Supplementary Information

A unified neurocognitive model of semantics language social behaviour and face recognition in semantic dementia

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| Factor 1: apathy | Peak coordinate | Peak R value | Voxel number | Side | Regions |
|-----------------|-----------------|--------------|--------------|------|----------|
|                 | -4.5 61 5.4 3.5  | 0.40         | 141          | L    | Superior frontal gyrus, medial part |
|                 | -4.8 22.5       | 0.36         | 140          | L    | Superior frontal gyrus, medial part |
|                 | 3 61.5 -12      | 0.38         | 111          | R    | Superior frontal gyrus, medial orbital part |
|                 | -4.5 61.5 -12   | 0.37         | 73           | L    | Superior frontal gyrus, medial orbital part |
| Factor 2: face  | 55.5 -28.5 -6   | 0.76         | 13791        | R    | Insula, fusiform, parahippocampal, rectus, anterior cingulate, and Heschl gyri; superior, middle and inferior temporal gyrus; temporal pole; inferior frontal gyrus; orbital part; olfactory cortex; superior frontal gyrus, medial orbital; Rolandic operculum |
|                 | -1.5 31.5 -16.5 | 0.60         | 474          | L    | Superior frontal gyrus, medial orbital part |
|                 | 4.5 -34.5       | 0.60         | 411          | R    | Anterior and middle cingulate gyri |
|                 | 55.5 -27 21     | 0.54         | 82           | R    | Rolandic operculum |
| Factor 3: naming| -37.5 -16.5 -37.5 | 0.71       | 4557         | L    | Superior, middle and inferior temporal gyrus; temporal pole; superior temporal gyrus; parahippocampal gyrus |
|                 | -21.3 -25.5     | 0.89         | 797          | L    | Lenticular nucleus, temporal pole; superior temporal gyrus; parahippocampal gyrus; rectus, superior temporal gyrus; superior frontal gyrus, medial orbital; anterior cingulate gyrus; supplementary motor area; superior temporal gyrus; middle temporal gyrus; superior parietal and supramarginal gyrus |
|                 | 51.6 -12        | 0.32         | 83           | R    | Insula, rectus, superior temporal gyrus; superior and inferior frontal gyrus; orbital part; anterior cingulate gyrus; supplementary motor area; superior frontal gyrus; medial and medial orbital part; olfactory cortex; Rolandic operculum |
| Factor 4: distribution | -1.5 -15.42 | 0.52 | 2543 | L | Superior frontal gyrus, medial and medial orbital part; olfactory cortex; Rolandic operculum |
| Factor 5: SD severity | 1.5 -4.5 48.5 | 0.53 | 2179 | R | Superior frontal gyrus, medial and medial orbital part; olfactory cortex; Rolandic operculum |
|                 | -67.5 -33 -4.5  | 0.46         | 1921         | L    | Middle and inferior temporal gyrus; inferior occipital gyrus |
|                 | -49.5 -48 45    | 0.51         | 665          | L    | Superior parietal and supramarginal gyrus |
|                 | 4.5 27.5 -58.5  | 0.39         | 579          | R    | Superior frontal gyrus, orbital |
|                 | -16.5 -22.5 -25.5 | 0.42     | 454          | L    | Orbitalplanum gyrus |
|                 | 34.5 24.5 -1.5  | 0.38         | 297          | R    | Insula |
|                 | -49.5 -61.5 -22.5 | 0.37   | 175          | L    | Inferior temporal gyrus |
|                 | -60 -52.5 15    | 0.35         | 155          | R    | Middle temporal gyrus |
|                 | 48 -49 45.5 46.5 | 0.45         | 108          | R    | Inferior parietal gyrus |
|                 | 64.5 -15 12     | 0.41         | 77           | R    | Superior temporal gyrus |
|                 | -60 -6.4 45     | 0.36         | 72           | R    | Superior temporal gyrus |
|                 | 18 -19.5 27     | 0.35         | 53           | R    | Rolandscopem gyrus |
|                 | -52.5 -45.9     | 0.39         | 52           | L    | Middle temporal gyrus |

Only positive clusters were reported (Cluster size > 50 voxels; n = 47; df = 45). The results of F2 & 3 were corrected by the permutation-based FWER (v = 100). Their q values are 0.02 and 0.007, respectively. Other results’ thresholds are uncorrected p < 0.05. VBCM: voxel-based correlation mapping. Source data are provided as a Source Data file.
| Peak coordinate | Peak R value | Voxel number | Side | Regions |
|-----------------|--------------|--------------|------|---------|
| Factor 1: apathy | -55.5 3.73 9.73 1750 L | | | Temporal pole; inferior frontal gyrus: orbital part; middle temporal gyrus |
| | -4.560.00.5 9.22 1373 L | | | Superior frontal gyrus: medial and orbital parts; anterior cingulate and rectus gyrus |
| | 4.5 0.60.60.6 9.02 879 R | | | Superior frontal gyrus: medial and orbital parts; anterior cingulate and rectus gyrus |
| | -0.40.62.60.7 7.16 175 L | | | Insula |
| | -3.10.5 2.5 5.16 150 M | | | Middle and superior temporal gyrus; parahippocampal and fusiform gyrus; temporal pole; Rolandic operculum |
| | -5.1 2.50.5 9.27 120 L | | | Middle and superior temporal gyrus; parahippocampal and fusiform gyrus; temporal pole; Rolandic operculum |
| Factor 2: face | 22.5 2.60.6 10 4127 R | | | Superior frontal gyrus: medial orbital part; Superior; middle and inferior temporal gyrus; insula; parahippocampal and fusiform gyrus; temporal pole |
| | 4.10.5 2.50.6 9.66 373 L | | | Olfactory cortex; superior frontal gyrus: medial orbital part; Superior; middle and inferior temporal gyrus; insula |
| Factor 3: naming | -55.5 4.50.5 10 9005 L | | | Superior; middle and inferior temporal gyrus; parahippocampal and fusiform gyrus; temporal pole |
| | -27 2.5-2.5 6.23 170 L | | | Olfactory cortex; rectus gyrus; Superior frontal gyrus; medial orbital part; Superior; middle and inferior temporal gyrus; parahippocampal and fusiform gyrus; temporal pole |
| | -57 2.5-2.5 5.99 155 L | | | Middle temporal gyrus; Superior frontal gyrus; medial orbital part; Superior; middle and inferior temporal gyrus; parahippocampal and fusiform gyrus; temporal pole |
| | -61.5 2.5-2.5 7.06 94 L | | | Middle temporal gyrus; Superior frontal gyrus; medial orbital part; Superior; middle and inferior temporal gyrus; parahippocampal and fusiform gyrus; temporal pole |
| Factor 4: disinhibition | 54.9 2.10.5 10 2502 R | | | Superior; middle and inferior temporal gyrus; parahippocampal and fusiform gyrus; temporal pole |
| | 6.10.5 2.5 9.82 877 L | | | Olfactory cortex; parahippocampal and fusiform gyrus; Superior frontal gyrus; medial orbital part; Superior; middle and inferior temporal gyrus; parahippocampal and fusiform gyrus; temporal pole |
| | -66.5 2.5-2.5 4.71 77 L | | | Middle temporal gyrus; Superior frontal gyrus; medial orbital part; Superior; middle and inferior temporal gyrus; parahippocampal and fusiform gyrus; temporal pole |
| | -0.5 -2.54.5 6.3 163 L | | | Superior frontal gyrus; medial orbital part; Superior; middle and inferior temporal gyrus; parahippocampal and fusiform gyrus; temporal pole |
| Factor 5: SD severity | -7.5 2.31.5-2.5 10 6914 R | | | Superior focal gyrus; inferior orbital gyrus; Insula; anterior and middle cingulate gyrus; rectus and Heschl gyrus; superior frontal gyrus; middle orbital and orbital parts; olfactory cortex; supplementary motor area; inferior frontal gyrus: orbital part; Rolandic operculum; caudate |
| | -64.5 2.5-2.5 9.50 2686 L | | | Middle and inferior temporal gyrus; parahippocampal and fusiform gyrus; Supplementary motor area; superior frontal gyrus: middle orbital and orbital parts |
| | 4.5 0.50.5 7.19 2463 R | | | Superior and inferior frontal gyrus; Superior parietal and angular gyrus; Middle temporal gyrus |
| | 9 2.52.5 7.92 864 R | | | Superior parietal and angular gyrus; Middle temporal gyrus |
| | -49.5 2.51.5 9.92 767 L | | | Superior parietal and anterior cingulate gyrus |
| | -13.5 2.50.5 7.08 585 L | | | Parahippocampal and fusiform gyrus |
| | 34.5 2.52.5 9.92 439 R | | | Insula |
| | -60.5 -5.5 6.40 244 R | | | Middle temporal gyrus |
| | 48 4.95.4 7.43 120 R | | | Superior parietal gyrus |
| | 21 2.52.5 4.23 110 R | | | Parahippocampal gyrus |
| | 64.5 2.51.5 5.62 95 R | | | Superior temporal gyrus |
| | 66 2.56.5 6.04 87 R | | | Middle temporal gyrus |
| | -58.5 3.1 5.66 68 R | | | Superior temporal gyrus |
| | -55.5 3.5 5.55 54 R | | | Middle temporal gyrus |

Only positive clusters were reported (Cluster size > 50 voxels; n = 47). The cross-validation $p$ values of F1-F5 were 0.18, 0.17, 0.002, 0.04, 0.17, respectively. SVR: support vector regression. Source data are provided as a Source Data file.
### Table 3: The significant clusters of the two-tailed SCCAN

| Factor | Region | Left | Right | L | R |
|--------|--------|------|-------|---|---|
| Factor 1: apathy | | | | | |
| SD severity | | | | | |
| -40.5 | 16.5 | 0.56 | 0.00001 | | |
| -37.5 | 18.0 | 0.28 | 0.00001 | | |
| -37.5 | 17.5 | 0.23 | 0.00001 | | |
| -37.5 | 17.0 | 0.20 | 0.00001 | | |
| -37.5 | 16.5 | 0.18 | 0.00001 | | |
| Factor 2: face | | | | | |
| Factor 3: naming | | | | | |
| Factor 4: disinhibition | | | | | |
| Factor 5: SD severity | | | | | |

**Note:** Only positive clusters were reported (Cluster size > 50 voxels, n = 47). The cross-validation p values of F1-F5 were 0.08, 0.00003, 0.17, 0.04, respectively. SCCAN: sparse canonical correlation analysis for neuroimaging. Source data are provided as a Source Data file.
Supplementary table 4. The R values of right face-related ROIs in SD patients.

| Face | OFA | FFA | pSTS | aSTS |
|------|-----|-----|------|------|
| Word-picture verification | 0.27 (0.02-0.52) | 0.41 (0.15-0.64) | 0.30 (0.01-0.54) | 0.46 (0.20-0.66) | 0.55 (0.31-0.73) |
| Perception | 0.27 (0.02-0.51) | 0.36 (0.08-0.59) | 0.27 (0.02-0.52) | 0.42 (0.15-0.62) | 0.39 (0.12-0.61) |
| Picture naming | 0.12 (0.07-0.40) | 0.09 (0.03-0.38) | 0.09 (-0.01-0.38) | 0.01 (-0.30-0.31) | 0.05 (0.26-0.33) |
| Perception | 0.30 (0.06-0.55) | 0.25 (0.06-0.4) | 0.37 (0.08-0.49) | 0.39 (0.10-0.61) | 0.42 (0.14-0.64) |
| Object | 0.07 (0.22-0.35) | 0.07 (0.22-0.35) | 0.02 (-0.31-0.27) | 0.06 (0.25-0.33) | 0.19 (0.11-0.45) |
| Picture matching | 0.01 (0.28-0.29) | 0.21 (0.07-0.46) | 0.05 (0.24-0.35) | 0.38 (0.10-0.60) | 0.35 (0.08-0.59) |
| Perception | -0.07 (-0.35-0.22) | -0.02 (-0.30-0.27) | -0.11 (-0.40-0.16) | -0.16 (-0.43-0.13) | -0.07 (-0.38-0.22) |
| Picture naming | -0.16 (-0.15-0.43) | -0.13 (-0.41-0.17) | -0.09 (-0.21-0.38) | -0.24 (-0.39-0.04) | -0.19 (-0.46-0.11) |

Two-tailed Pearson correlations were used (word-picture verification: n = 46, df = 44; perception: n = 44, df = 42; others: n = 47, df = 45). The numbers in parentheses are the 95% confidence intervals. The numbers in superscripts are the uncorrected P values. OFA: occipital face area; FFA: fusiform face area; pSTS: posterior superior temporal sulcus; aSTS: anterior superior temporal sulcus; ATL: anterior temporal lobe. Source data are provided as a Source Data file.
Supplementary table 5. The R values of left face-related ROIs in SD patients.

|                | OFA | FFA | pSTS | ATL | aSTS |
|----------------|-----|-----|------|-----|------|
| **Face**       |     |     |      |     |      |
| Word picture verification | 0.14 (-0.16-0.41) | 0.38 (-0.11-0.65) | 0.25 (-0.04-0.50) | 0.35 (0.07-0.58) | 0.22 (-0.08-0.48) |
| Picture matching | 0.08 (-0.20-0.37) | 0.33 (0.05-0.67) | 0.31 (0.07-0.56) | 0.43 (0.16-0.64) | 0.34 (0.06-0.57) |
| Picture naming  | 0.04 (-0.25-0.13) | 0.21 (-0.04-0.50) | 0.11 (-0.17-0.46) | 0.29 (0.01-0.54) | 0.33 (0.05-0.56) |
| Perception     | 0.23 (-0.37-0.52) | 0.39 (-0.23-0.60) | 0.19 (-0.11-0.46) | 0.30 (0.00-0.55) | 0.03 (-0.27-0.32) |
| **Object**     |     |     |      |     |      |
| Word picture verification | 0.03 (-0.26-0.32) | 0.31 (0.01-0.65) | 0.19 (-0.10-0.40) | 0.44 (0.17-0.66) | 0.43 (0.16-0.61) |
| Picture matching | -0.01 (-0.30-0.28) | 0.38 (-0.11-0.67) | 0.10 (-0.20-0.37) | 0.43 (0.16-0.64) | 0.17 (-0.42-0.70) |
| Picture naming  | 0.01 (-0.26-0.27) | 0.47 (0.21-0.67) | 0.21 (-0.08-0.57) | 0.52 (0.27-0.59) | 0.52 (0.28-0.70) |
| Perception     | 0.18 (-0.22-0.57) | 0.31 (-0.17-0.61) | 0.15 (-0.12-0.41) | 0.15 (-0.17-0.41) | 0.11 (-0.19-0.29) |

Two-tailed Pearson correlations were used (word-picture verification: n = 46, df = 44; perception: n = 44, df = 42; others: n = 47, df = 45). The numbers in parentheses are the 95% confidence intervals. The numbers in superscripts are the uncorrected P values. OFA: occipital face area; FFA: fusiform face area; pSTS: posterior superior temporal sulcus; aSTS: anterior superior temporal sulcus; ATL: anterior temporal lobe. Source data are provided as a Source Data file.
Supplementary table 6. The R values of left and right face-related ROIs in normal controls.

|                  | OFA | FFA | pSTS | aSTS |
|------------------|-----|-----|------|------|
| Face & right ROIs |     |     |      |      |
| Word picture verification | 0.19 (-0.38-0.28) | -0.30 (-0.65-0.17) | 0.27 (0.19-0.64) | -0.12 (-0.54-0.34) | -0.23 (-0.61-0.24) |
| Picture matching | 0.13 (-0.33-0.54) | -0.42 (-0.73-0.03) | -0.18 (-0.56-0.29) | -0.46 (-0.75-0.02) | -0.52 (-0.67-0.14) |
| Picture naming | 0.04 (-0.41-0.47) | -0.29 (-0.65-0.17) | 0.31 (0.13-0.69) | -0.06 (0.47-0.41) | -0.18 (-0.58-0.26) |
| Perception | 0.14 (-0.33-0.55) | -0.14 (-0.55-0.12) | 0.20 (-0.27-0.59) | 0.01 (-0.38-0.50) | 0.06 (-0.40-0.49) |
| Face & left ROIs |     |     |      |      |
| Word picture verification | 0.36 (-0.38-0.49) | 0.08 (-0.38-0.58) | -0.30 (-0.66-0.16) | 0.53 (-0.67-1.4) | -0.07 (-0.50-0.38) |
| Picture matching | -0.03 (-0.47-0.42) | -0.29 (-0.71-0.17) | 0.27 (0.20-0.64) | -0.54 (-0.79-0.13) | -0.11 (-0.34-0.14) |
| Picture naming | 0.15 (-0.33-0.54) | -0.02 (-0.44-0.42) | -0.07 (-0.40-0.39) | -0.20 (-0.59-0.27) | -0.11 (-0.54-0.13) |
| Perception | 0.28 (-0.19-0.64) | -0.26 (-0.63-0.21) | 0.01 (-0.42-0.47) | -0.02 (-0.46-0.42) | 0.02 (-0.43-0.46) |

Two-tailed Pearson correlations were used (n = 20, df = 18). The numbers in parentheses are the 95% confidence intervals. The numbers in superscripts are the uncorrected P values. OFA: occipital face area; FFA: fusiform face area; pSTS: posterior superior temporal sulcus; aSTS: anterior superior temporal sulcus; ATL: anterior temporal lobe. Source data are provided as a Source Data file.