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# A Proposed Number System for the 107 Cortical Areas of Economo and Koskinas, and Brodmann Area Correlations

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**Key Words**
Human cerebral cortex · Cytoarchitectonics · Economo-Koskinas Atlas · Brodmann area correlation

**Abstract**
In their *Atlas of Cytoarchitectonics of the Adult Human Cerebral Cortex*, Economo and Koskinas defined 54 'ground,' 76 'variant,' and 107 'modification' areas. The 107 modifications are topographically distributed as 35 frontal, 13 superior limbic, 6 insular, 18 parietal, 7 occipital, 14 temporal and 14 inferior limbic (or hippocampal). One way to make the Economo-Koskinas system more practical is to encode the complex symbol notations of the 107 cortical areas with numbers EK 1 through EK 107. The present study does that, and it further correlates Economo-Koskinas areas with Brodmann areas, based on an overview of the classical and modern neurohistological literature.


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## Introduction

The aim of this paper is to provide a concise overview of the cortical parcellation scheme into 107 areas proposed by Economo and Koskinas in their *Atlas of Cytoarchitectonics of the Adult Human Cerebral Cortex* [1], and to make more practical an otherwise not easily accessible source of information. Despite the general familiarity among neuroscientists with the Brodmann areas (fig. 1a, b), the present study, along with the preceding paper [2], attempts to make the Economo-Koskinas classification (fig. 1c, d) an option for any modern researcher who opts to follow it.

The topographic distribution of the 107 areas of Economo and Koskinas is summarized in table 1. On pages 218–220 of chapter 5 in their text volume [1], Economo and Koskinas number their 107 cortical modifications (table 2). One way to make the Economo-Koskinas (EK) system more practical [3] is to encode the complex symbol designations of the 107 cortical modifications with numbers EK 1 through EK 107 (table 2 and fig. 2, 3). Table 2 provides the original symbol designations and area names, along with corresponding Brodmann areas [4, 5]. Besides the books of Economo and Koskinas [1], Marburg [6], and Bonin [7], several modern papers [8–23] have been especially helpful in compiling the Brodmann area (BA) juxtapositions for table 2.

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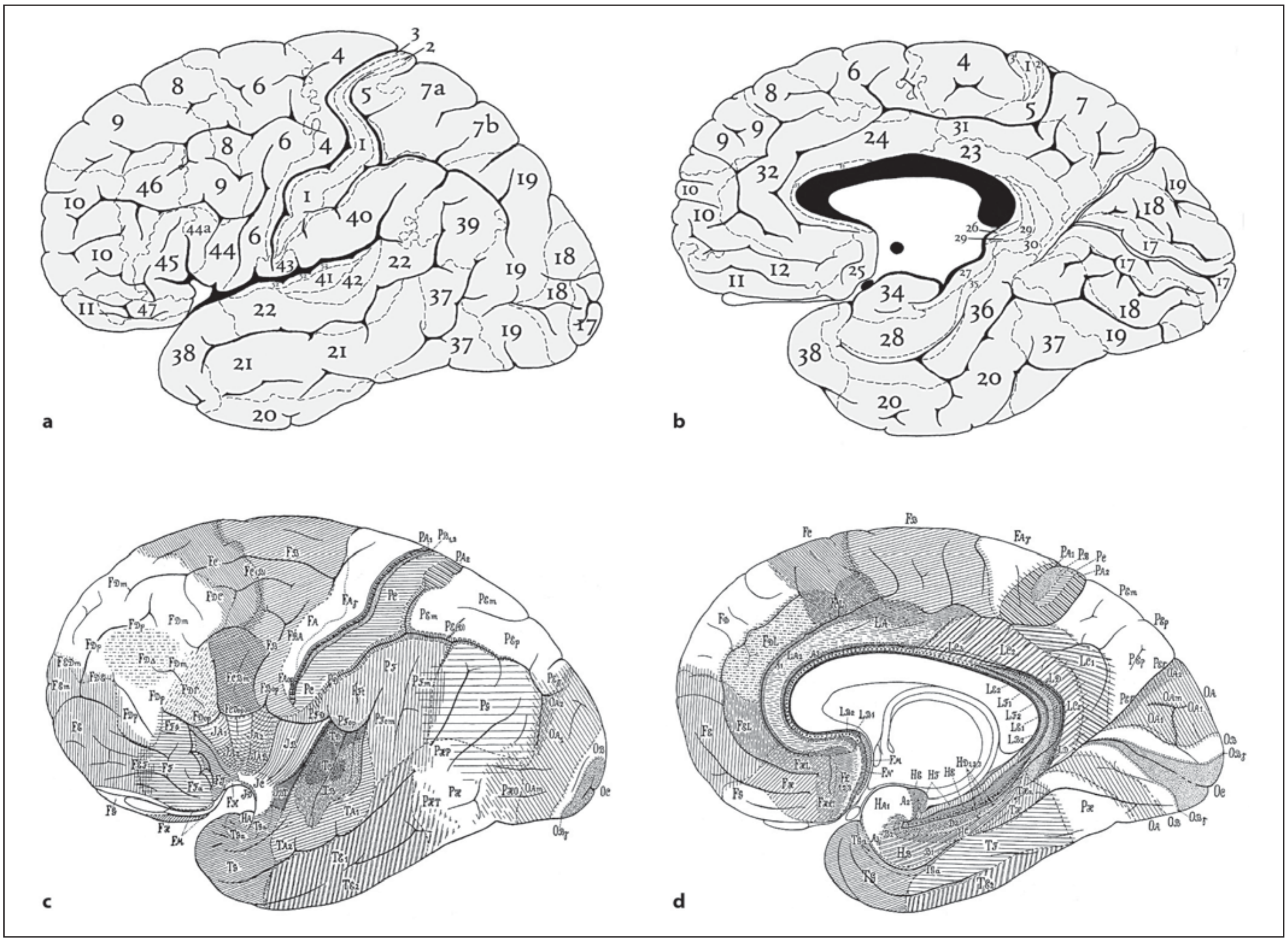


**Fig. 1.** Cytoarchitectonic cortical area maps of the convexity (**a**, **c**) and median facies (**b**, **d**) of the human cerebral hemispheres to show the relationship between Brodmann (**a**, **b**) and Economo-Koskinas (**c**, **d**) area divisions. Brodmann [4] used a numbering system, and Economo and Koskinas [1] a lettering system (cf. table 2 for area correlations in tabular form). Maps **a** and **b** newly redrawn by the author, based on Brodmann figures 85 and 86 [4] included as figures 6 and 7 by Economo and Koskinas in their text volume [1]. Maps **c** and **d** correspond to figures 19 and 20 in Economo and Koskinas [1], reproduced with the kind permission of Rights and Permissions Department, Springer-Verlag GesmbH, Vienna.

**Table 1.** Distribution of the 107 numbered modification areas of Economo and Koskinas [1] in the human cerebral cortex

| Lobe | Total number of areas | Numbering codes |
|---|---|---|
| Frontal | 35 | EK 1–EK 35 |
| Superior limbic | 13 | EK 36–EK 48 |
| Insular | 6 | EK 49–EK 54 |
| Parietal | 18 | EK 55–EK 72 |
| Occipital | 7 | EK 73–EK 79 |
| Temporal | 14 | EK 80–EK 93 |
| Inferior Limbic or Hippocampal | 14 | EK 94–EK 107 |

## Frontal Lobe

Frontally, in the region of architectural structure F*C* (EK 6) – which is larger in size than its homologous BA 8 [18] – one finds on the third frontal gyrus Broca's area for motor speech, and dorsally on the second and first frontal gyri in area F*C* the centers for the combined trunk, head and eye movements especially for the so-called 'spying' movements of the eyes on the second frontal gyrus [24]. All these movements are presentations of attention. As with speech, such movements involve many mental components and it is remarkable that this fact is expressed in

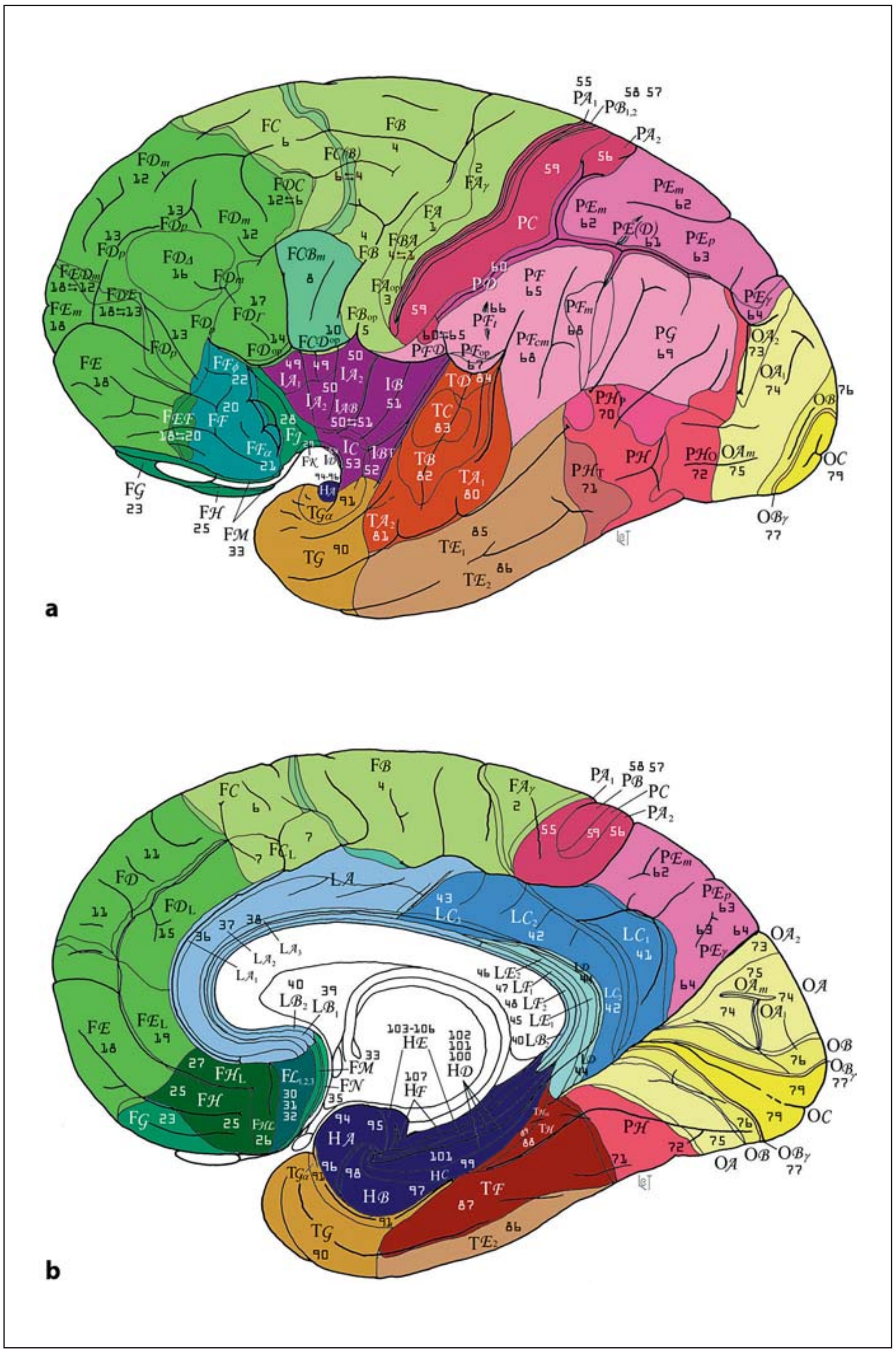


**Fig. 2.** Convexity (**a**) and median facies (**b**) of the human cerebral hemispheres. Economo-Koskinas cortical cytoarchitectonic areas are depicted in both the original lettering system and with EK area modification numbers (provided on pages 218–220 in chapter 5 of their text volume [1] and listed in table 2). Bidirectional arrows (⇆) have been used to denote transitional types of cortex. The Sylvian fissure is laid open in the lateral view, and the hippocampal and callosal sulci are laid open in the median view to expose deeper-lying structures. The color-coded representationof the seven lobes and their subregions is based on figures 96 and 97 of Economo and Koskinas [1] (cf. fig. 1c and d in the companion article [2]), with shade variations to indicate different regions, as well as variant, overlapping or transition areas. A model of the human brain, with the various fields of the cortical surface indicated in colors by Economo, was commercially available in the 1920s from Fabrikation Chirurgischer Instrumente Carl Reiner (Mariannengasse 17, Wien IX). Economo used models and demonstration in his December 3, 1929, lecture at the Section on Neurology of the New York Academy of Medicine; one such model is exhibited at the Institut für Geschichte der Medizin (Institute for the History of Medicine) of Vienna University, alongside Economo's death mask. Area initials and lobe coloring: F, frontal (green); L, superior limbic (blue); I, insular (violet); P, parietal (red); O, occipital (yellow); T, temporal (brown); H, hippocampal (deep blue). Cytoarchitectonically defined lobe boundaries do not coincide exactly with the usual gross anatomical boundaries, especially in the parietal and occipital regions. The drawings of the cytoarchitectonic area maps are based on figures 92 and 93 of Economo and Koskinas [1]; color designations are principally based on their figures 96 and 97 [1].

**Table 2.** General overview of the 107 cytoarchitectonic modification areas of Economo and Koskinas [1] in the human cerebral cortex, with EK area number designations and Brodmann area correlations

| EK area No. | EK area symbol[1] | Area name in English | Area name in Latin | Corresponding Brodmann area[2] |
|---|---|---|---|---|
| *Frontal lobe (F)* | | | | |
| Prerolandic region | | | | |
| 1 | $F\mathcal{A}$ | Precentral area[3] | Area praecentralis | 4 |
| 2 | $F\mathcal{A}_{\gamma}$ | Giant pyramidal precentral area | Area praecentralis gigantopyramidalis | 4 |
| 3 | $F\mathcal{A}_{op}$ | Precentral area in operculum | Area praecentralis in operculo | 4 |
| 4 | $F\mathcal{B}$ | Agranular frontal area[4] | Area frontalis agranularis | 6, 8, 9 |
| 5 | $F\mathcal{B}_{op}$ | Agranular frontal area in operculum | Area frontalis agranularis in operculo | 6 |
| 6 | $F\mathcal{C}$ | Intermediate frontal area | Area frontalis intermedia | 6, 8, 32 |
| 7 | $F\mathcal{C}L$ | Intermedio-limbic frontal area | Area frontalis intermedio-limbica | 32 |
| 8 | $F\mathcal{C}\mathcal{B}_{m}$ | Broca area (magnocellular agranular intermediate frontal area) | Area (frontalis intermedia agranularis magnocellularis in) Broca | 44 |
| 9 | $F\mathcal{C}I$ | Intermediate frontal area at the beginning of the insula | Area frontalis intermedia in limine insulae | 8 |
| 10 | $F\mathcal{C}_{op}$ | Opercular intermediate frontal area | Area frontalis intermedia opercularis | 8 |
| Frontal region | | | | |
| 11 | $F\mathcal{D}$ | Granular frontal area | Area frontalis granularis | 9, 32, 46 |
| 12 | $F\mathcal{D}_{m}$ | Magnocellular granular frontal area | Area frontalis granularis magnocellularis | 9 |
| 13 | $F\mathcal{D}_{p}$ | Parvicellular granular frontal area | Area frontalis granularis parvocellularis | 9, 10, 11, 12 |
| 14 | $F\mathcal{D}_{op}$ | Granular frontal area in operculum | Area frontalis granularis in operculo | 9, 10, 11, 12 |
| 15 | $F\mathcal{D}L$ | Limbic granular frontal area | Area frontalis granularis limbica | 32 |
| 16 | $F\mathcal{D}\Delta$ | Middle granular frontal area | Area frontalis granularis media | 8, 9, 46 |
| 17 | $F\mathcal{D}\Gamma$ | Triangular granular frontal area | Area frontalis granularis triangularis | 45 |
| 18 | $F\mathcal{E}$ | Frontopolar area | Area frontopolaris | 10, 32 |
| 19 | $F\mathcal{E}L$ | Limbic frontopolar area | Area frontopolaris limbica | 32 |
| Orbital (orbitomedial) region | | | | |
| 20 | $F\mathcal{F}$ | Granular orbital area[5] | Area orbitalis granularis | 13, 47 |
| 21 | $F\mathcal{F}_{\alpha}$ | Agranular orbital area[6] | Area orbitalis agranularis | 47 |
| 22 | $F\mathcal{F}_{\phi}$ | Pretriangular orbital area | Area orbitalis praetriangularis | 47 |
| 23 | $F\mathcal{G}$ | Area of straight gyrus (area recta) | Area recta (area gyri recti) | 11 |
| 24 | $F\mathcal{G}_{i}$ | Internal straight area | Area recta interna | |
| 25 | $F\mathcal{H}$ | Prefrontal area | Area praefrontalis | 11–14, 25, 32 |
| 26 | $F\mathcal{H}\mathcal{L}$ | Parolfactory prefrontal area | Area praefrontalis parolfactoria | 11–14, 25, 32 |
| 27 | $F\mathcal{H}L$ | Limbic prefrontal area | Area praefrontalis limbica | 32 |
| 28 | $F\mathcal{J}$ | Frontoinsular area[7] | Area frontoinsularis | 16 |
| 29 | $F\mathcal{K}$ | Frontal piriform area | Area piriformis frontalis | 16 |
| 30 | $F\mathcal{L}_{1}$ | Primary parolfactory area[8] | Area parolfactoria prima | 14, 25 |
| 31 | $F\mathcal{L}_{2}$ | Secondary parolfactory area | Area parolfactoria secunda | 14, 25 |
| 32 | $F\mathcal{L}_{3}$ | Tertiary parolfactory area | Area parolfactoria tertia | 14, 25 |
| 33 | $F\mathcal{M}$ | Geniculate area | Area geniculata | 25 |
| 34 | $F\mathcal{M}_{t}$ | Geniculate area of olfactory triangle | Area geniculata trigoni olfactorii | 25 |
| 35 | $F\mathcal{N}$ | Precommissural area | Area praecommissuralis | |
| *Superior limbic lobe (L)* | | | | |
| Anterior superior limbic region | | | | |
| 36 | $L\mathcal{A}_{1}$ | Precingulate agranular anterior limbic area[9] | Area limbica anterior agranularis praecingularis | 24 |
| 37 | $L\mathcal{A}_{2}$ | Anterior cingulate agranular anterior limbic area | Area limbica anterior agranularis cingularis anterior | 24 |
| 38 | $L\mathcal{A}_{3}$ | Cingulate agranular anterior limbic area limitans | Area limbica anterior agranularis cingularis limitans | 24 |
| 39 | $L\mathcal{B}_{1}$ | Anterior ultracingulate area | Area ultracingularis anterior | 24, 33 |
| 40 | $L\mathcal{B}_{2}$ | Area of the induseum[10] | Area indusei | 24, 33 |
| Posterior superior limbic region | | | | |
| 41 | $L\mathcal{C}_{1}$ | Dorsal posterior cingulate area[11] | Area cingularis posterior dorsalis | 31 |
| 42 | $L\mathcal{C}_{2}$ | Ventral posterior cingulate area | Area cingularis posterior ventralis | 23 |
| 43 | $L\mathcal{C}_{3}$ | Posterior cingulate area limitans | Area cingularis limitans posterior | 33 |
| Retrosplenial subregion | | | | |
| 44 | $L\mathcal{D}$ | Agranular retrosplenial area | Area retrosplenialis agranularis | 30 |
| 45 | $L\mathcal{E}_{1}$ | Superior retrosplenial area granulosa | Area retrosplenialis granulosa superior | 29 |
| 46 | $L\mathcal{E}_{2}$ | Inferior retrosplenial area granulosa | Area retrosplenialis granulosa inferior | 26, 29 |
| 47 | $L\mathcal{F}_{1}$ | Posterior ultracingulate area | Area ultracingularis posterior | 26 |
| 48 | $L\mathcal{F}_{2}$ | Ultracingulate area obtecta | Area (ultracingularis) obtecta | 26 |

**Table 2** (continued)

| EK area No. | EK area symbol[1] | Area name in English | Area name in Latin | Corresponding Brodmann area[2] |
|---|---|---|---|---|
| *Insular lobe (I)* | | | | |
| 49 | I$\mathcal{A}_1$ | Dorsal precentral insular area[12] | Area insulae praecentralis dorsalis | 14 |
| 50 | I$\mathcal{A}_2$ | Ventral precentral insular area | Area insulae praecentralis ventralis | 14 |
| 51 | I$\mathcal{B}$ | Postcentral insular area[13] | Area insulae postcentralis | 13 |
| 52 | I$\mathcal{B}$T | Postcentral insular area at temporal entrance | Area insulae postcentralis in limine temporali | 13 |
| 53 | I$\mathcal{C}$ | Orbitoinsular area | Area orbito-insularis | 15 |
| 54 | I$\mathcal{D}$ | Piriform insular area | Area insularis piriformis | 16 |
| *Parietal lobe (P)* | | | | |
| Postcentral region (anterior parietal) | | | | |
| 55 | P$\mathcal{A}_1$ | Giant pyramidal postcentral area | Area postcentralis gigantopyramidalis | 3a |
| 56 | P$\mathcal{A}_2$ | Giant pyramidal postparacentral area | Area postparacentralis gigantopyramidalis | 3a, 5 |
| 57 | P$\mathcal{B}_2$ | Oral postcentral area simplex | Area postcentralis oralis simplex | 3, 3b |
| 58 | P$\mathcal{B}_1$ | Oral postcentral area granulosa | Area postcentralis oralis granulosa | 3, 3b |
| 59 | P$\mathcal{C}$ | Intermediate postcentral area | Area postcentralis intermedia | 1, 2 |
| 60 | P$\mathcal{D}$ | Caudal postcentral area | Area postcentralis caudalis | 2, 5a |
| Superior parietal region | | | | |
| 61 | P($\mathcal{D}$)$\mathcal{E}$ | Superior parietal area (transition parietal postcentral area) | Area parietalis superior (area transitoris postcentralis parietalis) | 40, 2 |
| 62 | P$\mathcal{E}_m$ | Magnocellular superior parietal area | Area parietalis superior magnocellularis | 7, 7a, 5 |
| 63 | P$\mathcal{E}_p$ | Parvicellular superior parietal area | Area parietalis superior parvocellularis | 7, 7b, 5b |
| 64 | P$\mathcal{E}_\gamma$ | Giant pyramidal posterior superior parietal area | Area parietalis superior posterior gigantopyramidalis | 7, 7b, 5b |
| Inferior parietal region | | | | |
| 65 | P$\mathcal{F}$ | Supramarginal area[14] | Area supramarginalis | 40, 7b, 22 |
| 66 | P$\mathcal{F}_t$ | Tenuicortical supramarginal area | Area supramarginalis tenuicorticalis | 40, 7b, 22 |
| 67 | P$\mathcal{F}_{op}$ | Opercular supramarginal area[15] | Area supramarginalis opercularis | opercular |
| 68 | P$\mathcal{F}_{cm}$ | Posterior (magnocellular) supramarginal area | Area supramarginalis columnata magnocellularis (posterior) | 40 |
| 69 | P$\mathcal{G}$ | Angular area | Area angularis | 39, 7a |
| Basal parietal region | | | | |
| 70 | P$\mathcal{H}$P | Basal (temporooccipital) parietal area at parietal entrance | Area parietalis (temporooccipitalis) basalis in limine parietali | 37 |
| 71 | P$\mathcal{H}$T | Basal (temporooccipital) parietal area at temporal entrance | Area parietalis (temporooccipitalis) basalis in limine temporali | 37 |
| 72 | P$\mathcal{H}$O | Basal (temporooccipital) parietal area at occipital entrance | Area parietalis (temporooccipitalis) basalis in limine occipitali | 37 |
| *Occipital lobe (O)* | | | | |
| 73 | O$\mathcal{A}_2$ | Anterior peristriate area[16] | Area peristriata anterior | 19 |
| 74 | O$\mathcal{A}_1$ | Posterior peristriate area | Area peristriata posterior | 19 |
| 75 | O$\mathcal{A}_m$ | Magnocellular peristriate area | Area peristriata magnocellularis | 19 |
| 76 | O$\mathcal{B}$ | Parastriate area[17] | Area parastriata | 18 |
| 77 | O$\mathcal{B}_\gamma$ | Giant pyramidal parastriate boundary | Limes parastriatus gigantopyramidalis | 17/18 border |
| 78 | O$\mathcal{B}_\Omega$ | Maculae granulosae of parastriate area | Maculae granulosae areae parastriatae | 18 |
| 79 | O$\mathcal{C}$ | Striate area (granulosa)[18] | Area striata (granulosa) | 17 |
| *Temporal lobe (T)* | | | | |
| Supratemporal region | | | | |
| 80 | T$\mathcal{A}_1$ | Posterior superior temporal area | Area temporalis superior posterior | 22 |
| 81 | T$\mathcal{A}_2$ | Anterior superior temporal area | Area temporalis superior anterior | 22 |
| 82 | T$\mathcal{B}$ | Magnocellular supratemporal area simplex | Area supratemporalis magnocellularis simplex | 42, 22 |
| 83 | T$\mathcal{C}$ | Supratemporal area granulosa[19] | Area supratemporalis granulosa | 41 |
| 84 | T$\mathcal{D}$ | Intercalated supratemporal area | Area supratemporalis intercalata | 42, 22 |
| Temporal region proper | | | | |
| 85 | T$\mathcal{E}_1$ | Middle temporal area proper | Area temporalis propria media | 21, 37 |
| 86 | T$\mathcal{E}_2$ | Inferior temporal area proper | Area temporalis propria inferior | 20, 21 |
| Fusiform region | | | | |
| 87 | T$\mathcal{F}$ | Fusiform area | Area fusiformis | 36 |
| 88 | T$\mathcal{H}$ | Hippocampotemporal area[20] | Area hippocampotemporalis | 35, 36 |
| 89 | T$\mathcal{H}_\alpha$ | Agranular hippocampotemporal area | Area hippocampotemporalis agranularis | 35 |

**Table 2** (continued)

| EK area No. | EK area symbol[1] | Area name in English | Area name in Latin | Corresponding Brodmann area[2] |
|---|---|---|---|---|
| Temporopolar region | | | | |
| 90 | T$\mathcal{G}$ | Temporopolar area[21] | Area temporopolaris | 38, 35, 36, 52 |
| 91 | T$\mathcal{G}_\alpha$ | Agranular temporopolar area[22] | Area temporopolaris agranularis | 38, 35, 36, 52 |
| 92 | T$\mathcal{J}$ | Temporal piriform area[23] | Area piriformis temporalis | 16 |
| 93 | T$\mathcal{K}$ | Posterior area of substantia perforata | Area substantiae perforatae posterior | |
| *Hippocampal (inferior limbic) lobe (H)* | | | | |
| 94 | H$\mathcal{A}_1$ | Primary uncinate area | Area uncinata prima | 34 |
| 95 | H$\mathcal{A}_2$ | Secondary uncinate area | Area uncinata secunda | 34 |
| 96 | H$\mathcal{A}_3$ | Tertiary uncinate area | Area uncinata tertia | 34 |
| 97 | H$\mathcal{B}_1$ | Primary parauncinate area | Area parauncinata prima | 28 |
| 98 | H$\mathcal{B}_2$ | Secondary parauncinate area[24] | Area parauncinata secunda | 28 |
| 99 | H$\mathcal{C}$ | Rhinal area limitans[25] | Area rhinalis limitans | 28 |
| 100 | H$\mathcal{D}_1$ | Presubicular area granulosa limitans | Area praesubicularis granulosa limitans | 27 |
| 101 | H$\mathcal{D}_2$ | Middle presubicular area granulosa | Area praesubicularis granulosa media | 27 |
| 102 | H$\mathcal{D}_3$ | Glomerular presubicular area granulosa | Area praesubicularis granulosa glomerulosa | 27 |
| 103 | H$\mathcal{E}_{1\alpha}$ | Glomerular subicular pyramidal area | Area pyramidalis subiculi glomerulosa | |
| 104 | H$\mathcal{E}_{1\beta}$ | Subicular pyramidal area simplex | Area pyramidalis subiculi simplex | |
| 105 | H$\mathcal{E}_2$ | Pyramidal area of Ammon's horn[26] | Area pyramidalis cornu Ammonis | |
| 106 | H$\mathcal{E}_3$ | Pyramidal area of digitate gyrus of uncus[27] | Area pyramidalis gyri digitati unci | |
| 107 | H$\mathcal{F}$ | Area of fascia dentata[28] | Area fasciae dentatae | |

[1] An additional 13 ('transition') areas were marked by Economo and Koskinas [1] on their maps, but not explicitly listed among the 107 'modifications': F$\mathcal{BA}$, F$\mathcal{C}(\mathcal{B})$, F$\mathcal{CD}_{op}$, F$\mathcal{DC}$, F$\mathcal{DE}$, F$\mathcal{ED}_m$, F$\mathcal{EF}$, F$\mathcal{E}_m$, P$\mathcal{C}_\gamma$, P$\mathcal{E}(\mathcal{D})$, P$\mathcal{FD}$, P$\mathcal{F}_m$ and I$\mathcal{AB}$.

[2] On the basis of Economo and Koskinas [1], as well as references [6–23].

[3] Primary motor cortex.

[4] Economo and Koskinas [1] mark in their map a transition area F$\mathcal{BA}$ which corresponds to Brodmann area 6Va.

[5] Area F$\mathcal{F}$ partly corresponds to the orbitofrontal proisocortex of the monkey that lies between Brodmann areas 13 and 12 rostrally and the orbitofrontal peripaleocortex caudally [14].

[6] Not recognized by Brodmann in the human brain. Corresponds probably to granular isocortex in the anterior part of Brodmann area 11 in the macaque, which lies between Brodmann areas 10 rostrally and 13 caudally.

[7] Peripaleocortex in gyrus transversus insulae (pars inferior) and orbitofrontal peripaleocortex in the monkey [14].

[8] Areas F$\mathcal{L}_1$–F$\mathcal{L}_3$ in subcallosal gyrus.

[9] Areas L$\mathcal{A}_1$–L$\mathcal{A}_3$, anterior cingulate gyrus.

[10] Areas L$\mathcal{B}_2$, L$\mathcal{F}_1$ and L$\mathcal{F}_2$ belong to the supracommissural hippocampus [18].

[11] Areas L$\mathcal{C}_1$–L$\mathcal{C}_3$, posterior cingulate areas.

[12] Areas I$\mathcal{A}_1$ and I$\mathcal{A}_2$, anterior insula.

[13] Areas I$\mathcal{B}$ and I$\mathcal{B}$T, posterior insula.

[14] Rostral inferior parietal lobule.

[15] Economo and Koskinas mark in their map a transition area P$\mathcal{FD}$ which corresponds to Brodmann area 43 [1, 7].

[16] Anterior preoccipital zone.

[17] Posterior parastriate zone or extrastriate area.

[18] Primary visual cortex.

[19] Primary auditory cortex or supratemporal koniocortex.

[20] Posterior part of parahippocampal gyrus [13].

[21] Temporal pole.

[22] According to Economo and Koskinas [1], area T$\mathcal{G}_\alpha$ corresponds to Brodmann area 35.

[23] Temporopolar peripaleocortex in the macaque [14].

[24] In Plate CII of their Atlas, Economo and Koskinas [1] describe a tertiary parauncinate area H$\mathcal{B}_3$.

[25] Economo and Koskinas [1] mention a 'transition' area H$\mathcal{C}(\mathcal{D})$ from H$\mathcal{C}$ to H$\mathcal{D}$, perhaps corresponding to Brodmann area 48.

[26] Hippocampus proper.

[27] In his later studies, Economo [24] added areas H$\mathcal{E}_4$ and H$\mathcal{E}_5$.

[28] Dentate gyrus.

the anatomical picture of the corresponding area F$\mathcal{C}$ by a gradual increase in the number of granule cells in cortical layers II and IV.

Broca's area (BA 44 or Economo-Koskinas area F$\mathcal{CB}_m$) was considered by Brodmann [4] and Economo and Koskinas [1] as a particular human characteristic. Kreht [25] recognized it in the chimpanzee and Orang-Utan brain, and Bonin and Bailey [11] and Peden and Bonin [26] in the brain of the macaque.

Tomaiuolo et al. [27] produced a probability map of the pars opercularis of the inferior frontal gyrus using MRI by averaging location and extent in 108 individual normalized brains. The surface area of the pars opercularis is characterized by a distinct type of cortex, which is

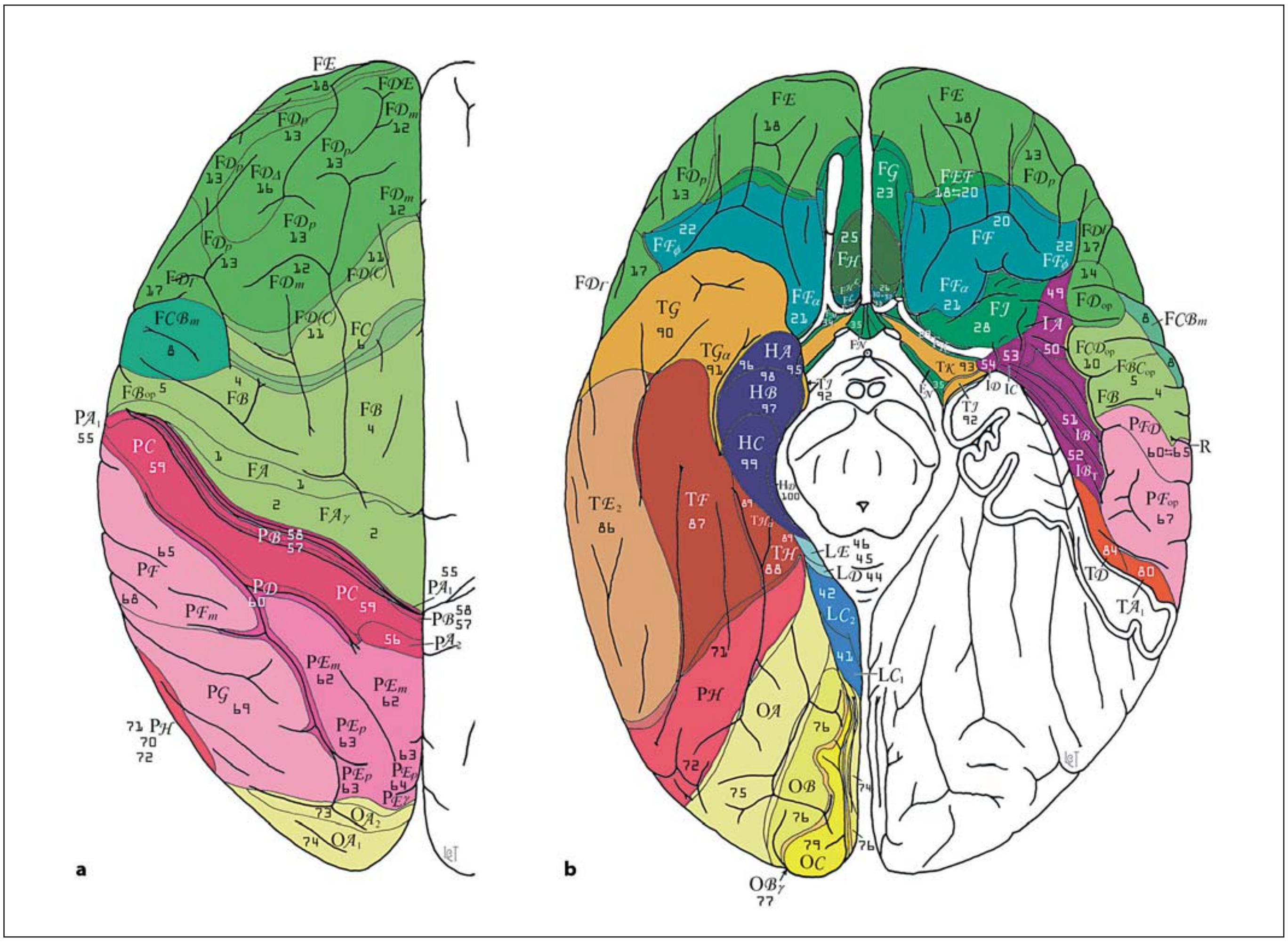


**Fig. 3.** Newly generated Economo-Koskinas cortical maps of the dorsal (**a**) and the ventral (**b**) cerebral surface in color. **b** In the view of the ventral surface of the brain, the temporal pole is left intact on the hemisphere shown on the left side of the illustration, while it is removed on the right side to expose orbital and insular regions (compare to fig. 2a). Drawings of the cytoarchitectonic areas are based on dorsal and ventral views of the brain in figures 94 and 95 of Economo and Koskinas [1], while color designations have been extrapolated from lateral and median hemispheric views in their figures 96 and 97 [1] (cf. also fig. 1c, d in the preceding article [2]), as well as from the region classification on pages 218–220 of the text volume [1]. Economo-Koskinas cortical cytoarchitectonic areas are depicted in both the original lettering system and with EK area modification numbers (listed explicitly in table 2). Area initials and lobe coloring: F, frontal (green); L, superior limbic (blue); I, insular (violet); P, parietal (red); O, occipital (yellow); T, temporal (brown); H, hippocampal (deep blue), with shade variations to indicate different regions, as well as variant, overlapping or transition areas. Bidirectional arrows (⇆) have been used to denote transitional types of cortex. R = Central sulcus of Rolando.

area F$\mathcal{CB}_m$ (EK 8), distinguishable from the posteriorly lying premotor cortex in area F$\mathcal{B}$ (EK 4 or ventral BA 6) in the precentral gyrus; BA 44 continues rostrally as area F$\mathcal{D}\Gamma$ (EK 17) or BA 45 [27].

More frontally, one finds portions of areas F$\mathcal{D}$ (EK 11) and F$\mathcal{E}$ (EK 18), which are rich in granule cells. Injuries sustained during the war had shown that lesions in the prefrontal region result in disturbances of attention, psychomotor activity, will and emotivity. These higher mental functions, localized in the frontal regions of the brain, Economo [24] termed 'the active part of psychic personality'.

The human primary and nonprimary motor cortices in the frontal lobe were given numbers 4 and 6 by Brodmann [4]. According to Zilles [18], Brodmann may have overestimated the extent of the human primary motor cortex and his delineation of BA 4 has been challenged; area F$\mathcal{A}_\gamma$ (EK 2) resembles the frontal core area more closely, with the consequence that a large part of area F$\mathcal{A}$ (EK 1) belongs to nonprimary motor cortex.

Area F$\mathcal{F}$ (EK 20) partly corresponds to the orbitofrontal proisocortex of the monkey that lies intercalated between the caudal orbitofrontal isocortex (BA 13 and 12) rostrally, and the orbitofrontal peripaleocortex caudally. Area F$\mathcal{F}_\alpha$ (EK 21) in the human brain probably corresponds to the granular isocortex in the anterior part of the orbital surface of the frontal lobe (BA 11) in the macaque monkey, which lies intercalated between the frontopolar BA 10 rostrally and BA 13 caudally. Areas F$\mathcal{H}$ (EK 25) and F$\mathcal{HL}$ (EK 26) in the human brain correspond to the paralimbic dysgranular isocortex (BA 14) on the ventromedial surface of the prefrontal cortex in the macaque monkey, which lies intercalated between the frontopolar granular isocortex (BA 10) rostrally and the orbitomesial archicortical proisocortex of the straight gyrus (BA 25) caudally. Area F$\mathcal{J}$ (EK 28) appears to correspond to the peripaleocortex in the inferior part of the transverse gyrus of the insula, and to the orbitofrontal peripaleocortex in the monkey [14].

Area F$\mathcal{F}$ (EK 20 or BA 47) lies rostrally and ventrally to area F$\mathcal{D}\Gamma$ (EK 17 or BA 45). Petrides and Pandya [28] designate the specific part of the zone previously labeled BA 47 as ventrolateral BA 47/12, which in the monkey receives input from the rostral inferotemporal visual association cortex and temporal limbic areas (i.e. perirhinal and parahippocampal cortices). On the other hand, the dorsally adjacent BA 45 receives input from the superior temporal gyrus (auditory association cortex) and the multimodal cortex in the upper bank of the superior temporal sulcus [28]. Petrides and Pandya [29] also define a BA 9/46, in addition to BA 46 (area F$\mathcal{D}\Delta$ or EK 16); together, BA 9/46 and BA 46 constitute the lower-half of the mid-dorsolateral frontal cortex, and are easily discernible from BA 9 in the upper mid-dorsolateral frontal cortex. BA 9 has basic connections similar to BA 46 and BA 9/46, with the difference that it does not receive input from the lateral parietal cortex; moreover, BA 9 does not exhibit a well-formed layer IV.

In the anterior cingulate cortex [18], areas F$\mathcal{C}$L (EK 7), F$\mathcal{D}$L (EK 15), F$\mathcal{E}$L (EK 19) and F$\mathcal{H}$L (EK 27) compare to BA 32; areas F$\mathcal{L}$ (EK 30–32) and F$\mathcal{M}$ (EK 33–34) correspond to BA 25.

Economo and Koskinas [1] mark some transitional types of cortex in their maps, but they do not list them in the 107 modifications (table 2). These include areas F$\mathcal{BA}$, F$\mathcal{C}(\mathcal{B})$, F$\mathcal{CD}_{op}$, F$\mathcal{DC}$, F$\mathcal{DE}$, F$\mathcal{ED}_m$, F$\mathcal{EF}$ and F$\mathcal{E}_m$. Following the logic of their nomenclature, areas F$\mathcal{BA}$, F$\mathcal{DC}$, F$\mathcal{DE}$ and F$\mathcal{EF}$ denote transition forms from one component area to the other (e.g. F$\mathcal{BA}$ marks the transition of area F$\mathcal{B}$ into F$\mathcal{A}$, F$\mathcal{DC}$ the transition of F$\mathcal{D}$ into F$\mathcal{C}$, and so on). Moreover, the designation F$\mathcal{C}(\mathcal{B})$ implies a part of area F$\mathcal{C}$ with an admixture of the type of neighboring area F$\mathcal{B}$, while the suffix subscript $m$ in areas F$\mathcal{ED}_m$ and F$\mathcal{E}_m$ signifies cellular variations, namely, with magnocellular characteristics. Finally, area F$\mathcal{CD}_{op}$ denotes a transitional opercular variant between areas F$\mathcal{C}_{op}$ and F$\mathcal{D}_{op}$.

## Superior Limbic Lobe

In the anterior cingulate cortex [18], area L$\mathcal{A}_3$ (EK 38) corresponds to BA 24, and area L$\mathcal{C}_3$ (EK 43) to BA 33; area L$\mathcal{A}_1$ (EK 36) overlaps with both BA 24 and BA 33. Concerning the retrosplenial archicortex [35], areas L$\mathcal{D}$ (EK 44), L$\mathcal{E}_1$ (EK 45) and L$\mathcal{E}_2$ (EK 46) are comparable to BA 30, BA 29 and BA 26. On the other hand, areas L$\mathcal{B}_2$ (EK 40), L$\mathcal{F}_1$ (EK 47) and L$\mathcal{F}_2$ (EK 48) belong to the supracommissural hippocampus [18].

One concern in the localization of cortical functions in the human brain is the boundary between the retrosplenial/cingulate and parahippocampal cortices. Brodmann [4, 5] depicted the retrosplenial cortex as fully surrounding the posterior and ventral edge of the splenium of the corpus callosum. Economo [24] provided the first subregional map of the posterior cingulate gyrus and showed a termination of the retrosplenial areas L$\mathcal{E}$ (EK 45–46) and L$\mathcal{D}$ (EK 44) at a plane caudal but not ventral to the splenium. Flat maps presented by Vogt et al. [10] show that the border between retrosplenial/posterior cingulate and parahippocampal cortices is caudal but not ventral to the splenium, being in close agreement with the view of Economo [24].

Every section through the retrosplenial cortex includes a segment of allocortical hippocampus and ectosplenial area L$\mathcal{F}$ (EK 47–48 or BA 26). In reviewing Brodmann's map of the posterior cingulate and retrosplenial cortices on the convoluted surface of the human brain, in the light of the findings of Economo and Koskinas [1] and their own immunohistochemical observations, Vogt et al. [10] underline the need for the following modifications: firstly, BA 29 and BA 30 extend further rostral; secondly, BA 30 does not significantly extend onto the caudomedial lobule, and when BA 29m does, it is to a minor extent; thirdly, the retrosplenial cortex does not extend as far ventral around the splenium.

At allocortical-isocortical transition points in the primate telencephalon, anatomists today recognize the concept of a 'dysgranular' cytoarchitecture (i.e. a weakly defined layer IV); such points are found in the orbitofrontal, insular, and anterior and posterior cingulate cortices [10]. Ngowyang [30] had described a 'dysgranular region' (regio dysgranularis) in the frontal lobe, associated with BA 8 and Economo-Koskinas areas F$\mathcal{C}$ (EK 6) and F$\mathcal{C}$L (EK 7). Going forward into BA 6, the granular layer appears sporadically, making this area 'hypogranular' or 'dysgranular'; forward of BA 6, the prefrontal cortex, and continuing through BA 10 of the frontal pole, the cortex is 'eugranular' [31].

Area L$\mathcal{D}$ (EK 44 or BA 30) is dysgranular rather than agranular, as it was originally thought [10]; its layer IV has a variable thickness, interrupted by large SMI-32 immunopositive neurons (nonphosphorylated neurofilaments) in layers IIIc and Va. Brodmann [4] referred to BA 30 as agranular. Economo [24] was quite explicit that area L$\mathcal{D}$ (EK 44) is not merely agranular, but that the 'granulous' layer of area L$\mathcal{E}$ (EK 45–46 or BA 29) is not continuous with the isocortical layer of area L$\mathcal{C}_2$ (BA 23 or EK 42). Economo [24] vacillated on the presence of a layer IV in area L$\mathcal{D}$ and showed a layer III(IV) below layer III therein. A dysgranular layer IV has a variable thickness and may even disappear as neurons of layer IIIc and Va intermingle. The dysgranular concept for a cortical architecture was obviously not defined during the early years of cortical cytoarchitectonics in terms of chemical signatures of neurons, as histochemical techniques were not available then. In a series of studies spanning over 30 years, Vogt et al. [10] described the dysgranular nature of area L$\mathcal{D}$ (BA 30) in the primate brain, using Nissl, Golgi and immunocytochemical methods, and its profound differences with the cytoarchitecture of granular BA 23a.

### Insular Lobe

The insular lobe includes the dorsal precentral insular area I$\mathcal{A}_1$ (EK 49), ventral precentral insular area I$\mathcal{A}_2$ (EK 50), postcentral insular area I$\mathcal{B}$ (EK 51), orbitoinsular area I$\mathcal{C}$ (EK 53) and piriform insular area I$\mathcal{D}$ (EK 54). Areas I$\mathcal{A}$, I$\mathcal{B}$ and I$\mathcal{C}$ correspond to BA 14, BA 13 and BA 15, respectively. The gradual transition of area I$\mathcal{A}$ backwards over the central sulcus of the insula to area I$\mathcal{B}$ is denoted by Economo and Koskinas [1] as area I$\mathcal{AB}$ (marked on their maps but not registered among the 107 modifications), which is characterized by a condensation of the granular layers and a reduction of pyramidal cell size.

### Parietal Lobe

Zilles and Palomero-Gallagher [21] provide a comparison of the cytoarchitectonic areas of the parietal lobe as defined by Brodmann [4] and Economo and Koskinas [1]; in their discussion, they include myeloarchitectonic, histochemical and functional considerations from later studies. Briefly, Brodmann [4] defines four areas (BA 1–3 and BA 43) in the postcentral region, whereas Economo and Koskinas [1] six (P$\mathcal{A}_1$, P$\mathcal{A}_2$, P$\mathcal{B}_1$, P$\mathcal{B}_2$, P$\mathcal{C}$ and P$\mathcal{D}$, EK 55–60). In the parietal region, Brodmann [4] defines four areas (BA 5, BA 7, BA 39–40), and Economo and Koskinas [1] nine (P$\mathcal{ED}$, P$\mathcal{E}_m$, P$\mathcal{E}_p$, P$\mathcal{E}_\gamma$, P$\mathcal{F}$, P$\mathcal{F}_t$, P$\mathcal{F}_{op}$, P$\mathcal{F}_{cm}$ and P$\mathcal{G}$, EK 61–69). According to the same authors [21], the basal parietal region P$\mathcal{H}$ (EK 72) most likely belongs to the visual cortex and includes the functionally defined areas V4 and V5.

The proposed subdivisions of the anterior parietal cortex made by Economo and Koskinas [1] are in wide use today, as are those suggested by Brodmann [16]. Area P$\mathcal{A}$ (EK 55–56), located in the depths of the central sulcus, is equivalent to BA 3a. Area P$\mathcal{B}$ (EK 57–58) is the 'sensory koniocortex', located on the caudal bank of the central sulcus and equivalent to BA 3b. Area P$\mathcal{C}$ (EK 59) includes both BA 2 and BA 1; BA 1 appears to be narrower than area P$\mathcal{C}$. Area P$\mathcal{D}$ (EK 60) corresponds to part of BA 2.

Concerning the primary somatosensory cortical areas and the subdivision of the posterior parietal lobe into a superior and an inferior lobule, the most accepted terminology today is that of Economo and Koskinas [1], which has also formed the basis for further contemporary cytoarchitectonic analyses and for experimentation in primates [18]. In the posterior parietal cortex, areas P$\mathcal{D}$ (EK 60) and P$\mathcal{E}$ (EK 62–64) roughly correspond to parts 5a and 5b of BA 5; areas P$\mathcal{F}$ (EK 65) and P$\mathcal{G}$ (EK 69) to parts 7b and 7a of BA 7 [16]. Brodmann [4] did not delineate any transition zones in the posterior parietal lobe [18]; in contrast, Economo and Koskinas [1] had marked such transition zones between the areas P$\mathcal{E}$, P$\mathcal{F}$, P$\mathcal{G}$, P$\mathcal{H}$ and O$\mathcal{A}$ in their cortical maps, which are in agreement with the observations of Eidelberg and Galaburda [12].

In the parietal lobe behind the central sulcus of Rolando, between the three sensory spheres which are most important for human understanding, those of touch, sight and hearing located in the postcentral gyrus and in Heschl's supratemporal gyrus and the walls of the calcarine sulcus, there is a wide cortical field on the convexity of the hemisphere occupied by parietal cortical type (type 3).

Next to these areas comes a series of centers, lesions of which produce cognitive deficits (for instance, cortical deafness and lack of understanding of words). Lesions of the most central, caudal, and basal portions of the infraparietal lobe, which comprises the gyrus angularis and basal portions of the inferior parietal lobe, provoke disturbances of a still higher order in mental and intellectual defect of a sensory-receptive nature [24].

Similarly to the case of the frontal lobe, the parietal areas $P\mathcal{C}_\gamma$, $P\mathcal{E}(\mathcal{D})$, $P\mathcal{FD}$ and $P\mathcal{F}_m$ are marked by Economo and Koskinas [1] on their maps, but not included among the 107 modifications (table 2). BA 43 in particular, which Brodmann [4] includes in the operculum, is not considered as an independent area by Economo and Koskinas [1], but as a transitional formation or mixing of areas $P\mathcal{D}$ (EK 60) and $P\mathcal{F}$ (EK 65), designated $P\mathcal{FD}$ (indicated as EK 60⇆65 in fig. 2a and 3b) [7]. Areas $P\mathcal{C}_\gamma$ and $P\mathcal{F}_m$ denote cellular variations containing, respectively, giant pyramidal and magnocellular neurons. Area $P\mathcal{E}(\mathcal{D})$ is a variant of area $P\mathcal{E}$ with an admixture of the neighboring cortical type $P\mathcal{D}$. In comparing grasp versus pointing tasks, Frey et al. [23] identify two significant foci of activation in the hemisphere contralateral to the performing right hand. The first area is located in the left parietal cortex at the junction of the intraparietal sulcus and the postcentral gyrus. This site is likely within the most superior, rostral aspect of BA 40, corresponding to area $P\mathcal{F}$ or $P\mathcal{DE}$.

The functionally defined secondary somatosensory cortex (SII) is located in the parietal operculum, hidden within the Sylvian fissure. BA 40 and BA 43 extend into the parietal operculum and are candidates for SII on topographic grounds; they partially correspond to the opercular modification $P\mathcal{F}_{op}$ (EK 67) and to subcentral area $P\mathcal{FD}$, respectively. Based on measurements of the 'gray level index' (an indicator of the volume fraction of neuron somata), Eickhoff et al. [32] identify four heterogeneous cytoarchitectonic regions as anatomical correlates of the human SII, which they term areas OP 1 through 4. Area OP 4 is similar in location to BA 43 and to Economo-Koskinas area $P\mathcal{FD}$, as it contains large pyramidal cells in layers IIIc and Va.

In the supramarginal gyrus of the rostral inferior parietal cortex, Economo and Koskinas [1] subdivide BA 40 into five areas, $P\mathcal{F}$ (EK 65), $P\mathcal{F}_{cm}$ (EK 68), $P\mathcal{F}_m$, $P\mathcal{F}_{op}$ (EK 67) and $P\mathcal{F}_t$ (EK 66) which have been confirmed in general lines by Caspers et al. [33] with observer-independent quantitative methods; in the caudal inferior parietal cortex, Caspers et al. [33] distinguish a caudal region termed $P\mathcal{G}p$ and a rostral region termed $P\mathcal{G}a$, this latter fitting to area $P\mathcal{G}$ (EK 69) in the angular gyrus (roughly BA 39).

**Occipital Lobe**

The primary visual area or striate cortex is area $O\mathcal{C}$ (EK 79 or BA 17), the parastriate cortex is area $O\mathcal{B}$ (EK 76–78 or BA 18), and the peristriate cortex is area $O\mathcal{A}$ (EK 73–75 or BA 19) [15]. A border zone located at the boundaries of BA 17 and BA 18 and containing giant pyramidal cells in the lower part of layer III is the Economo-Koskinas area $O\mathcal{B}_\gamma$ (EK 77, limes parastriatus gigantopyramidalis).

The total surface of the koniocortex in the visual sensory sphere (area $O\mathcal{C}$) in both hemispheres was estimated at about 50 $cm^2$. The total number of cells about $1.4 \times 10^9$, i.e. 10% of the total number of nerve cells of the entire cortex. The area striata is thus more than four times richer in cells than any other region [24].

**Temporal Lobe**

Based on pathological and physiological considerations, Economo [24] localized the understanding of the word *speech* in cortical area $T\mathcal{A}_1$ (EK 80) of the left hemisphere, the understanding of the word *sense* in the caudal transitional region of $T\mathcal{A}_1$ towards $P\mathcal{F}$ (EK 65), and the understanding of *music* in $T\mathcal{A}_2$ (EK 81) and the temporal pole; appreciation of higher tones in parts in the bottom of the Sylvian fissure, while that of lower tones more towards outer portions. Area $T\mathcal{C}$ (EK 83) is koniocortex, i.e. sensory cortex representing the *primary acoustic sphere*, into which run acoustic fibers from the medial geniculate body.

Economo and Horn [34] further investigated the cytoarchitectonics of the auditory cortex in seven adult and two juvenile brains. They found the superior temporal surface and the length of the Sylvian fissure larger on the left side. According to Meyer [35], the initial attempts at investigating the cytoarchitectonics of the auditory cortex were those by Campbell [36], Rosenberg [37], and by Brodmann [4], who had identified it with BA 41, but who largely missed the most characteristic feature that this area shares with all other 'sensory' cortices, i.e. the 'granulation', first described by Economo and Koskinas [1]. Economo and Horn [34] attribute the striking variations in size among individuals and between the two hemispheres possibly to handedness or differences in musicality.

The koniocortex in the human temporal lobe encompasses areas $T\mathcal{C}$ (EK 83) and $T\mathcal{D}$ (EK 84) or BA 41 and part of BA 42 and is located on Heschl's gyrus (transverse temporal gyrus); area $T\mathcal{A}$ (EK 80–81) contains Wernicke's speech area, while the cerebral 'belt' areas in all likelihood are BA 22 and part of BA 42, which correspond to areas T$\mathcal{A}$ (EK 80–81) and T$\mathcal{B}$ (EK 82) [17, 38].

Using cytoarchitectonic, myeloarchitectonic, and histochemical criteria, as well as three-dimensional reconstruction based on serial sections, Hackett et al. [39] identified a homologous cortical auditory region in the macaque, chimpanzee, and human brain. It has been known from the classical cytoarchitectonic studies that the human auditory cortex comprises a central 'core' region, characterized by a koniocortical cytoarchitecture and dense myelination, and the surrounding nonprimary 'belt' fields, characterized by para- or pro-koniocortical cytoarchitecture. Within area T$\mathcal{C}$ (EK 83), which closely corresponds to BA 41 and the 'core' region of Hackett et al. [39], Economo and Horn [34] describe 11 distinct types of granular cortex. The 'belt' field of the human auditory cortex [39], on the other hand, seems to correspond to the medial portion of the koniocortical T$\mathcal{D}$ (EK 84) sector of Economo and Koskinas [1] and Economo and Horn [34].

In sections cut perpendicularly to the radial orientation of layer III apical dendrites, the small pyramidal cells are arranged in short radial columns that partially extend into layers II and IV [39]; such a feature seems to correspond to what Economo and Koskinas [1] call 'rain shower formation' *(Regenschauerformation)*. With regard to the columnar organization of the belt region, layer III pyramidal cells are arranged in organized vertical columns [39, 40], which Economo and Koskinas [1] call 'organ pipe formation' *(Orgelpfeifenformation)*.

Economo and Koskinas [1] and Economo and Horn [34] were among the first to notice individual differences in the auditory fields and marked asymmetries between the two hemispheres: Heschl's gyrus is generally single and longer on the left side and double and shorter on the right side; the planum temporale (located caudally to Heschl's gyrus, in Economo-Koskinas area T$\mathcal{B}$ or EK 82) is larger on the left side [17, 41]. Such asymmetries may underlie the modern idea of a functional differentiation of the two cerebral hemispheres and the predilection of the left hemisphere (right ear) for verbal tests, and that of the right hemisphere (left ear) for music recognition [41].

Suzuki and Amaral [9] make the point that, in contrast to Brodmann [4], Economo and Koskinas [1] divide the medial temporal lobe into a rostral area T$\mathcal{G}$ and two caudal areas, T$\mathcal{H}$ (EK 88) and T$\mathcal{F}$ (EK 87), with area T$\mathcal{G}$ further subdivided into a medial area T$\mathcal{G}_\alpha$ (EK 91) and a larger lateral area T$\mathcal{G}$ (EK 90). Like Elliot Smith [42], Economo and Koskinas [1] also illustrate the temporal polar cortex as being continuous with the anteroventral portion of the medial temporal lobe. Areas T$\mathcal{G}$ (EK 90) and T$\mathcal{G}_\alpha$ (EK 91) encompass BA 38, anterior BA 35 and anterior BA 36. The nomenclature and cortical demarcations of Brodmann [4] concerning the description of the medial temporal lobe in primates is vague and inconsistent across species [9]. In contrast, the cytoarchitectonic descriptions of the medial temporal lobe by Economo and Koskinas [1], Economo [24], and Bonin and Bailey [11] provide a much more detailed cytoarchitectonic analysis, as determined by Suzuki and Amaral [9] in a reevaluation of the cytoarchitectonic and chemoarchitectonic connections of the medial temporal lobe in the macaque monkey. Areas T$\mathcal{F}$ (EK 87) and T$\mathcal{H}$ (EK 88) belong to the posterior part of the parahippocampal gyrus, whereas the anterior part of the parahippocampal gyrus comprises mainly the entorhinal cortex and the associated perirhinal cortex [13].

Area T$\mathcal{J}$ (EK 92) seems to be homologous to the hyperchromic, coarse-celled temporopolar peripaleocortex in the macaque monkey [14]. Besides area T$\mathcal{J}$, the peripaleocortical agranular claustral region (BA 16 in *Cercopithecus*) is also homologous to a certain extent to human area I$\mathcal{D}$ (EK 54) [18].

## Hippocampal (Inferior Limbic) Lobe

The inferior limbic lobe contains the hippocampal gyrus, which lies from the isthmus until near the temporal pole and contains the entire uncinate gyrus, the subiculum, the dentate gyrus, and Ammon's horn. Above the splenium, the hippocampal rudiment, induseum griseum, or areas L$\mathcal{B}_2$ (EK 40) and H$\mathcal{F}$ (EK 107), there is a single layer of densely packed ganglion cells, SMI-32 immunopositive (nonphosphorylated neurofilament protein immunoreactivity). Adjacent to the induseum griseum is the subicular rudiment or area H$\mathcal{E}$ (EK 103–106), which has many fewer and more dispersed neurons. These two areas together form the fasciolate gyrus on the dorsal surface of the corpus callosum [10].

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