Totentanz.
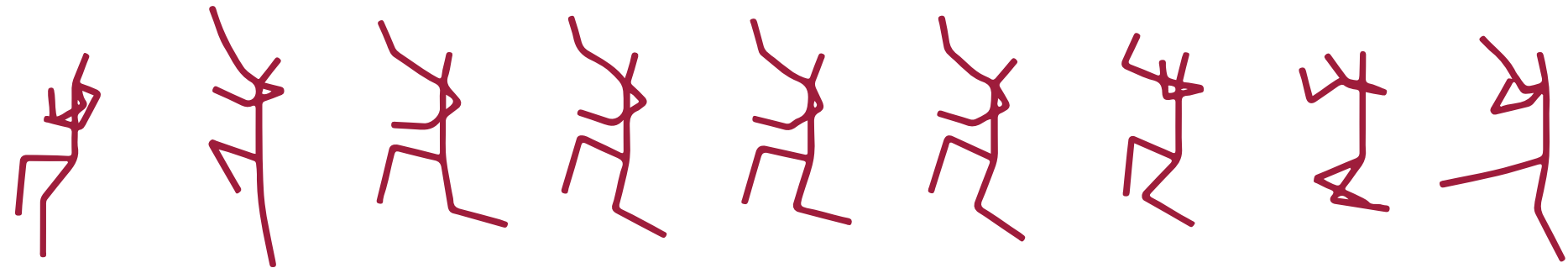# Operationalizing Aby Warburg's *Pathosformeln*

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Totentanz. Operationalizing Aby Warburg's *Pathosformeln*

1. *Mnemosyne*

The object of this study is one of the most ambitious projects of twentieth-century art history: Aby Warburg's *Atlas Mnemosyne,* conceived in the summer of 1926 – when the first mention of a *Bilderatlas*, or "atlas of images", occurs in his journal – and truncated three years later, unfinished, by his sudden death in October 1929. *Mnemosyne* consisted in a series of large black panels, about 170x140 cm., on which were attached black-and-white photographs of paintings, sculptures, book pages, stamps, newspaper clippings, tarot cards, coins, and other types of images (**Figure 1.1**). Warburg kept changing the order of the panels and the position of the images until the very end, and three main versions of the *Atlas* have been recorded: one from 1928 (the "1-43 version", with 682 images); one from the early months of 1929, with 71 panels and 1050 images; and the one Warburg was working on at the time of his death, also known as the "1-79 version", with 63 panels and 971 images (which is the one we will examine). But Warburg was planning to have more panels – possibly *many* more –[1] and there is no doubt that *Mnemosyne* is a dramatically unfinished and controversial object of study.

2. Operationalizing *Pathosformeln*

For Warburg, these thousand images were all inter-connected, and the ambition of the *Atlas* was to make visible – through the shock of a gigantic montage – morphological similarity across historical time. This is what the *Atlas* is: the meeting-point of form and history. Two concepts that are usually at odds with each other, and which he wanted to yoke together. But how exactly are we supposed to see this conjunction – how, for instance, are we supposed to read these panels: left to right, top to bottom, center to periphery?[2] The size and position of individual images vary, and hence also their relevance; the panels are accompanied by extremely laconic, or even cryptic, captions; the texts Warburg wrote for the *Atlas* are very few and extremely compressed – so that Gombrich was hardly wrong when,

in his intellectual biography of Warburg, he compared *Mnemosyne* to "certain types of twentieth-century poetry – he must have been thinking of Pound's *Cantos*, or Eliot's *Waste Land* – where hosts of historical or literary allusions hide and reveal layers upon layers of private meanings".[3] An enigmatic work, in other words; often compared to Benjamin's *Passagenwerk*, but in truth much more elusive than that. One thread through the labyrinth is however offered by Warburg's greatest conceptual creation: the *Pathosformel*, or formula for (the expression of) *Pathos*. Passion, emotion, suffering, agitation – *Pathos* is a term with many (and perhaps too many) semantic shades,[4] though they all share the "superlative" degree (Warburg's word) of the feeling involved. "Antique formulas of intensified physical or psychic expression", as he wrote in the essay on Dürer in which he introduced the notion;[5] an "external sign" for "a state of excitement or inner emotion", as the essay on Botticelli has it.[6] An image of the body, that simultaneously conjures up a particularly intense emotion.

A powerful concept, the *Pathosformel*, because it manages to combine semantic opposites.[7] *Pathos* and *Formel*: a sudden, overpowering force – and a stable patterning which replicates itself over time, and thus enables the *Nachleben* (afterlife, survival, persistence: another of Warburg's keywords) of antiquity into early modern Europe. "The formulas of dynamic pathos *all'antica*", writes Warburg in the "Introduction" to

Figure 1.1 *Mnemosyne*, Panel 46

The young maid carrying a basket in Ghirlandaio's "Birth of John the Baptist" (the third image in the upper row of the panel), whom Warburg often referred to as "nymph" or "ninfa", will be discussed later in this essay. With its 27 images, this panel is almost twice as crowded as the mean for the Atlas, which is just above 15 images.

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1 In one of his last journal entries, in October 1929, Warburg speaks of an "Atlas von circa 200 Tafeln": see *Gesammelte Schriften* vol. VII, Karen Michels and Charlotte Schoell-Glass, eds, Berlin, Akademie Verlag, 2001, p. 543.

2 "Opaque is why some images are privileged by their relative largeness or central position", writes for instance Christopher D. Johnson, "and why other appear devalued by their smallness or marginal position." See *Memory, Metaphor, and Aby Warburg's Atlas of Images*, Cornell UP, 2012, p. ix. In the case of **Figure 1.1**, for example, the "central" image is the maid in the right hand corner of the third image of the top row: which is in no way obvious to an observer. And the rule keeps changing from panel to panel.

3 E. H. Gombrich, *Aby Warburg. An intellectual biography*, 1970, Chicago UP, 1986, p. 302.

4 "Typical [of the historic semantics of 'Pathos'] is a massive polysemy of both concept and object": Ultich Port, *Pathosformeln. Die Tragödie und die Geschichte exaltierter Affekte (1755-1888)*, Wilhelm Fink Verlag, München 2005, p. 23.

5 Aby Warburg, "Dürer and Italian Antiquity", 1905, now in *The Renewal of Pagan Antiquity*, The Getty Research Institute, Los Angeles 1999, p. 555.

6 "Sandro Botticelli's *Birth of Venus* and *Spring*. An Examination of Concepts of Antiquity in the Italian Early Renaissance" [1893], in *The Renewal of Pagan Antiquity*, p. 141. There is a marked similarity between Warburg's formulations and T. S. Eliot's famous passage on the "objective correlative" in the essay "*Hamlet* and His Problems": "The only way of expressing emotion in the form of art is by finding an 'objective correlative'; in other words, a set of objects, a situation, a chain of events which shall be the formula of that *particular* emotion; such that when the external facts, which must terminate in sensory experience, are given, the emotion is immediately evoked." See *The Sacred Wood*, 1920, Methuen, New York 1972, p. 100.

7 On this point, see in particular Salvatore Settis, "Pathos und Ethos, Morphologie und Funktion", in W. Kemp, G. Mattenklott, M. Wagner, M. Warnke, eds, *Vorträge aus dem Warburg-Haus*, Band 1, De Gruyter, Berlin 1997, pp. 39-44. The analogy between the inner tension of Warburg's concept and the Nietzschean polarity of Dyonisian and Apollonian has also often been noticed (see, for a recent example, Colleen Becker, "Aby Warburg's *Pathosformel* as methodological paradigm", *Journal of Art Historiography*, 9, 2013, pp. 12); in the "Introduction" to *Mnemosyne* Warburg had himself ironically observed that it was "no longer necessary [...] to adopt a revolutionary posture to identify the essence of Antiquity in the symbol of the double hermes Apollon-Dyonisos". Aby Warburg, *Der Bilderatlas Mnemosyne. Einleitung,* in *Gesammelte Schriften*, II.1, Martin Warnke, ed., p. 4.

Mnemosyne, achieved an "overpowering hegemony" among artistic conventions; the term returns in the annotations to panels 40 ("infanticide [...] Excess of *Pathosformel*") and 57 ("*Pathosformel* in Dürer"), while *Pathos* is associated in various ways with Panels 41, 41a, 42, 44, 49, 52, 70, and 73. If the *Bilderatlas* has a center, the *Pathosformel* is it.

Much excellent critical work has been done on *Pathosformeln*; but, as far as we know, no one has ever tried to "operationalize" the concept – that is to say, to transform it into a series of quantifiable operations, thus turning it into an instrument to actually *measure* the objects it refers to. That the *Pathosformel* had clearly *not* been conceived with this outcome in view makes the attempt more difficult, obviously, but also more meaningful: since virtually all key concepts of art history, literary theory, aesthetics etc. pose exactly the same problem, research in quantitative cultural history must either ignore all existing concepts, which would be barbaric, or else find some way to use them to "measure" reality. But speaking of "operationalizing a concept" is slightly misleading, as it suggests that one gets to work on the whole concept at once, whereas in fact the first step of the process consists in breaking up the concept, to identify which of its elements are both *open to quantification* – because that's the point of operationalization to begin with – but also *essential to the architecture of the concept*.[8] You want to operationalize the core of the concept, not some peripheral aspect that happens to be easy to quantify. Before any counting begins, you must really *analyze* the concept: take it apart, and consider the value of its various elements.

And the first thing one notices, in doing so, is how internally unbalanced the *Pathosformel* is. *Pathos* and *Formel* are not just semantic opposites, they have also very different conceptual weights: *Pathos* being much more important than *Formel*. Warburg's creativity when he is writing about the former is extraordinary: in the "Introduction" to *Mnemosyne*, which is a very short text of four or five pages, we find "orgiastic fervor", "phobic impressions", "highest inner emotion", "passionate experience", "pagan exaltation", "boundless unleashing", "interior abandon", "murderous drunkenness", "paroxistic fervor", "resounding eloquence" – and more. This is clearly a notion that fires his imagination. *Formel*, not at all. So, we began our work by splitting the concept, and looking at ways to "measure" *Pathos*.

3. Anatomy of *Pathos*

Some secondary literature. In *Pathosformeln* "the outward movements of the whole body [...] convey inner emotion", writes David Freedberg: "swaying bodies, vigorously flowing drapery, and hair flying in the breeze conveyed inner states of psychic excitation." The concept "gave art history access to [the] fundamental anthropological dimension [...] of the *symptom* [...] understood as *movement in bodies*", adds Georges Didi-Huberman; and Philippe-Alain Michaud, in *Aby Warburg and*
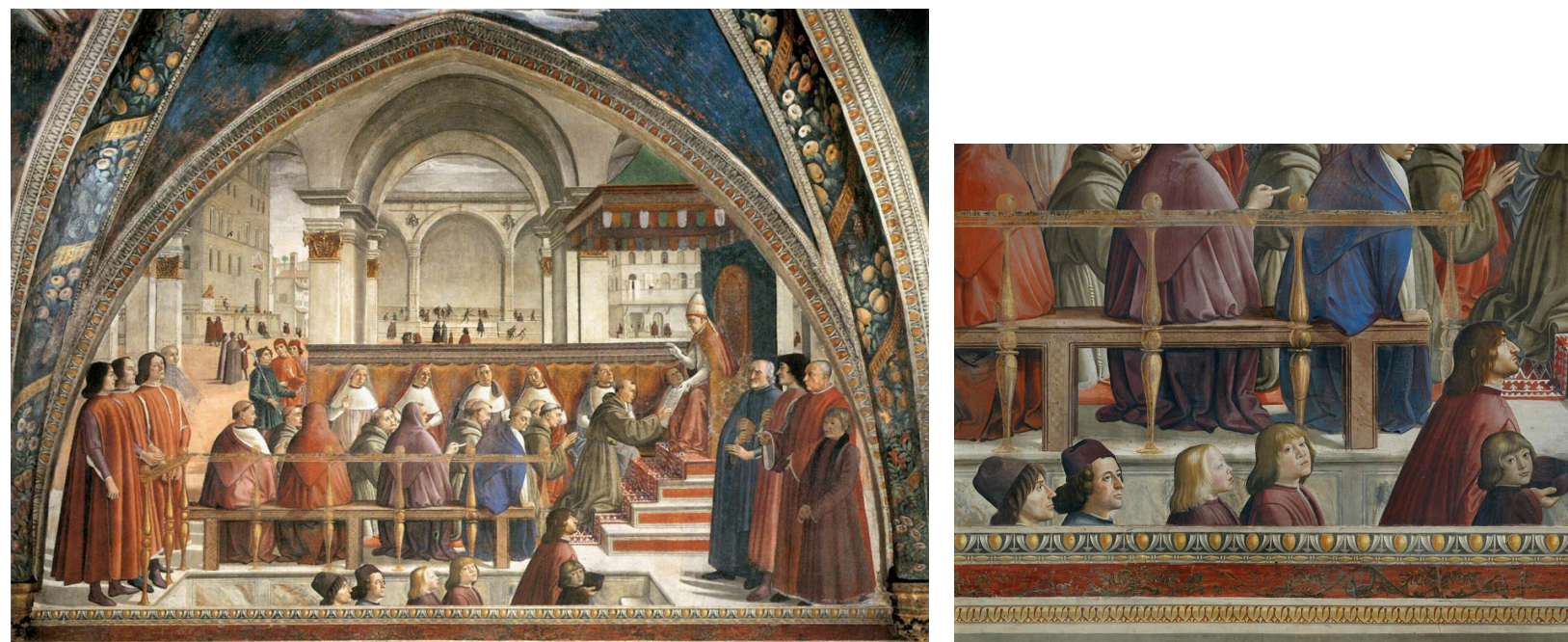
Figure 3.1. Domenico Ghirlandaio, The Confirmation of the Franciscan Rule, 1483, Cappella Sassetti, Florence

the Image in Motion: "it was not the motionless, well-balanced body that served as the model for the imitation of Antiquity, as in Winckelmann [but] the body caught in a play of overwhelming forces". A "hysterical" body, concludes Sigrid Schade in an essay in which one of Charcot's patients is described as performing an "alphabet of passionate gestures with her body".[9]

Movements of the whole body ... swaying bodies ... hysterical body ... body caught in a play of overwhelming forces ... And the face? Silence. Strange. Even stranger, given the role the face plays in that crucial text – Darwin's *The Expression of Emotions in Man and the Animals*: "Finally, a book that helps me"[10] – encountered by Warburg along the path that would lead him to the *Pathosformel*. Warburg will work on how images express inner emotions, Darwin's book contains 34 images of human emotions – and in 32 of them, the analysis centers on the face.[11] The "muscles round the eyes" are discussed as early as the second page of the "Introduction"; "eyebrows", "corners of the mouth" "facial muscles", "frowning" and "blushing" follow in the next couple of pages; "I shall often have to refer [...] to the muscles of the human face" [23], Darwin explains – and the first three images of the book are indeed anatomical drawings of these muscles [24-5]. In reaffirming the importance of Darwin's book for Warburg's trajectory, Carlo Ginzburg singled out a page centering on "laughter", "smiles", "the tear-stained visage", and "the swift passage from laughter to tears".[12] Darwin focused "above all on facial expressions", concludes Philip Fisher in *The Vehement Passions* – and we couldn't agree more.[13]

A book that helps me. And then Warburg does the opposite of what Darwin had done. Not for lack of interest in facial expressions as such: "The Art of Portraiture and the Florentine Bourgeoisie" (1902), with its striking analysis of the six visages emerging from the "underworld" – Poliziano, Pulci, Franco, and the three Medici children: **Figure 3.1** – makes that perfectly clear. But, Warburg wasn't interested in facial expression *in connection with Pathos*. His observations on flowing hair in Botticelli as a sign of "excitement and inner emotion" are perfect in this respect: hair brings *Pathos* as close as possible to the face – it literally attaches it to the face – *without actually involving it*.[14] There is something extreme in this avoidance, but the main point is that Warburg was right: focusing on the body rather than the face underlined the discon-

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8 For an attempt in this direction, see the operationalization of the concept of "tragic collision" in Hegel's *Aesthetics* in Franco Moretti, " 'Operationalizing': or, the function of measurement in modern literary theory", Literary Lab Pamphlet 6, 2013, especially pp. 9-13.

9 David Freedberg, "Memory in Art: History and the Neuroscience of Response", in Suzanne Nalbantian, Paul M. Matthews, and James L. McClelland, eds, *The Memory Process. Neuroscientific and Humanistic Perspectives*, MIT Press, 2011, p. 349. Georges Didi-Huberman, "Foreword. Knowledge: Movement (The Man Who Spoke to Butterflies)", in Philippe-Alain Michaud, *Aby Warburg and the Image in Motion*, 2004, Zone, NY 2007, p. 15. Philippe-Alain Michaud, *ivi*, , p. 27-8. Sigrid Schade, "Charcot and the Spectacle of the Hysterical Body. The 'pathos formula' as an aesthetic staging of psychiatric discourse – a blind spot in the reception of Warburg", *Art History*, December 1995, p. 509.

10 The words "Endlich ein Buch, das mir hilft" were first quoted by Gombrich (*Aby Warburg*, cit., p. 72), without providing a date. In a lecture at the Warburg Institute in 2016, Sigrid Weigel has shown that the words first appeared in Warburg's journal on November 26, 1888 – and were then trascribed *verbatim* in the German edition of Darwin's text that he brought to Kreuzlingen thirty-six years later, in 1924. Weigel's lecture can be found at: https://www.youtube.com/embed/Nw5CbUrLLf0

11 The two exceptions refer to the feeling of impotence expressed by shrugging one's shoulders – arguably the weakest of all emotions in the book. Photos of emotions in children often include the whole body, but the analysis routinely focuses on faces, and even the book's typography points readers in the same direction: in the pages on the "expression of suffering" in children, the running header calls attention to "weeping"; later, it mentions "oblique eyebrows" in reference to images of "grief". With emotions in adults, fourteen out of nineteen images *only* show the face; the body is not even visible – let alone meaningful.

12 Carlo Ginzburg, "Le forbici di Warburg", in Maria Luisa Catoni, Carlo Ginzburg, Luca Giuliani, Salvatore Settis, *Tre figure. Achille, Meleagro, Cristo*, Feltrinelli, Milano 2013, p. 116.

13 Philip Fisher, *The Vehement Passions*, Princeton UP, 2002, p. 23.

14 "The surface mobility of inanimate accessory forms, draperies and hair", writes Warburg, "which Poliziano commended to [Botticelli] as characteristic of antique works of art, was an easily manipulated external sign that could be added *wherever he needed to create the semblance of intensified life*. Botticelli readily made use of this expedient to show human figures *in a state of excitement, or even of inner emotion*." ("Sandro Botticelli's *Birth of Venus* and *Spring*", cit. , p. 141 (italics added)).

tinuity between his *Pathos* and Darwin's emotions. The meaning of *Pathos*, and its relationship to the modern concept of the emotions, are of course extremely large questions; but, bluntly put, *Pathos* is too powerful to be conveyed by the necessarily very subtle movements of "the muscles round the eyes" and "the corners of the mouth"; it grabs the whole body – it *takes control* of the body. One is "overpowered" by it; "paralyzed" by fear, "inflamed" by anger, "flooded", "crushed", "taken over": all passives.[15] By contrast, we usually "feel" an emotion – behaving, grammatically at least, as active subjects. We "have" an emotion – whereas a passion has us. And the face is part of the difference: expressing an inner state by subtle small movements is already a sign of mastery over it – and mastery is antithetical to the idea of *Pathos*.

Following the implicit logic of Warburg's work, then, and of the critical literature on *Pathosformeln*, we excluded facial expressions from our model, because they didn't seem to belong to the core of the concept. We may be wrong of course, but the decision highlights a key aspect of the process of operationalization: it forces you *to be absolutely clear about your interpretation of a concept*. You either include the face in your measurements, or you don't. Clarity is not an optional, it's not a matter of style: it's a logical constraint. And the epistemology of the humanities has probably a lot to gain from a few more constraints.

So: no face, and a focus on the "outward movements of the whole body", as Freedberg puts it. The whole body ... basically, arms and legs. The "dancing" and "running" nymphs and maenads of the Florentine essays;[16] even more, arms: the raised arms of the Venetian woodcut that Warburg singled out in the essay in which the *Pathosformel* was first introduced as a "most telling" image [555] (**Figure 3.2**): four maenads raise their swords, ready to strike, while Orpheus lifts his left arm in a vain gesture of defense. Reflecting on the "humanly true gestures" of *Pathosformeln*, Freedberg mentions "the wailing mother with her arms outstretched in sorrow"; a propos Goya's "Desastres", he notices the temptation "of raising one's own arms to bring down the hatchet."[17] But the strongest connection between arms and *Pathos* comes from three essays from a recent collection, in which Salvatore Settis focuses on the dead arm of Meleager's and Christ's, which falls downward at a right angle from the body (**Figures 3.3-3.4**), Carlo Ginzburg discusses the Maenad's raised arms, including the "Maenad under the Cross" of Panel 42 of *Mnemosyne* (**Figure 3.5**), and, most striking of all, Maria Luisa Catoni singles out the uncanny image of a woman rushing forwards while throwing her arms backwards (**Figure 3.6**).[18]

Figure 3.2. Woodcut from Ovid, Metamorphoses, Venice 1497

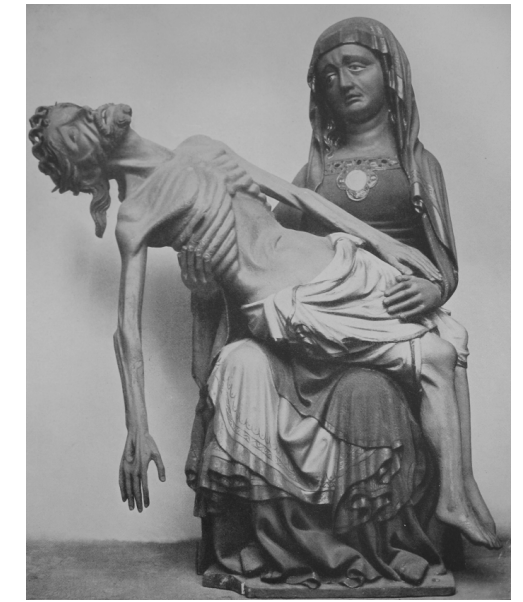**Figure 3.3.** Raphael, The Deposition, 1507, Galleria Borghese

Figure 3.4. Pieta/Vesperbild, St-Nikolai-Kapelle, Soest. From A. Ludorff, Die Bau- und Kunstdenkmäler des Kreises Soest, Münster 1905
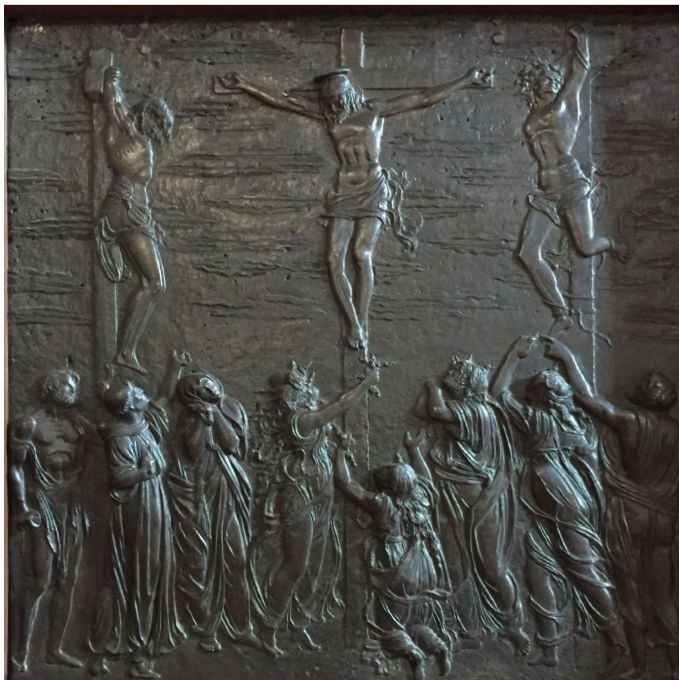

Figure 3.5. Bertoldo di Giovanni, Crucifixion, 1485-1490, Museo Nazionale del Bargello, Florence

Figure 3.6. Maiano/Sangallo, Morte di Francesco Sassetti, 1480s, Cappella Sassetti, Florence

15 "Whereas our modern understanding of passion is essentially active, in antiquity and for a long time thereafter the meaning of *passio* [Greek: *pathos*] was [...] essentially "passive" [...] both *pathos* and *passio* do in fact mean "suffering" [...] Stoic and Christian views [...] considered the passions to be maladies of the soul": Erich Auerbach, "*Passio* as Passion", in *Time, History, and Literature*, Princeton UP 2014, p. 165.

16 "Sandro Botticelli's *Birth of Venus*" and "On *Imprese Amorose* in the Earliest Florentine Engravings" [1905], in *The Renewal of Pagan Antiquity*, passim.

17 David Freedberg, "Empathy, Motion and Emotion", in Klaus Herding and Antje Krause-Wahl, eds, *Wie sich Gefühle Ausdruck verschaffen: Emotionen in Nahsicht*, Driesen, Taunusstein, 2007, pp. 29, 38.

18 See Salvatore Settis, "*Ars moriendi*: Cristo e Meleagro", Carlo Ginzburg, "Le forbici di Warburg", and Maria Luisa Catoni, "Donna disperata in movimento. Peripezie di un particolare", in *Tre figure*, cit. On a lateral note, let's add that, whereas arms are crucial to *Pathosformeln,* hands and finger are not. At

first it seems odd, given how "expressive" they can be – so much so, that a whole language has been developed out of their movement – but, as for the face earlier, *Pathos* doesn't agree with subtlety of expression. The frequent association (by Agamben, Michaud, and others) between the *Pathosformel* and Andrea De Iorio's *La mimica degli anthich investigata nel gestire napoletano* (Naples 1832) – where hands play without question the central role – is thus, in our opinion, completely wrong. One need only consult the final index of gestures ("Indice terzo, De' gesti"), to realize that there are just three positions for the arms (plus one each for "elbow", "humerus", and "shoulders"), whereas "dita" and "mani" add up to a phenomenology of about 40 distinct positions ("dita curvandosi obliquamente l'uno dopo l'altro", "indice e medio rovesci, in diverse posizioni", and "mano e dita aperte, ed accostate al naso"...), for a total of about 150 occurrences. All of which is wholly incompatible with Warburg's observations on the human body.

4. "... and saw the skull beneath the skin."

We will return to Catoni's "desperate woman in motion" at the end of the pamphlet. Now, in entering the quantitative part of this study, we have to address a fundamental difference between computational art criticism, and similar work on literature or music. The latter have notational forms whose units are easily encoded, and whose grammar can also be programmed: with a little work, an algorithm can uncontroversially establish active and passive voices in *Ulysses*, or chart the occurrences of the bare fifth in Mahler. With Ghirlandaio and Dürer, we have no comparable segmentation of the language. Take Warburg's introduction of the *Pathosformel* via a series of images of Orpheus's death (**Figure 4.1**). You look at them, and easily recognize a formula that repeats itself at a distance of twenty centuries. But how can this intuitive similarity be actually *measured*?

Our answer came in three steps. First, we detached individual human figures from their context by enclosing each of them in a sort of "box" (**Figure 4.2**): if *Pathos* is expressed by the body, then we would focus on *nothing but* the body. Second, and more drastic, we eliminated color, clothes, faces, hands, and reduced bodies to mere skeletons (**Figure 4.3**). "One ought to first put in place each of the bones, and then add their relative muscles", Alberti had written in *Della Pittura*;[19] and after completing our work, we have also been told that painters and sculptors have long used mannequins that look a lot like our skeletons. But these are not the reasons we came up with the idea of the skeletons: they were not meant to reproduce the actual steps of the practice of painting (though, occasionally, they may also do that); they arose from the need to have a notational system made of simple units. And these twelve-stick figures provided just that: an alphabet for *Pathosformeln*. We knew we were losing a lot. But the alphabet mattered more.[20]

At this point, we took our third and most radical decision: we would measure only one kind of variable: the eleven angles of the body's joints, combined into "skeleton vectors". If *Pathos* is conveyed by "outward movements", "outstretched arms" and the like, then the angles formed by arms and legs would be a measure of it. Not "the" measure – with a complex concept, alternatives are always imaginable – but "a" measure for sure; a proxy for the work done by the muscles of our body. "Limbs extending into space [violate] the upright carriage [...] indicative of poise and control", a recent essay on the Cinquecento has observed;[21] and angles track their violation. Wider angle, greater violation, greater *Pathos*. It's not so simple of course, but this is the basis. Plus, angles allowed us to effectively ignore everything about the body itself (size, proportions, long legs, broad shoulders – whatever), to

Figure 4.1. A *Pathosformel* emerges. Left to right: detail of vase from Nola, Louvre, 470 BC; etching after 5th century BC vase from Chiusi, G.F. Gamurrini, *Annalii dell' instit. di corrisp. archeol.* 1879; Woodcut from Ovid, *Metamorphoses,* Venice 1497; Northern Italian engraving, late 15th century AD, School of Mantegna, Hamburg Kunsthalle; Albrecht Dürer, "Death of Orpheus", 1494, Hamburg Kunsthalle
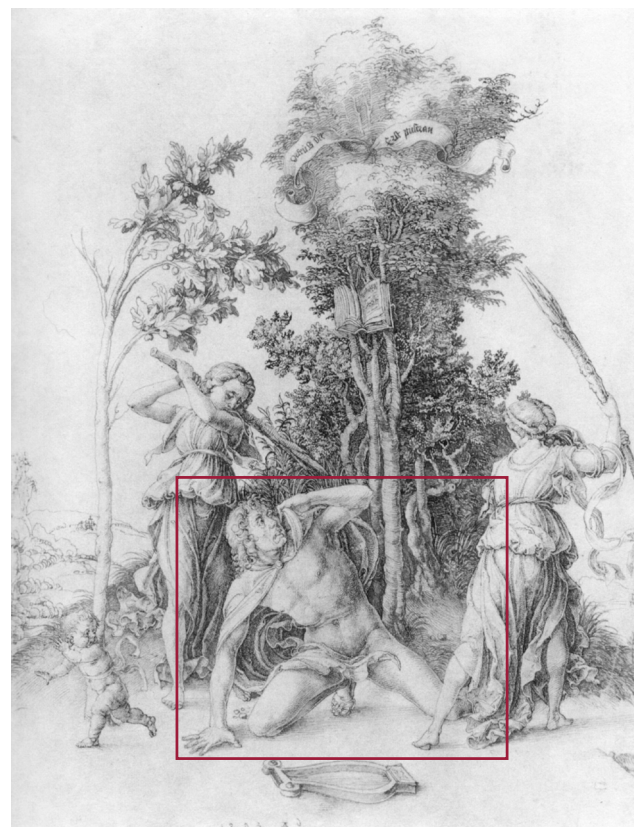

Figure 4.2. Extraction. The box around the body is created by drawing a line on the figure, from head to toe, and then using it to estimate a "bounding box" centered on the body, and enclosing its limbs.
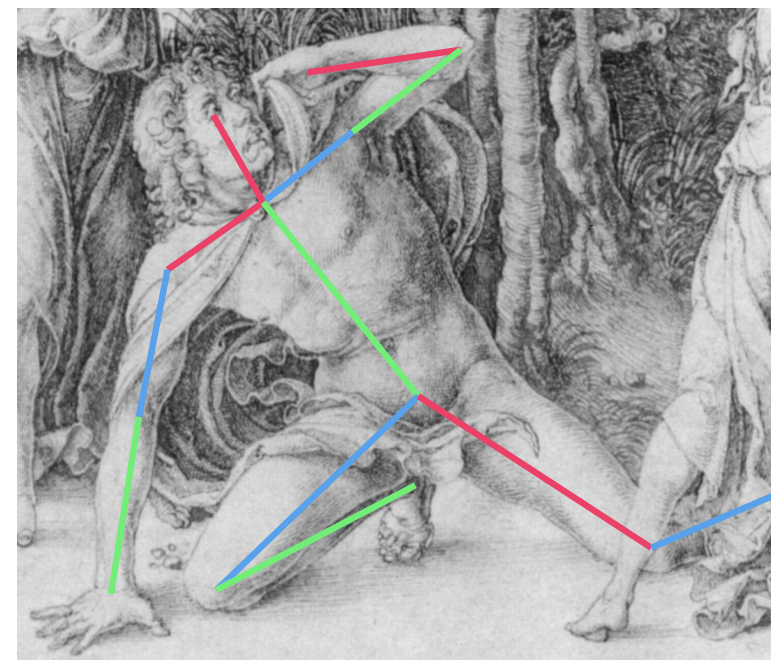

Figure 4.3. X-ray

Our skeletons are made of twelve segments – the lower and upper legs, the spine, the lower and upper arms, the shoulders, and the neck – which represent a compromise between anatomical accuracy and consistent reproducibility. The reason we have shoulders and not hips, for example, is that the latter are usually invisible – they lie, barely implied, below layers of clothing – and our initial experiments revealed that they would be tagged almost at random.

Figures in the *Bilderatlas* are often mirrored, rotated, and – in Greek pottery or constellation-maps – even upside-down. If left uncompensated, this spectrum of positions would quickly become the dominant feature in the data. We therefore rotate each skeleton so as to make the spine always vertical, and mirror the poses horizontally, so that the higher arm is always on the left. We thus end up with one angle per body-part, minus the spine, or eleven angles in total.

The decision to straighten the spine is clearly a questionable one – even more so, as several *Pathosformeln* (Laokoon in particular) involve a strong torsion of the trunk. But we could think of no alternative option – and, as we will soon see, the impact over the results seems to have been negligible.

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19 The passage is quoted by Salvatore Settis in "*Ars moriendi*: Cristo e Meleagro", *Tre figure*, cit., p. 102.

20 Christopher D. Johnson, *Memory, Metaphor, and Aby Warburg's Atlas of Images*, cit., p. 129, quotes a passage from Cassirer's *Language and Myth* that goes very much in the same direction: "If language is to grow into a vehicle of thought, an expression of concepts and judgments, this evolution can only be achieved at the price of forgoing the wealth and fullness of immediate experience. In the end, what is left of the concrete sense and feeling content it once possessed is little more than a bare skeleton."

21 Sharon Fermor, "Movement and gender in sixteenth-century Italian painting", in Kathleen Adler and Marcia Pointon, eds, *The Body Imaged. The human form and visual culture since the Renaissance,* Cambridge UP, 1993, pp. 141-3.

focus exclusively *on its movements*. Angles highlighted *the dynamism of the body*; the "life in motion" that Warburg had closely associated with *Pathosformeln*. And again, we may be completely wrong in our wager on angles; but it's a *conceptual* wager – an interpretation of the inner architecture of the *Pathosformel* – and not just a convenient way to measure things.

Eleven angles: that was all the algorithm had, to "recognize" *Pathosformeln*. But – what exactly is a *Formel*?

5. "From formulas to forms"

We began by pointing out the internal unbalance of the concept of the *Pathosformel*; dis-assembled it into *Pathos* and *Formel*, focused on *Pathos*, dissected it further into body, face, legs, arms... Now, the skeletons bring us into the realm of *Formel*: concrete images are transformed into "iconographic schemes" made of "discrete minimal units that are repeatable and combinable", to quote Catoni's essay (49, 69). Segments and angles are exactly that: discrete, minimal, combinable, and repeatable units.

But are the skeletons an instance of a "formula" – or of a "form"? The question may sound a bit precious, but the two concepts are not identical, and the difference seems to consist in this: that form has primarily, to quote the "Introduction" to *Mnemosyne*, an "anti-chaotic function":[22] faced with the whirlwind of passions and movements, form operates a selection of the materials to be represented, and organizes them into a structure. There is an *agonistic* quality to this process: *anti*-chaotic: "a conflict [...] between a forming power and a material to be overcome", as Panofsky put it in the essay on the *Kunstwollen*.[23] This sense of a struggle is missing from the idea of *Formel*/formula, which entails, first, a further reduction of the elements – a "smaller form", as the diminutive suffix suggests – but also, and more importantly, the completely new dimension of *time*. A formula is not just a "lesser" form, it's a form *that has learned to replicate itself*. Replication is always at the horizon of the concept of form: this is "the repeatable element in literature", as one of us had put it in an earlier essay;[24] made of "repeatable units", in Catoni's words. But: repeat*able*; not yet repeat*ed*. Formulas actualize what in forms is a mere potentiality; they are forms that have survived – that have achieved a *Nachleben*. Here, the two axes of *Mnemosyne* converge towards a common conceptual ground: "form", with its mastery of empirical chaos, emerges as the fundamental concept of aesthetic *morphology*, while "formula", with its permanence across time, functions as the cornerstone of an aesthetic *history*.

Final point. Form generates formula, and never viceversa. So, it's not surprising that formulas should elicit a vague sense of longing for that original that is only imper-

fectly visible in their replication. "Man will *zurück*", writes Nietzsche in the summer of 1885, reflecting on the nostalgia that for him characterizes German philosophy: "Men want to turn *back*, from the Church fathers to the Greeks, from the north to the south, from formulas to forms."[25] *Aus den Formeln zu den Formen*. But in the reality of things *we can only "see" forms because of their survival as formulas*: a form that has not turned into a formula is theoretically imaginable but – never having reproduced itself – would be practically unknowable. So Warburg was right, in anchoring his historical morphology on formulas rather than forms. And now, let's finally look at what a formula is like.

6. Ninfa

"What has happened?" writes André Jolles to Aby Warburg on December 23, 1900.

> *Cherchez la femme*, my dear. A young lady is playing with me a cruel game. [...] Am I running after her – or she after me? I no longer know. [...] Now she is Salome, dancing with her lethal charm [...] now Judith, proud in her triumph, carrying with bouncing steps the head of the murdered general. Now she seems to hide in the budding grace of little Tobias, striding bravely and happily [...] At times I see her in a seraphim [...] or in Gabriel, bringing the joyful message [...] in a maid at the Wedding, or in a terrified mother fleeing from the Slaughter of the Innocents. I have tried to see her again as I first had, in S. Maria Novella; but in the meantime, she has multiplied herself...

Salome, Judith, Tobias, seraphim, Gabriel, maid, mother ... This is what a formula is like. Always the same fundamental type, but in ever-changing embodiments. One of which was for Jolles and Warburg particularly arresting: the one Jolles had encountered in Santa Maria Novella – Ghirlandaio's basket-bearing maid, in the lower right corner of the "Birth of Saint John the Baptist", in the Tornabuoni Chapel (**Figure 6.1**). The Nymph, Warburg would call her, with a name that immediately evoked the *Nachleben der Antike*.

The Nymph and her Panel were for us the test case to see whether the skeleton-vectors worked. We took all fully-visible human bodies in Panel 46, turned them into skeleton-vectors, focused on the first principal component of the dataset – that is to say, on the single series of data that contained the highest variance (**Figure 6.2**) – and it was immediately clear that this single axis was enough to differentiate all the Nymphs in the panel, on the left side of the diagram, from all the other figures, on the right side (**Figure 6.3**).

Now, the principal component is not a feature chosen by the researcher – it's a statistical property of the data, independent of any subjective agenda. But, it perfectly separated nymphs from non-nymphs. Were sticks and angles a good proxy for Pathosformeln? In the case of the Nymph, yes: skeletons worked like fingerprints, singling out Jolles' young lady from all the other figures.[26] So, a new question became

Figure 6.1 "Ces nymphes, je le veux perpétuer"

"'Hurry-Bring-It' in the Tornabuoni circle. Domestication", reads Warburg's annotation to the panel. Visible in several images of Panel 46 – sometimes in a central position [46.11], sometimes peripheral [46.6], or even hidden in the background [46.5] – This figure is viewed from different angles, and moves in different directions; her figure is further developed in Panel 47 (as "head-huntress") and 48 ("Fortuna"), and becomes a central illustration of Warburg's concept of the *Nachleben*.

Creation of the Ninfa
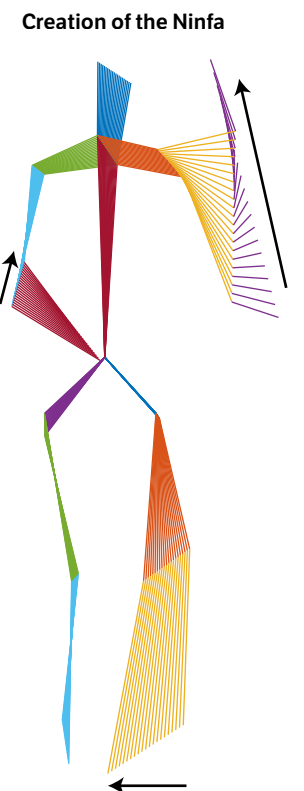
Figure 6.2 *Mnemosyne*, Panel 46: a synthetic representation of bodily movements

The "poses" in this figure have no correspondence with actual poses of the arms or legs of the bodies in Panel 46: they are the visualization of the principal component of the data – that is to say, of the direction of greatest variance. The reason the skeleton's arm seems to "move" more than its leg is due to the fact that the variance in the angles is greatest for the forearm than for any other limb.

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22 Aby Warburg, *Der Bilderatlas Mnemosyne. Einleitung*, cit., p. 3.

23 Erwin Panofsky, "Der Begriff des Kunstwollens", *Zeitschrift für Aesthetik und allgemeine Kunstwissenschaft*, XIV, 1920, p. 339.

24 Franco Moretti, "The Slaughterhouse of Literature", 2000, now in *Distant Reading*, Verso, London-New York, 2013.

25 Friedrich Nietzsche, *Werke. Kritische Gesamtausgabe*, hrsg. Giorgio Colli and Mazzino Montinari. Vol. 7.3, Nachgelassene Fragmente, Herbst 1884- Herbst 1885, Berlin-New York 1974, p. 413 (August-September 1885, 41[4]).

26 In so doing, the skeleton vectors also proved that the flowing hair and drapery so frequently evoked

imaginable: could the skeletons do the same at a larger scale than a single panel, potentially capturing all of Warburg's *Pathosformeln*? And beyond that, could they also be more than just fingerprints? Because a fingerprint identifies, yes, but it tells you absolutely nothing about the figure it has recognized. Identification is not analysis; possibly, it's not even really knowledge, except in a very narrow sense. Could our skeletons do better than that?

7. Clusters

First question first. To see whether skeleton-vectors worked on a larger scale than a single panel, we extracted 1,665 bodies from 21 of the 63 panels of the *Atlas*, and ran a k-means clustering algorithm that divided the skeleton vectors into 16 clusters.[27] Sixteen was a pragmatic compromise between two opposite pitfalls: too few clusters, and dissimilar poses end up together, making clusters inconsistent; too many, and similar poses are forcibly separated, which is also wrong. A two-dimensional reduction of the eleven dimensions of our data (**Figure 7.1**), in which the 16 clusters were quite well-separated, suggested that our choice was within a plausible range – and so, 16 clusters it was.

Now, each of these clusters grouped together morphologically similar bodies, arranged in order of their similarity around the cluster's "central" skeleton-vector (**Figure 7.2**). But each cluster was more complicated than these 16 figures suggest, as it was processed by an agglomerative hierarchical algorithm, which produced a tree of the distances among skeleton-vectors, and among the poses they corresponded to. (**Figure 7.3**)

With this *Totentanz* of skeletons – some clusters have hundred of them, seemingly engaged in an endless round dance – our step-by-step operationalization of *Pathosformeln* had reached its conclusion. If the logic we had followed was sound, the angles that measured the distance of the limbs from the central axis of the body should have succeeded in identifying the "state of excitement" – the *Pathos* – War-

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by Warburg, and even more by his interpreters (especially when writing about Ghirlandaio's maid), play no essential role in the representation of *Pathos*: they were of course entirely absent from our measurements – yet the *Pathosformel* of the Nymph emerged with perfect clarity (a fact that would be confirmed by all subsequent experiments). Garments and hair may perhaps *add* some emotional meaning, but are not indispensable to the evocation of inner emotion.

27 Moving beyond the scale of a single panel had to confront the fact that the resolution of the Bilderatlas' original plates is not good enough to identify many of the smaller human figures; we thus spent a considerable amount of time finding higher-resolution versions of the images for the skeleton annotations; subsequently, human figures were cropped out, and the positions of the limbs drawn by manual annotation, using three separate annotations per body for consistency. We describe this process in detail in: Leonardo Impett and Sabine Süsstrunk. "Pose and Pathosformel in Aby Warburg's Bilderatlas." *European Conference on Computer Vision*. Springer LNCS, vol. 9913, 2016. This is the reason our corpus is limited to about one third of the Atlas' panels. More recent experiments have however suggested that some computer vision techniques can automatically estimate human poses quite reliably, making a skeleton-vector analysis of much larger image collections imaginable. Subsequent results will be available at warburg.epfl.ch.
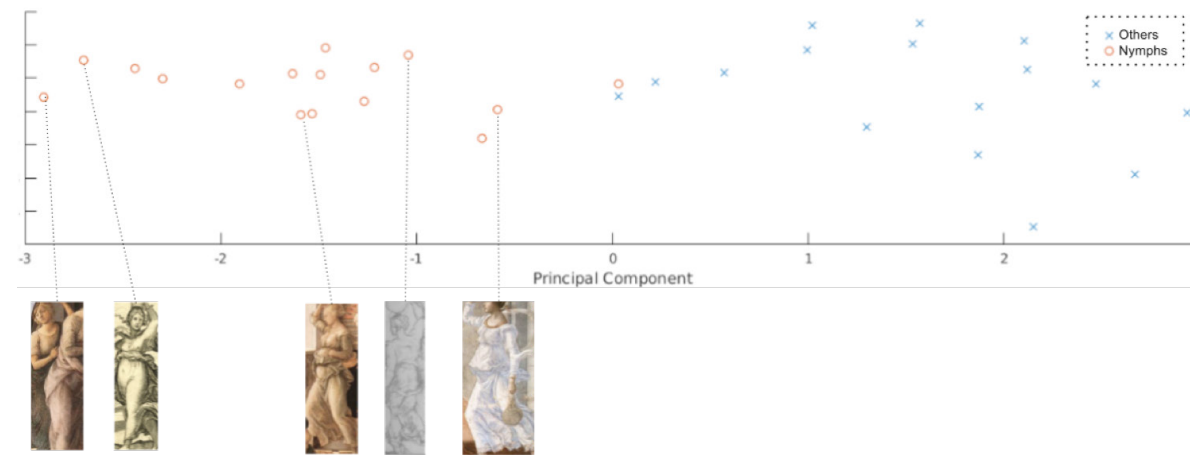

Figure 6.3 *Mnemosyne*, Panel 46: quantitative data and image separation

Figure 7.1 *Mnemosyne's* morphological clusters: a two-dimensional view

Clustering is a computational tool that uses numerical values to place objects that are "near" in the same cluster, and those that are "far" in a different one; our hope was for the algorithm to filter poses in such a way as to separate *Pathosformeln* from the other images, and, ideally, suggest possible relationships among them.
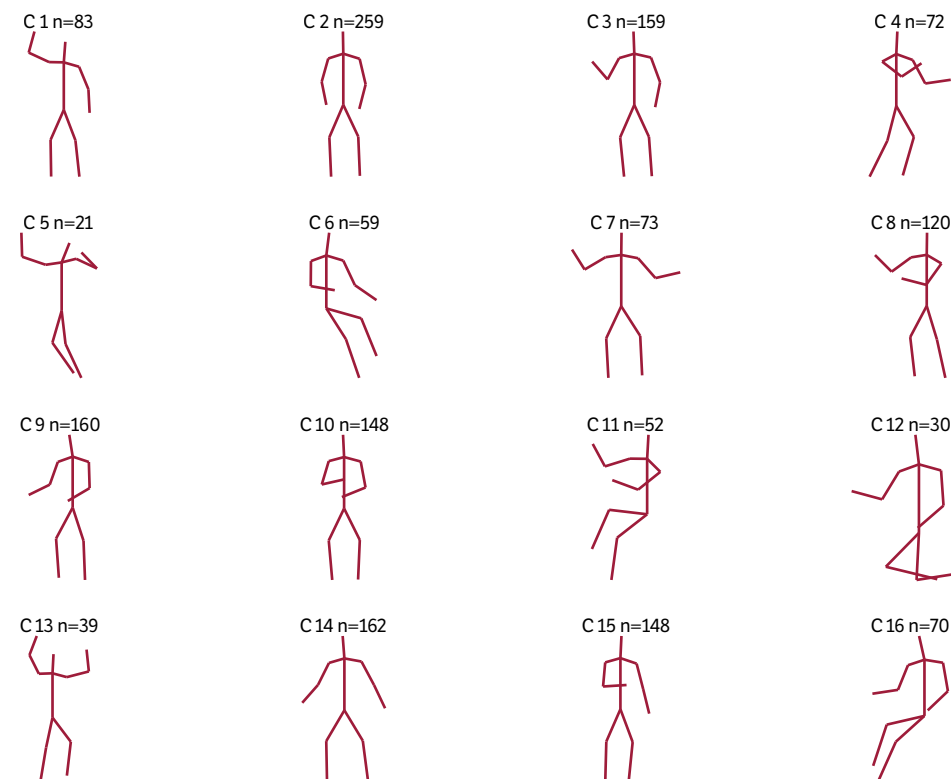

Figure 7.2 Totentanz

A cluster is defined entirely by its center-point, and each skeleton-vector "belongs" to a given cluster if it is closer to its center-point than to any other's. Conversely, the center-point is itself defined as the average of all the cluster's members. The K-means clustering algorithm is a recursion between these two definitions, until they are perfectly consistent with each other.
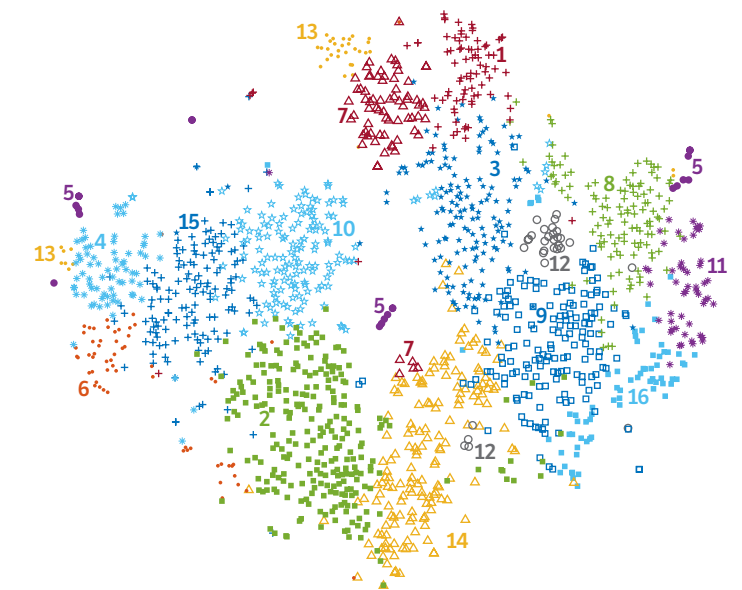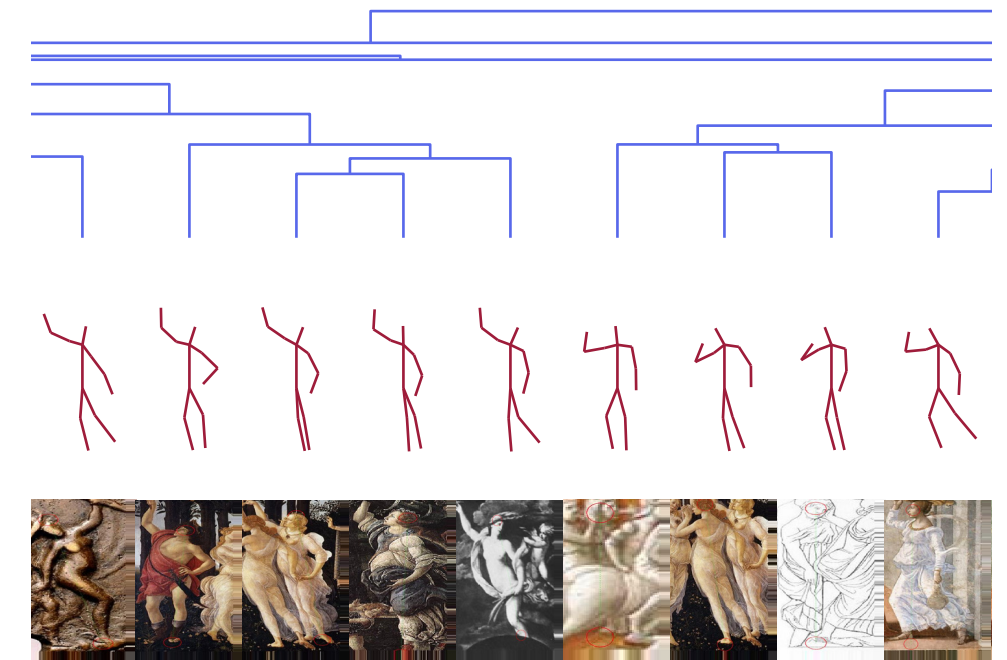

Figure 7.3 An example: cluster 1

A section of cluster 1, indicating the tree of distances between the various skeletons, and the images from which the skeletons have been abstracted (under the image are listed a series of metadata – panel and image number, date of the original work, and so on). The relationship between *all* the skeletons in a cluster and the "central" skeletons of **Figure 7.2** is analogous to that between formulas and forms: the nine skeletons in this image (and the other 74 that compose the full cluster) are as many variations on the same basic morphology.
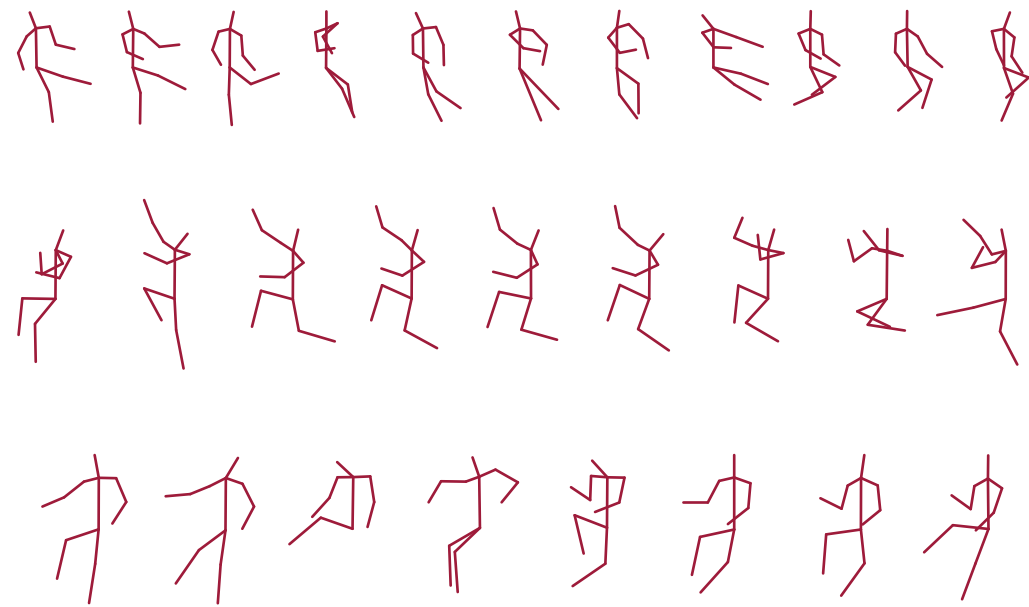
Figure 8.1 Agitated skeletons ...

Figure 8.2 ... but perfectly stable bodies. Two kneeling warriors. Florence, 1465; The blood of the Redeemer. Bellini, 1460; The banquet of Herod. Ghirlandaio, 1485-90.; The banquet of Herod. Filippo Lippi, 1464 (all cluster 11); Birth of St. John the Baptist. Ghirlandaio, 1486 (cluster 16)

burg had in mind. To see whether this was the case, we turned back from the skeletons to the paintings.

8. "Life in motion"

At a first glance, **Figure 7.2** seemed to include seven "agitated" clusters: 1, 5, 6, 7, 11, 13, 16. But they quickly fell into very different groups. Clusters 6, 11, and 16 were just a misreading: though the skeletons looked unsettled (**Figure 8.1**), the bodies from which they had been extracted were actually perfectly stable: kneeling, lying down, sitting and so on (**Figure 8.2**). This was a cautionary tale about the flaws of our procedure: we had started by "boxing" bodies and abstracting them from their context, and whenever body and context were strongly linked this of course worked poorly. So, we excluded clusters 6, 11, and 16 from further analysis.

Next came cluster 5. In purely geometric terms, this was the most "agitated" cluster of all (**Figure 8.3)**; but the agitation turned out to be the result of odd positions, mostly in vases and astrological maps (**Figure 8.4**), which had nothing to do with *Pathos*. Second cautionary tale, less obvious than the first: there is a correlation between physical posture and inner emotional state – that's the whole idea of the *Pathosformel*: *Pathos* is made visible through bodily movements – but the correlation is not a linear one in which the "superlative of emotion", as Warburg calls it, corresponds to a "superlative of physical agitation". *Pathos* does require physical turbulence, and extreme *Pathos* does seem to occupy a specific position within
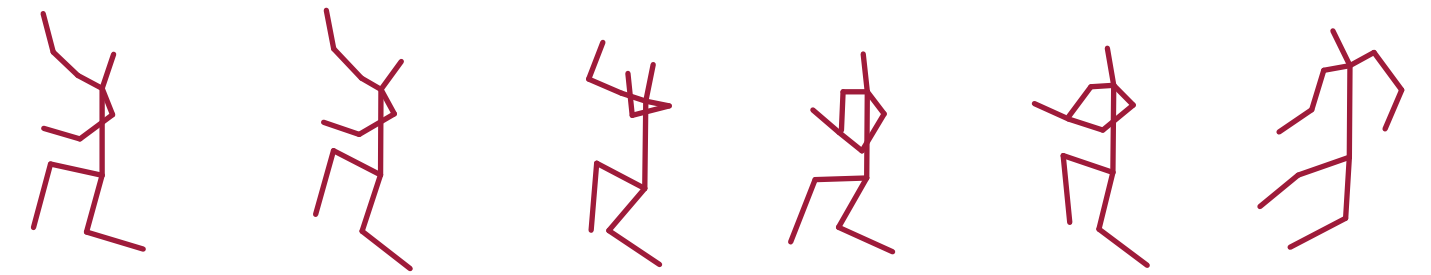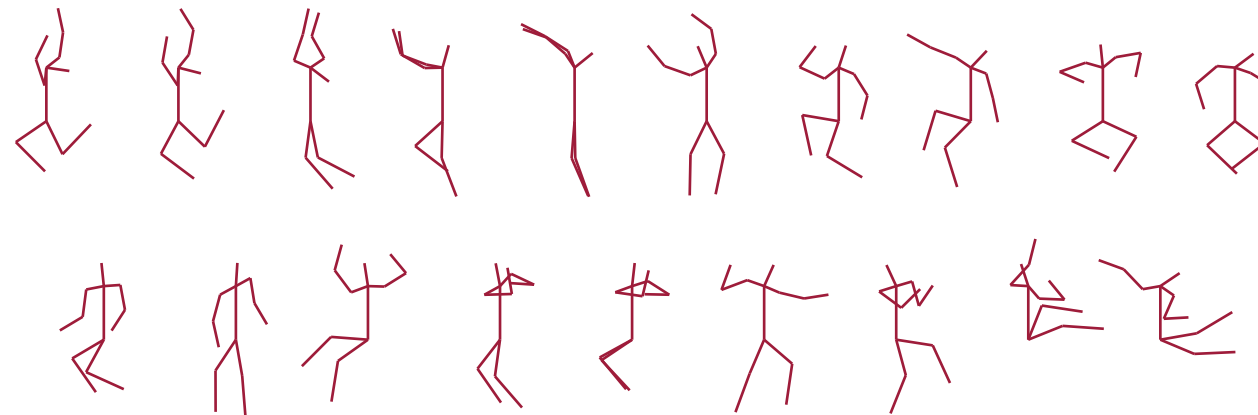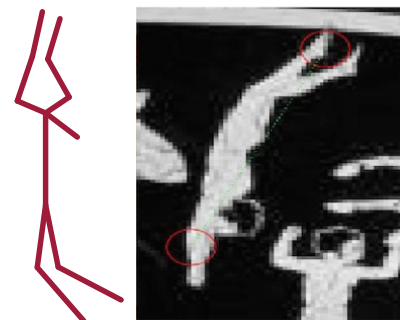

Figure 8.3 Somersaults ...

Figure 8.4 ... without *Pathos*

A star, personified as a young boy, running away from the Sun (Puglia 420 BC). In Furtwangler and Reichold, *Griechische Vasenmalerei*, Munich 1921-32.

The legend of Perseus on the Greek celestial globe. Reproduced in 'M. Manilii Astronomicon', Richard Bentley, London 1739.

the spectrum of possible movements – but it's not the *extreme* position. It's more interesting than that.

This left three clusters, which were those where *Pathosformeln* finally began to emerge: cluster 7 (**Figure 8.5**)**,** 13, (**Figure 8.6)** and especially, cluster 1, which included the largest number of those Warburg himself had explicitly indicated as *Pathosformeln* (**Figure 8.7**): the Headhuntress, the nymph from Ghirlandaio, Fortuna, nymphs from Botticelli, Laokoon, and Orpheus.

If one now returns to the two-dimensional reduction of the 16 clusters of **Figure 7.1,** it's easy to notice the three *Pathosformeln*-rich clusters at the top right of the distribution: at once close to each other, and peripheral with respect to the other 13 clusters. **Figures 8.8-14** break down the overall distribution, moving from the bottom center towards the periphery, in a crescendo of movement: from the figures at rest of **Figure 8.8**, to the more spread out distribution of images of moderate movement (holding, greeting) of **Figures 8.9-10**, the apparent agitation of figures that are actually kneeling and sitting (**Figures 8.11**), the extremely scattered cluster of astrological images (**Figure 8.12**), and finally the three genuinely agitated clusters of **Figure 8.13**.

So, the algorithm had indeed worked above the scale of a single panel, identifying the *Pathosformeln* and separating them from the other images of the human body; the way was open for an enlargement of the *Mnemosyne* project well beyond what Warburg had himself been able to do. But there was something strange about these findings. We were hoping the algorithm would separate *Pathosformeln* from all other figures – and that had indeed happened. But we were also hoping the algorithm would separate *Pathosformeln from each other* – and that, clearly, had not happened at all. *Pathosformeln* clustered together, in a small corner of the distribution. Why? Warburg usually speaks of *Pathosformeln*, plural, implying that there is a difference between the formula for Orpheus, the headhuntress, the imperial conqueror, Fortuna, and so on. "To each *Pathos* its schema", as Settis had put it in "Pathos und Ethos" [45]; and in Warburg's notebooks there is an early page which outlines a "Schematismus der Pathosformeln" – a large spreadsheet subdivided into rows for "running", "dancing", "pursuit", "triumph", "victory" and so on.[28] We, too, had been expecting a differentiation of that kind. And instead, this. Why were the Ninfa and Laokoon close to each other, or Fortuna and the dying Orpheus?

9. Oxymoron

Clearly, the algorithm had "seen" a similarity among the *Pathosformeln*' skeleton vectors, which seemed to consist in this: *Pathosformeln* were all correlated to a *simultaneous movement of both arms and legs*; arms more than legs usually, for both anatomical and cultural reasons – they are easier to move, and can do many

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28 See Claudia Wedepohl, "Von der 'Pathosformel' zum 'Gebärdensprachatlas' ", in M.A. Hurttig and T. Ketelsen, eds, *Die entfesselte Antike. Aby Warburg und die Geburt der Pathosformel*, Walther König, Köln 2012, p. xx. In the photograph Wedepohl includes in her essay, the page seems to have remained completely empty.
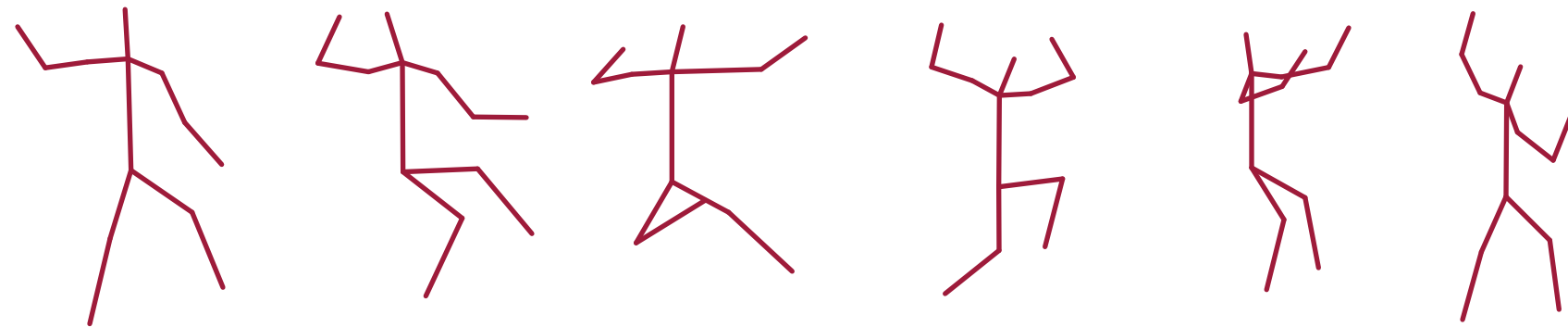

Figure 8.5 Cluster 7   a   b   c
a) Pedagogue, from the group of the Niobides; Roman copy of Greek sculptures of the end of the 4th century BC; b) The Astrologer (formerly: St. John of Patmos). Portuguese painter, 15th century; c) The death of Pentheus. Pompeii, 45-79 AD.
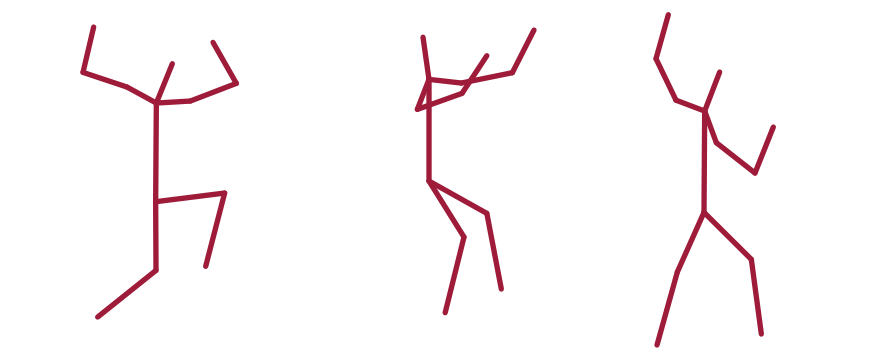

Figure 8.6 Cluster 13   a   b   c
a) Farnese Atlas, 50-25 BC. Roman copy of a Greek original from the second century BC; b) Lives of the Saints. Jacopo del Sellaio, second half of the 15th century; c) The death of Saint Peter martyr. Ghirlandaio, 1485-1490.
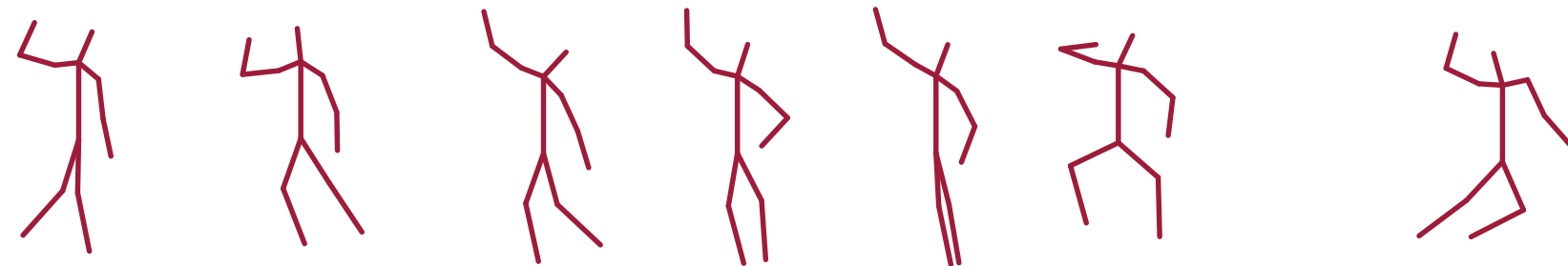

Figure 8.7 Cluster 1   a   b   c   d   e   f
a) Judith's maid bearing the head of Holophernes. Ghirlandaio, 1489; b) Ninfa. Ghirlandaio, 1486; c) Fortuna grabbed by Kairos. Camillo Agrippa's medal, 1580; d) Spring. Botticelli, 1485-87; e) Laokoon, first century AD (?). Our image has Laokoon's right arm bent backwards, as a result of the post-1957 restoration of the statue, whereas in Warburg's *Atlas* the right arm was extended upwards. Though the detail is clearly quite meaningful, it does not change the cluster to which the image belongs: we inserted both Laokoons in our corpus, and they both fell within cluster 1; f) Death of Orpheus. Detail of a vase from Nola, 4th century BC.

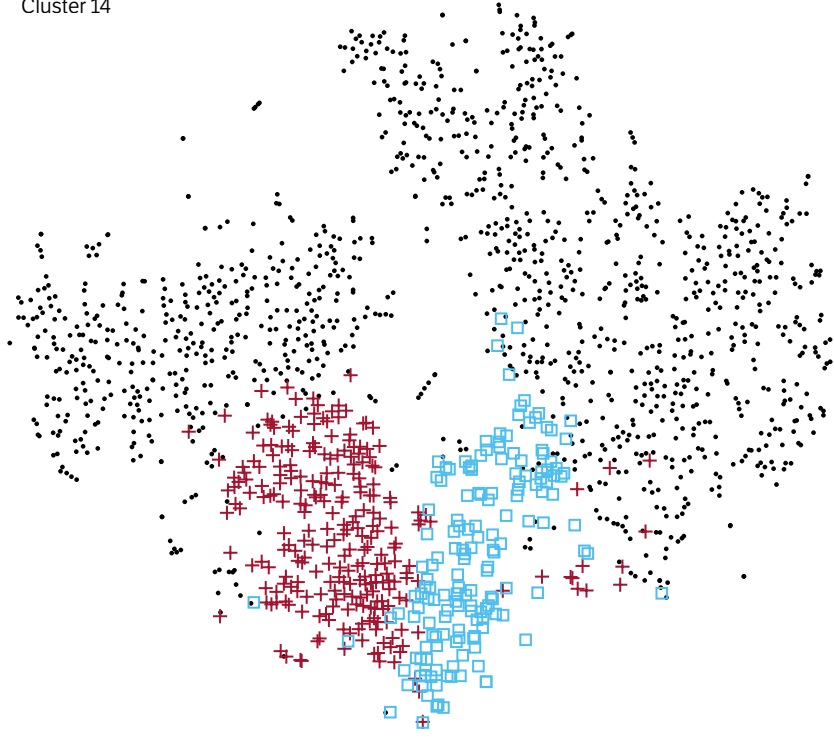**Figure 8.8**
- • Others
- + Cluster 2
- □ Cluster 14

Figure 8.9
- • Others
- + Cluster 3
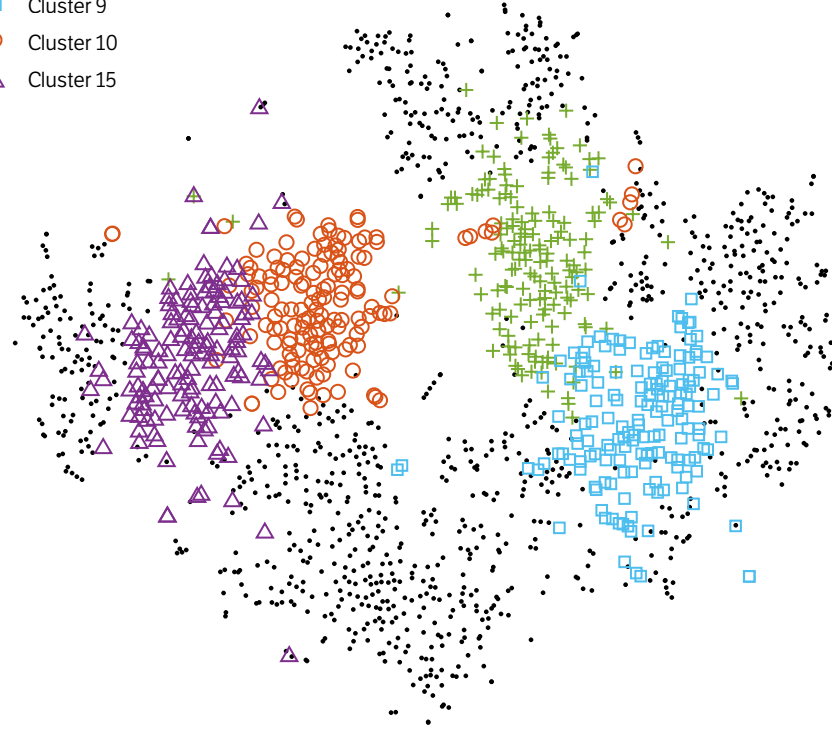- □ Cluster 9
- ○ Cluster 10
- △ Cluster 15

Figure 8.10
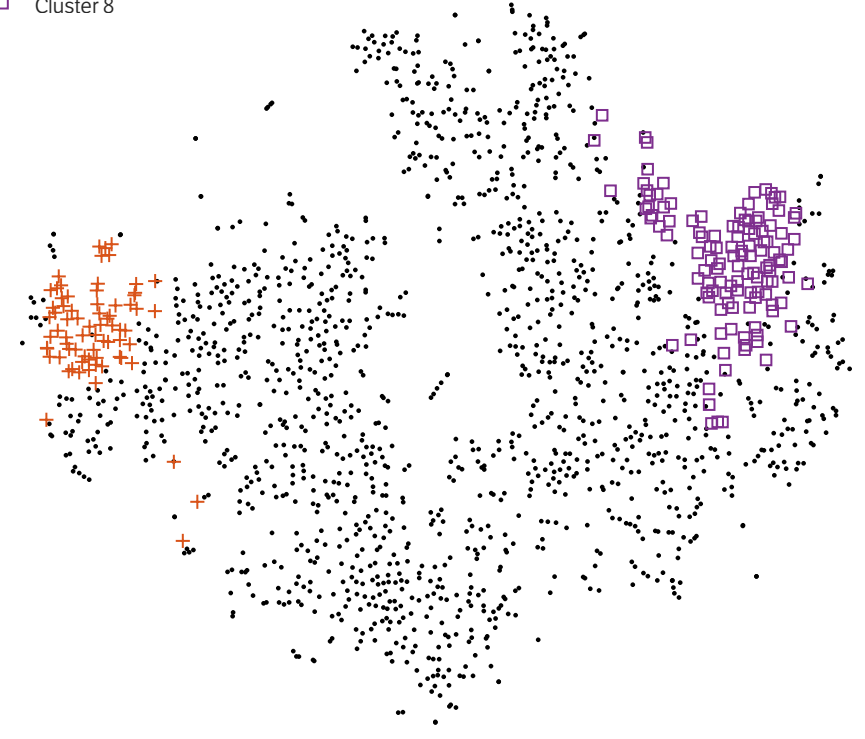- • Others
- + Cluster 4
- □ Cluster 8

Figure 8.11
- • Others
- + Cluster 6
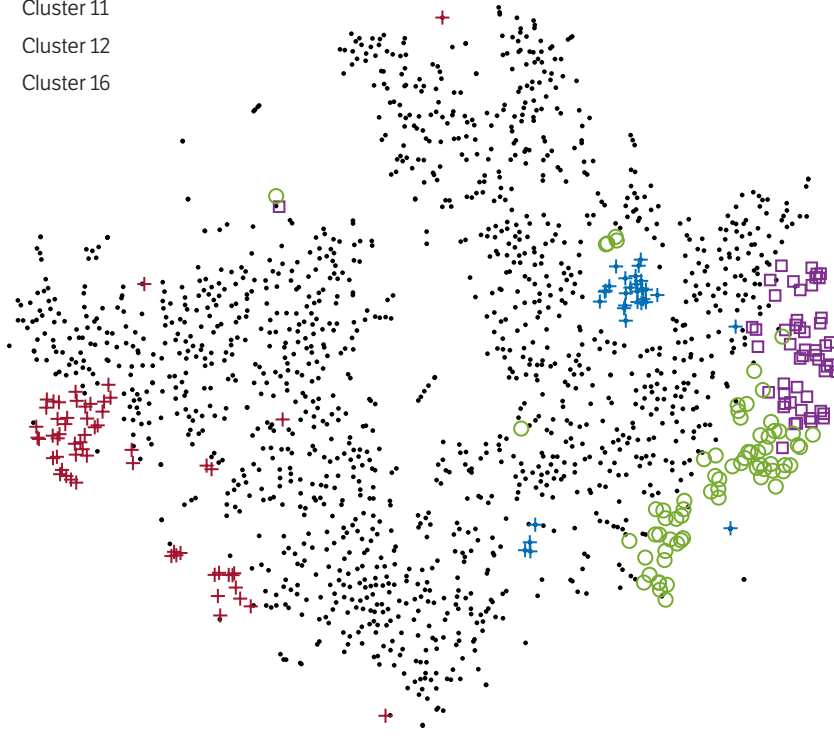- □ Cluster 11
- + Cluster 12
- ○ Cluster 16

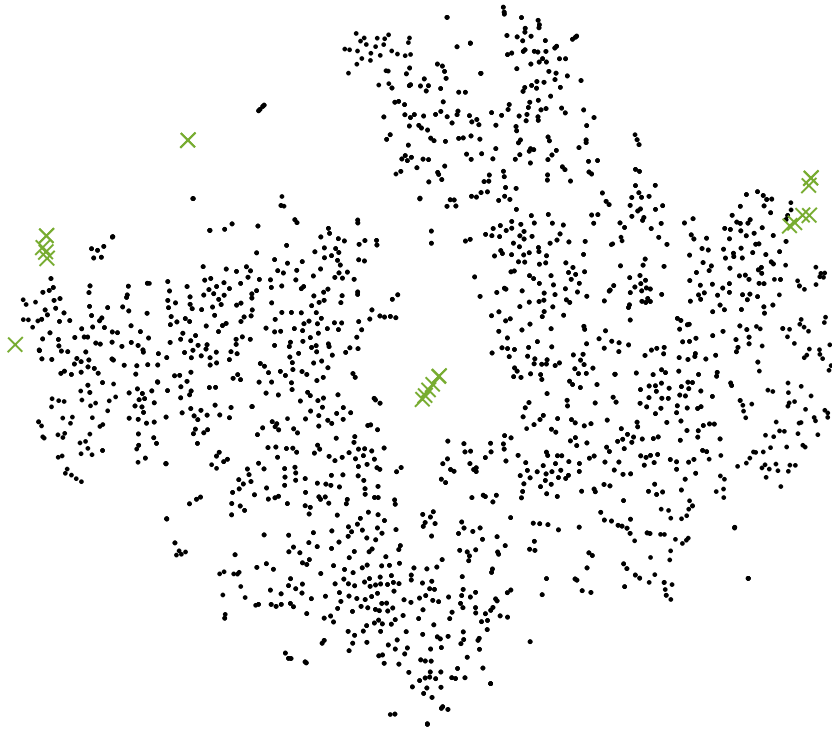**Figure 8.12**
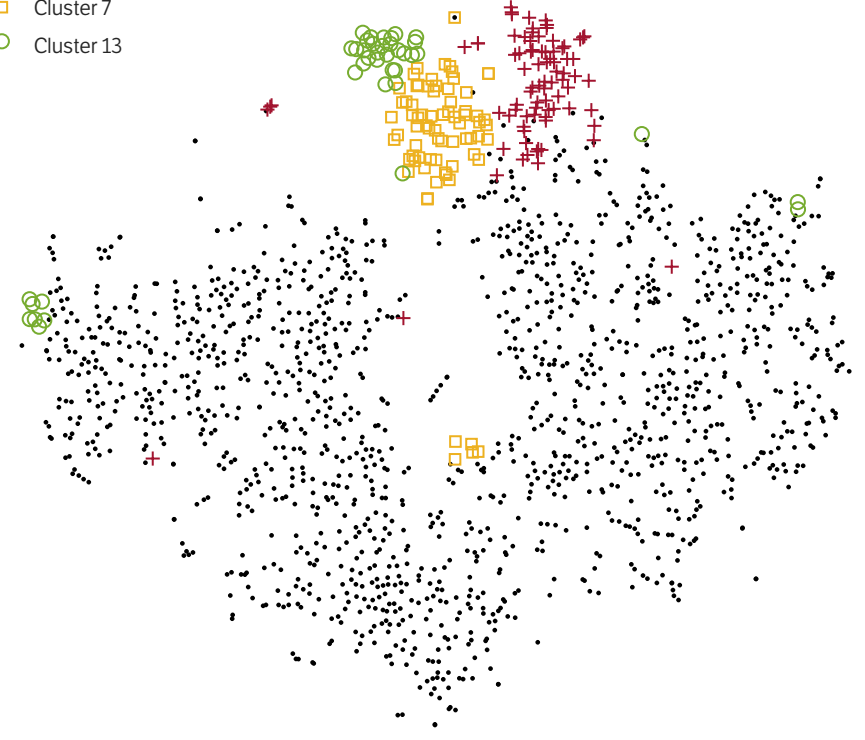- • Others
- ✕ Cluster 5

Figure 8.13
- • Others
- + Cluster 1
- □ Cluster 7
- ○ Cluster 13

more things – but as a rule both. This was the shared morphological feature around which the algorithm had clustered *Pathosformeln* together.

In *Meaning in the Visual Arts*, Panofsky compared this double movement of the *Pathosformel* to the *contrapposto*, or "counterpose", of much Western sculpture.[29] It's an interesting intuition, but mostly because of the *differences* between the two conventions. In the *contrapposto*, legs and arms are typically very well coordinated; whether in waiting (**Figure 9.1**) or in action (**Figure 9.2**), upper and lower body are involved in a single fluid movement. These are superbly *unified* bodies. *Pathos*, breaks the unity. That's it's signature. Arms and legs are committed to *separate* movements: carrying a basket, and walking a little too fast (Ninfa); supporting the earth, and trying not to slip under its weight (Atlas); holding the sail, and keeping one's balance on the waves (Fortuna); trying to protect himself from deadly blows, and to stand up (Orpheus); keeping snakes at bay, and attempting to move (Laokoon). These are bodies fighting on two fronts at once: arms struggling with one threat, and legs with a different one. A dissonance is inserted between the upper and the lower part of the body.

We took these images to Aminian Kamiar, who teaches bio-mechanics at EPFL, and he observed that these were all very unstable poses, that couldn't be held for long. Which makes sense, they represent movement, and it's awkward to stop in mid-stride.[30] Tasha Eccles, at Stanford, pointed us in a different direction, mentioning the "Lifeforms" software, developed by Tecla Shiphorst and Merce Cunningham, which had allowed dance choreography to subvert in a profoundly counterintuitive way the spontaneous coordination of the parts of the body. Lifeforms "expands what we think we can do", Cunningham explained; "on the computer the body is represented by joints", added Shiphorst (with a sentence that applies just as well to our skeleton vectors), and this reduction allowed to create "something that was not natural". Not natural; this is the key. The "superlative of emotion" is not expressed by a "superlative of physical movement" – the somersaults of Cluster 5 we have examined above – but by this *calling into question the "natural" unity of the body*. Dissonance. *Passiones* "as agitation", writes Auerbach: "as motion, but in an aimless and undirected way".[31] The sign of *Pathos* is that the body is no longer one. *Je est un autre.*

Now, we are quite confident about the morphological aspects of our findings. When it comes to interpreting their anthropological or aesthetic meaning, however, we feel much more in the dark. On this, the best starting point remains Catoni's "desperate woman in motion" of **Figure 3.5**. "The contradictory movements of her arms on one side, and of her legs, body and head on the other, generate an oxymoron of sorts", she writes:

> her body has the narrative meaning of an affirmative verb – running to help – while the violent backward thrust of the arms declares its impossibility, thereby negating it. [67-8]

Negating with the arms what is affirmed by the rest of the body: oxymoron is the right word for this body in enigmatic conflict with itself. The desperate woman is a *Pathosformel* of a superlative kind, Catoni writes, and there is no doubt about it; but one could go further: this is not "a" *Pathosformel*, this is *the limit-case for the very idea of the Pathosformel*. And like all extreme cases, it has an epistemological clarity that other instances lack. If *Pathosformeln* present us with a series of disjointed bodies, the "desperate woman" seems for her part to represent *the abstract sign of disjunction itself*. The image is not part of Warburg's corpus, but in the *Atlas* there is a Maenad that resembles it because of the position of her arm – and see what an absolute outlier that detail makes her (**Figure 9.3**).

We are often asked about the relationship between close and distant reading, qualitative and quantitative, individual case and large aggregates. Catoni's work and ours are radical instances of the opposite approaches: hers, a concete philological reconstruction that connects, one by one, a whole chain of individual images; ours, an abstract geometrical pattern that mixes together completely unrelated figures. Couldn't be more different. But if one resists the temptation of declaring the two methods incompatible – if one just looks at what **Figure 9.3** shows, then a relationship emerges: the "desperate woman" indicates the direction – the oxymoron – towards which our small army of skeletons is also heading; while the fact that there *is* a small army behind her shows that the body-as-oxymoron is not an isolated aberration, but the logical unfolding of the inner structure of all *Pathosformeln*. Quantity and quality remain different; but they illuminate each other. And this, is enough.

Figure 9.1. David, Michelangelo, 1504, Galleria dell'Accademia, Florence

Figure 9.2. The Townley Discobolus, Roman copy of a 5th century B.C. discobolus by Myron, British Museum, London

Figure 9.3

29 Erwin Panofsky, *Meaning in the Visual Arts*, 1955, Penguin, Hammondsworth 1970, pp. 311-2.

30 This is true even for the Nymph, the most "domesticated" (Warburg's word) of these figures: for someone carrying a basket on her head, walking fast is not a good idea (not for nothing do most commentators wonder at her pace, and don't know how to explain it). That said, considering Ghirlandaio's figure a *Pathosformel* – as has been done by Warburg and most of his commentators – seems to us to stretch the meaning of the image, whose point consists more in *controlling* a possible original *Pathos*, than in expressing its pure and simple *Nachleben*. In this sense, Ghirlandaio's nymph is one of those interesting cases in which the interpretation of an image does not follow from its quantitative morphology, but is somewhat at odds with it.

31 Erich Auerbach, "*Passio* as Passion", *cit.*, p. 168. See also Froma Zeitlin's observations on the body in Greek tragedy: "what interests the audience most in the somatics of the stage is the body in an unnatural state of *pathos* [suffering] – when it falls furthest from its ideal of strength and integrity [...] reduced to a helpless or passive condition – seated, bound, or constrained [...] in the grip of madness or disease."

Froma I. Zeitlin, "Playing the Other: Theater, Theatricality, and the Feminine in Greek Drama", in John J. Winkler and Froma Zeitlin, eds, *Nothing to do with Dionysos? Athenian Drama in its Social Context*, Princeton UP, 1990, p. 72.