ROLE OF THE MIDBRAIN IN DESCENDING CONTROL OF SWIM BEHAVIOUR IN THE *XENOPUS LAEVIS* TADPOLE

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INTRODUCTION

Research has shown that the midbrain is able to influence behavioural motor decisions (1). The neural circuitry that regulates motor responses is essential to the survival of all animals, including humans. Thus, by identifying the significance of the midbrain as a critical component of motor decision, it will elucidate further its functional role.

OBJECTIVE

To investigate the functional role of the midbrain descending pathway that interacts with the motor system to elicit that tadpole's swim behaviour.

BACKGROUND

The *Xenopus laevis* tadpole is responsive to two sensory pathways that initiate swimming:

- **Light dimming**
  Following a decrease in light intensity, a pathway has been shown to descend through the midbrain for sensory integration and modulation of swimming (2).
- **Skin touch**
  Following trunk skin stimulation, ascending axons from sensory pathway neurons project to the midbrain (3).

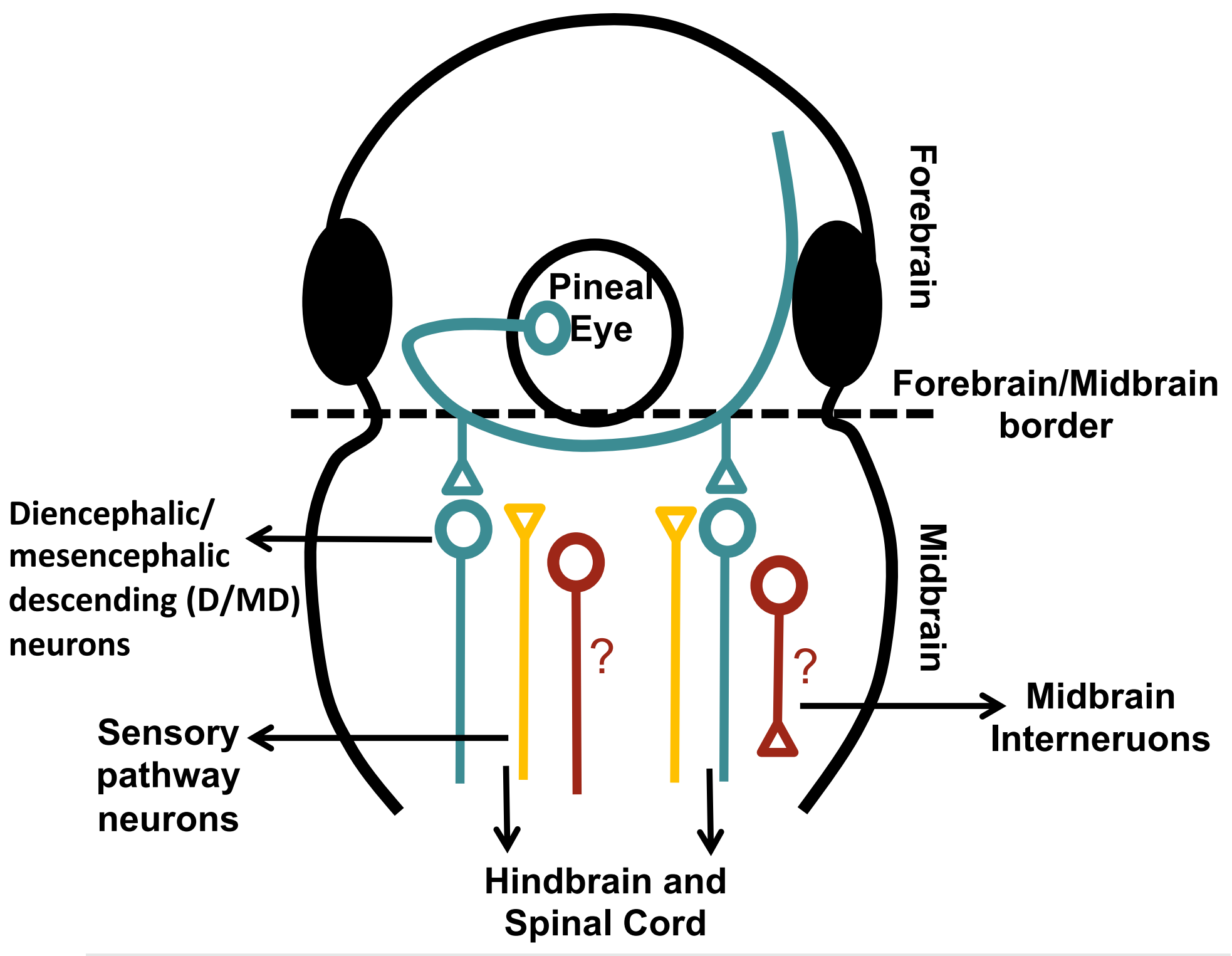

Figure 1: Simplified illustration of axonal projections in the midbrain of the *Xenopus laevis* tadpole

METHODS

Animal Preparation

- Control animals = Intact animals were placed in tadpole (de chlorinated) water

Dissections were carried out in saline following brief exposure to 0.1% MS-222.

- Sham-operated animals = Dorsal opening of the skin to expose the CNS.
- Lesioned animals = A transverse lesion through the midbrain/hindbrain border.

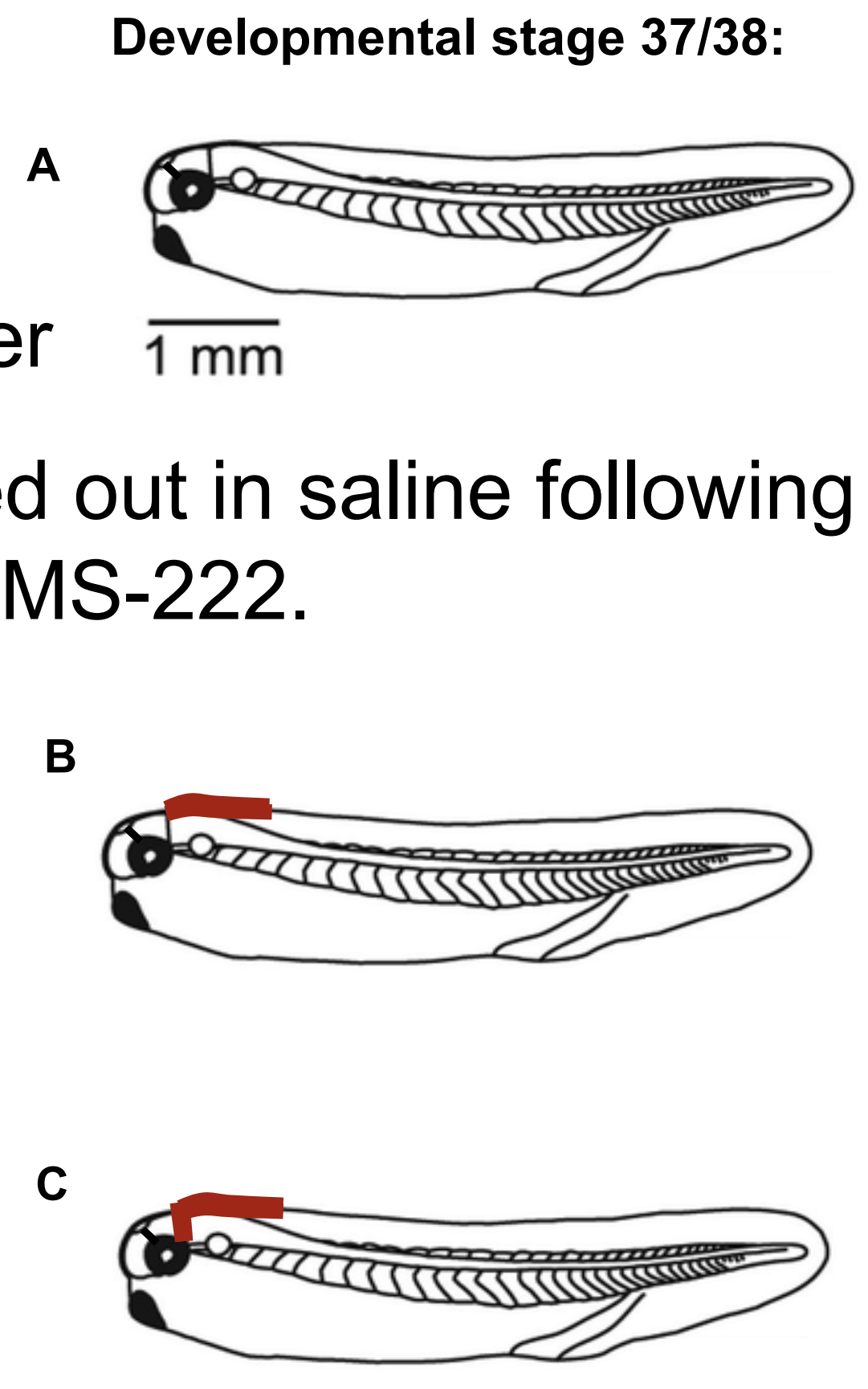

Figure 2: Schematic representation of the Xenopus tadpole with lesions. A, control B, sham-operated C, lesioned

Behavioural Set up

A digital camera was used to film high speed videos (420 frames per second).

- All tadpoles began each trial in a sylgard petri dish filled with water or saline and positioned dorsally
- A short poke was used to stimulate skin receptors on the body or tail to initiate a swim response.
- Each animal was allowed to recover between trials (~5min).

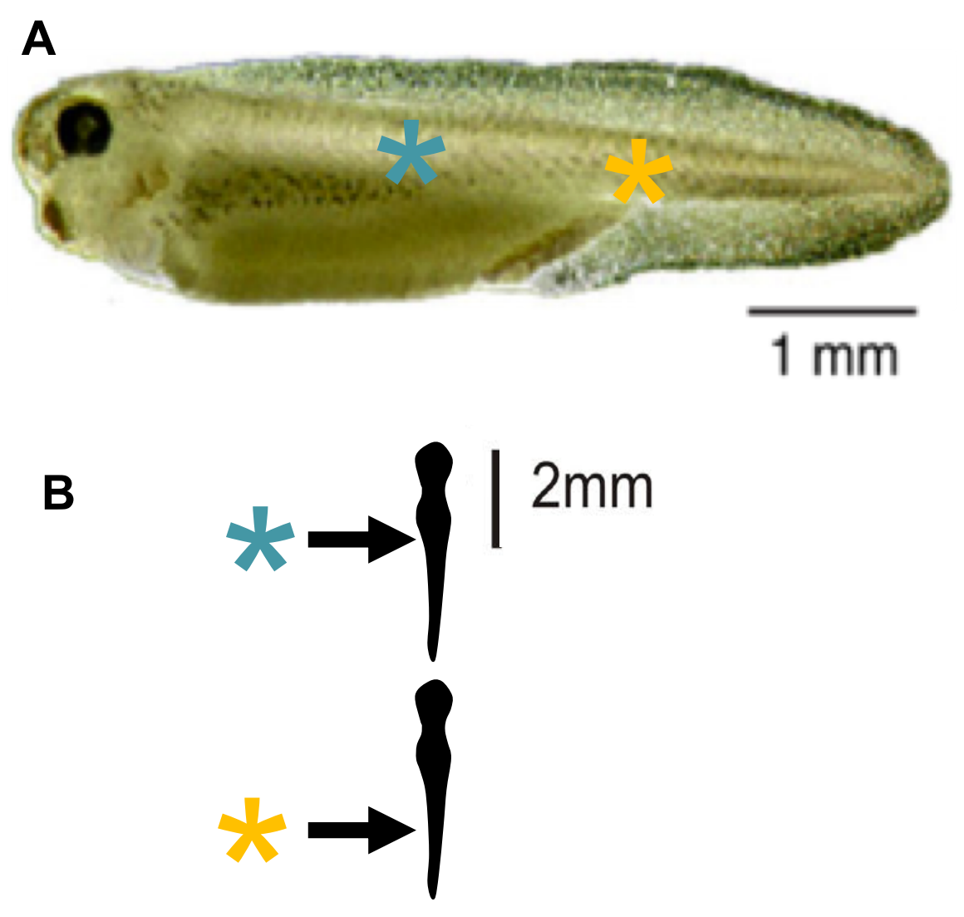

Figure 3: The Xenopus tadpole with stimulus sites marked (*) in A, lateral and B, dorsal view. (body stimulus: blue, tail stimulus: yellow)

Analysis

- Videos analysed using Image J software to determine the delay between skin stimulation and the onset of swimming

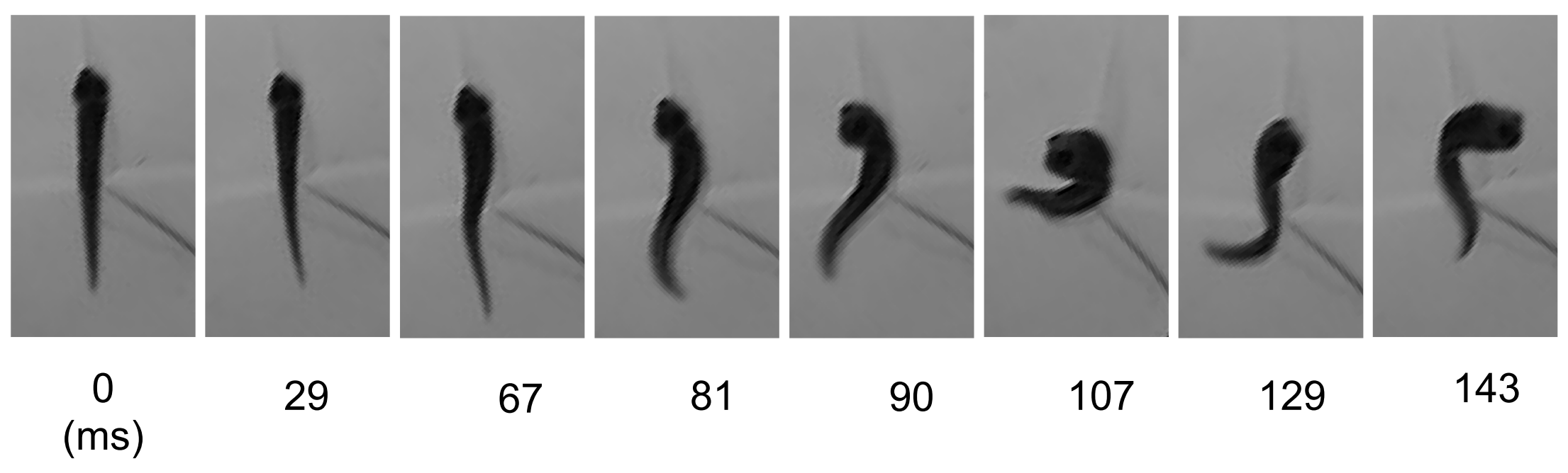

Figure 4: Response to a short stroke to the tail with a hair seen from dorsal view. (Skin stimulation: 0ms, first bent: 81ms)

- All experimental data were plotted and statistically analysed using SPSS software.

RESULTS

Initiation of Swimming

Lack of descending midbrain control of the motor system, significantly increases *(P=0.03)* the delay to the start of swimming when the tadpole is stimulated on the body, but not when stimulation is applied on the tail *(P=0.25)*.

These preliminary results suggest a possible functional role of the midbrain in the initiation of swimming.

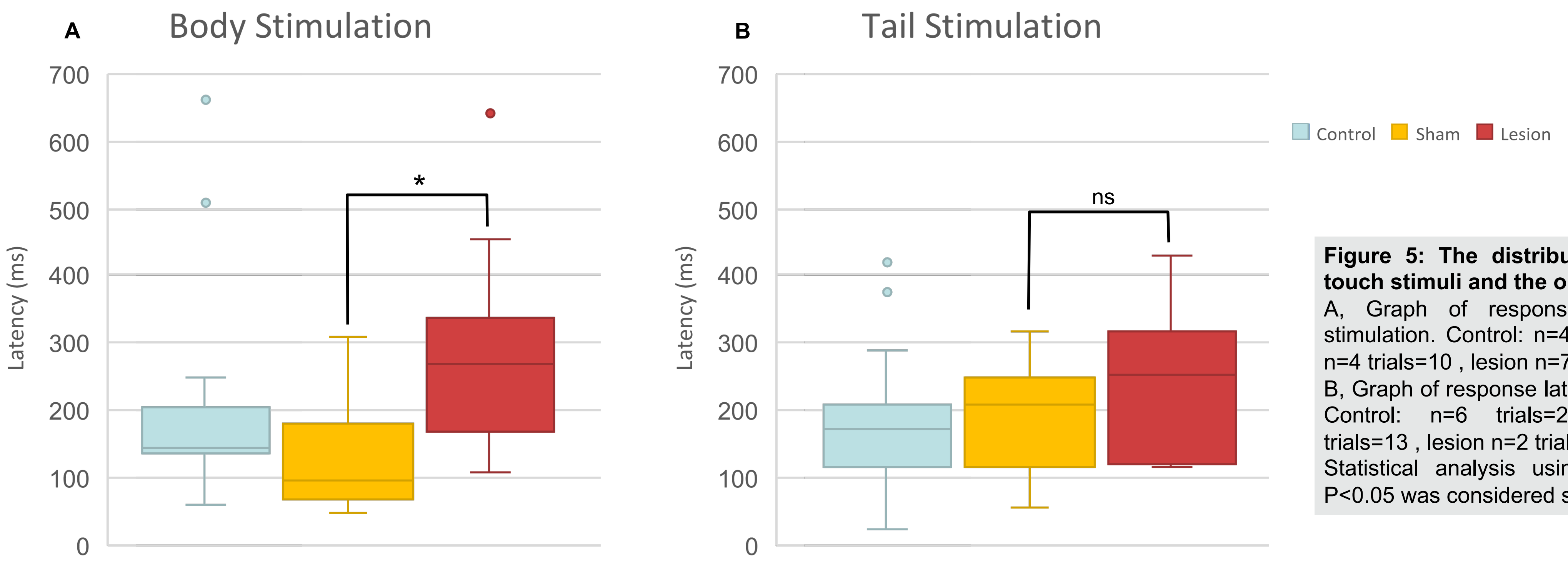

Figure 5: The distribution of latency between touch stimuli and the onset of swimming.
A, Graph of response latency to body skin stimulation. Control: n=4 trials=12, Sham-operated: n=4 trials=10 , lesion n=7 trials=21.
B, Graph of response latency to tail skin stimulation. Control: n=6 trials=21, Sham-operated: n=4 trials=13 , lesion n=2 trials=7.
Statistical analysis using Mann-Whitney U Test; P<0.05 was considered statistically significant.

Side of first motor response

Attenuation of midbrain descending control affects the side of the first motor activity. In lesioned animals the first bend frequently happened on the unstimulated side of the stimulus, relative to control animals.

This leads to the tadpoles behaviour being predictable and predatable, suggesting a role of the midbrain in predator avoidance.

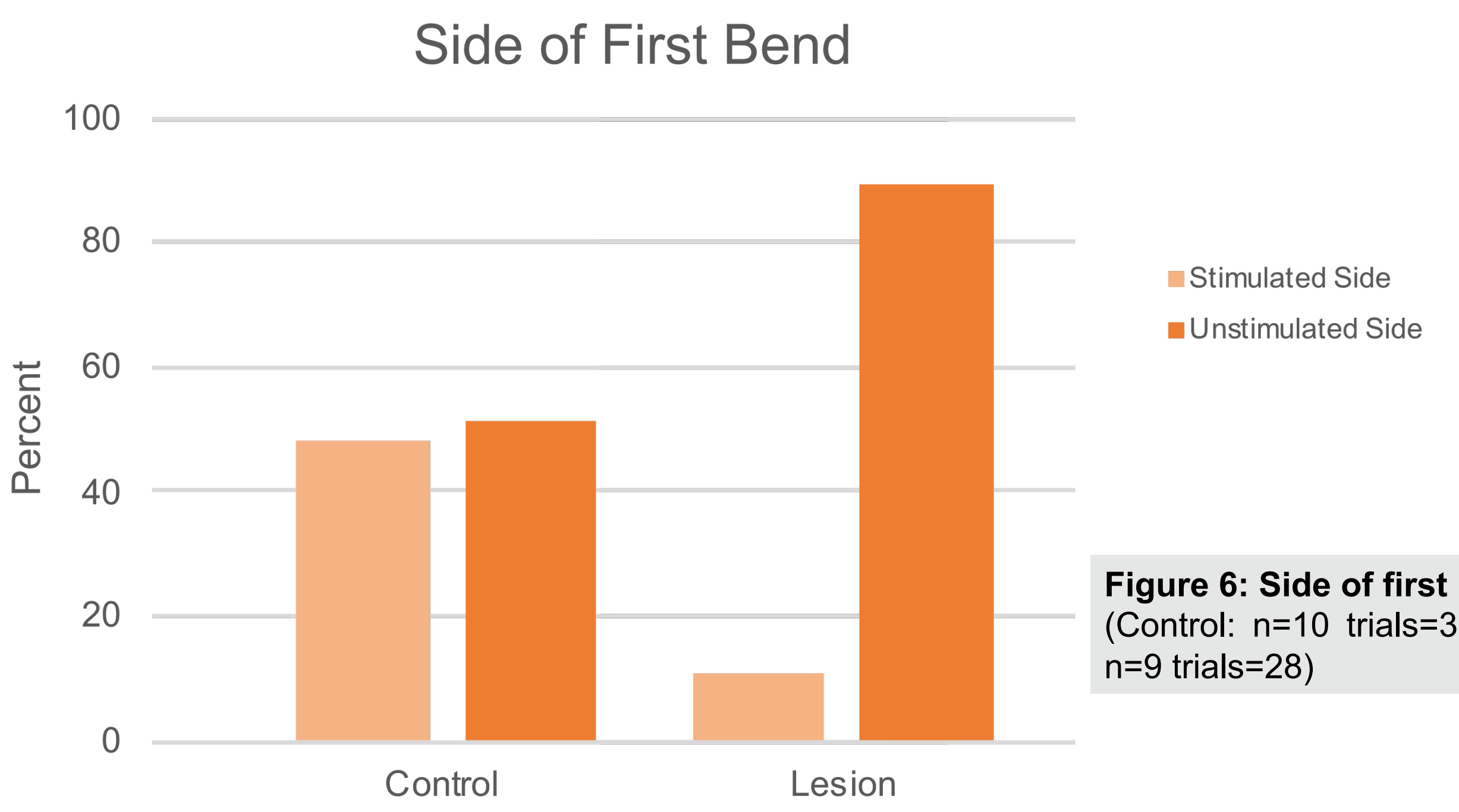

Figure 6: Side of first bend (Control: n=10 trials=33, lesion n=9 trials=28)

Observational Data

Lesioning of the midbrain/hindbrain border affects the posture of the tadpole. Indicating the role of the midbrain in postural control of tail orientation during swimming as seen in larval zebrafish (4).

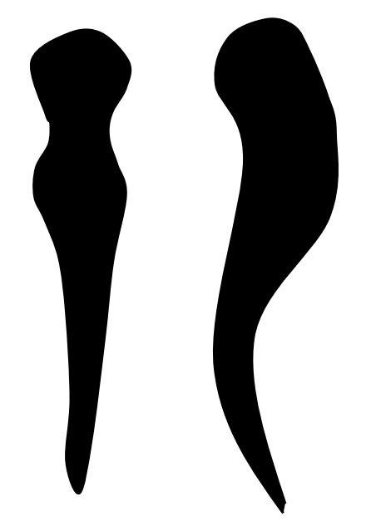

Figure 7: Example of swim posture and the orientation of the tail seen in the dorsal view

References

1. Jamieson D, Roberts A (2000). Responses of young Xenopus laevis tadpoles to light dimming: possible roles for the pineal eye.
2. Jamieson, D. and Roberts, A. (1999). A Possible Pathway Connecting the Photosensitive Pineal Eye to the Swimming Central Pattern Generator in Young Xenopus laevis Tadpoles.
3. Li, W., Perrins, R., Soffe, S., Yoshida, M., Walford, A. and Roberts, A. (2001). Defining classes of spinal interneuron and their axonal projections in hatchling Xenopus laevis tadpoles.
4. Thiele, T., Donovan, J. and Baier, H. (2014). Descending Control of Swim Posture by a Midbrain Nucleus in Zebrafish. Neuron, 83(3), pp.679-691.

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