Comment on "Irrationality in mate choice revealed by túngara frogs": maybe túngara frogs are rational after all

Paulo Natenzon*

September 2015

Abstract

Lea and Ryan (Reports, 28 August 2015, p. 964) interpret mate choice data collected from frogs in the laboratory as being incompatible with rational choice models currently used in sexual selection theory. A close look at their data supports the hypothesis that some options offered in the lab are easier to compare than others. If we take into account that some pairs of options are easier to compare, and that frogs operate under conditions of uncertainty, we can restore rationality to túngara frogs.

*Department of Economics, Washington University in St. Louis, St. Louis, MO 63130, USA. E-mail: pnatenzon@wustl.edu. I am indebted to John Yiran Zhu (The Wharton School, University of Penn- sylvania) for bringing this study to my attention, and to Amanda M. Lea for useful comments.

Lea and Ryan [2] simulate three different male frog calls in the lab, which they label as target (A), competitor (B) and decoy (C). Table 1 below shows how often female frogs chose each alternative when every pairwise combination was offered: A versus B, B versus C, and A versus C. Binary comparisons are statistically significant and (stochastically) transitive: $B > A$, $A > C$, and $B > C$. Hence the binary choice data reveals a complete and transitive ranking of the three options: $B > A > C$.

The two bottom rows in Table 1 show that, instead of making choices in alignment with the ranking, frogs were more likely to choose A over B when all three alternatives were offered. This choice reversal seems irrational given the benchmark $B > A > C$ obtained from binary choices. Here, I employ the same narrow meaning of "rational" that the authors import from standard microeconomic theory: that all choice alternatives can be ordered in a complete and transitive ranking, according to a unidimensional value (which we name "darwinian fitness" or "consumer utility") and that observed choices reflect the relentless pursue of the maximization of this value. I show, using the published data, that observed behavior is indeed compatible with the maximization of expected value under uncertainty.

Multiple factors contribute to uncertainty and may lead to errors in mating choices among animals. Mating choices are made in complex, dynamic environments; individuals exhibit complex traits; time spent contemplating available mate options can increase the risk exposure to predators; organisms have limited cognitive resources; and so on. These factors lead to *limited sampling*: organisms obtain imperfect evidence about the value of each alternative before making a choice.

Using the ranking $B > A > C$ as a rational benchmark, we can use the proportion of choice mistakes in the published data to assess how difficult it is for frogs to correctly discriminate the options in each pair. The most difficult pair to discriminate is (A, B), where the inferior alternative A was chosen 37% of the time; 31% chose the inferior option C from (B, C); but only 16% of mistakes occurred in (A, C). Choosing the best option is an easier task for frogs when choosing among (A, C) than in other pairs.

Evidence from psychology and psychophysics (based on human subjects) can provide insight on what determines the difficulty of comparing and discriminating a given pair of stimuli. First, subjects tend to make more mistakes when the difference in value between stimuli is small. Pairs of options that are close to equality in value tend to be harder to discriminate, while pairs in which one of the options is far superior tend to be easier to discriminate. Based on values alone, the pair (B, C) should be the easiest to discriminate, because B and C are more distant in value according to the rational benchmark $B > A > C$. The data reveals that value is not the only factor at play.

So in order to account for the results, we must turn to a second factor: stimulus similarity. For a *fixed* difference between the value of two stimuli, the more similar the stimuli, the more reliable is the comparison or the discrimination between them [4].[1] In marketing studies of consumer choice, the decoy option C is designed to be similar to the target option A and clearly inferior [1]. Figure 1.D in [2] provides evidence that the decoy C in the frog experiment was designed according to the same methodology. The Figure represents the location of A, B and C in the 2-dimensional space of simulated characteristics. Options A, C are closer to each other than B, C along every dimension.[2]

To maximize the expected value of the chosen alternative under limited sampling, a rational actor must optimally respond to the difficulty of comparing each pair of alternatives. In a random draw of three potential mates A, B and C from the same population, each possible strict ranking is equally likely:

$$\begin{array}{ll} B > A > C & \quad B > C > A \\ A > B > C & \quad C > B > A \\ A > C > B & \quad C > A > B \end{array}$$

To see how one more easily comparable pair of options should affect rational choice among three alternatives, suppose that the only thing a frog can reliably tell from the limited sampling of male calls A, B, C before making a choice is that $A > C$, while the other comparisons are very difficult and unreliable. Conditional on the event $A > C$, the three rankings on the left column remain equally likely, while the three rankings on the right column are deemed impossible. This increases the likelihood that A is the best option: on average A is the best option in two out of every three times. Hence, based only on the information that $A > C$, a rational decision maker should choose A.

More realistically, the probability that option B is chosen won't be zero. Even when A and C are very easy to compare, limited sampling also provides some information about the value of option B. If the sampled evidence in favor of B is strong enough, option B will be chosen. The important lesson is that, when A and C are easier to compare, option B starts at a disadvantage. In the current study, the presence of the decoy C makes A more likely to be chosen than B—it increases the proportion of mistakes in the particular set of alternatives used in the experiment. This is precisely what would be predicted by a model of rational choice, where frogs maximize the expected value of the choice in a random draw of three options from the population.

In summary, the published data is compatible with a model in which: (i) frog preferences are rational, in the sense of being described by a complete and transitive ranking of every alternative according to value; (ii) frogs see the alternatives in each choice trial as randomly drawn from the same population; (iii) frogs obtain limited sampling evidence about the value of available options before making a choice; and (iv) frogs take advantage of the comparability of alternatives in order to maximize the expected value of the choice.

[1] Keeping the difference between stimuli values constant is key. In general, increasing the similarity of two stimuli without controlling for value can decrease the value difference, and the overall effect of these two opposing factors can go in either direction. See [3] for illustrative examples.

[2] Options A, B are also closer along every dimension than B, C. By the same logic, the high rate of mistakes in (A, B) can be attributed to A being inferior but very close in value to B.

References

[1] Joel Huber, J. W. Payne, and C. Puto. Adding asymmetrically dominated alternatives: Violations of regularity and the similarity hypothesis. Journal of Consumer Research, 9(1):90–98, 1982.

[2] Amanda M Lea and Michael J Ryan. Irrationality in mate choice revealed by túngara frogs. Science, 349(6251):964–966, 2015.

[3] Paulo Natenzon. Random choice and learning. Working Paper, April 2015.

[4] Amos Tversky and J. Edward Russo. Substitutability and similarity in binary choices. Journal of Mathematical Psychology, 6(1):1–12, 1969.

Acknowledgements

I am indebted to John Yiran Zhu (The Wharton School, University of Pennsylvania) for bringing this study to my attention, and to Amanda M. Lea for useful comments.

Table 1

Presented alternatives	n	A	B	C
A and B	118♀	.37	.63	–
B and C	90♀	–	.69	.31
A and C	90♀	.84	–	.16
A, B, and C	40♀	.55	.28	.17
A, B, and ~~C~~	79♀	.61	.39	–

Table 1: Responses by female túngara frogs in the published dataset (supplemental material online, see [2]). The first three rows correspond to binary choice data and support $B > A > C$ as a rational benchmark. The fourth row shows proportions when all three options are available. The fifth row shows proportions when option C was located on the ceiling, so that it was presented but unreachable. While B is more likely to be chosen than A in binary choice (first row), the opposite happens in the presence of C (last two rows).