INFLUENCE OF ODORANTS ON THE BEHAVIOUR OF THE DOMESTIC 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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I seem to have been only a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.

Sir Isaac Newton (1642-1727)

Publications and Communications Arising from this Thesis

Papers

Burne, T. H. J. and L. J. Rogers. Responses to odorants by the domestic chick. *Physiology and Behavior,* in press.

Published Abstracts

Burne, T. H. J. and L. J. Rogers. (1995). Odour perception and memory in chicks. *Australasian Society for the Study of Animal Behaviour,* **22**, 9.

Burne, T. H. J. (1996). Olfactory learning by the chick embryo. *Proceedings of the Australian Neuroscience Society,* **7**, 237.

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SUMMARY

Previous studies have suggested that olfaction influences the development of behaviour in the domestic chick but there has been no detailed investigation of graded responsiveness to odorants of different concentrations or of olfactory memory. This thesis reports research on olfaction in 1-day-old chicks, describes experiments that examine concentration-dependent and lateralized responses to a number of odorants. It also reports intersensory effects of stimulation by light on olfactory lateralization and the effects of olfactory experience during development.

A new task for testing olfactory responses of chicks was designed and validated. The chicks were presented with a 4 mm diameter coloured bead, at which they pecked readily, affixed to a tube containing odorant. Using this task differential concentration-dependent responses were obtained for *iso*-amyl acetate, allyl sulfide, ammonia, cineole, limonene, eugenol, methyl anthranilate (MeA) and geraniol. The measures recorded during 10-second trials were pecking and head shaking. Repeated testing of the same chick was made possible by changing the colour of the bead presented together with odorant in each trial, thereby preventing habituation of pecking. It was concluded that presentation of these odorants stimulates receptors (olfactory or trigeminal) within the chick's nasal cavity, rather than receptors in the mouth or eyes, because responses to odorants did not occur following occlusion of both of the chick's nostrils.

Three odorants were used to investigate the possibility of sex differences in sensitivity to odour. Males and females responded similarly to *iso*-amyl acetate and allyl sulfide but males were more responsive to eugenol. They shook their heads more than females in response to all the concentrations presented. However, the latency to shake the head did not vary between males and females.

Unilateral occlusion of the left or right nostril revealed a right nostril bias in responsiveness to eugenol and allyl sulfide, confirming the previous finding (using clove oil) of Vallortigara and Andrew (1994). Chicks using the right nostril shook their heads more to eugenol and demonstrated suppressed levels of pecking to allyl sulfide, compared to chicks using the left nostril. However, no lateralization was found for *iso*-amyl acetate, ammonia, cineole, limonene, MeA or geraniol. It is suggested that the presence or absence of lateralization in day old chicks may be due, in part, to the relative involvement of the olfactory or trigeminal systems and may depend on the brain region(s) that is (are) activated in the presence of an odorant.

Lateralized control of olfactory responses is affected by exposure to light during incubation and this effect is sex-dependent. Males incubated in complete darkness during the last 3 days of incubation showed greater lateralization to eugenol (right nostril bias)

than dark-incubated females. Exposure to light during the last 3 days of incubation induced an asymmetry for head shaking responses to eugenol in females (right nostril bias) and removed the asymmetry for head shaking in males. Light exposure also induced an asymmetry (right nostril bias) for pecking by males but not females, to beads scented with allyl sulfide, indicating sex differences in light-induced asymmetry within the visual system.

Using a modified passive avoidance learning task (PAL) it was shown that chicks associate the odour of MeA with a red bead. Chicks trained with the taste or the taste and odour of MeA showed typical disgust responses (high levels of head shaking and bill wiping), unlike chicks presented with a red bead together with odour alone. However, during testing all chicks showed high levels of avoidance of the red bead compared to a blue bead. These results indicate that chicks form a memory of an odorant, associating it with bead colour by 10 min after training.

Chicks can also form a memory of an odour presented during the latter part of incubation and early post-hatching life (day E20 to 18 h post-hatching). Chicks exposed to the odour of moist food displayed suppressed levels of pecking, compared to unexposed controls, at a bead presented together with this odour. They generalised the memory to the odour of wood litter, but there was no effect of exposure to the food odour during incubation on the response to the odours of feathers or faeces.

The final chapter discusses the importance of odours in regulating behaviour of chicks, in particular in learning to feed and in avoiding harmful substances. The differential lateralization in response to odorants found in this thesis is discussed in terms of the intersensory processing of visual and olfactory cues. The role of olfactory memory is described in terms of the need for rapid and effective recall of aversive stimuli in precocial animals. It concludes with a brief comparison of the onset of functioning and relative use of the different sensory systems in precocial and altricial species.

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LIST OF ABBREVIATIONS

A	cross sectional area
Ac	nucleus accumbens
BN	binarial
BN_0	binarial and presented with 0 µl of odorant
BN_{10}	binarial and presented with 10 µl of odorant
C	concentration
χ^2	chi-square test
CPP	cortex prepiriformis
D	diffusion coefficient
Da	incubated in the dark
day E#	embryonic day #
EC_{50}	50% effective concentration
ED_{50}	50% effective dose
F_r	Friedman test statistic
HA	hyperstriatum accessorium
HD	hyperstriatum dorsale
HIS	hyperstriatum intercalatum supremum
HV	hyperstriatum ventrale
IMHV	intermediate and medial portions of the hyperstriatum ventrale
J	rate of diffusion
KW	Kruskal-Wallis test statistic
LHRH-ir	luteinizing hormone releasing hormone immunoreactive
Li	incubated in the light
LiCl	lithium chloride
LN	left nostril in use
LOT	lateral olfactory tract
LPO	lobus parolfactorius
MeA	methyl anthranilate
MOT	medial olfactory tract
N	neostriatum
NA	value or range of values could not be calculated
nMesV	mesencephalic nucleus
nPrV	principal sensory trigeminal nucleus
nTTD	descending trigeminal tract
P	probability
PA	paleostriatum augmentatum
PAL	passive avoidance learning
PP	paleostriatum primitivum
ppm	parts per million
PPE mRNA	preproenkephalin messenger ribonucleic acid
Q	Cochran Q test statistic
QFT	quinto-frontal tract
r	Pearson correlation coefficient
RN	right nostril in use
r_s	Spearman rank order coefficient of correlation
S	nucleus septalis
SEM	standard error of the mean
v/v	volume per volume
z	z-statistic

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