

Syllabus

Linguistics 333 (Moreton)*

2023 January 9 (M)

Time: MWF 1:25–2:15
Places: Dey 304, or: Zoom: Meeting ID 978 8455 3588, passcode 095940 ➡
Instructor Elliott Moreton, moreton@unc.edu
Office hours: (tentatively:) W 11–1 and by appointment
Office: Smith 101, or: Zoom: Meeting ID 973 4347 1746, passcode 531096 ➡
Textbook: none

This class is in-person only. Zoom links are provided in case the University has to switch to remote learning for some reason during the semester.

1 Target audience, course goals, and learning objectives

Linguistic theory asks why human language is the way it is, and not some other way. This course explores a range of “other ways” found in nature. We will compare human language with the communication systems used by other animals, with special focus on natural acoustic communication in humans, birds, and non- and pre-human primates. The course is meant for undergraduates in Linguistics, Psychology, Biology, Computer Science, or any other field which touches on communication.

Part I: Anatomy and acoustics. The first part of the course will concentrate on the anatomy of the sound-producing organs in these species, and on the acoustics of the sounds produced by them. Students will learn how to record, manipulate, and measure sound files using the Praat software (freeware used in phonetics labs around the world), and the basics of interpreting sound spectrograms. We will read research papers in which the principles covered in this section are used to reconstruct the vocal abilities of extinct human relatives, such as Neanderthals, from fossils.

Part II: Formal structure. Next, we will turn to the structure of communication systems. Some species have a small, fixed vocal repertoire; others, like humans, titi monkeys, and Bengalese finches, can produce a very large number of utterances by combining smaller units according to rules. What are these rules like in other species, and how do they compare with the rules used in human language? We will approach this question using concepts from formal language theory such as finite automata and Markov processes, and we will implement models of actual human and animal data using the JFLAP state-machine simulator.

Part III: Meaning, learning, and variation. The last part of the course focuses on how the different communication systems convey messages (roughly speaking, meanings), and how these systems are acquired by their users. We will look especially closely at two controversial and intertwined questions, the *innateness* and *evolution* of communication systems.

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The right textbook for this course has yet to be written. We will rely instead on book chapters and original research reports in linguistics, psychology, computer science, and other fields. The readings will be made available through Sakai or the World Wide Web.

Original field research. To get direct experience of what we're reading about, the course will include a substantial lab and field component consisting of homework assignments and a major semester project. The project will involve making and analyzing field recordings of the song of the American Robin in search of the principles that govern its combinatorial structure.

As part of the General Education curriculum satisfying the Empirical Investigation Lab requirement, this course will enable students to:

1. Take empirical measurements using appropriate apparatus.
2. Generate and test hypotheses.
3. Gather, store, and organize data.
4. Analyze and report on data and hypothesis testing.

As part of the General Education curriculum satisfying the Quantitative Reasoning Focus Capacity requirement, this course will enable students to:

1. Summarize, interpret, and present quantitative data in mathematical forms, such as graphs, diagrams, tables, or mathematical text.
2. Develop or compute representations of data using mathematical forms or equations as models and use statistical methods to assess their validity.
3. Make and evaluate important assumptions in the estimation, modelling, and analysis of data, and recognize the limitations of the results.
4. Apply mathematical concepts, data, procedures, and solutions to make judgements and draw conclusions.
5. Synthesize and present quantitative data to others to explain findings or to provide quantitative evidence in support of a position.

As part of the General Education curriculum satisfying the Natural Scientific Investigation Focus Capacity requirement, this course will enable students to:

1. Use scientific knowledge, logic, and imagination to construct and justify scientific claims about the articulation, acoustics, and perception of the sounds used by humans, other mammals (especially primates), and birds, including validation of theory through rigorous empirical testing.
 2. Generate and test hypotheses or theories, use logic and creativity to design investigations to test these hypotheses, collect and interpret data, make inferences that respect measurement error, build and justify arguments and explanations, communicate and defend conclusions, revise arguments and conclusions based on new evidence and/or feedback from peers, and synthesize new knowledge into broader scientific understanding.
 3. Evaluate science-related claims and information from peer-reviewed sources by examining the relationship between the evidence, arguments, and conclusions presented and by assessing consistency with existing knowledge from valid and reliable scientific sources.
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2 Prerequisites

The only prerequisite for this class is Linguistics 101, Introduction to Language, or the equivalent. A knowledge of high-school algebra is assumed.

3 Specific requirements and policies

Final grades for the course will be calculated as follows:

- 10% *Attendance and participation.* Students are supposed to come to class, do the assigned readings on time, and participate in class activities and discussion. Missing classes will make it hard to keep up. It will also lower your participation grade (unless due to illness or other unavoidable events, which it is your responsibility to document). *Please note that this class is in-person only.*
- 35% *Homework.* Homework includes problem sets and labs, of which there will be about 6. As is often the case in linguistics courses, the homework may be meant as preparation for the class, not the other way around. Students may have to figure out how to do things which they have not yet been shown how to do.
- 30% *Exams.* There will be two midterms and one final, all cumulative from the beginning of the course. Each will count for 10% of the final grade.
- 25% *Final field project.* To get direct experience of animal-communication research, we will investigate the combinatorial structure of the song of the American Robin (*Turdus migratorius*). Robins are common, easy to recognize, and voluble. Their song is complex enough to be interesting but not so complex as to be unmanageable in a semester project. Best of all, very little is known about it. We will formulate a research question, then design, execute, and analyze a field experiment to answer it, and finally present the question and the results to the class. This will take place in several steps, and I'll be giving details as each one comes up.

Numeric grades will be converted to UNC's letter-grade system by mapping the numeric range from 60 to 100 onto the 10 passing letter grades from D to A, with four numeric points per step (except that A has 5 points, 96 to 100). It is possible to do well in this class and still get a grade other than A.

4 Where to find necessary things on line

The main tools we will be using to communicate in this course are the following:

1. The class log ➡¹, on the World Wide Web, which is updated after each class. Here you will find
 - (a) A brief outline of what was covered each day
 - (b) A list of any assignments made that day
2. The Sakai site ➡². Everyone who is enrolled in the class should already have access to it. Our class's ID, if you need it, is LING333.001.SP23. The main things we will need there are

¹<https://users.castle.unc.edu/~moreton/Ling333/333log.html>

²<http://sakai.unc.edu>

- (a) Course materials like slides, handouts, and readings (under **Resources**)
- (b) The place to pick up and return written assignments (under **Assignments**)
- (c) The discussion forum for asynchronous collaboration (under **Forums**)
- (d) The gradebook (under **Gradebook**)
- (e) In case UNC-CH switches to remote learning during the semester: Recordings and transcripts of any class meetings held by Zoom (under **Panopto**) **These are for class members only!**

Any use of a class recording by a student shall be for educational purposes only. Students may not record a class on their own, in any format, without prior express authorization from the University and may not copy, reproduce or distribute any recording that they access. Students requesting the use of assistive technology as an accommodation should contact Accessibility Resources & Service. ➡³

3. The Zoom meeting link (see p. 1 of the syllabus). If Zoom is not already installed on your computer, please go to <https://software.sites.unc.edu/zoom/> ➡⁴ to get it.

³<https://ars.unc.edu/>

⁴<https://software.sites.unc.edu/zoom/>

5 Approximate schedule

Week	Date	Topics and readings
1	1/9 M 1/11 W 1/13 F	Acoustics. Installing and using Praat software. <i>Johnson (2012, Ch. 1); Denes and Pinson (1993, Ch. 4).</i>
2	1/18 W 1/20 F	Source/filter theory of phonation. Resonances of a half-open uniform tube. <i>Johnson (2012, Ch. 5).</i>
3	1/23 M 1/25 W 1/27 F	Formants and vocal-tract length. Sexual dimorphism and its adaptive significance. <i>Fitch (2000); Fitch and Reby (2001).</i>
4	1/30 M 2/1 W 2/3 F	Human vocal anatomy. Perturbation theory. Acoustics of vowels. <i>Johnson (2012, Ch. 6); Ladefoged (2011, Ch. 3).</i>
5	2/6 M 2/8 W 2/10 F	Comparative primate vocal anatomy and physiology. Evolution of human vocal tract. Vocal capabilities of extinct human relatives. <i>Fitch et al. (2016).</i>
6	2/13 M 2/15 W 2/17 F	Vocal anatomy and physiology in songbirds. <i>Suthers (1999).</i> Midterm 1.
7	2/20 M 2/22 W 2/24 F	Combinatorial structure. Finite-state syntax in birdsong. <i>Hockett (1960); Catchpole and Slater (2008, Ch. 8); Honda and Okanoya (1999).</i>
8	2/27 M 3/1 W 3/3 F	Levels of structure in birdsong and non-human primate vocalizations. First-order Markov processes. <i>Kroodsma (2005, 255–267).</i>
9	3/6 M 3/8 W 3/10 F	Combinatorial structure in vocalizations of primates. Recording birds in the field. <i>Robinson (1979), Chomsky (1957, Ch. 3), Culy (1985).</i>
10	3/20 M 3/22 W 3/24 F	Functional referentiality and compositional semantics. <i>Engesser et al. (2016); Robinson (1984).</i> Midterm 2.
11	3/27 M 3/29 W 3/31 F	Intro to robin project and making field recordings. Innate vs. learned vocal behavior in birds. Song dialects. <i>Kroodsma (2005, 79–89); Otter et al. (2020).</i>
12	4/3 M 4/5 W	The auditory-template model of birdsong acquisition. <i>Catchpole and Slater (2008, Ch. 3, pp. 49–60)</i>
13	4/10 M 4/12 W 4/14 F	Sensitive periods in acquisition of birdsong and human language. Vocal learning (or not) in non-human primates. <i>Mayberry and Kluender (2018); Marler (1991); Fischer and Hammerschmidt (2020).</i>
14	4/17 M 4/19 W 4/21 F	Innately constrained learning. Course wrap-up. <i>Berent et al. (2008), Fehér et al. (2009)</i>
15	4/24 M 4/26 W 4/28 F	Robin-project presentations.
16	5/5 M	FINAL EXAM, 4 p.m.

6 Policies

Attendance. If you miss a class, it is your responsibility to get missed materials from Sakai or other students. Always check the website if you have been absent.

Reading. Students are expected to come to class having done the readings. If I start getting the impression that people aren't doing the readings, I'm going to institute pop quizzes. These are annoying because they waste class time, but coming to class without having done the reading wastes even more class time.

Homework. You'll get detailed information about each one when it's assigned, but there are some general points that apply to all of them.

1. Homework will be handed in via the **Assignments** tool on Sakai (see Section 4).
2. Homework should be **in .pdf format** (not .doc, .docx, .rtf, etc.). Software for doing things with pdf files, such as annotating them, can be obtained free from ITS ➡⁵.
3. Homeworks handed in on time will be graded on a scale from 1 to 3 in a way that will be explained along with each assignment using a *grading rubric*. The 1–3 scale will map linearly onto an *approximately* 60–100 scale in computation of the final grade. Other homeworks will receive a zero. Hence, a 0 is *much* worse than a 1.

Late assignments. As a general rule, NO LATE ASSIGNMENTS WILL BE ACCEPTED FOR CREDIT. Exceptions *may* be made if

- You got *advance* permission (by asking me *before* the due date) to hand in an assignment late, or
- You couldn't come to campus on the day the assignment is due because of a serious illness or other unexpected emergency. You need to get the assignment in at the earliest possible opportunity with a *written explanation* of the situation. Email is best.

Collaboration, citation, and outside sources. It is a really good idea to discuss assignments with others in the class and solve the problems together. However, each person should write up their solution alone.

The library and the World Wide Web are full of information, and you are encouraged to use them to supplement the class materials. If the explanation of some topic in the class reading leaves you puzzled, it can be very helpful to track down a different explanation elsewhere. HOWEVER, you should remember that HOMEWORK AND EXAM PROBLEMS ARE FOR SOLVING, NOT FOR LOOKING UP THE ANSWERS TO. If your assignment is to figure out the song syntax of a particular bird species, it is emphatically not OK to look up articles which discuss the song of that particular species!

If you collaborate or consult out-of-class sources on an assignment, you need to acknowledge them in the writeup, to give credit where it is due.

⁵<https://software.sites.unc.edu/software/adobe-creative-cloud/>

The Carolina Honor Code is in effect in this class, and I will treat violations seriously. You should review it at <http://instrument.unc.edu>^a. If you have questions about interpretation, you should bring them to me. **Every assignment you hand in must be accompanied by a signed statement that you have complied with the Code requirements in everything related to that work,** e.g., “I completed this assignment in full compliance with the Honor Code.”

^a<http://instrument.unc.edu>

7 Partnerships

Most of the assigned work in this class will be done with a partner, for a shared grade (unless otherwise specified). There are several reasons for this.

One is purely practical. The final project is going to take more work than one person can reasonably be asked to do, so you will have to work with someone in order to finish the project on time and do a good job. But, the final project shouldn't be the first time you and your partner work together. Collaboration on homeworks during the first part of the semester gives you the opportunity to get the bugs out of the partnership.

Another reason is pedagogical. Again and again throughout the semester, each of you is going to find yourself having to explain something to your partner. Both of you will understand it better as a result.

Finally, this is how real research is done! You work with other people, share the ideas, share the labor, spot opportunities or mistakes that the other person overlooked, present the results together, and share the credit (or ignominy). It's none too early to start getting used to this aspect of research culture.

I will be assigning partners, on the basis of questionnaires, to insure that there is a fair distribution of skills and backgrounds among the partnerships. It is your job to insure that there is a fair distribution of work within each partnership. For the final project, this is mandatory: your project proposal must include an account of how you have agreed to divide up the work. Explicit agreements are not required for the homework, but informal ones are a darn good idea. Partners will work together on the homeworks and the final project, but not on the exams. Partners are jointly responsible for handing in the assignment; that is, if it doesn't show up on time, it counts against both people.

8 Equipment and software

Audio equipment: Many assignments (including the “reading” assignments) will involve listening to audio files, either from Sakai or on the Web. You'll hear better if you have a pair of headphones or earphones. The kind used with portable MP3 players are fine. The headphones will plug into the headphone jack, speaker jack, or USB port on your laptop or desktop computer.

Some assignments, and the final project, will require making audio recordings. To record, you'll need a microphone. For recording humans, each partnership will be issued with a mike that plugs into your computer's sound card. At this footnote is a page of links to free software for making audio recordings on smartphones and laptops..⁶ For making field recordings of birds, we'll be using more sophisticated equipment which can be signed out from the Linguistics Department.

Speech analysis software: A very nice speech-analysis package called Praat is available free for download from the Institute of Phonetic Sciences in Amsterdam. ⁷There are versions for PC,

⁶<https://www.temi.com/blog/user-friendly-apps-to-record-and-trim-audio-on-any-device/>

⁷<http://www.praat.org>

Mac, and Linux.

State-machine simulation software: We will be using the JFLAP simulator ➡⁸ to build automata which simulate the formal structure of human and non-human communication systems. It, too, is available for PC, Mac, and Linux, and I will provide instructions on how to install it when the time comes.

A mirror: Once or twice I'll ask you to bring a small mirror to class, for observing your own articulators. The best kind is the folding pocket mirror, the kind which has a regular mirror and a magnifying mirror hinged together (so you can see around corners). However, a plain old hand mirror works fine, as does a mirror app on a smartphone.

The International Phonetic Alphabet. We'll need to use the IPA without being able to hand-write it. Here are some links that may help:

9 The International Phonetic Alphabet

We'll need to use the IPA. Here are some links that may help:

1. A freeware Unicode IPA font, Charis SIL ➡⁹ that works on Windows, Mac, and Linux systems.
2. An IPA keyboard ➡¹⁰ webpage. You type by clicking on IPA symbols, then cut and paste the result into your word processor.
3. Guidance on typing IPA on a Windows machine ➡¹¹
4. Guidance on typing IPA on a Mac ➡¹²

10 General UNC-CH course policies and resources

Accessibility Resources The University of North Carolina at Chapel Hill facilitates the implementation of reasonable accommodations, including resources and services, for students with disabilities, chronic medical conditions, a temporary disability or pregnancy complications resulting in difficulties with accessing learning opportunities.

All accommodations are coordinated through the Accessibility Resources and Service Office. See the ARS Website for contact information: <https://ars.unc.edu> or email ars@unc.edu.

Attendance Policy No right or privilege exists that permits a student to be absent from any class meetings, except for these University Approved Absences:

1. Authorized University activities
2. Disability/religious observance/pregnancy, as required by law and approved by Accessibility Resources and Service and/or the Equal Opportunity and Compliance Office (EOC)
3. Significant health condition and/or personal/family emergency as approved by the Office of the Dean of Students, Gender Violence Service Coordinators, and/or the Equal Opportunity and Compliance Office (EOC).

Please communicate with me early about potential absences. Please be aware that you are bound by the Honor Code when making a request for a University approved absence.

⁸<http://www.jflap.org>

⁹<https://software.sil.org/charis/>

¹⁰<https://westonruter.github.io/ipa-chart/keyboard/>

¹¹<https://www.gouskova.com/2016/09/04/international-phonetic-alphabet-fonts-and-keyboards/>

¹²http://wstyler.ucsd.edu/posts/ipa_with_osx.html

Counseling and Psychological Services CAPS is strongly committed to addressing the mental health needs of a diverse student body through timely access to consultation and connection to clinically appropriate services, whether for short or long-term needs. Go to their website: <https://caps.unc.edu/> or visit their facilities on the third floor of the Campus Health Services building for a walk-in evaluation to learn more.

Diversity Statement I value the perspectives of individuals from all backgrounds reflecting the diversity of our students. I broadly define diversity to include race, gender identity, national origin, ethnicity, religion, social class, age, sexual orientation, political background, and physical and learning ability. I strive to make this classroom an inclusive space for all students. Please let me know if there is anything I can do to improve, I appreciate suggestions.

Honor Code Statements

1. All students are expected to follow the guidelines of the UNC honor code. In particular, students are expected to refrain from “lying, cheating, or stealing” in the academic context. If you are unsure about which actions violate that honor code, please see me or consult honor.unc.edu. (source: Department of Asian Studies)
2. Students are bound by the Honor Code in taking exams and in written work. The Honor Code of the University is in effect at all times, and the submission of work signifies understanding and acceptance of those requirements. Plagiarism will not be tolerated. Please consult with me if you have any questions about the Honor Code. (source: syllabus from section of HIST 486 offered in 2015)
3. The University of North Carolina at Chapel Hill has had a student-administered honor system and judicial system for over 100 years. The system is the responsibility of students and is regulated and governed by them, but faculty share the responsibility. If you have questions about your responsibility under the honor code, please bring them to your instructor or consult with the office of the Dean of Students or the Instrument of Student Judicial Governance. This document, adopted by the Chancellor, the Faculty Council, and the Student Congress, contains all policies and procedures pertaining to the student honor system. Your full participation and observance of the honor code is expected (honor.unc.edu). (source: syllabus from section of GEOG 67 offered in 2015)

Syllabus changes The professor reserves the right to make changes to the syllabus, including project due dates and test dates. These changes will be announced as early as possible.

Title IX statement Any student who is impacted by discrimination, harassment, interpersonal (relationship) violence, sexual violence, sexual exploitation, or stalking is encouraged to seek resources on campus or in the community. Please contact the Director of Title IX Compliance (Adrienne Allison – Adrienne.allison@unc.edu), Report and Response Coordinators in the Equal Opportunity and Compliance Office (reportandresponse@unc.edu), Counseling and Psychological Services (confidential), or the Gender Violence Services Coordinators (gvsc@unc.edu; confidential) to discuss your specific needs. Additional resources are available at safe.unc.edu.

Undergraduate Testing Center The College of Arts and Sciences provides a secure, proctored environment in which exams can be taken. The center works with instructors to proctor exams for their undergraduate students who are not registered with ARS and who do not need testing accommodations as provided by ARS. In other words, the Center provides a

proctored testing environment for students who are unable to take an exam at the normally scheduled time (with pre-arrangement by your instructor). For more information, visit <http://testingcenter.web.unc.edu/>.

- Additional student resources**
1. The Learning Center: The UNC Learning Center is a resource both for students who are struggling in their courses and for those who want to be proactive and develop sound study practices to prevent falling behind. They offer individual consultations, peer tutoring, academic coaching, test prep programming, study skills workshops, and peer study groups. If you think you might benefit from their services, please visit them in SASB North or visit their website to set up an appointment: <http://learningcenter.unc.edu>.
 2. The Writing Center: The Writing Center is located in the Student and Academic Services Building and offers personalized writing consultations as well as a variety of other resources. This could be a wonderful resource to help with your writing assignments in this course (and any assignments in your other courses). You do not need a complete draft of your assignment to visit; they can help you at any stage! You can chat with someone in the writing center or set up as appointment on their website: <http://writingcenter.unc.edu>.
 3. Resources for Success in Writing: UNC has a Writing Center that provides one-on-one assistance to students free of charge. To make an appointment, browse the Writing Center's online resources, or submit a draft online. They have additional useful information, such as handouts on how to cite online.

References

- Berent, I., T. Lennertz, J. Jun, M. A. Moreno, and P. Smolensky (2008). Language universals in human brains. *Proceedings of the National Academy of Sciences, U.S.A.* 105(14), 5321–5325.
- Catchpole, C. K. and P. J. B. Slater (2008). *Bird song: biological themes and variations* (2nd ed.). Cambridge, England: Cambridge University Press.
- Chomsky, N. (1957). *Syntactic structures*. The Hague: Mouton.
- Culy, C. (1985). The complexity of the vocabulary of Bambara. *Linguistics and Philosophy* 8, 345–351.
- Denes, P. B. and E. N. Pinson (1993). *The speech chain: the physics and biology of spoken language* (2nd ed.). New York: W. H. Freeman.
- Engesser, S., A. R. Ridley, and S. W. Townsend (2016). Meaningful call combinations and compositional processing in the southern pied babbler. *Proceedings of the National Academy of Sciences* 113(21), 5976–5981.
- Fehér, O., H. Wang, S. Saar, P. P. Mitra, and O. Tchernikovski (2009). *De novo* establishment of wild-type song culture in the zebra finch. *Nature* 459(28), 564–568.
- Fischer, J. and K. Hammerschmidt (2020). Towards a new taxonomy of primate vocal production learning. *Philosophical Transactions of the Royal Society B* 375(1789), 20190045.
- Fitch, W. T. (2000). The phonetic potential of nonhuman vocal tracts: comparative cineradiographic observations of vocalizing animals. *Phonetica* 57(2–4), 205–218.
- Fitch, W. T., B. de Boer, N. Mathur, and A. A. Ghazanfar (2016). Monkey vocal tracts are speech-ready. *Science Advances* 2(e1600723), 1–7.
- Fitch, W. T. and D. Reby (2001). The descended larynx is not uniquely human. *Proceedings of the Royal Society of London (B)* 268, 1669–1675.
- Hockett, C. F. (1960). The origin of speech. In W. S.-Y. Wang (Ed.), *Human communication: language and its psychobiological bases*, pp. 4–12. San Francisco: W. H. Freeman.
- Honda, E. and K. Okanoya (1999). Acoustical and syntactical comparisons between songs of the White-Backed Munia (*Lonchura striata*) and its domesticated strain, the Bengalese Finch (*Lonchura striata* var. *domestica*). *Zoological Science* 16, 319–326.
- Johnson, K. (2012). *Acoustic and auditory phonetics* (3rd ed.). Malden: Blackwell.
- Kroodsma, D. (2005). *The singing life of birds*. Boston: Houghton Mifflin.
- Ladefoged, P. (2011). *Vowels and consonants: an introduction to the sounds of language* (3rd ed.). Malden, Massachusetts: Blackwell.
- Marler, P. (1991). The instinct to learn. In S. Carey and R. Gelman (Eds.), *The epigenesis of mind*, Chapter 2, pp. 37–66. Hillsdale: Erlbaum.
- Mayberry, R. I. and R. Kluender (2018). Rethinking the critical period for language: new insights into an old question from American Sign Language. *Bilingualism: Language and Cognition* 21(5), 886–905.
- Otter, K. A., A. McKenna, S. E. LaZerte, and S. M. Ramsay (2020). Continent-wide shifts in song dialects of White-Throated Sparrows. *Current Biology* 30, 1–5.
- Robinson, J. G. (1979). An analysis of the organization of vocal communication in the titi monkey *Callicebus moloch*. *Zeitschrift für Tierpsychologie* 49, 381–405.
- Robinson, J. G. (1984). Syntactic structures in the vocalizations of wedge-capped capuchin monkeys, *Cebus olivaceus*. *Behaviour* 90, 46–79.
- Suthers, R. A. (1999). The motor basis of vocal performance in songbirds. In M. D. Hauser and M. Konishi (Eds.), *The design of animal communication*, pp. 37–62. Cambridge, Massachusetts:

MIT Press.