Research Article

STRUCTURAL MANIFESTATION OF THE FUNCTIONAL HIPPOCAMPO-CORTICAL CONNECTIONS IN HUMANS

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Abstract

The human brain is a complex network of interconnected regions that collaborate to support cognitive processes and memory formation. The hippocampus, a crucial hub for episodic memory and spatial navigation, and the cortical areas, responsible for higher-order cognitive functions, are intricately intertwined. These hippocampal-cortical connections suggest that asymmetry in the hippocampal neuronal activity may directly influence the formation of synaptic connections among cortical neurons, thus modulating the processes of neuroplasticity and triggering the formation of cortical functional and morphological asymmetry. This research paper aims to provide a comprehensive overview of the association between hippocampus size and cortical area sizes, shedding light on their synergistic interplay in supporting cognitive processes. Four human brain specimens (2 male, 2 female) were utilized, and the dimensions of the hippocampus and specific cortical gyri were measured using the Einscan H 3D laser scanner. The results revealed asymmetry and variability in sizes across brain regions and hemispheres. Specifically, the right hemisphere exhibited larger hippocampal size compared to the left hemisphere, with the frontal gyri predominantly larger on the right side. Additionally, the right hippocampus showed significant correlations with contralateral inferior and middle frontal gyri, while the left hippocampus displayed pronounced correlations with contralateral middle and superior lateral frontal gyri. The findings highlight the influential role of the hippocampus in shaping cortical area sizes, particularly in the frontal gyri. These results contribute to our understanding of the complex interdependence between the hippocampus and cortical areas, with implications for memory-related disorders and cognitive deficits. Further research is needed to explore the developmental and aging changes in hippocampal-cortical connections and their impact on brain function.

Keywords: Hippocampus, Cortical areas, 3D scanning, Size, Memory, Cognition, Interdependence

Introduction

The human brain, a marvel of complexity, comprises various interconnected regions that collaborate to support cognitive processes and facilitate memory formation and retrieval. Among these regions, the hippocampus and cortical areas emerge as vital players, intricately intertwined in a dynamic network. The hippocampus, located in the medial temporal lobe, has long been recognized as a critical center for episodic memory and spatial navigation. Meanwhile, cortical areas, distributed across the cerebral cortex, are responsible for higher-order cognitive functions, including perception, language, attention, and executive control [1]. Understanding the nature of the relationship between the hippocampus and cortical areas is pivotal to unraveling the fundamental mechanisms underlying memory and cognition. This research paper aims to provide a comprehensive overview of the association between hippocampus size with cortical area sizes. It delves into the complex connections between those two structures shedding light on their synergistic interplay in supporting cognitive processes and influencing the measurements of these two vital areas [2]. By synthesizing findings from the Einscan 3D scanner this paper aims to emphasize the role of the hippocampus in influencing the size of different cortical areas. Through an integrative approach, this research endeavors to enhance our comprehension of the complex interdependence between the hippocampus and cortical areas, providing valuable insights into the broader framework of cognitive neuroscience. Ultimately, this exploration may pave the way for novel avenues of research and clinical interventions targeting memory-related disorders and cognitive deficits [3]. The objective of this research is to uncover the structural manifestations of the functional connections between the hippocampus and cortical areas [4]. It aims to establish morphological correlations between the volume of specific brain regions (frontal, temporal, parietal, and occipital gyri) and the dimensions of the hippocampus on both the same and opposite side of the brain [5].

Materials and Methods

Four specimens of the human brain (2-male; 2-female) without visually detected malformation and pathology were included in our study. Brains 1 and 2 were the male brains while brains 3 and 4 were the female brains. General dissection tools were applied for anatomical dissection; an electric saw was used for craniotomies; EinScan H 3D laser scanner was used for the building of 3D models; 3D Shining software was used for the measuring on the 3D models; IBM SPSS software was applied for the statistical analysis of the obtained data [6]. The data was obtained on 4 brain models involving left and right hemispheres. The research was approved by the ethical committee [7].

- After the routine educational craniotomy, the brain was extracted from the cranial cavity and its surface was cleaned from the arachnoid mater and cerebral vessels while closely avoiding any damage to the gyri. The brainstem was dissected at the level of the midbrain to expose the parahippocampal gyrus and uncus of the ventral surface of the cerebral hemispheres (Figure 1).

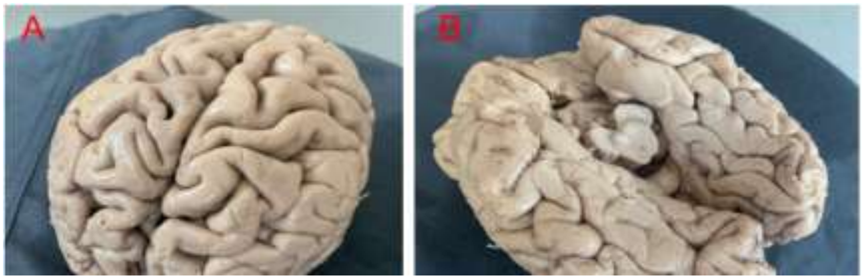

Figure 1. The extracted human brain with the arachnoid mater and vessels removed. A. Dorsal surface of the cerebral hemispheres; B. Ventral surface of the brain (the brainstem is dissected).

- Then, the cerebral hemispheres are positioned on the rotatory table of the EinScan 3D scanner. The blue light 3D scanner was used to digitize the cerebral hemispheres and the "Shining 3D" application was employed to measure the surface areas of all gyri [8]. The difference in the light angles and reflection points on photos are analyzed *via* the software to build the 3D model of the specimen. Then the temporal lobes of the brain are dissected. The floor of the lateral ventricles with the hippocampus and dentate gyrus in the bottom is exposed and cleaned from the choroid plexuses (Figure 2). The scaling and rotation settings allow to set up the accurate dimensions of the structures with a maximum of 0.07 px residual level [9].

Figure 2. The dissected brain with the removed gray and white matter from the superior and middle temporal gyri of the temporal lobe of the brain. The floor of the lateral ventricle is cleaned exposing the head, body, and tail of the hippocampus (H).

- The 3D scanner obtained two scans of the hemispheres one from the surface of the lateral ventricle towards the surface of the cerebral hemisphere and another from the bottom of the lateral ventricle towards the top of the lateral ventricle (Figure 3). Then we began measuring the different cortical areas using the Shining 3D software by slowly highlighting the area and allowing the software to calculate the surface area [10].

Figure 3. Digital model of precentral gyrus being measured using the measuring tools available in the Shining 3D software. Surface area was being measured in this photo.

- Following the digitization of the surface areas, the cortex of the temporal and occipital lobes was dissected revealing the hippocampus at the floor of the lateral ventricle, and the surface area of the hippocampus, and parahippocampal formation were measured as well [11]. After measuring all the different cortical areas we went on to measure the hippocampus and used the distance tool instead of the surface area tool [12]. We measured the head, body and tail of the hippocampus [13]. After obtaining those measurements we measured the surface area for the hippocampus (Figure 4) [14].

Figure 4. Digital model of hippocampus in Shining 3D software.

The descriptive statistics and correlation analysis were performed using the IBM SPSS software to identify the general morphological tendencies and statistically significant relationships between the morphological parameters of the hippocampus and the ipsi- and contralateral cortical gyri in males and females [15].

Standard protocol approvals, registrations, and patient consents

There was no potential harm to participants. Work was performed following safety rules and regulations set by the anatomy and neurology department leadership [16].

Data availability

Anonymized data not published within this article will be made available by request from any qualified investigator [17].

Results

In general, the right hemisphere of the brain exhibited larger hippocampal size compared to the left hemisphere. The measurements of cortical areas on the right hemisphere were mostly greater than those on the left hemisphere. Notably, the occipital gyri were predominantly larger in the left hemisphere, except for brain 4 where the measurements were very close on both sides. On the other hand, the frontal gyri tended to be larger in the right hemisphere. The right hippocampi were generally larger than the left hippocampi, except in the case of brain 3 where the left hippocampus was larger. Furthermore, brains 1 and 4 exhibited predominantly larger left temporal gyri. These findings highlight the asymmetry and variability in the sizes of hippocampus and cortical areas across different hemispheres and brain regions where the right hemispheres have larger frontal gyri while the left hemispheres have larger temporal gyri (Tables 1-8).

Table 1. Measurements of brain 1 cortical areas and hippocampus. (left and right hemispheres).

Brain 1-Left			Brain 1-Right		
		Surface area mm^2			**Surface area mm^2**
Frontal gyri	Precentral	1,991.33	Frontal gyri	Precentral	2185.55
	Superior lateral frontal	3536.85		Superior lateral frontal	2644.47
	Superior medial frontal	2440.37		Superior medial Frontal	2461.23
	Middle frontal	1952.92		Middle fronsstal	2325.01
	Inferior frontal	1328.28		Inferior frontal	1663.87
	Straight gyrus	493.13		Straight gyrus	489.31
	Anterior orbital	444.06		Anterior orbital	495.79
	Posterior orbital	622.44		Posterior orbital	572.99
	Lateral orbital	386.38		Lateral orbital	443.79
	Medial orbital	569.78		Medial orbital	533.11
Temporal gyri	Superior temporal	1345	Temporal gyri	Superior temporal	1118.57
	Middle temporal	2410.99		Middle temporal	2018.93
	Inferior temporal	2116.85		Inferior temporal	2315.88
	Fusiform gyrus	2776.68		Fusiform gyrus	2582.21
	Parahippocampa	929.48		Parahippocampal	899.33
	Uncus	146.26		Uncus	122.02
Parietal lobe	Postcentral	2361.97	Parietal lobe	Postcentral	2339.21
	Superior parietal	3678.74		Superior parietal	3098.74
	Inferior parietal	2058.25		Inferior parietal	2112.7
	Precuneus	1641.55		Precuneus	1643.24
Occipital lobe	Occipital gyrus	2014.45	Occipital lobe	Occipital gyrus	1972.19
	Lingual gyrus	778.56		Lingual gyrus	742.66
	Cuneus	1774.64		Cuneus	1739.87

Hippocampus	Head	19.057 mm	Hippocampus	Head	16.94 mm
	Body	15.25 mm		Body	13.23 mm
	Tail	16.075 mm		Tail	11.32 mm
	Area	858.64 mm^2		Area	1060.51 mm^2

Table 2. Measurements of brain 2 cortical areas and hippocampus. (left and right hemispheres).

Brain 2-Left			**Brain 2-Right**		
		Surface area mm^2			**Surface area mm^2**
Frontal gyri	Precentral	1676.43	Frontal gyri	Precentral	1868.8
	Superior lateral frontal	2806.91		Superior lateral frontal	2044.5
	Superior medial Frontal	2547.66		Superior medial Frontal	2808.84
	Middle frontal	1849.12		Middle frontal	1970.51
	Inferior frontal	1205.64		Inferior frontal	1351.35
	Straight gyrus	578.39		Straight gyrus	542.79
	Anterior orbital	495.15		Anterior orbital	330.5
	Posterior orbital	453.6		Posterior orbital	437.37
	Lateral orbital	403.14		Lateral orbital	594.58
	Medial orbital	528.79		Medial orbital	552.01
Temporal gyri	Superior temporal	1552.94	Temporal gyri	Superior temporal	1621.9
	Middle temporal	2263.01		Middle temporal	2176.51
	Inferior temporal	1822.82		Inferior temporal	2252.55
	Fusiform gyrus	2251.15		Fusiform gyrus	2408.75
	Parahippocampal	899.56		Parahippocampal	731.34
	Uncus	197.98		Uncus	234.45
Parietal lobe	Postcentral	1774.87	Parietal lobe	Postcentral	2056.65
	Superior parietal	3038		Superior parietal	2971.75
	Inferior parietal	2357.28		Inferior parietal	2025.86
	Precuneus	1703.61		Precuneus	1631.57
Occipital lobe	Occipital gyrus	1855.28	Occipital lobe	Occipital gyrus	1874.32
	Lingual gyrus	855.82		Lingual gyrus	741.17
	Cuneus	1727.43		Cuneus	1618.13
Hippocampus	Head	16.94 mn	Hippocampus	Head	18.14 mm
	Body	15.3 mm		Body	13.94 mm
	Tail	17.37 mm		Tail	15.24 mm
	Area	952.97 mm^2		Area	1038.96 mm^2

Table 3. Measurements of brain 3 cortical areas and hippocampus. (left and right hemispheres).

Brain 3-Left			**Brain 3-Right**		
		Surface area mm^2			**Surface area mm^2**
Frontal gyri	Precentral	1913.55	Frontal gyri	Precentral	2093.48
	Superior lateral frontal	3098.47		Superior lateral frontal	3108.65
	Superior medial frontal	2418.95		Superior medial Frontal	23337.97

	Middle frontal	2085.88		Middle frontal	2145.93
	Inferior frontal	1566.11		Inferior frontal	1655.58
	Straight gyrus	506.63		Straight gyrus	459,71
	Anterior orbital	388.09		Anterior orbital	422.12
	Posterior orbital	565.01		Posterior orbital	448,9
	Lateral orbital	429.99		Lateral orbital	476.44
	Medial orbital	541.04		Medial orbital	574.72
Temporal gyri	Superior temporal	1250.06	Temporal gyri	Superior temporal	1563.36
	Middle temporal	2105.26		Middle temporal	2125.12
	Inferior temporal	2024.98		Inferior temporal	1988.06
	Fusiform gyrus	2370.87		Fusiform gyrus	2178.65
	Parahippocampal	883.33		Parahippocampal	808.42
	Uncus	175.19		Uncus	197.72
Parietal lobe	Postcentral	2082.8	Parietal lobe	Postcentral	1965.96
	Superior parietal	3119.96		Superior parietal	2914.81
	Inferior parietal	2261.16		Inferior parietal	2116.81
	Precuneus	1534.9		Precuneus	1575.31
Occipital lobe	Occipital gyrus	1852.19	Occipital lobe	Occipital gyrus	1966.45
	Lingual gyrus	795,54		Lingual gyrus	737.46
	Cuneus	1536.44		Cuneus	1430.14
Hippocampus	Head	14.28 mm	Hippocampus	Head	13.41 mm
	Body	14.94 mm		Body	13.78 mm
	Tail	17.32 mm		Tail	16.36 mm
	Area	871.22 mm^2		Area	741.16 mm^2

Table 4. Measurements of brain 4 cortical areas and hippocampus. (left and right hemispheres).

Brain 4-Left			**Brain 4-Right**		
		Surface area mm^2			**Surface area mm^2**
Frontal gyri	Precentral	1992.04	Frontal gyri	Precentral	1863.62
	Superior lateral frontal	3025.91		Superior lateral frontal	3178.68
	Superior medial frontal	2332.8		Superior medial frontal	2120.51
	Middle frontal	2074.88		Middle frontal	2261.45
	Inferior frontal	1528.57		Inferior frontal	1646.25
	Straight gyrus	470.91		Straight gyrus	370.09
	Anterior orbital	420.94		Anterior orbital	403.81
	Posterior orbital	495.69		Posterior orbital	527.34
	Lateral orbital	441.89		Lateral orbital	418.71
	Medial orbital	561.47		Medial orbital	549.09
Temporal gyri	Superior temporal	1330.87	Temporal gyri	Superior temporal	1451.63
	Middle temporal	2067.8		Middle temporal	1979.15
	Inferior temporal	2160.06		Inferior temporal	1946.76
	Fusiform gyrus	2158.9		Fusiform gyrus	2179.39
	Parahippocampal	826.01		Parahippocampal	724,51

	Uncus	175.98		Uncus	159.88
Parietal lobe	Postcentral	1942.31	Parietal lobe	Postcentral	1978.18
	Superior parietal	3014.51		Superior parietal	3129.46
	Inferior parietal	2222.8		Inferior parietal	2227,53
	Precuneus	1507.34		Precuneus	1574.71
Occipital lobe	Occipital gyrus	1833.36	Occipital lobe	Occipital gyrus	1870.43
	Lingual gyrus	723.06		Lingual gyrus	677.82
	Cuneus	1304.97		Cuneus	1342.29
Hippocampus	Head	17	Hippocampus	Head	18
	Body	17		Body	13
	Tail	16		Tail	16
	Area	675		Area	840

Table 5. Correlations between left hippocampus and bottom frontal gyri.

		Hippocampus surface area L mm^2	**Straight gyrus R**	**Straight gyrus L**	**Anterior orbital R**	**Anterior orbital L**	**Posterior orbital R**	**Posterior orbital L**	**Lateral orbital R**	**Lateral orbital L**	**Medial orbital R**
Hippocampus Surface area L mm^2	Pearson correlation	1	0.972	0.841	-0.25	0.494	-0.519	-0.006	0.813	-0.658	0.139
	Sig. (2-tailed)		0.028	0.159	0.75	0.506	0.481	0.994	0.187	0.342	0.861
	N	4	4	4	4	4	4	4	4	4	4
Straight gyrus R	Pearson correlation	**.972**	1	0.857	-0.243	0.663	-0.386	-0.039	0.821	-0.777	-0.081
	Sig. (2-tailed)	0.028		0.143	0.757	0.337	0.614	0.961	0.179	0.223	0.919
	N	4	4	4	4	4	4	4	4	4	4
Straight gyrus L	Pearson correlation	0.841	0.857	1	-0.709	0.741	-0.707	-0.538	.998"	-0.408	0.148
	Sig. (2-tailed)	0.159	0.143		0.291	0.259	0.293	0.462	0.002	0.592	0.852
	N	4	4	4	4	4	4	4	4	4	4
Anterior orbital R	Pearson correlation	-0.25	-0.243	-0.709	1	-492	0.796	0.96	-0.752	-0.292	-0.381
	Sig. (2-tailed)	0.75	0.757	291		0.508	0.204	0.04	0.248	0.708	0.619
	N	4	4	4	4	4	4	4	4	4	4
Anterior orbital L	Pearson correlation	0.494	0.663	0.741	-0.492	1	-0.122	-0.491	0.72	-0.604	-0.517
	Sig. (2-tailed)	0.506	0.337	0.259	0.508		0.878	0.509	0.28	0.396	0.483
	N	4	4	4	4	4	4	4	4	4	4
Posterior orbital R	Pearson correlation	-0.519	-0.386	-0.707	0.796	-0.122	1	0.611	-0.746	-0.28	-0.786
	Sig. (2-tailed)	0.481	0.614	0.293	0.204	0.878		0.389	0.254	0.72	0.214
	N	4	4	4	4	4	4	4	4	4	4
Posterior orbital L	Pearson correlation	-0.006	-0.039	-0.538	.960*	-0.491	0.611	1	-0.584	-0.38	-0.223
	Sig. (2-tailed)	0.994	0.961	0.462	0.04	0.509	0.389		0.416	0.62	0.777
	N	4	4	4	4	4	4	4	4	4	4
Lateral orbital R	Pearson Correlation	0.813	0.821	.998"	-0.752	0.72	-0.746	-0.584	1	-0.345	0.195
	Sig. (2-tailed)	0.187	0.179	0.002	0.248	0.28	0.254	0.416		0.655	0.805
	N	4	4	4	4	4	4	4	4	4	4

Lateral orbital L	Pearson correlation	-0.658	-0.777	-0.408	-0.292	-0.604	-0.28	-0.38	-0.345	1	0.619
	Sig. (2-tailed)	0.342	0.223	0.592	0.708	0.396	0.72	0.62	0.655		0.381
	N	4	4	4	4	4	4	4	4	4	4
Medial orbital R	Pearson correlation	0.139	-0.081	0.148	-0.381	-0.517	-0.786	-0.223	0.195	0.619	1
	Sig. (2-tailed)	0.861	0.919	0.852	0.619	0.483	0.214	0.777	0.805	0.381	
	N	4	4	4	4	4	4	4	4	4	4

Note: *Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed)

Table 6. Correlations between right hippocampus and occipital gyri.

		Hippocampus surface area R mm^2	**Precuneus R**	**Precuneus L**	**Occipital gyrus R**	**Occipital gyrus L**	**Lingual gyrus R**	**Lingual gyrus L**	**Cuneus R**	**Cuneus L**
Hippocampus surface area R mm^2	Pearson correlation	1	.961	.871	-.094	.628	.407	.416	.870	.750
	Sig. (2-tailed)		.039	.129	.906	.372	.593	.584	.130	.250
	N	4	4	4	4	4	4	4	4	4
Precuneus R	Pearson correlation	**.961**	1	.910	.147	.727	.633	.534	.970*	.899
	Sig. (2-tailed)	.039		.090	.853	.273	.367	.466	.030	.101
	N	4	4	4	4	4	4	4	4	4
Precuneus L	Pearson correlation	.871	.910	1	-.064	.399	.691	.809	.844	.880
	Sig. (2-tailed)	.129	.090		.936	.601	.309	.191	.156	.120
	N	4	4	4	4	4	4	4	4	4
Occipital gyrus R	Pearson correlation	-.094	.147	-.064	1	.645	.588	-.002	.383	.418
	Sig. (2 tailed)	.906	.853	.936		.355	.412	.998	.617	.582
	N	4	4	4	4	4	4	4	4	4
Occipital gyrus L	Pearson correlation	.628	.727	.399	.645	1	.483	-.010	.824	.673
	Sig. (2-tailed)	.372	.273	.601	.355		.517	.990	.176	.327
	N	4	4	4	4	4	4	4	4	4
Lingual gyrus R	Pearson correlation	.407	.633	.691	.588	.483	1	.794	.753	.908
	Sig. (2-tailed)	.593	.367	.309	.412	.517		.206	.247	.092
	N	4	4	4	4	4	4	4	4	4
Lingual gyrus L	Pearson correlation	.416	.534	.809	-.002	-.010	.794	1	.523	.733
	Sig. (2-tailed)	.584	.466	.191	.998	.990	.206		.477	.267
	N	4	4	4	4	4	4	4	4	4
Cuneus R	Pearson correlation	.870	.970'	.844	.383	.824	.753	.523	1	.952
	Sig. (2-tailed)	.130	.030	.156	.617	.176	.247	.477		.048
	N	4	4	4	4	4	4	4	4	4
Cuneus L	Pearson correlation	.750	.899	.880	.418	.673	.908	.733	.952	1
	Sig. (2-tailed)	.250	.101	.120	.582	.327	.092	.267	.048	
	N	4	4	4	4	4	4	4	4	4

Note: *Correlation is significant at the 0.05 level (2-tailed).

Table 7. Correlations between left hippocampus and occipital gyri.

		Hippocampus surface area L mm^2	Precuneus R	Precuneus L	Occipital gyrus R	Occipital gyrus L	Lingual gyrus R	Lingual gyrus L	Cuneus R	Cuneus L
Hippocampus surface area L mm^2	Pearson correlation	1	.609	.797	.276	.221	.935	.958	.659	.855
	Sig. (2-tailed)		.391	.203	.724	.779	.065	.042	.341	.145
	N	4	4	4	4	4	4	4	4	4
Precuneus R	Pearson correlation	.609	1	.910	.147	.727	.633	.534	.970	.899
	Sig. (2-tailed)	.391		.090	.853	.273	.367	.466	.030	.101
	N	4	4	4	4	4	4	4	4	4
Precuneus L	Pearson correlation	**.797***	.910	1	-.064	.399	.691	.809	.844	.880
	Sig. (2-tailed)	.021	.090		.936	.601	.309	.191	.156	.120
	N	4	4	4	4	4	4	4	4	4
Occipital gyrus R	Pearson correlation	.276	.147	-.064	1	.645	.588	-.002	.383	.418
	Sig. (2-tailed)	.724	.853	.936		.355	.412	.998	.617	.582
	N	4	4	4	4	4	4	4	4	4
Occipital gyrus L	Pearson correlation	221	.727	.399	.645	1	.483	-.010	.824	.673
	Sig. (2-tailed)	.779	.273	.601	.355		.517	.990	.176	.327
	N	4	4	4	4	4	4	4	4	4
Lingual gyrus R	Pearson correlation	.935	.633	.691	.588	.483	1	.794	.753	.908
	Sig. (2-tailed)	.065	.367	.309	.412	.517		.206	.247	.092
	N	4	4	4	4	4	4	4	4	4
Lingual gyrus L	Pearson correlation	**.958**	.534	.809	-.002	-.010	.794	1	.523	.733
	Sig. (2-tailed)	.042	.466	.191	.998	.990	.206		.477	.267
	N	4	4	4	4	4	4	4	4	4
Cuneus R	Pearson correlation	.659	.970*	.844	.383	.824	.753	.523	1	.952
	Sig. (2-tailed)	.341	.030	.156	.617	.176	.247	.477		.048
	N	4	4	4	4	4	4	4	4	4
Cuneus L	Pearson correlation	.855	.899	.880	.418	.673	.908	.733	.952	1
	Sig. (2-tailed)	.145	.101	.120	.582	.327	.092	.267	.048	
	N	4	4	4	4	4	4	4	4	4

Note: *Correlation is significant at the 0.05 level (2-tailed).

Table 8. Correlations between the left hippocampus and parietal gyri.

		Hippocampus surface area L mm^2	Postcentral R	Postcentral L	Superior parietal R	Superior parietal L	Inferior parietal R	Inferior parietal L
Hippocampus surface area L mm^2	Pearson correlation	1	.252	-.074	-.704	.170	-.984*	.304
	Sig. (2-tailed)		.748	.926	.296	.830	.016	.696
	N	4	4	4	4	4	4	4
Postcentral R	Pearson correlation	.252	1	.729	.416	.949	-238	-.771
	Sig. (2-tailed)	.748		.271	.584	.051	.762	.229
	N	4	4	4	4	4	4	4
Postcentral L	Pearson	-.074	.729	1	.301	.905	.194	-.936

	correlation							
	Sig. (2-tailed)	.926	.271		.699	.095	.806	.064
	N	4	4	4	4	4	4	4
Superior parietal R	Pearson correlation	-.704	.416	.301	1	.345	.634	-.617
	Sig. (2-tailed)	.296	.584	.699		.655	.366	.383
	N	4	4	4	4	4	4	4
Superior parietal L	Pearson correlation	.170	.949	.905	.345	1	-.102	-.884
	Sig. (2-tailed)	.830	.051	.095	.655		.898	.116
	N	4	4	4	4	4	4	4
Inferior parietal R	Pearson correlation	**-.984***	-.238	.194	.634	-.102	1	-.375
	Sig. (2-tailed)	.016	.762	.806	.366	.898		.625
	N	4	4	4	4	4	4	4
Inferior parietal L	Pearson correlation	.304	-.771	-.936	-.617	-.884	-.375	1
	Sig. (2-tailed)	.696	.229	.064	.383	.116	.625	
	N	4	4	4	4	4	4	4

Note: *Correlation is significant at the 0.05 level (2-tailed).

The significance of these findings becomes apparent as we explore the intricate connections between the hippocampus and cortical areas. Our research revealed compelling correlations between the surface areas of the hippocampus and specific gyri in both hemispheres. Notably, the right hippocampus showed significant correlations with contralateral inferior and middle frontal gyri, as well as ipsilateral superior lateral frontal and straight gyri. Similarly, the left hippocampus displayed pronounced correlations with contralateral middle and superior lateral frontal gyri and ipsilateral inferior frontal and straight gyri. Additionally, we discovered a positive correlation between the surface area of the precuneus and the hippocampus in the same hemisphere. These findings highlight the linkage and functional relationships between the hippocampus and various cortical areas, shedding light on the complex neural mechanisms underlying memory and cognition. The observed findings of the hippocampus influencing the size of different frontal gyri emphasizes the vital connection between the hippocampus and prefrontal cortex. Such insights deepen our understanding of the role of the hippocampus in influencing the size of certain gyri whether ipsilaterally or contralaterally.

The novel findings regarding the morphological relationships between the hippocampus and specific gyri highlight the influential role of the hippocampus in shaping cortical area sizes. These results suggest the presence of intriguing functional connections between these brain regions. Importantly, our morphometric analysis revealed that the size of the hippocampus exhibited dominance in male specimens compared to females, and on the right side of the brains in both subgroups. These findings align with extensive literature on the subject, further emphasizing the substantial impact of the hippocampus on cortical area sizes. By elucidating the intricate interplay between the hippocampus and cortical regions, these findings contribute to a deeper understanding of the complex neural mechanisms underlying memory and cognition. Such insights not only expand our knowledge of brain region interactions but also open up new avenues for investigating the functional dynamics of the hippocampo-cortical association.

Discussion

The hippocampus, situated in the medial temporal lobe, plays a pivotal role in memory formation and spatial navigation, exerting significant influence over cortical areas involved in diverse cognitive processes. Within the parahippocampal gyrus, the entorhinal cortex acts as a gateway between the neocortex and hippocampus, receiving inputs from sensory and association areas and transmitting them to the hippocampus through the perforant pathway. Reciprocal connections complete an information loop between the entorhinal cortex and hippocampus. The hippocampus was larger than parahippocampus in the right hemispheres however the parahippocampus was larger than hippocampus in the left hemisphere signifying the less activity the left hippocampus might be having compared to the right hippocampus, leading to this size difference.

Surrounding the hippocampus, the parahippocampal cortex encompasses interconnected regions like the perirhinal, postrhinal, and parahippocampal cortices, contributing to episodic memory encoding and retrieval. The hippocampal-prefrontal network, formed by extensive connections between the hippocampus and frontal cortex, particularly the inferior frontal cortex, is vital for memory consolidation and executive functions. The frontal gyri in the right hemisphere were predominantly larger than the left hemisphere. The results show the significance of the hippocampus in influencing the size of the different frontal gyri where a bigger the bigger hippocampus in the right hemisphere lead to bigger frontal gyri in the right hemisphere. This highlights the crucial coordination they play in allowing us to learn, remember and make informed decisions in our daily lives. The temporal cortex, including the superior, middle, and inferior gyri, integrates sensory information with memory processes. The temporal gyri demonstrated clear asymmetry between the two hemispheres with no clearer pattern of size dominance. The parietal cortex, especially the posterior parietal cortex, aids in spatial processing and attention, receiving inputs from the hippocampus for spatial memory and navigation. There was no clear pattern with the size of the hippocampus and the size of the parietal gyri in both hemispheres. The occipito-temporal cortex, encompassing regions like the fusiform gyrus, connects with the hippocampus to integrate visual information with object and scene memory. The occipital gyri tended to be predominantly larger on the left side of the brains which eluded to some contralateral relationship between the hippocampus and occipital gyri where as mentioned before the hippocampus was mainly larger on the right side of the brains. Thalamic nuclei, such as the anterior thalamic nuclei, establish dense connections with the hippocampus to contribute to spatial memory and navigation. Moreover, the hippocampus forms strong connections with the amygdala, facilitating the interplay between emotional experiences and memory formation. These interactions allow the amygdala to modulate hippocampal activity, influencing the consolidation and retrieval of emotionally salient memories. The intricate web of connections involving the hippocampus underscores its essential role in shaping the size and functioning of specific gyri and cortical areas, highlighting its significance in cognitive processes and memory formation.

Conclusion

The hippocampus is a critical structure for memory formation and consolidation. It is also heavily interconnected with other cortical areas, including the prefrontal cortex, the parahippocampal gyrus, and the entorhinal cortex. These connections allow the hippocampus to integrate information from different sensory modalities and to form new associations between memories.

The hippocampus and prefrontal cortex play complementary roles in memory processing. The hippocampus is thought to be involved in the initial encoding of memories, while the prefrontal cortex is involved in the consolidation and retrieval of memories. Damage to either of these structures can impair memory function.

In addition to its role in memory, the hippocampus is also involved in other cognitive functions, such as spatial navigation and emotion processing. The connections between the hippocampus and other cortical areas are essential for these functions.

Further research is needed to better understand the role of the hippocampus in cortical processing. This research could lead to new treatments for memory disorders and other cognitive impairments. With future studies exploring different research questions such as how do the connections between the hippocampus and other cortical areas change with development and aging?

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