



**ORGANIZATION OF THE
VISUAL PATHWAYS AND VISUAL
LATERALIZATION IN THE CHICK**

A thesis submitted for the degree of Doctor of
Philosophy of the University of New England

By

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I certify that the substance of this thesis has not already been submitted for any degree and is not currently being submitted for any other degree or qualification.

I certify that any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

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SUMMARY

This thesis reports research on the organization of the bilateral thalamo-Wulst (thalamofugal pathway) and tecto-rotundal (tectofugal pathway) projections in the chick using fluorescent retrograde tracers. It also examines asymmetry of these projections and the differential contributions of the two visual pathways to functional lateralization.

The research began by examining the abilities of various fluorescent tracers to label the bilateral projections of the two visual pathways. In the thalamofugal pathway, rhodamine B isothiocyanate (RITC), Fluorogold (FG) and True blue (TB) were found to label both the ipsilateral and contralateral projections. However, differential labelling effects were found in the tecto-rotundal projections: RITC and red (rhodamine) beads labelled both the ipsilateral and contralateral projections, but FG, TB and green (fluorescein) beads labelled only the ipsilateral projections. It was found that FG and TB (and maybe also green beads) were taken up by the nerve endings, were transported possibly to the point where the axon collateral branches from the main axon, but failed to be transported to the cell body.

After injecting RITC and FG or TB into the left or right visual Wulst, labelled neurones in the nucleus geniculatus lateralis pars dorsalis (GLd) and the forebrain were examined. The general pattern of labelling in GLd was found to be in agreement with previous reports showing that the cell bodies labelled by tracers injected into the contralateral Wulst are located in the dorsal-lateral parts of GLd and the ipsilateral labelled neurones in the medial-ventral GLd. Although the distribution areas of ipsilaterally and contralaterally labelled neurones overlap partly, very few double-labelled neurones were found (only 0.01% double-labelled neurones). This suggests that the ipsilateral and contralateral projections to the Wulst come from different neuronal populations of the thalamus. In the forebrain, the labelled neurones were found in the neostriatum frontale, pars lateralis (NFl), the neostriatum intermedium (NI), the dorso-lateral neostriatum, and the archistriatum intermedium (AI). These intratelencephalic connections may have significance for the functioning of the visual Wulst in higher information processing.

Using RITC, it was possible to confirm previous findings of asymmetry in the thalamofugal projections. In addition, the asymmetry was definitely located in the contralateral GLd-visual projections because absolute counts of labelled neurones rather than *c/i* ratio (the ratio of number of contralateral labelled neurones to number of ipsilateral labelled neurones) could be used. The asymmetry is such that there are more projections from the left side of the thalamus to the right visual Wulst of the forebrain than from the right side of the thalamus to the left visual Wulst in the chick.

The organization of the neural projections from the optic tectum (TeO) and pretectal nuclei complex, n. subpretectalis/n. interstitio-pretecto-subpretectalis (SP/IPS), to the n. rotundus (Rt) in chicks was studied using all five tracers. Both the ipsilateral and contralateral tecto-rotundal projections were found to be organised topographically in as much as different sublaminae of the stratum griseum centrale (SGC) project in an orderly manner to Rt and the n. triangularis (T). The deepest stratum of SGC projects to T. Deep SGC projects to the dorsal Rt and superficial SGC projects to the ventral Rt. A band running through the centre of Rt receives input from the central sublamina of SGC, and the caudal central Rt receives input from a deeper sublamina than does the rostral central Rt. The SP/IPS projects to the ipsilateral Rt only and the projection order is dorsal SP to dorsal Rt, ventral SP to ventral Rt and middle SP to the central band of

Rt. The neurones in IPS and the nucleus of the tractus tectothalamicus (nTT) project to T. Thus, Rt and T receive topographically both tecto- (excitatory) and SP/IPS- (inhibitory) projections. The possible functional implications for parallel information processing in these projections are discussed.

FG and RITC were also injected into Rt on each side of the thalamus and the labelled neurones in TeO were examined. In TeO, the distribution areas of the neurones labelled ipsilaterally and contralaterally to Rt overlap completely and up to 45% of the tectal cells were found to be double-labelled by both FG and RITC. Therefore, many tectal neurones have axon collaterals so that they project to the Rt on both sides of the thalamus and must send information simultaneously to both sides of the brain. A two-stage visual transmission model in the tectofugal pathway of the chick was proposed.

Using RITC, we found that the organization of the tectofugal visual projections to Rt was largely symmetrical (males only examined). There are numerous projections from each TeO to its contralateral Rt but, in contrast to reports for the pigeon, no asymmetry was present in these when considered across the entire TeO. However, calculation of the ratio of contralateral to ipsilateral projections for the ventral TeO only revealed significant asymmetry. Symmetry from the dorsal TeO was present in the *c/i* ratio for projections. Despite this mild asymmetry in the ventral TeO projections, the chick differs from the pigeon which has marked asymmetry in the contralateral TeO-Rt projections.

The contribution of the two visual pathways to lateralization of visual behaviour in chicks was assessed using unilateral injections of 0.5 μ l of 100 mM monosodium glutamate into localised regions of the forebrain. Glutamate treatment of the left visual Wulst impaired pebble-floor performance and elevated attack and copulation scores, but this did not occur following injection of the right visual Wulst. Thus, the left visual Wulst only is involved in the control of these three visually guided behaviours. By contrast, glutamate injections of the left ectostriatum affected only the attack behaviour and not performance in the pebble-floor task or copulation responses. The results indicate that the tectofugal and thalamofugal pathways have different roles in the lateralization of visual functions.

Functional lateralization of choice between a familiar and an unfamiliar chick was examined using monocular testing. The left eye system (LES) is better able to recognize conspecific individuals and then make a choice to approach one or the other than the right eye system (RES). This lateralization is not dependent on light exposure during the last stages of incubation. However, visual/social experience with broodmates posthatching affects preference and choice: it elevates the ability of RES to recognize conspecific individuals. It is proposed that the tectofugal pathway is involved in this performance, although higher centres must also have a role.

The final chapter discusses how the organization of the two visual pathways may be involved in the neural mechanisms underlying lateralized behaviours tested in this thesis.

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LIST OF ABBREVIATIONS

AA	archistriatum anterior
AChE	acetylcholinesterase
AI	archistriatum intermedium
AId	archistriatum intermedium, pars dorsalis
AIv	archistriatum intermedium, pars ventralis
AM	archistriatum mediale
AP	archistriatum posterior
BIN	binocular
CDL	area corticoidea dorsolateralis
DAB	diaminobenzidine
DIVA	nucleus dorsalis intermedius ventralis anterior
DLA	nucleus dorsolateralis anterior thalami
DLAlr	nucleus dorsolateralis anterior thalami pars lateralis rostralis
DLAmc	nucleus dorsolateralis anterior thalami pars magnocellularis
DLL	nucleus dorsolateralis anterior thalami pars lateralis
DLLd	nucleus dorsolateralis anterior thalami pars lateralis, pars dorsalis
DLLv	nucleus dorsolateralis anterior thalami pars lateralis, pars ventralis
DLLvv	nucleus dorsolateralis anterior thalami pars lateralis, pars ventroventralis
DLP	nucleus dorsolateralis posterior thalami
DLPc	caudal part of DLP
DLPr	rostral part of DLP
DMSO	dimethyl sulfoxide
E	ectostriatum
Ep	periestriatal belt
FB	Fast blue
FG	Fluorogold

FPL	fasciculus prosencephali lateralis
GABA	γ -aminobutyric acid
GAD	glutamic acid decarboxylase
GLd	nucleus geniculatus lateralis, pars dorsalis
GLv	geniculatus lateralis, pars ventralis
HA	hyperstriatum accessorium
IHA	nucleus intercalatus of hyperstriatum accessorium
HIS	hyperstriatum intercalatum superior
HD	hyperstriatum dorsale
Hp	hippocampus
HV	hyperstriatum ventrale
HRP	horseradish peroxidase
ICo	nucleus intercollicularis
LE	left ectostriatum
Imc	nucleus isthmi, pars magnocellularis
IMHV	intermediate medial hyperstriatum ventrale
Ipc	nucleus isthmi, pars parvocellularis
IPS	nucleus interstitio-prelecto-subprelectalis
LA	nucleus lateralis anterior thalami
LdOPT	nucleus lateralis dorsalis nuclei optici principalis thalami;
LES	left eye system
LN	left neostriatum
LW	left Wulst
N	neostriatum
NC	neostriatum caudale
NCL	neostriatum caudolaterale
NF	neostriatum frontale

NFI	neostriatum frontale pars lateralis
NI	neostriatum intermedium
NVE	a group of chicks without visual experience of broodmates (in Chapter 8)
nTT	nucleus of the tractus tectothalamicus
OM	tractus occipitomesencephalicus
OPT	nucleus opticus principalis thalami
Ov	nucleus ovoidalis
PA	paleostriatum augmentatum
PHA-L	phaseolus vulgaris-leucoagglutinin
QF	tractus quintofrontalis
RE	right ectostriatum
RES	right eye system
RITC	Rhodamine B isothiocyanate
RN	right neostriatum
RSd	nucleus reticularis superior, pars dorsalis
RSv	nucleus reticularis superior, pars ventralis
Rt	nucleus rotundus
RW	right Wulst
SAC	stratum album centrale of the tectum
SE	standard error
SGC	stratum griseum centrale of the tectum
SGFS	stratum griseum et fibrosum superficiale of the tectum
SGP	stratum griseum periventriculare of the tectum
SO	stratum opticum
SOD	supraoptic decussation
SODd	dorsal supraoptic decussation
SODv	ventral supraoptic decussation

SP	nucleus subpretectalis
SPC	nucleus superficialis parvocellularis
SpM	nucleus spiriformis medialis
SpRt	nucleus suprarotundus
SRt	nucleus subrotundus
T	nucleus triangularis
TB	True Blue
TeO	tectum opticum
TPO	area temporo-parieto-occipitalis
TSM	tractus septomesencephalicus
TT	tractus tectothalamicus
VE	a group of chicks with visual/social experience of broodmates (in Chapter 8)

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