[21] and (c) Stremoukhov and Simanski.[22] The digital tracings representing the Astrakhan 2, Bechon and Levitsky portraits were created for this publication.

Note: All images sourced from (a) – (c) are in the Public Domain —published in Russia before 1917 (Article 1256, Book IV Civil Code of the Russian Federation No. 230-FZ, 2006); published anywhere in the world before 1909 (1909 Copyright Act)

Image/Year	Medium	Artist	Iconographic & Historiographic References	Iconographic type
Astrakhan1 ^ 1775-1785	Oil on canvas	Unknown Astrakhan painter	Voensky et al: 1775-1785, from an original portrait belonging to Count I. I. Vorontsov-Dashkov; considered the most reliable[23]	**Astrakhan primary type**
Astrakhan2 1775-1785	Oil on canvas	Unknown	Pomarnatsky: 1774-1783, of low quality, resembles a neat German doctor[24] Lopatin: Astrahkan icon painter, 1780; Suvorov was told it resembles a common acquaintance[25] Zamostyanov: Unknown artist, a copy of the "Astrakhan portrait" from 1780[26]	Astrakhan
Bechon 1795	Miniature - watercolor gouache	Karol (Charles) Bechon (1732-1812) French-Polish miniaturist	Stremoukhov and Simanski: Suvorov spent all of 1795 in Warsaw, and a longitudinal groove between the eyes is characteristic of all portraits from life[27] Pomarnatsky: Bechon's miniatures have iconographic authenticity because they match descriptions from contemporaries of Suvorov (wrinkled face, arched, raised eyebrows, heavy eyelids)[28] Lopatin: Bechon kept an art school in Warsaw[29]	**Bechon primary type**
Schröder 1795	Mezzotint	Johann Heinrich Schröder (1757-1812) German portrait artist	Rovinsky, Stremoukhov and Simanski, Pomarnatsky: based on the Bechon miniature Suvorov presented to M. Grimm in 1795[30]	Bechon
Lasinio 1795	Engraving	Carlo Lasinio (1759-1838) Italian engraver	Stremoukhov and Simanski: a Bechon type with very few changes[31]	Bechon
Apraksin ^ 1786	Oil on canvas	Unknown	Voensky et al.: Unknown artist, 1786, after an original portrait from the collection of Stepan Apraksin, a contemporary of Suvorov known to prioritize likeness over artistic merit; similar to Schröder's engraving of a Bechon miniature[32] Pomarnatsky: Unknown artist, end of 18th century, derived from the Astrakhan portrait[33]	Bechon or Astrakhan
Levitsky 1786	Oil on canvas	Dmitry Levitsky (1735-1822) Russian portrait artist, St Petersburg	Pomarnatsky: Unknown artist, end of the 18th century. Typically attributed to Levitsky, but perhaps the work of a student of Levitsky (twice restored), and a variation of the Bechon-Walker types from 1795-1797[34] Zamostyanov: Levitsky, 1786, possibly from memory, and has many imitations[35]	Bechon
Obolensky 1796	Oil on canvas	Unknown	Stremoukhov and Simanski: a copy from the Prince V. Obolensky collection, belonging to descendants of Suvorov's daughter, considered the basis for Walker 1 (see below) engraving on basis of similar nose; cannot judge if this is an original or a copy[36]	Bechon
Walker1 1797	Mezzotint	James Walker (c. 1760-1823) British; Russian Imperial Engraver	Stremoukhov and Simanski: turn of head similar to Bechon, much in common with facial features, in particular the eyes; mouth and chin very different and constitute a grimace[37] Pomarnatsky: Engraving of a (since lost) portrait by the English artist, John Augustus Atkinson, 1796[38]	Bechon

Image/Year	Medium	Artist	Iconographic & Historiographic References	Iconographic type
Walker2 ^ 1799	Mezzotint	As above	Stremoukhov and Simanski: from a portrait by John Augustus Atkinson. Contemporary of Suvorov considered it a good likeness. Similar to Walker1 in head pose, but mouth and nose different, and the similarity to Bechon's portrait is unquestionable. Compared to Schmidt's portrait the mouth is too small[39]	Bechon
Kreutzinger1 1799	Oil on canvas	Josef Kreutzinger (1757-1829) Austrian Imperial court painter and engraver	Pomarnatsky: One of three portraits from Vienna while Suvorov was based there, the first being lost[40] Stremoukhov and Simanski: It is unknown if painted from life[41] Voensky et al: the original portrait disappeared but Kreutzinger painted another one from an original sketch[42] Zamostyanov: contemporaries thought it too European, but Denis Davydov, who met Suvorov when a child, preferred a reproduction of a Kreutzinger portrait[43]	**Kreutzinger primary type**
Kreutzinger2 1799 or 1800	Oil on canvas or reproduction	As above	Pomarnatsky: Oil on canvas by Kreutzinger, 1799[44] Voensky et al.: 1800 reproduction of an original portrait by Kreutzinger from 1799, and undoubtedly the prototype for Kreutzinger 1[45]	Kreutzinger
deMaistre ^ 1799	Miniature -Watercolor and gauche	Xavier de Maistre (1763-1852) French artist, writer and military officer; served with Suvorov	Voensky et al.: after a miniature by Count Xavier de Maistre belonging to the Grand Duke Nicolay Mikhailovitch, and chosen for publication by Glinka for a book dedicated to Count Miloradovich; resembles Kreutzinger's portrait[46] Pomarnatsky and Lopatin: miniature by de Maistre[47]	Kreutzinger
Neidl ^ 1799	Copper engraving	Johann Josef Neidl (1776-1832) Hungarian printmaker	Rovinsky: based on Kreutzinger's portraits, there are 37 iterations of this engraving[48] Stremoukhovand Simanski: the most common image of Suvorov outside of Russia; Teutonic in appearance and not a successful portrait[49]	Kreutzinger
Berger 1800	Line and stipple engraving	Daniel Berger (1744-1824) German engraver	Stremoukhov and Simanski: with the French painter and aquatint engraver, Philibert-Louis Debucourt (1755-1832); a Kreutzinger type, a senseless lower lip that is prominent and sagged[50]	Kreutzinger
Schmidt 1800	Pastel on pergament	Johann Heinrich Schmidt (1749-1829) German portrait artist	Stremoukhov and Simanski: undertaken in Prague and lost for nearly 100 years until found in Russia and purchased by Tsar Nicolay II in 1898; the best portrait of Suvorov in his declining years [51] Pomarnatsky: the last lifetime portrait of Suvorov, including asymmetrical folds at the mouth and a slightly protruding lower lip[52]	**Schmidt primary type**

Table 1: Portraits analyzed. The portraits are organized by iconographic type (and refer Figure 1); ^portraits with an associated likeness assessment.
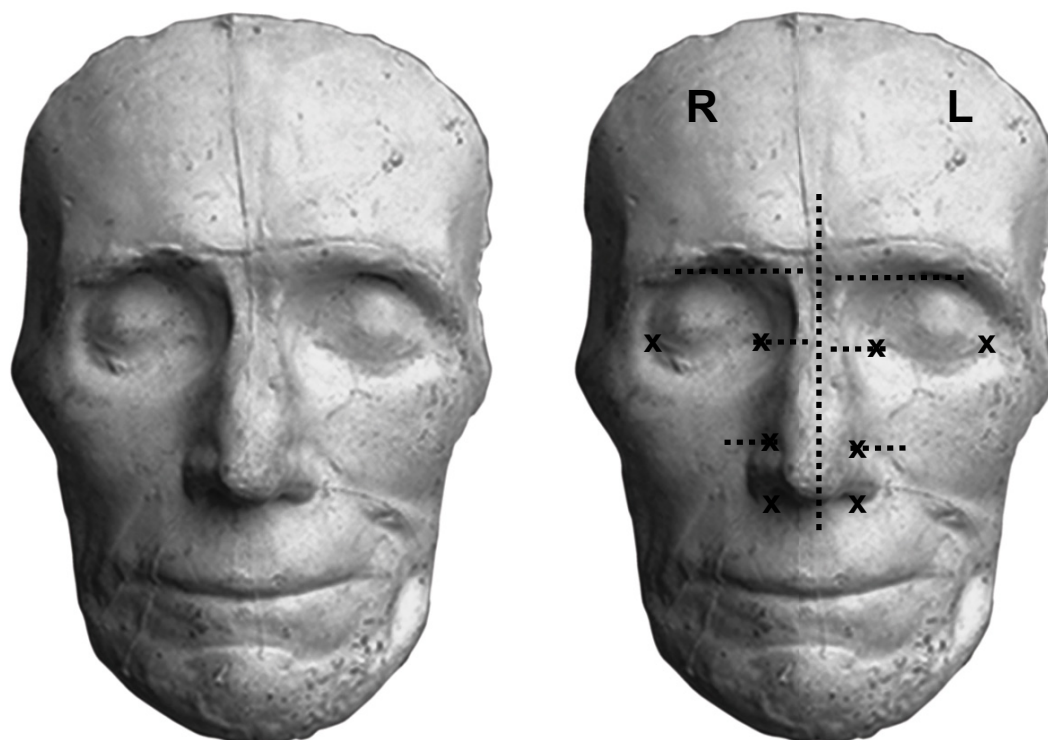
Figure 2. Death mask indications of fluctuating asymmetry. Original photograph supplied by AZ (Canon EOS 600D, f/7.1, ISO-3200, focal length 55mm, focal point nasal bridge). The image has been resized to 300dpi and the shading equalized in a graphics program; the image on the right, which illustrates the possible presence of bilateral asymmetry in the eyes and nose, is at 84% transparency.

basis for a mezzotint by the German portrait artist, Johann Heinrich Schröder;[69] and a miniature by the French artist and military officer Count Xavier de Maistre, who served at Suvorov's Headquarters in 1799, and which illustrates a book dedicated to Count Miloradovich, who also served with Suvorov.[70]

Although a useful historical reference, a death mask is not synonymous with a living face.[71] Suvorov died from a protracted illness[72] and the mask was very likely taken from his supine body. Even in life there are changes to the face from standing and sitting to lying down, with the statistically significant impacts being a raising and widening of the outer eye corners, upper cheeks, nose wings, mouth corners and outer jaw—though the inner eye corners are relatively unaffected.[73] These shifts in feature locations, together with artifacts arising from procuring the mask, such as smoothing out facial lines,[74] are all variables that can, and will, confound a death mask to portrait comparison. Allowing for the foregoing, the human face also typically includes intrinsic, and idiosyncratic, fluctuating asymmetries in the size and orientation of the paired features.[75] Suvorov's death mask suggests, as illustrated in Figure 2, a left eye located lower on the face, and a shorter left nasal wing (left and right being that of the death mask). The death mask also indicates the nasal bridge has a marked vertical depression, and, according

to Stremoukhov and Simanski, all of the portraits that have evidence of a life sitting depict a correspondingly deep vertical fold.[76]

Materials and Methods

Hereinafter the portraits are referred to by either the artist, or the location/collection where the artist is unknown (refer Table 1). Facial feature orientations (left/right) are those of the depicted face, which is the inverse of the picture frame.

The 16 images from online collections were uploaded into a graphics program. The Schmidt portrait was mirror-reversed to have a right head turn, and all images were rotated to the horizontal and vertical orientation of the picture border or frame. Each was then further rotated so that a line connecting the outer eye corners (exocanthia) was horizontal. The degree of rotation required to achieve this was recorded as a proxy for head cant, which is the tilting of the head towards one shoulder. The portraits were then cropped to the head and shoulders and uploaded to the landmark digitization software, *tps*Dig32.[77] The landmarks were manually applied for greater precision and, as illustrated in Figure 3, comprised 84 landmark coordinates:
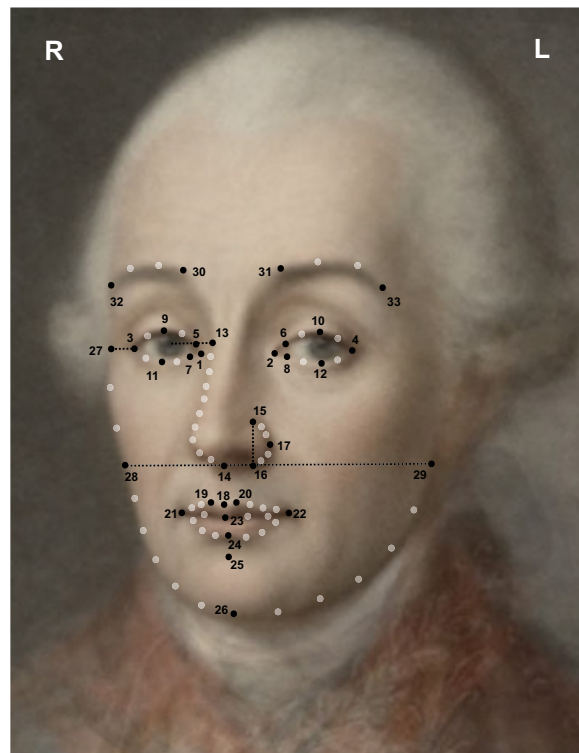
Figure 3. The homologous landmarks (black dots) and equidistant points (gray dots) applied to the portraits. The dashed lines indicate where a landmark was identified horizontally out from another landmark. Refer to Supplementary Materials Table SM2 for the landmark definitions. The image is a geometric morphometric average of the 16 lifetime portraits depicting Suvorov, with the forehead and hair averaged separately and excluding Berger's depiction of a helmet.

33 homologous and 51 equidistant. The location of the right inner eye corner (endocanthion) is obscured in the Kretuzinger1 and de Maistre portraits, and so was estimated from the curve of the upper and lower eyelids.

For illustrative purposes, statistical averages of the portraits were achieved using *tps*Super32,[78] which outputs the average image with greater emphasis (darker) where the pixel intensities show stronger agreement. There are, however, known artifacts associated with the process. Averaging photographs produces faces that are assessed as both younger and more attractive than the images that comprise it, due to a smoothing effect on the facial textures, and this effect increases with the number of images averaged.[79] Figures 3 and 5, for example, are the average of the 16 portraits analyzed in this study (excluding Berger's depiction of a helmet) and appear to show a much younger, and likely more attractive, Suvorov.

The 84 landmark coordinates for each portrait were entered into the geometric morphometric software *morphologika*2.5[80] and Procrustes registered (scaled, rotated, translated). Procrustes registration results in the coordinate data being unitless, and enables the analyses to occur independently of differences in overall size, including physical dimensions and image resolution, and

the orientation of the face within the digital image. Figure 4 illustrates this process (top left), together with, for each portrait, the locations of the Procrustes registered landmarks connected to form a wireframe.

Following Procrustes registration, a Principal Component Analysis (PCA) was undertaken in *morphologika*2.5, with the statistical output including dynamic wireframes to illustrate the shape variance at selected points along the Principal Component (PC) axes. A multivariate regression with one independent variable was also undertaken with the PCs capturing $\geq 95\%$ of the overall variance, to identify the extent to which the iconographic types agree with the death mask morphology. The results are deformation grids that illustrate the shape variance related to the regression, which can be exaggerated to enhance the visualization of the results, with the statistical significance of the variance calculated using Wilks' Lambda and Goodall's F-test. A Goodall's F-test involving groups requires the number of images in the dataset to be approximately twice the number of landmarks.[81] Here, the groups are the iconographic types, numerically coded (1-4) by the year the primary type was produced: Astrakhan (ff 1780), Bechon (1795), Kreutzinger (1799), Schmidt (1800), and the distinctive death mask asymmetry is captured by seven landmarks (Figure 3 landmarks 1-4 and 14-16).
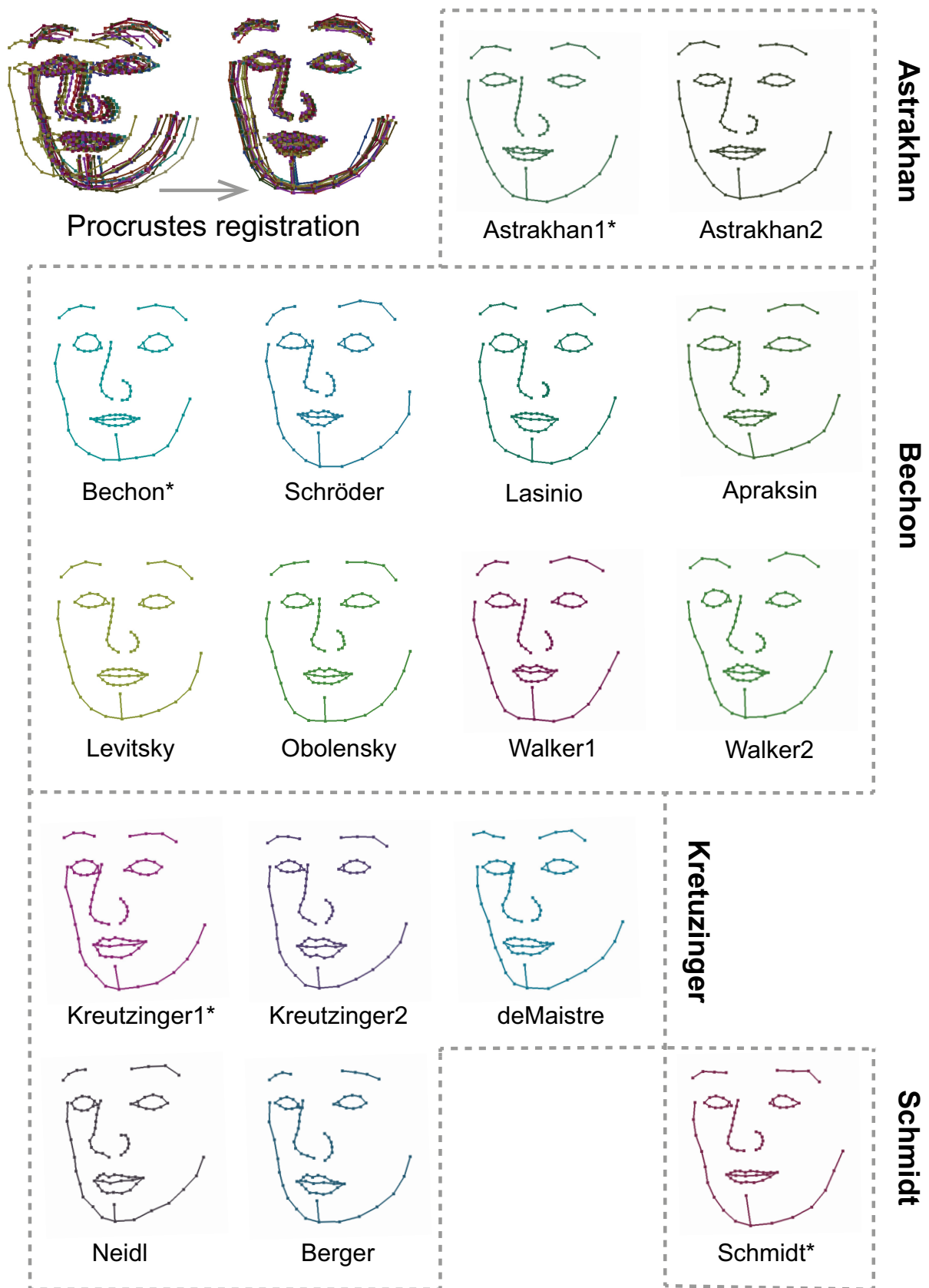
Astrakhan

Procrustes registration

Astrakhan1*   Astrakhan2

Bechon

Bechon*   Schröder   Lasinio   Apraksin

Levitsky   Obolensky   Walker1   Walker2

Kretuzinger

Kreutzinger1*   Kreutzinger2   deMaistre

Neidl   Berger

Schmidt

Schmidt*

Figure 4. Procrustes registration of the landmark coordinates. The primary types are indicated by an asterisk.
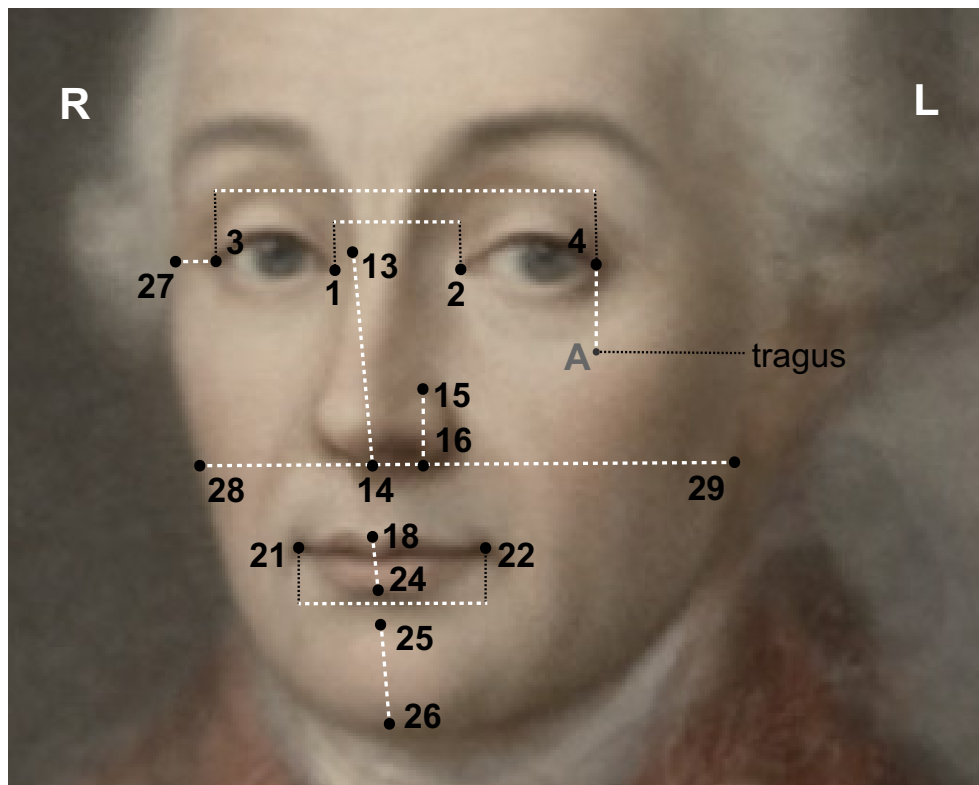
Figure 5. Inter-Landmark Distances (ILDs) and estimations of Head Pose (turn and pitch). Eyes: inner eye spacing (landmarks 1-2), outer eye spacing (3-4); Nose: nose length (13-14), nose wing height (15-16); Mouth: nose-mouth distance (14-18) mouth width (21-22), height of the lips (18-24); Turn: cheek widths (14-28/14-29) and outer face width (3-27); Pitch: Point A-4 (in pixels) and chin height (25-26). Refer to Supplementary Materials Table SM2 for the landmark definitions.

In order to identify specific feature measures, a set of variables covering 11 inter-landmark distances (ILDs) were selected. The distances were calculated in a spreadsheet from the Procrustes registered x, y landmark coordinate data using Pythagoras theorem: distance xy_1 to $xy_2 = \sqrt{[(x_1-x_2)^2 + (y_1-y_2)^2]}$. As is illustrated in Figure 5, the extent of head turn (left/right) is estimated as a proportion of the cheek widths. However, no ILD, individually or in combination, was found to effectively identify head pitch (up/down). Head pitch was, therefore, estimated in a graphics program as the vertical distance in pixels between the center of the notch of the left ear (tragus) and the left exocanthion (Point A, Figure 5), with the mid-tragus estimated for Schröder, Lasinio, Kretuzinger1, Neidl, Berger and Schmidt. As mentioned earlier, head cant was derived from the angulation of the exocanthia prior to Procrustes registration.

To identify the extent to which these measures are related to the main shape variance, the ILDs, head pose variables and PC scores accounting for $\geq$ 95% of the overall variance were entered into the statistical software, PAST 4.01,[82] and Pearson's parametric correlation coefficient (r) applied. The values of each variable for individual portraits are in Supplementary Materials Table SM3.

Results

The first four Principal Components (PCs) account for 76% of the portrait's overall shape variance (PC1: 46%, PC2: 14%, PC3: 10%, PC4: 6%). PCs 1-3 attain statistical significance for the head pose and facial feature variables (see Table 2), and most of these are concentrated in PC1 (Supplementary Materials Table SM4 lists the full set of PC1-10 scores and variance).

Figure 6 plots the variance arising from PC1-2. As can be seen, the Astrakhan types, and more so, the Kreutzinger types, form distinct clusters, while the Bechon types are more widespread. Of the latter, the Apraksin portrait is more closely associated with the Astrakhan types. Of the Bechon types, three form a cluster: Levitsky, Walker2, and Obolensky.

The PC1 wireframes and PC correlation coefficients (see Table 2) indicate that the variance within PC1 is primarily head turn and pitch. The wireframe deformations, however, indicate inconsistencies in how these have been depicted. Both PC1 wireframes show that, on average, the portraits depict the outer edge of Suvorov's nose wing on the same vertical plane as the left inner eye corner. Although nose width has been found to increase, on average, by 5% with a supine body position,[83]

	Variable	PC1	PC2	PC3	PC4
H **e** **a** **d** **p** **o** **s** **e**	**Cant**	-0.47	0.11	-0.50*	0.12
	Turn (R/L cheek width)	0.88***	-0.25	-0.33	0.03
	R cheek width	0.92***	0.00	-0.24	0.05
	L cheek width	-0.63**	0.66**	0.38	0.03
	Outer face width	0.87***	0.09	-0.04	0.00
	Pitch (Point A)	0.52*	0.28	-0.50*	0.11
	Chin height	0.57*	0.49	0.19	-0.31
E **y** **e** **s**	Inner eye spacing	0.24	0.01	0.03	0.47
	Outer eye spacing	0.66**	0.01	0.50*	0.29
N **o** **s** **e**	Nose length	-0.62*	0.01	0.22	0.10
	Nose wing height	-0.67**	-0.47	-0.23	-0.02
M **o** **u** **t** **h**	Nose-mouth distance	-0.28	0.22	-0.58*	0.04
	Mouth width	-0.26	0.40	0.05	0.47
	Height of the lips	-0.52*	-0.51*	0.01	-0.08

*p < 0.05; **p < 0.01; ***p < 0.001*

Table 2. Relationship (Pearson's r) of head pose and feature variables to PC1-4. The statistically significant relationships are shaded.

the death mask (refer Figure 2) suggests Suvorov's face in life may have included endocanthia located within the breadth of the nose wings. However, regardless of a sitter's eye spacing and nose width, the impact of 2D perspective is to shift the edge of the nose wing away from the inner eye corner as the head turns, and this should present as a shape attribute of the more turned portraits. As can be seen in Figure 7, only Bechon, Schröder, Lasinio, Kreutzinger2 and Schmidt are compliant with this perspective for head turn.

The impact of 2D perspective on a downwards head pitch includes an increase in the appearance of the length of the nose and the nose wing. As is evident in Figures 6 and 7, a disproportionately much longer nose wing, compared to a relatively minimal increase in nose length, is a dominant characteristic of the Kreutzinger types. PC1-2 are also significant for lip fullness, which, with the exception of de Maistre, is also a feature of Kreutzinger types.

The PC2 wireframes indicate variance in the depiction of Suvorov's facial breadth between wide and narrow occurs relatively independently of the extent of head turn. Bechon and Lasinio, both Bechon types, have high negative PC2 scores (Figure 6), which indicates a distinctive depiction of Suvorov with a narrow face, large round eyes, full lower lip, and relatively short chin height. This pattern is reversed in the Schmidt portrait, and to a lesser extent in Schröder and Apraksin (Bechon types), and the two Astrakhan portraits. The clustering pattern of PC2, and the similarity in the

depiction of the eye corners in relation to head turn perspective (refer Figure 7), indicates Lasinio is very likely derived from, and closely adheres to, a Bechon miniature, but has a greater degree of head turn than the Bechon analyzed here. Schröder has also depicted Suvorov with a greater degree of head turn, however the distance of this work from the Bechon miniature along the PC2 axis suggests Schröder has deviated from the original more than Lasinio.

Figure 8 plots the variance contained within PC3 and PC4, and only relatively subtle patterns of difference remain between the portraits. PC3 has a low, but significant, statistical correspondence with the depiction of head cant and the shape variance in estimated head pitch that was not captured by PC1. While PC4 is not statistically significant for any of the variables (Table 2), this component locates the Apraksin portrait closer to Astrakhan2 than the primary type, Astrakhan1. The relationship of head cant to the estimation of head pitch is illustrated in Figure 9. Most of the portraits have depicted Suvorov with a head cant to the left, including the mirror-reversed Schmidt portrait. The exceptions are Schröder, which is close to upright, and four of the Kreutzinger types, which depict Suvorov with a head cant to the right. The miniature by de Maistre depicts Suvorov with a strong left head cant, but this work is not downwardly pitched.

When a head is canted towards or away from the artist/ viewer, 2D perspective will foreshorten and lengthen the facial
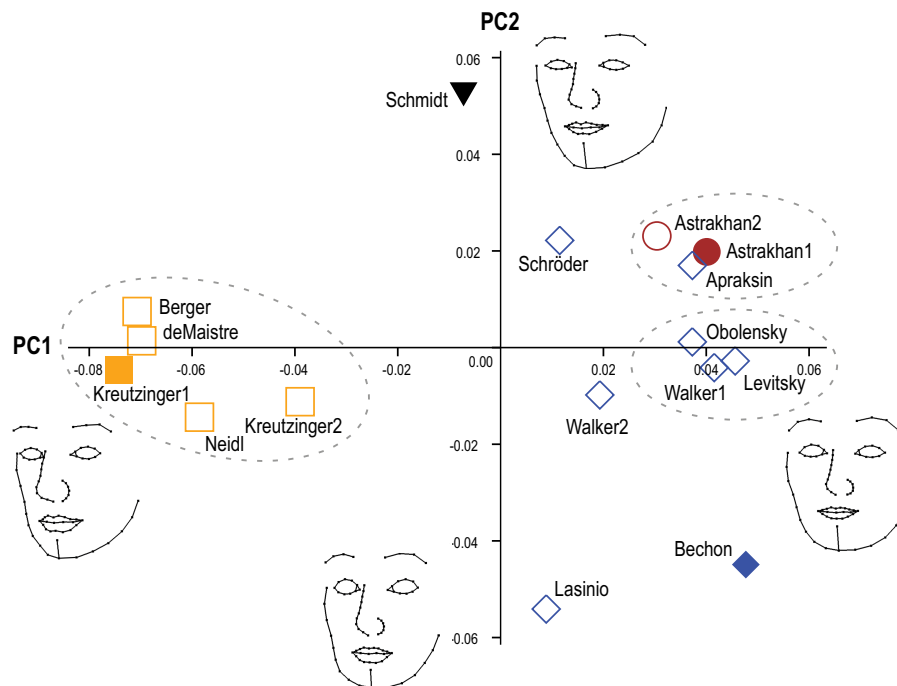
Figure 6. PC1 and PC2 (60% variance). The iconographic types are coded as follows: circles = Astrakhan type, diamonds = Bechon type, squares = Kreutzinger type; inverted triangle = Schmidt. The primary types are filled shapes. The ellipses indicate meaningful clusters by type. The wireframes are extracted from PC1 (x axis) -0.08 & +0.05 and PC2 (y axis) -0.05 & +0.06.

features in a similar way to head pitch. This has, therefore, contributed to de Maistre clustering closely with the strongly turned, downwardly pitched Kreutzinger types in the shape variance of PC1-2 (refer Figure 6). In PC3, this close clustering no longer occurs. Instead, the de Maistre miniature attains a very similar PC3 score as Walker2 and Apraksin.

PC3 is inversely correlated with head pitch (refer Table 2), and Levitsky, estimated to be the most upwardly pitched of the portraits (refer Figure 9), is located at the maximum value of the PC3 negative scores (refer Figure 8). The Obolensky portrait has a nearly identical PC3 score as Levitsky, yet was not estimated as upwardly pitched from the location of the tragus of the ear and eye corner. Obolensky also clusters with Levitsky and Walker1 within PC1-2, and all three have a similar depiction of head turn (refer Figure 6). Because the Obolensky portrait has depicted Suvorov's ears higher on the head, this resulted in an estimation of a relatively neutral head pitch, and furthermore, compared to Levitsky, depicts a longer lower jaw and a shorter chin (refer Figures 1 and 4). These shape changes, together with a raised ear position, indicate the Obolensky artist has attempted to reduce the degree of upwards head pitch in the Levitsky portrait, while maintaining Levitsky's portrayal of Suvorov looking down on the viewer. Walker1 does not form part of the PC3 Levinsky-Obolensky cluster, and does not repeat the inconsistent perspective of the Obolensky portrait.

For the seven landmarks selected to capture the fluctuating asymmetry suggested by the lower left eye corner and shorter left nasal wing of Suvorov's death mask, PC1-6 accounts for 96% of the variance. A multivariate regression including all of the portraits with iconographic type as the independent variable is statistically significant with Wilk's Lambda 0.19, F-test 6.45 and $p = 0.007$, and which accounts for 13% of the overall variance. When the multivariate regression is repeated without Kreutzinger1 and de Maistre, the results are weaker, but still significant (Wilk's Lambda 0.20, F-test 4.55, $p = 0.03$, 11% variance). The PC1-6 scores from both analyses are in Supplementary Materials, Table SM5.

The shape variance arising from the multivariate regressions with and without the Kreutzinger1 and de Maistre portraits are illustrated by wireframes and deformation grids in Figure 10. Seen more clearly when the variance is exaggerated by a factor of two, the iconographic types differ in the location of the inner eye corners and length of the nose wing, and this shape variance is only slightly less pronounced when Kreutzinger1 and de Maistre are excluded from the analysis. The pattern of the variance captured by this multivariate regression is that the Astrakhan and Bechon types tend to depict a shorter nasal wing and a left eye corner that is located lower on the face, and this agrees with the death mask's fluctuating asymmetry. In contrast, a longer nose wing and a left eye corner located higher on the face — a mirror-reversal of the death mask asymmetry — tends to be present in the Kreutzinger types and the mirror-reversed Schmidt.
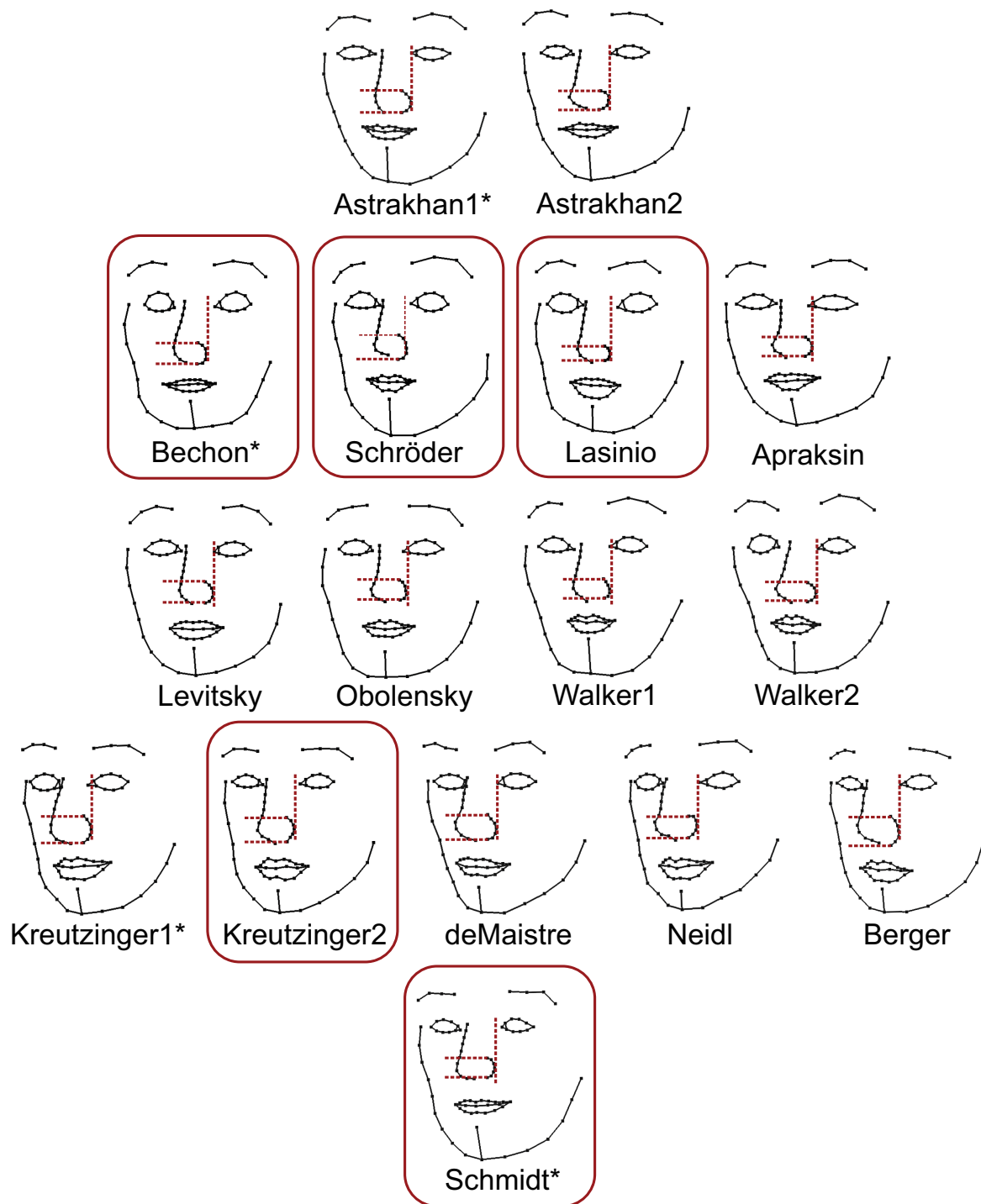
Figure 7. Inconsistent depictions of head turn and pitch. The vertical lines indicate the distance between the inner eye corner and outer nose wing, with the portraits that comply with head turn perspective enclosed in a rectangle. The horizontal lines indicate nose wing height. The portraits are organized by iconographic type, with the primary type indicated by an asterisk.

Discussion

It is well-established within art history that portraits are not stable representations of a sitter's face. In both original and derivative works, the way in which a sitter is depicted is subject to the skills and style of the artist, the conventions of a time and place, the materials and methods of production, and the portrait's purpose.[84] The general relationship of these factors to this analysis of 16 lifetime portraits depicting Alexander Suvorov are first discussed, followed by a revision of the iconographic types identified by the 19th century Russian art historians, Stremoukhov and Simanski,[85] and in the 20th century art historian, Pomarnatsky.[86] Each revision is illustrated by what are essentially Suvorov portrait phenotypes: statistical averages derived from the portraits constituting the revised iconographic type, with the forehead and hair averaged separately.

The main findings of our geometric morphometric analyses are that head pose is the primary shape difference between the iconographic types. Unlike female sitters from the period, portraits of male sitters do not tend to have a discernible bias in the direction of their depicted head turn,[87] and so it is unusual that only Schmidt depicts Suvorov's head turned to the left (Figure 1). The portraits analyzed here include a number of reproductive prints of works that have since been lost, presumably to private collections. According to White, because reproductions are printed in reverse, they are not reliable sources for identifying laterality in historical portraits.[88] However, to retain the original orientation of an artwork, reproductions are achieved in reverse, and in the 18th century this could be undertaken either in reference to a mirror,[89] or, as recommended in 1775, by tracing the outlines of the original work onto transparent paper and turning this over to achieve the required reversal.[90] It is conceivable that the popular demand for portraits of Suvorov may have encouraged some artists to not reverse an original work. However, all 16 portraits analyzed contain shading patterns that are consistent with the light source favored by European artists throughout history: 30° - 60° from the right, that is, from the upper left of the picture frame.[91] Therefore, the orientation of the reproductions would appear to be consistent with the works they reference.

Revised Astrakhan type

The Apraksin portrait clusters with both Astrakhans (Figures 6 and 8), which, as suggested by Pomarnatsky,[92] makes it an Astrakhan type. On the basis of the similarity of shape variance (Figure 8), our geometric morphometric results also indicate that the Apraksin portrait is more likely a derivative of Astrakhan2. A lifetime associate of Suvorov did not consider the original Astrakhan to be a good likeness,[93] yet the derivative Apraksin portrait is from a

collection known to prioritize likeness over artistic merit.[94] Research involving contemporary portraits has found that a consistent exaggeration of a sitter's facial distinctiveness, including head pose as well as the facial features, is considered a very good portrait likeness by familiar viewers.[95] The Apraksin portrait has a greater degree of left head cant than both of the Astrakhan types (Figure 9), and has exaggerated the fluctuating asymmetries suggested by Suvorov's death mask, namely a lower left inner eye corner and a shorter left nose wing. These fluctuating asymmetries are present to a statistically significant degree across the portraits analyzed (Figure 10), indicating that they were likely a distinctive feature of Suvorov's face in life. However, the asymmetry of the inner eye corners is only very subtly present in Astrakhan2 and absent from Astrakhan1. This suggests that the Apraksin portrait is a derivative work produced by an artist who was either familiar with Suvorov's facial appearance in life or could perceive, and exaggerate, the subtle distinctiveness depicted in Astrakhan2. It also suggests that Astrakhan2 is the result of a life sitting, and is more likely a primary type than Astrakhan1.

What has not been exaggerated in the Apraksin portrait is mouth width. There is evidence from an eyewitness that Suvorov's mouth was wide,[96] which is also suggested by Suvorov's death mask (Figure 2), even when allowing that in life the mouth widens by 12% with a supine body position.[97] Although Astrakhan2 is not the most frontally orientated portrait (Figure 6), this work depicts Suvorov with the widest mouth in the dataset (refer Supplementary Materials Table SM2), which adds further evidence that this portrait was produced from life. Nearly all of the portraits analyzed here, however, and in particular the Walker mezzotints, depict a relatively narrow mouth, and this is very likely due to long held conventions in Western European portraiture. Gérard de Larisse's 1764 *Principles of Drawing* advised artists that the width of the mouth is only slightly greater than the width of the nose,[98] and a recent study that covered all historical periods found that European portraits tend to portray both men and women with a low mouth width to face height ratio.[99] Why Kreutzinger1, and the derivatives of this work, also tend to depict Suvorov with excessive lip fullness (Figure 6, Table 1) is not clear at this time.

New Levitsky type

The Levitsky portrait from 1796, possibly undertaken in St Petersburg (refer Table 1), has little evidence of attaining a life sitting with Suvorov, and was not considered a primary type by Pomarnatsky.[100] Pomarnatsky associated this portrait with the Bechon types produced a decade later, and in particular, the Walker mezzotint from 1797 (Walker1). Stremoukhov and Simanski do not include the Levitsky portrait in their iconography, and thought Walker1
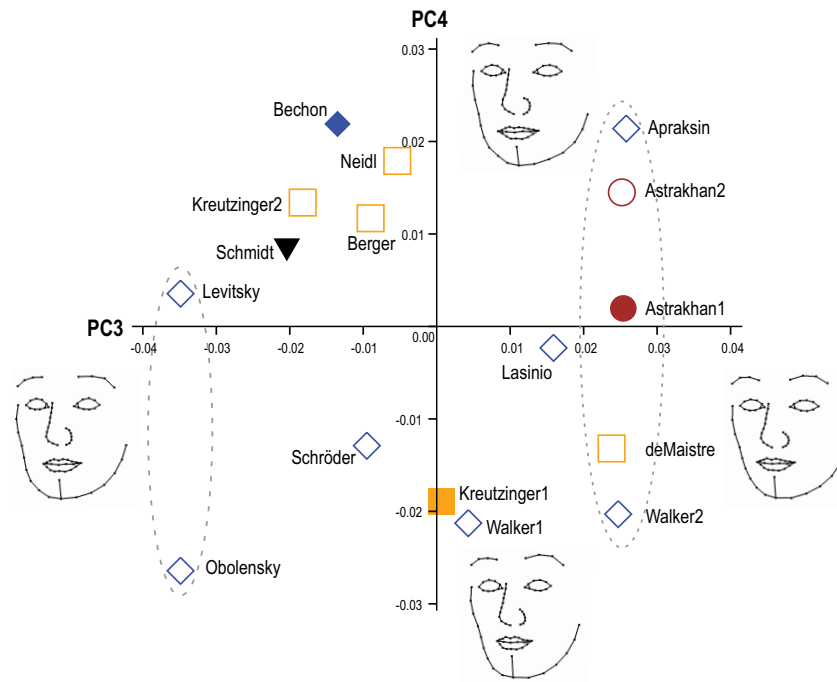
Figure 8. PC3 and PC4 (16% variance). The iconographic types are coded as follows: circles = Astrakhan type, diamonds = Bechon type, squares = Kreutzinger type; inverted triangle = Schmidt. The primary types are filled shapes. The ellipses indicate meaningful clusters by type. The wireframes are extracted from PC3 (x axis) -0.04 & +0.03 and PC4 (y axis) -0.03 & +0.02.
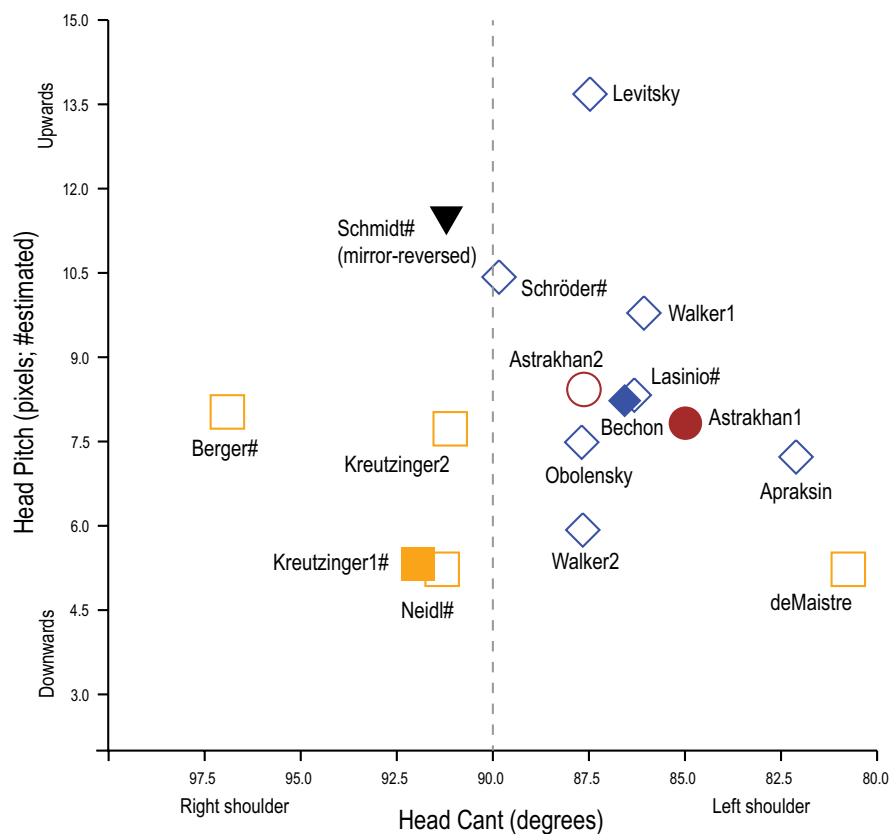

Figure 9. Head cant and pitch. The iconographic types are coded as follows: circles =Astrakhan type, diamonds = Bechon type, squares = Kreutzinger type; inverted triangle = Schmidt. The primary types are filled shapes; #indicates an approximate estimation of head pitch.
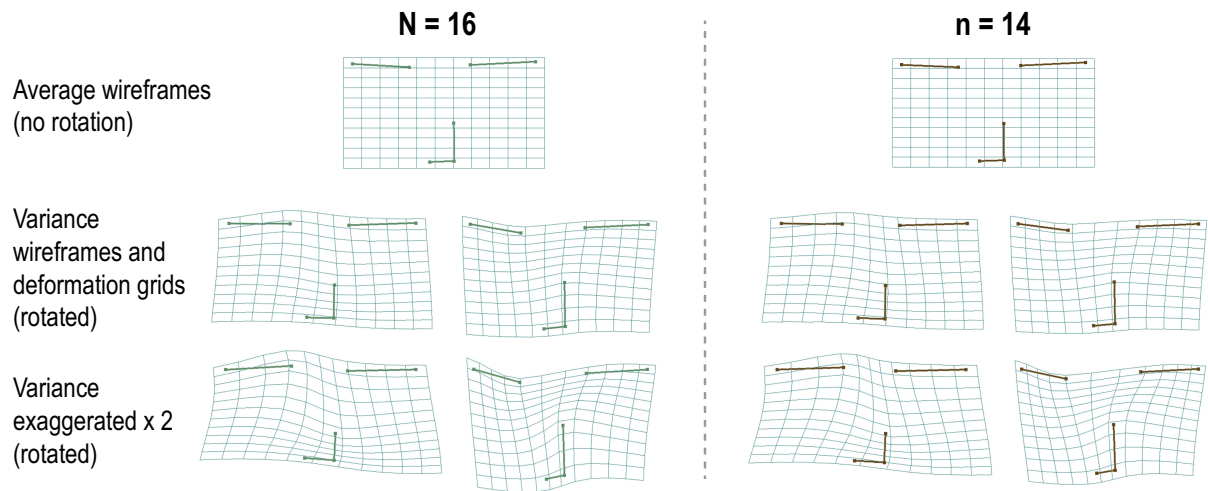
Figure 10. Multivariate regression of the eye corner locations and nose wing height by iconographic type (1-4). The results on the left include all 16 portraits, the results on the right (n = 14) exclude Kreutzinger1 and de Maistre. The deformation grids have been rotated so that the exocanthia landmark coordinates are horizontal.

a derivative of the portrait from the Obolensky collection that was produced the year before.[101] Our analyses of the portraits' shapes results in Levitsky, Walker1 and Obolensky forming a fairly distinct cluster (Figure 6), primarily due to a similarity of depicted head turn and pitch. These three portraits are also the only works in this dataset to depict Suvorov with a relatively strong upwards head pitch, and all three position Suvorov looking down on the viewer. This orientation enhances the hooded appearance of the eyelids, which is a facial characteristic described by an associate of Suvorov.[102] In addition, this pose serves to signal Suvorov's high status: contemporary studies have found that an upwards head pitch is statistically significant for dominance in male subjects,[103] likely because positioning the viewer below enhances the perception of power.[104] There is evidence, however, that the artist who produced the Obolensky portrait sought to reduce Suvorov's head pitch, though was not completely successful in adapting the facial shapes to this change in 2D perspective. In essence, the Obolensky portrait depicts upwardly pitched features within a neutrally pitched head. While the Walker1 reproduction also portrays Suvorov with a reduced head pitch, it lacks the inconsistencies of the Obolensky portrait. It is therefore more likely that Walker1 is a derivative of Levitsky, and not Obolensky, as suggested by Stremoukhov and Simanski,[105] and that the Levitsky portrait is a new primary type.

Revised Bechon type

Only one of Bechon's many miniatures of Suvorov was able to be sourced for this analysis; the remaining three

Bechon types in this revised iconography are reproductive prints. The Schröder mezzotint is known to be derived from a (since lost) Bechon miniature which has evidence of being considered a good likeness.[106] Our findings are that it is Lasinio's engraving that is most similar to the Bechon primary type, although it may have been derived from a different miniature. Both Bechon and Lasinio depict Suvorov with large eyes, a representation that agrees with a lifetime description,[107] and that the two portraits cluster closely on the shape variance of PC2 (Figure 6) agrees with Stremoukhov and Simanski's assessment of Lasinio having changed little of the Bechon miniature it references. [108]

While Lasinio's portrait conforms closely to the Bechon primary type, many engravers of the period wished their work to be respected, and costed, as an original translation by an artist, and not the slavish depiction of another's efforts by a mere copyist—and therefore added original elements during the translation.[109] Our analysis indicates Schröder has deviated more than Lasinio from the Bechon miniature, and while it cannot be proven, likely added elements of originality that may have compromised the likeness attributed to the original work. It is also possible that the original was not a particularly good likeness, given this is only inferred from Suvorov presenting this lost Bechon miniature to a colleague. Studies of contemporary portrait photographs have found that sitters are poor judges of their own likeness, possibly because most people only regularly see themselves when looking in mirrors, and this is to inspect, not recognize, the face reflected there.[110]

Suvorov's assessment of his own likeness would have been further compromised by all of the Bechon miniatures being produced while Suvorov was in Warsaw in 1795. As reported in the same year by Suvorov's *aide-de-camp* and only lifetime biographer, Johann Friedrich Anthing: "It is Ɛ among the singular, though unimportant circumstances of his life, that he [Suvorov] has not made use of a looking-glass for twenty years."[111]

Walker's mezzotint of 1799 (Walker2) was also considered a good likeness.[112] However, the later geometric morphometric components (PC2-4, Figures 6 and 8) locate this work in a similar shape space as Walker1, which — as discussed above — our analysis suggests is derived from Levitsky. Contributing to this clustering is that both Walker portraits depict Suvorov with the outer edge of the left nose wing in vertical alignment with the left inner eye corner (Figure 7). The Bechon miniature and both reproductions by Lasinio and Schröder differ in depicting the outer edge of the nose some distance from the inner eye corner. The Walker reproductions are derived from, since lost, portraits by John Atkinson. In addition to applying the artistic convention of a very narrow mouth width (Figure 4), Atkinson and/or Walker have likely followed another long-held Western European convention, which in Alexander Browne's *Ars Pictoria* of 1669 is described as follows: "the Eyes must be the length of one Eye distant from the other; and that their inward Corners be perpendicularly over the outside of the Nostrils punctually."[113] A century later, in de Lairesse's *Principles of Drawing*, this relationship is maintained even when the head is turned.[114] The Atkinson-Walker portraits are not, of course, the only works to follow this convention. Apart from Bechon, Schröder and Lasinio, only one of the portraits by Kreutzinger (Kreutzinger2) and the Schmidt portrait depict Suvorov with a head turn that conforms to the 2D perspective of a living face.

In historical portraits, and more noticeably in allegorical works, the degree of depicted head cant is symbolic of the power and status of the subject, with older, and more powerful, men typically less canted.[115] A reduction in head cant is apparent in Suvorov's later portraits, and may be why the Schröder reproduction depicts Suvorov as close to upright (Figure 9). However, while the degree of head cant can be subject to artistic convention, the direction is a biological characteristic. Head cant is typically in the opposite direction to an individual's dominant eye; e.g., most right-handed people are right eye dominant, and therefore display a characteristic left head cant.[116] Suvorov is shown to be right handed in the eight portraits that include Suvorov holding a sword or with a Fieldmarshal's baton (Bechon, Schröder, Lasinio, Levitsky, Walker1, Walker2, Kreutzinger2, Neidl) and most of the portraits depict Suvorov's head canted to the left shoulder. The exceptions are the two portraits by Kreutzinger, and the derivatives of Kreutzinger1 (Neidl, Berger), all of which depict Suvorov's head canted to the

right. These four Kreutzinger types also tend to reverse the fluctuating asymmetry indicated by Suvorov's death mask, which, together with the direction of head cant, indicates Josef Kreutzinger very likely produced original works that portray the mirror-averse Suvorov in mirror-reverse.

Revised Kreutzinger type

Evidence of mirror-reversal is more marked in the Kreutzinger oil painting currently provenanced to the State Hermitage Museum St Petersburg (Kreutzinger1), which depicts Suvorov gesturing with an un-gloved right hand towards the scene of a distant battle. Although Kreutzinger has some evidence of a life sitting with Suvorov, the artist is reported to have lost the original(s), and therefore created new work(s) from memory and preparatory drawings.[117] Mirror-reversal in Kreutzinger1, however, is unlikely due to poor memory, and more likely the result of both pragmatism and the role of symbolism in Western European figurative art. If the Kreutzinger1 oil painting had portrayed Suvorov's face in what appears to have been the original orientation of a right head turn, left head cant, such a pose would require the depiction of Suvorov's body (a task typically relegated to studio assistants[118]) to be similarly reversed. Mirror-reversal was necessary, therefore, to avoid a complex body position, such as the right arm crossing over the body, or portraying Suvorov gesturing towards battle with his left hand and thereby signifying the sinister.[119] Neidl's reproduction has reduced the degree of head turn (Figure 6), but is similarly mirror-reversed, as is Berger's engraving, which, according to Rovinsky, references Neidl.[120] It is highly likely that Kreutzinger's mirror-reversal is present in all of the iterations of Neidl that flourished during 1799 and 1800, including a reproduction by Thomas Clarke that graces the frontispiece of the 1800 English translation of Suvorov's lifetime biography.[121]

Geometric morphometrics locates the de Maistre portrait with the Kreutzinger types for head pose (Figure 6), which agrees with Voensky and colleagues' assessment from 1907.[122] However, our findings do not indicate de Maistre is similarly mirror-reversed. Instead, the clustering is due to the artist portraying Suvorov with a strong head turn and left head cant towards the viewer, with the latter morphologically resembling the Kreutzinger portrait downwards head pitch. The de Maistre portrait also has evidence of being considered a good likeness (ibid.), as does one of the Kreutzinger reproductions.[123] This Kreutzinger reproduction could be Kreutzinger2, which is less strongly mirror-reversed, and is the only Kreutzinger type to portray Suvorov's head turn with the 2D perspective appropriate for the depiction of a living face. It is possible, therefore, that Kreutzinger2 is the basis for Kreutzinger1, and therefore the primary type—which was also suggested by Voensky, et al.[124]

Figure 11. Revised Astrakhan type: average of Astrakhan1, Astrakhan2, Apraksin. Primary type (revised): Astrakhan2

Figure 12. New Levitsky type: average of Levitsky, Obolensky, Walker1. Primary type (new): Levitsky

Figure 13. Revised Bechon type: average of Bechon, Schröder, Lasinio, Walker2. Primary type: Bechon

Figure 14. Revised Kreutzinger type: average of Kreutzinger1, Kreutzinger2, Neidl, Berger (including two non-Kreutzinger types, de Maistre and Schmidt). Primary type: possibly Kretuzinger2

The Schmidt type

Schmidt's portrait is the last lifetime portrait of Suvorov, and because this was mirror-reversed for these analyses, it is included in the Kreutzinger portrait average (Figure 14). It is not, however, a Kreutzinger type. Schmidt differs from all of the portraits analyzed here in that the artist shows Suvorov looking to the left with a slight upwards head pitch and a deflected gaze (refer Figure 1). A deflected gaze is associated with a sitter's power and status,[125] and a study of contemporary images indicates that looking up and to the left is characteristic in the depictions of moral heroes.[126] If this holds for the Schmidt portrait, this is an unusual choice for portraying a military professional, and particularly one with Suvorov's reputation. There is, however, evidence that the artist may have been informed by Suvorov's knowledge of the influence of physiognomy on European portraiture. Physiognomy, popularized in the 18th century by the Swiss pastor, Lavater,[127] holds that the shape and form of the external facial features are a direct manifestation of the inner mind and soul. Physiognomy likely influenced a number of portraits of Suvorov, including, for example, an intaglio etching produced in 1799 by the French Revolution artist Wilbrode-Magloire-Nicolas Courbe that Stremoukhov and Simanski considered fanciful.[128] As recalled by Fuchs, Suvorov's *chargé d'affaires* and confidant, immediately prior to their portrait sitting Suvorov made it clear to Schmidt that he was aware of, and disagreed with, both his reputation and the claims of physiognomy:

> *Ваша кисть изобразит черты лица моего— они видны; но внутреннее человечество мое сокрыто. Итак, скажу вам, что я проливал кровь ручьями. Содрогаюсь. Но люблю моего ближнего; во всю жизнь мою никого не сделал несчастным, ни одного приговора на смертную казнь не подписывал, ни одно насекомое не погибло от руки моей.*[129]

> *Your brush will depict the features of my face—they are visible; but my inner humanity is hidden. So, I will tell you that I spilled blood in streams. I shudder. But I love my neighbor; in all my life I have not made anyone unhappy, I have not signed a single death sentence, not a single insect has died at my hand.*

Conclusions

As an experimental case study, the main aim of this research was to investigate whether a geometric morphometric approach, initially applied to portraits in collaboration with groups of contemporary portrait artists, could be meaningfully applied to diverse 18th century portraits depicting the same sitter. In this instance, we have found that our analyses of 16 life-time portraits of the Russian military commander, Generalissimo Alexander Vasilyevich Suvorov, largely agrees with, and supplements, the iconographic research undertaken by 19th and 20th century Russian art historians, albeit with some revision. Although the sensitivity of geometric morphometrics to even slight variations in orientation in 2D images is often a confounding variable, our analyses indicate head pose variation is a useful factor for distinguishing between the Suvorov portraits, as most of the derivative works depict a reduced or exaggerated head turn, pitch and/or cant. However, due to either the imposition of artistic conventions of the time or the skill of the artist, this is not always in agreement with 2D perspective. An unexpected outcome of this study is the considerable evidence of mirror-reversal in Joseph Kreutzinger's original depiction of Suvorov. This work informed the 1799 copper engraving by Johann Neidl, which, within a few years, was subject to 37 iterations. These were subsequently distributed across Western Europe and North America, leading to a mirror-reflection of the mirror-averse Suvorov becoming—at least outside of Russia—his most familiar face.

Further research with different historical figures may indicate our findings are common to 18th century portraiture, or may not. It is not possible to generalize from a single case study, though our results do suggest some caution in assuming an original portrait is not a mirror-reversal. Although there has been critique of digital art history being primarily about the technological,[130] what is most strongly indicated by this research is that a geometric morphometric analysis can complement, and be directly contextualized within, art history's concerns of authenticity, derivation, likeness and style in portraiture.

NOTES

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11   Mikhail B. Stremoukhov and Panteleimon I. Simanski, *Zhizn Suvorova [The Life of Suvorov in Artistic Images]* (Moscow: Grosman i Knebel', 1900), 330.

12   Stremoukhov and Simanski, *Zhizn Suvorova [The Life of Suvorov in Artistic Images]*, 374.

13   Stremoukhov and Simanski, 344.

14   Andrei Pomarnatsky, *Portrety Suvorova. Ocherki Ikonografii [Suvorov's Portraits: Essays on Iconography]* (Leningrad: State Hermitage Ed., 1963), 26.

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22   Stremoukhov and Simanski, *Zhizn Suvorova [The Life of Suvorov in Artistic Images]*, 164, 175, Appendix.

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34   Pomarnatsky, 134–35.

35   Zamostyanov, "Portrety Generalissimusa [Portraits of the Generalissimo]."

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ALEXEY ZOTOV is a Senior Researcher, Associate Professor with PhD in Technology.
In his youth, he was a cadet at the Suvorov Military School, where he met the world's
first astronaut Yuri Gagarin, who inspired him to study history. Alexey specializes in
biographical research of prominent personalities of Russia in the 18th - 19th centuries
and on the history of the Napoleonic wars; he is the author of 3 books and 50 articles, and
collaborated internationally with renowned British and Canadian historians David Chandler
and Ben Weider.

SUSAN HAYES is a research academic specialising in identifying patterns of shape variation
in 2D images of the face, and relating the results to the broader socio-cultural and historical
contexts of production and reception. In addition to her interest in portraiture, Susan's
interdisciplinary output includes research publications in the archaeological sciences,
palaeontology, forensic sciences, and the psychology of face perception. Susan has a PhD
in biological anthropology, an MFA, and a BA(Hons) in cultural studies.

Correspondence email: susan_hayes@uow.edu.au