Exploration of the Sensitivity and Visual Field of African Clawed Frogs to Visual and Lateral Line Stimuli

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Introduction

African Clawed Frogs (*Xenopus laevis*) are aquatic frogs that use their lateral line and visual systems to detect prey or predators (Claas & Dean 2006). They have an extensive dorsal binocular visual field (Grant & Keating 1975) and eyes that accommodate little but are emmetropic in air (Chung et al. 1986).

Our preliminary study tested the frogs' responsiveness to visual stimuli and the locations that are effective. In addition, lateral line stimuli were used throughout the preliminary studies to compare response frequencies for lateral line and visual stimuli. Lateral line stimuli created waves on the surface of the water surrounding the frog in contrast to visual stimuli that create no waves for the frog to detect.

Our first hypothesis was that frogs will respond more to the stimulus rod that has a black marking than to clear rods. The visual field above the frog is 180°, so we thought all stimulus directions would elicit responses, at least for near stimuli. We also hypothesized that the accuracy of turning to visual stimuli would be comparable to that for lateral line stimuli.

Methods

- Two *X. laevis*, albino & normal pigmentation (Fig 1a.)
- Octagonal testing arena with 4 cm. of water (Fig 1b.)
- Apparatus with four rods (two are marked black)
  - Rods concealed by an array of cylinders
- Behavior recorded on DVD
- Measured angles and distances (Fig 1. c)
- Excel and Statgraphics for statistics and figures

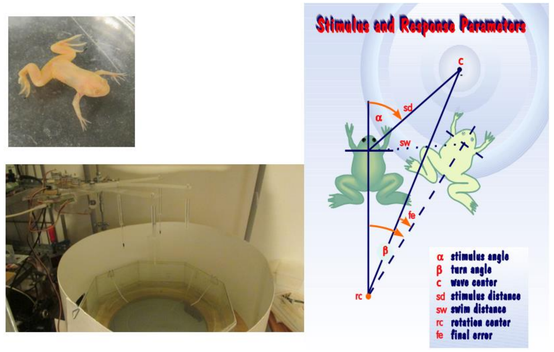

Figure 1. a) Albino *Xenopus laevis*. B)Test arena. C) Measurement definitions.

For stimuli closer than 5 cm, frogs respond more to rod with black band

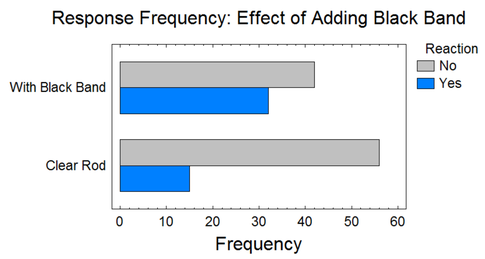

Figure 2 : Response frequency to visual stimuli with and without a black band. Stimulus distance less than 50 mm. Chi-squared=8.09, p<0.005, N=145

Results

Response frequency to visual stimuli increases as distance decreases

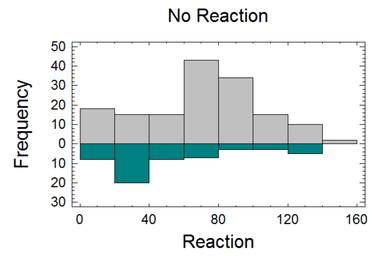

Figure 3.. Comparison of reaction frequency vs stimulus distance for visual stimuli only. Median angles for responses are smaller than those for no responses (W=-1348.5, P<0.0004, N=206). Distributions differed significantly (Kolmogorov & Smirnov DN=0.39. K-S Statistics=2.47, approx . P=0.000009).

Response frequency to visual stimuli increases for rostral stimulus angles

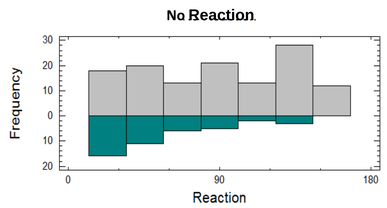

Figure 4: Comparison of reaction frequency vs stimulus angle for visual stimuli only. Median angles for responses are smaller than those for no responses (W=-1348.5, P<0.0004,N=206). Distributions differed significantly (Kolmogorov & Smirnov DN=0.34. K-S Statistics=2.15, approx. P=0.0002).

Stimulus distance did not affect response frequency for lateral line stimuli

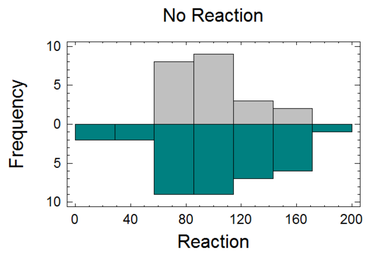

Figure 5: Comparison of reaction frequency vs stimulus distance for lateral line stimuli only. Lateral line stimuli were frequently used while the frog was facing the margin of the test arena. Distribution of stimulus distance did not differ between trials with a reaction and without. (K-S=0.82, DN=0.22, Approximate P Value=0.52, W= 21.50, P-Value=0.74, N=58).

Stimulus angle did not affect responses to lateral line stimuli

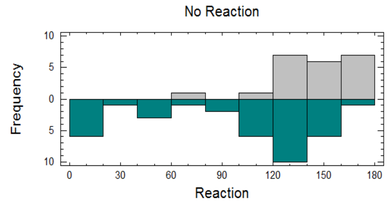

Figure 6: Comparison of reaction frequency vs stimulus angle for lateral line stimuli only. Lateral line stimuli were frequently used while the frog was facing the margin of the test arena. Distribution of stimulus angles did not differ between trials with a reaction and without. (K-S=0.82, DN=0.22, Approximate P Value=0.52, W= 21.50, P-Value=0.74, N=58).

Both frogs turn equally well to visual and lateral line stimuli

Turn angle vs stimulus angle for visual stimuli only

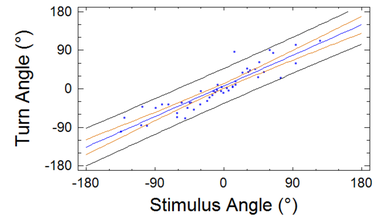

Figure 7: Regression of turn angle on stimulus angle for visual stimuli only (black band). Slope is 0.79± 0.05, t = 16.1, p < 0.0001, y-intercept is 6.69 ± 2.92, t = 2.29, p = 0.03, N=48, R^2 adj = 84.3%.

Turn angle vs stimulus angle for lateral line stimuli only

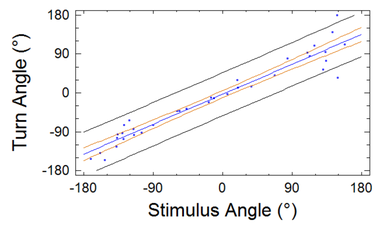

Figure 8: Regression of turn angle on stimulus angle for lateral line stimuli only. Slope is 0.77 ± 0.04, t = 21.1, p < 0.0001, y-intercept is -3.18 ± 4.06, t = 0.78, p = 0.44, N=35, R^2 adj = 92.7%.

Turn angle vs stimulus angle for clear rod visual only

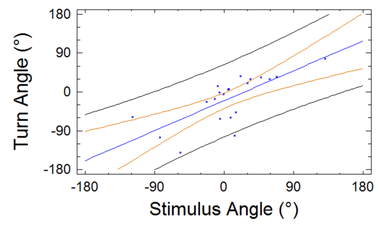

Figure 9: Regression of turn angle on stimulus angle for clear rod visual only. The slope is 0.77± 0.17, t = 4.60, p = 0.0002, y-intercept is -20.29 ± 8.61, t = -2.36, p = 0.03, N=20, R^2 adj = 50.2%.

Turn angle vs stimulus angle for lateral line plus visual

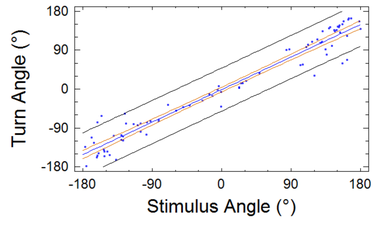

Figure 10: Regression of turn angle on stimulus angle for lateral line stimuli with black band. The slope is 0.83± 0.02, t = 38.02, p < 0.0001, y-intercept is -1.15 ± 2.75, t = -0.42, p = 0.68, N=81, R^2 adjusted = 94.7%.

Locations of visual stimuli not eliciting a response are widely distributed

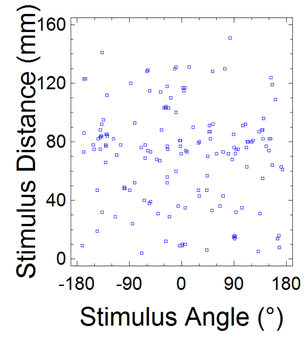

Figure 11: No difference was shown by above X,Y scatterplot for responses to lateral line stimuli at multiple stimulus distances and multiple stimulus angles.

Locations of visual stimuli eliciting a response are more proximal and rostral

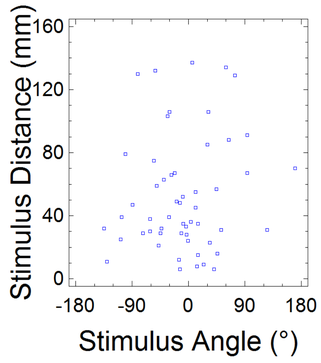

Figure 12: Response Frequency for Visual Stimuli was much higher at closer distances and angles closer to 0º shown by X,Y scatterplot above.

Conclusions

- Preliminary results confirm the preference for visual stimuli closer to the frog. (Fig 2, 3, 12)
- Frogs responded more to visual stimuli that were more directly in front of them than to stimuli behind them, i.e., at larger angles. (Fig 4, 12)
- Stimulus angle and distance did not affect lateral line stimuli response frequency. (Figs 5 & 6)
- Both frogs responded more to lateral line stimuli than to visual stimuli.

References

Chung, S.H., Stirling, R.V.,Gaze, R.M. (1975). J. *Embryol. Exp Morphol.* 33:915-940.

Claas, B., and Dean, J. (2006). *J. Comp. Physiol. A*, 192(10), 1021-1036. doi: 10.1007/s00359-006-0137-2

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