Matrices of the Wiring Diagram of the Human Cerebrum: An MRI-based Systematics of Anatomic Connectivity

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Introduction: Currently, one of the most important problems in neuroscience to be solved is the wiring diagram of the human brain. To this end, different approaches have been used in an attempt to elucidate the connections in the cerebrum in terms of their topographic arrangement and topography (Makris et al. 1999) as well as in the forms of matrices (Stephan et al. 2001). Our group has previously formulated an MRI-based parcellation system of the white matter and resultant maps of human cerebral connectivity (Makris et al. 1999). This system, consisting of volumetrically quantifiable parcellation units (PUs), considered the topography of specific white matter pathways as well as anatomic individuality. Although connectivity maps of the human cerebrum were provided, a comprehensive list of each unit's cortical and subcortical connections was not created. In the present study, such a list has been compiled in matrix form. This connectivity matrix reflects the current body of experimental animal and human data and, although substantial in detail, is assumed to be both partial and approximate. This is inevitable given that the sources of data relating to fiber system organization are limited largely to inferences from crude dissections, or extrapolations from non-human primate experiments.

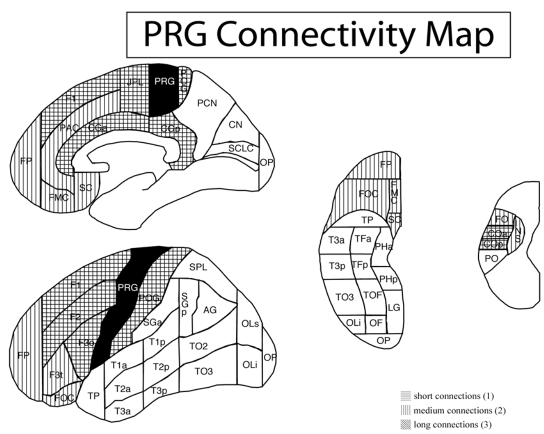
Methods: As in our previous approach using the white matter as the focus for the mapping of cerebral corticocortical, corticothalamic and corticostriatal connectivity, a meta-analysis of relevant human and non-human primate literature was conducted. Coding of connections was as follows: "1" was assigned to U-fibers and short intragyral and juxtagyral (both intralobar and juxtalobar) connections, "2" was assigned to medium-range intralobar (non-juxtagyral) connections, and "3" was assigned to long-range connections (intra- and interlobar association as well as corticothalamic and corticostriatal connections).

Results: Forty-eight cortical, 7 thalamic, and 10 striatal PU matrices have been formulated. Three examples are shown in the table for the thalamic medial dorsal parcellation unit (M) and the cortical PUs precentral gyrus (PRG) and postcentral gyrus (POG). In the figure, the resulting connectivity map is included for PRG.

PU: M	Connectivity Summary
CGa	0
CO	0
F1	3
F2	3
F3t	3
F3o	3
FMC	3
FO	3
FOC	3
FP	3
PAC	3
PRG	0
SC	3
JPL	0
AG	0
CGp	0
PCN	0
PO	0
POG	0
SGa	0
SGp	0
SPL	0
H	0
INS	0
PHa	3
PHp	0
PP	0
PT	0
T1a	0
T1p	0
T2a	0
T2p	0
T3a	0
T3p	0
Tfa	0
TFp	0
TO2	0
TO3	0
TOF	0
TP	3
CALC	0
CN	0
LG	0
OF	0
OLi	0
OLs	0
OP	0
SCLC	0

PU: PRG	Connectivity Summary
Cga	2
CO	1,2
F1	1,2
F2	1,2
F3t	2
F3o	1,2
FMC	2
FO	2
FOC	2
FP	2
PAC	2
PRG	1,2,3
SC	2
JPL	1,2
AG	0
CGp	2
PCN	0
PO	0
POG	1
Sga	0
SGp	0
SPL	0
H	0
INS	2,3
Pha	0
PHp	0
PP	0
PT	0
T1a	0
T1p	0
T2a	0
T2p	0
T3a	0
T3p	0
Tfa	0
TFp	0
TO2	0
TO3	0
TOF	0
TP	0
CALC	0
CN	0
LG	0
OF	0
Oli	0
Ols	0
OP	0
SCLC	0

PU: POG	Connectivity Summary
Cga	0
CO	1
F1	0
F2	0
F3t	0
F3o	0
FMC	0
FO	0
FOC	0
FP	0
PAC	0
PRG	1
SC	0
JPL	0
AG	2
CGp	1
PCN	2
PO	1,2
POG	1,2,3
Sga	1,2
SGp	2
SPL	1,2
H	0
INS	1,2
Pha	0
PHp	0
PP	0
PT	0
T1a	0
T1p	0
T2a	0
T2p	0
T3a	0
T3p	0
Tfa	0
TFp	0
TO2	0
TO3	0
TOF	0
TP	0
CALC	0
CN	0
LG	0
OF	0
Oli	0
Ols	0
OP	0
SCLC	0



Discussion: The cortical mantle orchestrates information processing in the brain via associational, commissural and projectional connections. Through these types of connections, each cortical area relates to other cortical and subcortical regions following a general scheme of connectivity, allowing for integrated functioning within the central nervous system. These connections are mediated by fiber bundles, which are topographically organized within the white matter of the brain. Detailed knowledge of connections of each cortical region with other cortical regions is relevant for formulating hypotheses in cognitive and clinical neuroscience.

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