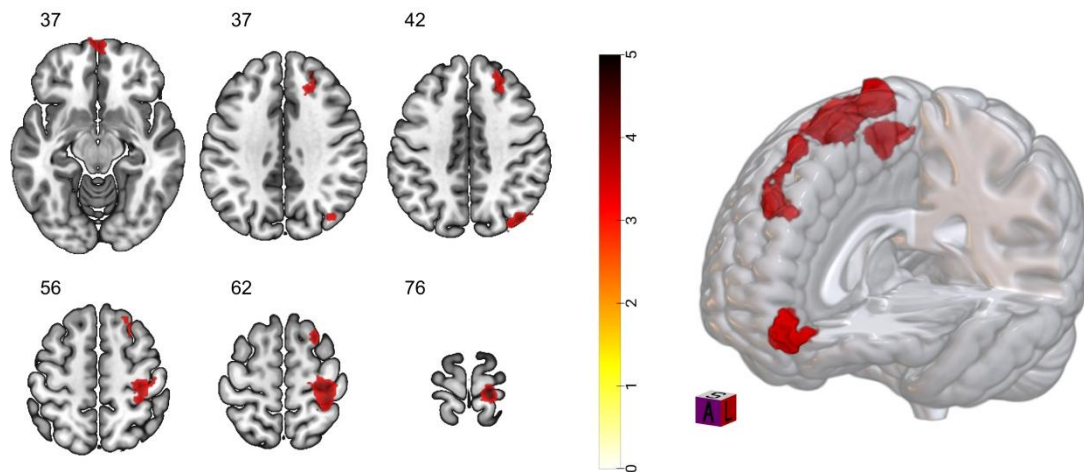




Supplementary Figure 1. Task-related brain responses during olfactory stimulation.

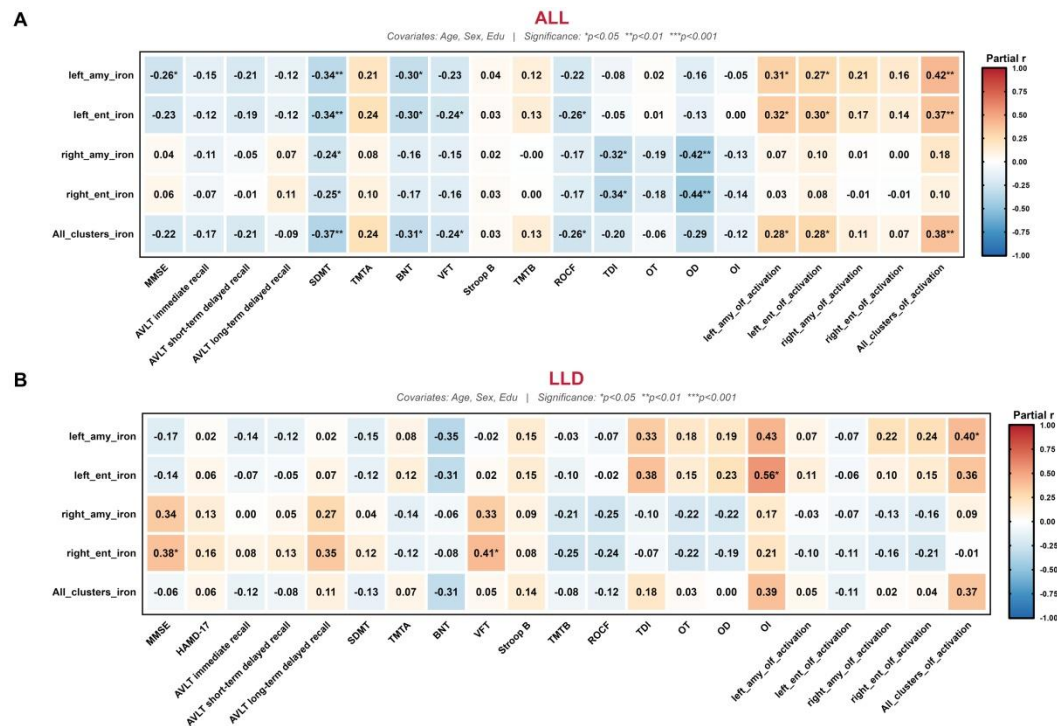
Whole-brain one-sample t-test of the olfactory task contrast across all available participants with usable task-fMRI data (Puncorrected < 0.001 , cluster $p < 0.05$). Significant clusters were observed in the “Odor $<$ Air” direction. The color bar indicates T values.

Supplementary Table 1. Brain areas showing task-related responses during the olfactory fMRI paradigm.

BrainRegion	Area Size	Cluster Size	MNI coordinates (x y z)	Tmax
Right PoG postcentral gyrus	439	1040	18 -28 76	4.858
Right PrG precentral gyrus	199			
Right Cerebral White Matter	156			
Right SPL superior parietal lobule	135			
Unknown	110			
Unknown	89	170	42 -76 42	4.591
Right MOG middle occipital gyrus	57			
Right AnG angular gyrus	16			
Right SFG superior frontal gyrus	198	287	24 16 62	4.133
Right MFG middle frontal gyrus	49			
Right Cerebral White	26			

BrainRegion	Area Size	Cluster Size	MNI coordinates (x y z)	Tmax
Matter				
Unknown	14			
Unknown	174	249	-6 72 -12	4.025
Right FRP frontal pole	35			
Left FRP frontal pole	33			

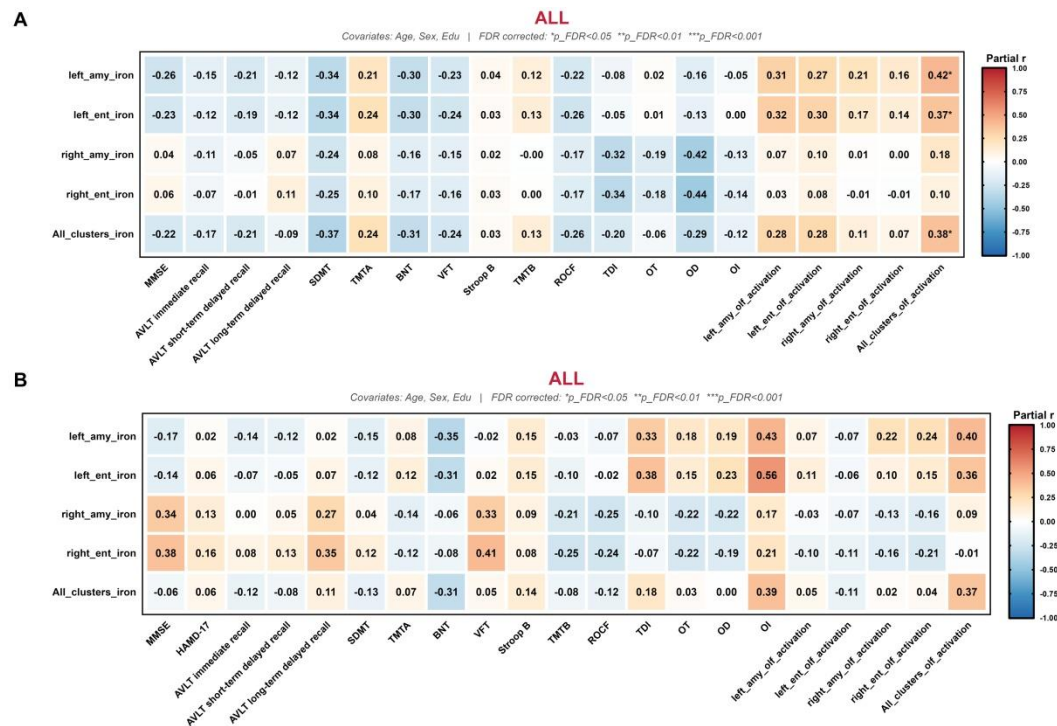
Note: Anatomical labels were assigned using the Neuromorphometrics atlas. Labeled areas with fewer than 10 voxels were not included in the table. MNI, Montreal Neurological Institute; Tmax, maximum t value.



Supplementary Figure 2. Correlation analyses between regional brain iron concentration, cognitive performance, olfactory function, and olfactory-related brain activation.

(A) Heatmap of partial correlation coefficients in all participants before FDR correction. (B) Heatmap of partial correlation coefficients in LLD patients before FDR correction. Rows represent regional or whole-cluster brain iron concentration measures, including the left amygdala, left entorhinal cortex, right amygdala, right entorhinal cortex, and all significant clusters combined. Columns represent global cognition, domain-specific cognitive performance, olfactory function, and olfactory task-related activation measures. Warmer colors indicate positive correlations, and cooler colors indicate negative correlations, with color intensity reflecting the magnitude of the partial correlation coefficient (r). Partial correlations were adjusted for age, sex, and years of education. Asterisks indicate significance levels: $p < 0.05$, $p < 0.01$, $p < 0.001$. **Abbreviations:** LLD: late-life depression; MMSE: Mini-mental State Examination; AVLT: Auditory Verbal Learning Test; SDMT: Symbol-Digit Modality Test; TMTA: Trail-Making Test A; TMTB: Trail-Making Test B; Stroop B: The Stroop Color and Word Test B; BNT: Boston Naming Test; VFT: Verbal Fluency

Test; ROCF: Rey-Osterrieth Complex Figure; TDI: Threshold-Discrimination-Identification; OT: Olfactory Threshold; OD: Odor Discrimination; OI: odor identification; amy: amygdala; ent: entorhinal cortex; olf: olfactory.



Supplementary Figure 3. Correlation analyses between regional brain iron concentration, cognitive performance, olfactory function, and olfactory-related brain activation after FDR correction.

(A) Heatmap of partial correlation coefficients in all participants after FDR correction.

(B) Heatmap of partial correlation coefficients in LLD patients after FDR correction.

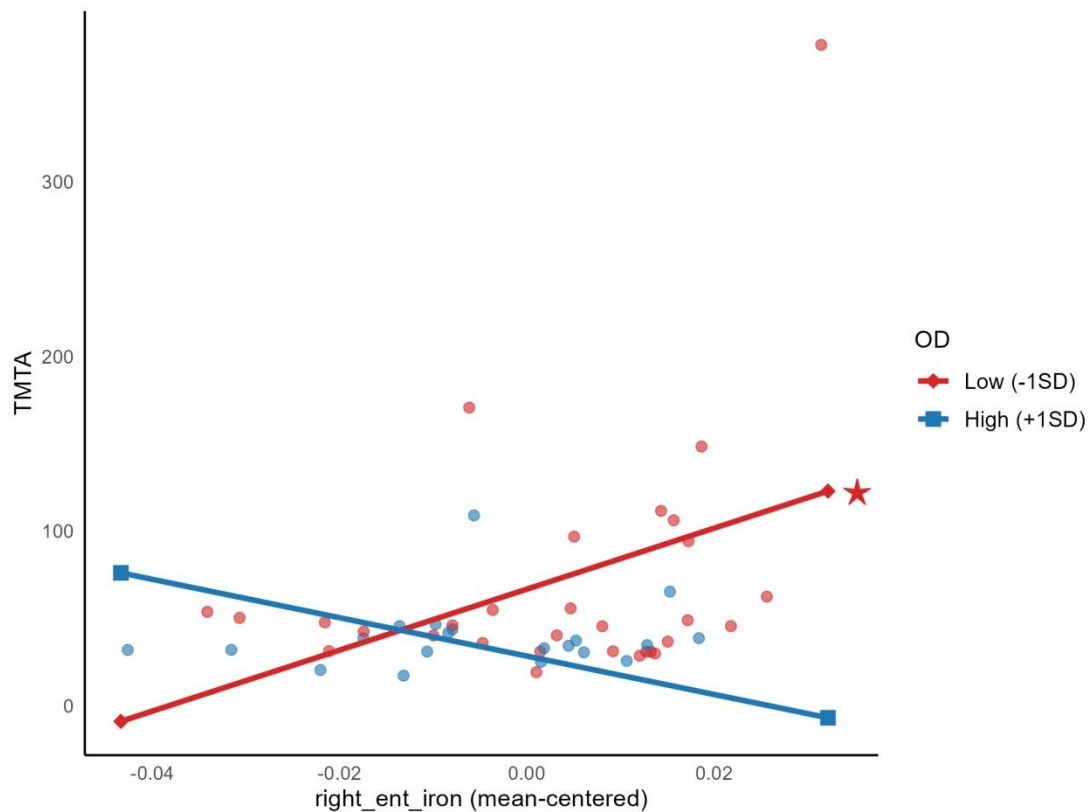
Rows represent regional or whole-cluster brain iron concentration measures, including the left amygdala, left entorhinal cortex, right amygdala, right entorhinal cortex, and all significant clusters combined. Columns represent global cognition, domain-specific cognitive performance, olfactory function, and olfactory task-related activation measures. Warmer colors indicate positive correlations, and cooler colors indicate negative correlations, with color intensity reflecting the magnitude of the partial correlation coefficient (r). Partial correlations were adjusted for age, sex, and years of education. FDR correction was applied separately within each analytical domain using the Benjamini-Hochberg procedure. Asterisks indicate significance levels after FDR correction: * $q < 0.05$, ** $q < 0.01$, *** $q < 0.001$. **Abbreviations:**

LLD: late-life depression; MMSE: Mini-mental State Examination; AVLT: Auditory Verbal Learning Test; SDMT: Symbol-Digit Modality Test; TMTA: Trail-Making Test A; TMTB: Trail-Making Test B; Stroop B: The Stroop Color and Word Test B; BNT: Boston Naming Test; VFT: Verbal Fluency Test; ROCF: Rey-Osterrieth Complex Figure; TDI: Threshold-Discrimination-Identification; OT: Olfactory Threshold; OD: Odor Discrimination; OI: Odor Identification; amy: amygdala; ent: entorhinal cortex; olf: olfactory.

Supplementary Table 2. Results of exploratory moderation analyses with nominally significant interaction effects ($p < 0.05$).

X	M	Y	β	p	q	95% CI
right_ent_iron	OD	TMTA	-467.607	< 0.001	0.046	[-700.221, -234.993]
left_amy_iron	OT	MMSE	-44.338	0.017	0.737	[-80.231, -8.444]
left_amy_iron	OT	SDMT	-116.366	0.025	0.780	[-217.138, -15.593]
left_amy_iron	OT	TMTA	469.857	0.033	0.845	[40.389, 899.325]
right_amy_iron	OT	TMTA	-511.840	0.011	0.642	[-899.802, -123.878]
right_ent_iron	OT	TMTA	-519.222	0.012	0.642	[-916.277, -122.167]
right_amy_iron	OD	TMTA	-423.565	0.001	0.055	[-650.575, -196.554]
left_amy_iron	OT	ROCF	-53.401	0.043	0.845	[-104.912, -1.89]
left_ent_iron	OT	ROCF	-47.194	0.022	0.780	[-87.368, -7.019]

X = predictor (regional iron concentration); M = moderator (olfactory measure); Y = cognitive outcome; q = FDR-corrected p value. Only the right entorhinal cortex $\times$ OD interaction survived FDR correction (q = 0.046); this effect was not significant in sensitivity analyses using HC3 robust standard errors ($p = 0.376$) or after exclusion of influential observations (Cook's $D > 4/n$; $p = 0.334$).



Supplementary Figure 4. Odor discrimination moderates the association between iron concentration in the right entorhinal cortex and TMTA performance.

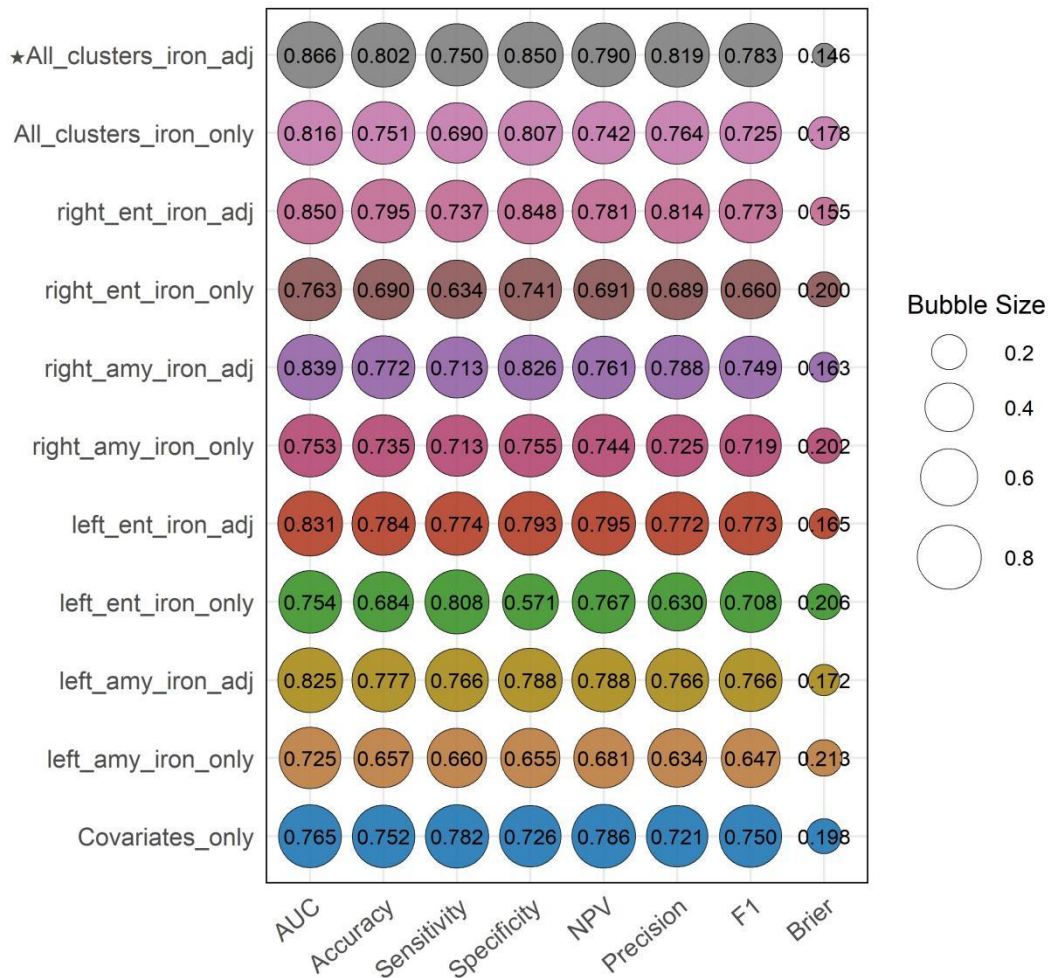
The lines represent model-predicted values from the moderation analysis at low (-1 SD) and high ($+1$ SD) levels of OD, with covariates held constant. At low OD levels, iron concentration in the right entorhinal cortex was positively associated with TMTA, whereas this association was not significant at high OD levels. The star indicates a significant simple slope ($p < 0.05$). **Abbreviations:** ent: entorhinal cortex; Trail Making Test Part A (TMTA); odor discrimination (OD).

Supplementary Table 3. Results of exploratory mediation analyses with nominally significant indirect effects (ACME $p < 0.05$).

X	M	Y	ACME	<i>p</i>	<i>q</i>	95% CI
		AVLT				
right_amy_iron	OD	immediate recall	-44.800	0.047	0.831	[-97.451,-0.579]
		AVLT				
right_ent_iron	OD	immediate recall	-51.434	0.042	0.831	[-106.480,-1.673]
		AVLT				
right_amy_iron	OD	long-term delayed recall	-23.192	0.024	0.831	[-51.455,-2.047]
		AVLT				
right_ent_iron	OD	long-term delayed recall	-27.119	0.020	0.831	[-58.190,-3.497]
right_amy_iron	OD	SDMT	-91.193	0.036	0.831	[-207.665,-5.117]
right_ent_iron	OD	SDMT	-103.441	0.033	0.831	[-234.592,-6.080]
right_amy_iron	OD	TMTA	507.915	0.010	0.827	[33.518,1292.806]
right_ent_iron	OD	TMTA	540.499	0.012	0.827	[35.129,1359.379]
All_clusters_iron	OD	TMTA	394.864	0.043	0.831	[4.633,1083.250]

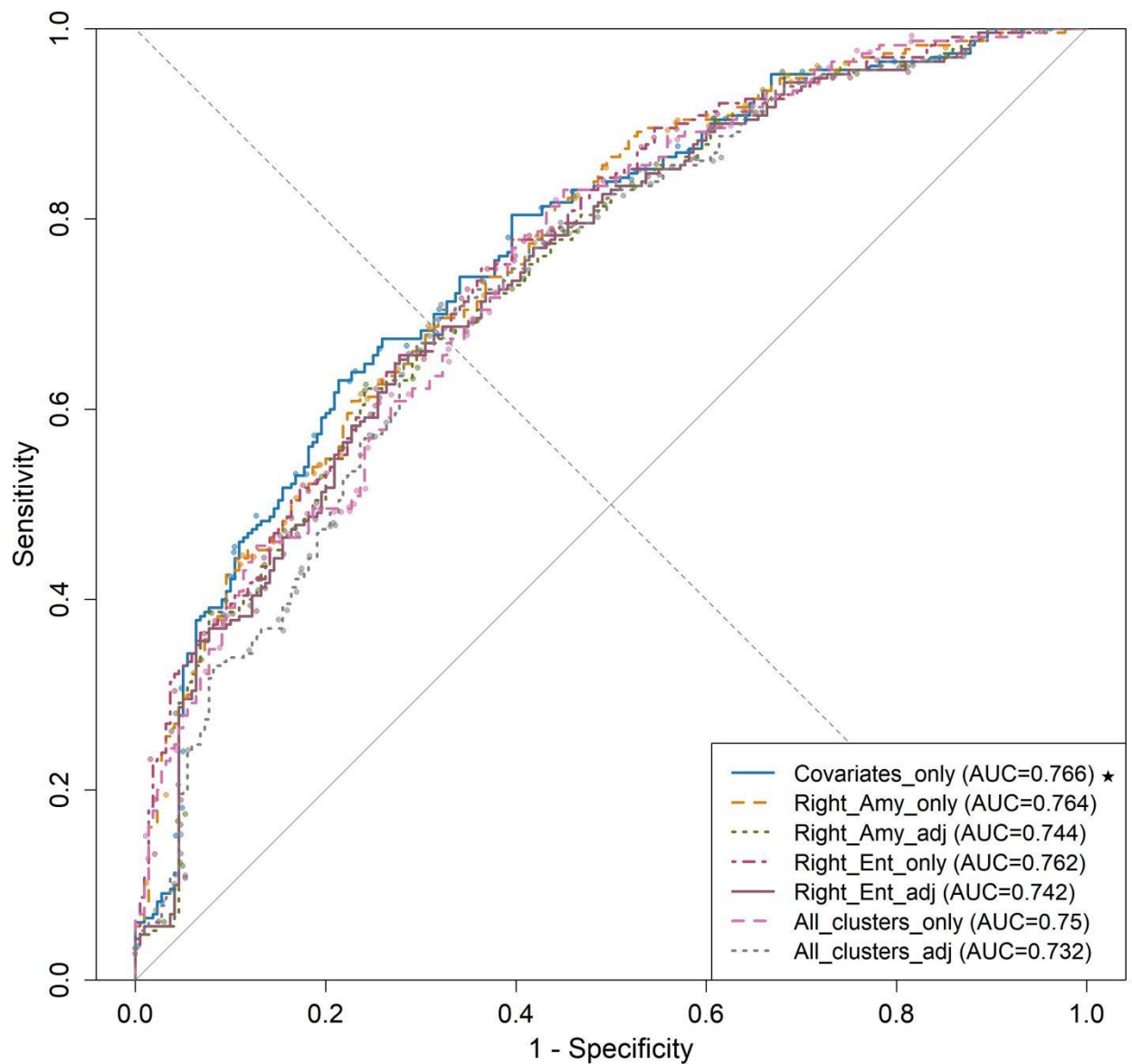
X	M	Y	ACME	<i>p</i>	q	95% CI
right_amy_iron	OD	VFT	-34.636	0.012	0.827	[-68.509,-6.346]
right_ent_iron	OD	VFT	-38.452	0.016	0.827	[-77.164,-7.176]

X = predictor (regional iron concentration); M = mediator (olfactory measure); Y = cognitive outcome; ACME = average causal mediation effect; q = FDR-corrected p value. No indirect effect survived FDR correction.



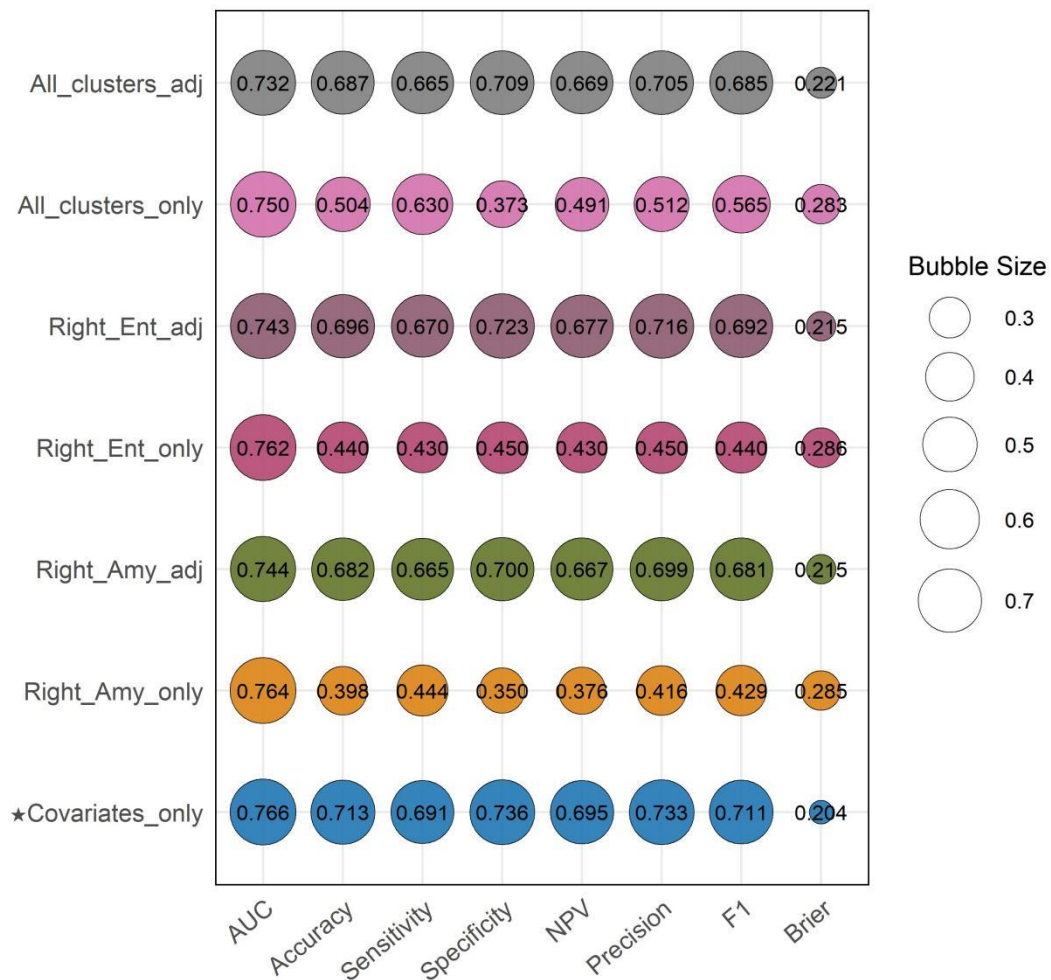
Supplementary Figure 5. Performance bubble chart for regional brain iron-based LLD prediction models.

Performance metrics including AUC, accuracy, sensitivity, specificity, NPV, precision, F1-score, and Brier score for all LLD prediction models. Bubble size corresponds to the magnitude of each metric. The optimal model is marked with a ★ on the y-axis label. **Abbreviations:** LLD: late-life depression; HC: healthy control; amy: amygdala; ent: entorhinal cortex; AUC: area under the curve; NPV: negative predictive value; F1: F1-score.



Supplementary Figure 6. ROC curves for predicting olfactory dysfunction using regional brain iron concentration.

ROC curves for olfactory dysfunction prediction models based on iron-only, covariates-only, and iron-adj predictors. The covariates-only model showed the highest AUC(★). **Abbreviations:** TDI: Threshold-Discrimination-Identification; amy: amygdala; ent: entorhinal cortex; ROC: receiver operating characteristic; AUC: area under the curve; adj: adjusted.



Supplementary Figure 7. Performance bubble chart for regional brain iron-based olfactory dysfunction prediction models.

Performance metrics including AUC, accuracy, sensitivity, specificity, NPV, precision, F1-score, and Brier score for all TDI prediction models. Bubble size represents the magnitude of each metric. The optimal model is marked with a ★ on the y-axis label. **Abbreviations:** TDI: Threshold-Discrimination-Identification; amy: amygdala; ent: entorhinal cortex; AUC: area under the curve; NPV: negative predictive value; F1: F1-score.