The time has come for Tufts to institute an interdisciplinary major in Cognitive and Brain Science. Drawing on research from fields as disparate as computer science and animal learning, perceptual psychology and linguistics, neuroanatomy and philosophy, the growing international community of researchers in cognitive and brain science has now achieved the level of mutual understanding, and accumulated the substantial body of results, necessary to support an intellectually responsible and challenging undergraduate program. Tufts is arriving at this conclusion relatively late. Virtually all the universities by which we measure ourselves have offered undergraduate programs in cognitive science (under various different names) for several years—MIT and the Ivy League, Indiana, Michigan, Berkeley and San Diego, Carnegie Mellon and Vanderbilt and Rochester, to name a few top programs. These programs are quite disparate in their outlook and their coverage (see Appendix B); we have developed our own distinctive program, building on the particular strengths of Tufts.

The central issue in cognitive science is how the mind works. The central conception in the field is of the brain as a biological information-processing device. Cognitive and Brain Science is an inherently interdisciplinary area, drawing on psychology, neuroscience, linguistics, philosophy of mind, computer science, and biology. A Cognitive and Brain Science degree would provide excellent preparation for careers in the sciences, computer fields, health professions, law, and education.

We have a cadre of faculty members across Arts and Sciences and Engineering (and potentially the Medical School) who are internationally distinguished leaders in many branches of cognitive and brain science. The departments most centrally involved - psychology, computer science, and philosophy – are excited about mounting this curriculum, which will also be the first major curricular enterprise involving the newly expanded Center for Cognitive Studies. We already offer courses that, with little or no adjustment, constitute almost all the core curriculum of a first-rate program, as well as many distinctive courses that other universities would love to be able to offer. Through our preliminary experimental offerings, we have already attracted an enthusiastic and highly talented group of potential majors. With only a modest investment in further resources – one position in computer science and one in linguistics – we can leverage the strengths of existing faculty into a fully interdisciplinary program that will be one of the best and most well-rounded undergraduate programs in cognitive and brain sciences in the world. (Appendix C discusses these needs.)

The Tufts Cognitive and Brain science major sketched below will be based in the Psychology Department, where our greatest strengths in the field lie, and where we already have in place most of the administrative machinery necessary to manage such a program. We envision a challenging curriculum that will attract the brightest and most motivated students. Students will be required to take a core of courses in psychology, a basic range of courses in the other constituent disciplines, and a series of upper-level courses in which they can specialize to some degree in one or more constituent fields. The program will be completed with a required research experience accompanied by a
senior seminar, in which all students will discuss current literature, the research of graduate students at Tufts, and their own research. Majors will also be strongly encouraged to attend a semester of the senior seminar in their sophomore or junior years, in order to prime them for the research experience and also in order to build community among the majors.

The program as proposed here is largely constructed out of courses already in place in Psychology, Philosophy, Child Development, and Computer Science. However, in order to make the major coherent and distinct from the generic experimental psychology major, the following additions to the curriculum are proposed (note that these are already approved or are in the process of being approved by the curriculum committee):

1. Introduction to Cognitive and Brain Sciences (PSY 29). This will be offered yearly and is a reconfiguration of an existing course in the Psychology curriculum (Human Neuropsychology) that is already being offered once a year. We envision this as the starting point for the major, and as such it will be a survey of topics in Cognitive and Brain Science, capturing most of the content covered in our very successful pilot course taught this past spring. Phil Holcomb and Haline Schendan will serve as course supervisors and they will be augmented by a series of lectures from other members of the program including especially Ray Jackendoff and Dan Dennett. This course is being taught this Spring (07).

2. Three courses in Linguistics: Introduction to Linguistics, Syntactic Theory, and Semantics.

3. Two new courses in Computer Science (COMP 14 and COMP 131) that will enable students to see the relevance of Computer Science to cognitive science, and that will give students the tools to take upper-level computer science courses relevant to this program. Note that COMP 14 would have a prerequisite of COMP 11, although students coming in with advanced placement credit could take this course directly. Here some further investment in staffing is necessary (see Appendix C).

4. Jackendoff’s course in Cognition of Society and Culture was offered in fall ‘06.

5. Senior Seminar in Cognitive and Brain Science (Psy195). This will be a weekly, year-long meeting of all seniors in the Cognitive and Brain Science major as well as interested graduate students and faculty. The seminar will be administered by one faculty member for the entire year (worth 1 credit, given at the end of the second semester). The purpose of the seminar is to allow students to present data and ideas from their research projects and to learn from faculty and grad students who will also present. To help build cohesion earlier in the major, we will strongly encourage all others in the major to attend one semester of the senior seminar prior to their senior year.

6. We anticipate that further courses will be added as staffing is developed (see Appendix C).
Judging from an informal survey in the experimental Introduction to Cognitive and Brain Sciences course in spring ‘06, we anticipate 20 majors per year, perhaps half of whom would not ordinarily have been psychology majors.

Proposed interdisciplinary major in Cognitive and Brain Science (13 courses + Senior Seminar in Cognitive and Brain Science).

This curriculum allows a wide range of options. It requires considerable interdisciplinary breadth at the beginning level. Advanced students may choose to continue to be broadly interdisciplinary, or they may choose primarily to “track” within a single discipline such as psychology, philosophy, or linguistics (and we hope eventually computer science). If they choose the latter, the senior seminar will still maintain the interdisciplinary perspective. Students will select their program in consultation with their advisors. Students who wish to modify the requirements below must have the approval of their advisors and the Cognitive and Brain Science Steering Committee.

A, 6 required courses
1. PSY 29 Intro to Cognitive and Brain Science
2. PSY 31 Statistics (or CD140)
3. PSY 32 Experimental psychology
4. PHIL 15/PSY 64 Introduction to Linguistics
5. COMP 11 Introduction to Computer Science (or AP credit)
6. COMP 14 Computational Concepts in Biological and Cognitive Sciences

B, 3 intermediate courses, one from each of the following groups:
1. PSY 11 Developmental Psychology
   PSY 25 (or 103) Physiological Psychology
   PSY 26 Animal Learning and Cognition
   PSY 27 Perception
   PSY 28 Cognitive Psychology
   CD 51 Intellectual Development in Young Children
2. COMP 131 Artificial Intelligence
3. PHIL 3 Language and Mind
   PHIL 33 Logic
   PHIL/PSY 151 Syntactic Theory
   PHIL/PSY 150 Semantics

C, 4 advanced courses, drawn from at least two of the following groups
1. PSY 129 Cognitive Neuroscience
2. PSY 124 Cognitive Neuroscience of Perception
3. PSY 148 Cognitive Neuroscience of Learning and Memory
4. PSY 112 Biological Basis of Psychopathology
5. PSY 127 Behavioral Endocrinology
6. PSY 123 Psychopharmacology
PSY 126 Origins of Cognition
PSY 140 Mathematical Psychology
PSY 144 Memory and Retention
PSY 146 Comparative Cognition and Behavior
PSY 139 Social Cognition
PSY 142 Seminar in Affective Neuroscience
PSY 154 Psychosis

2. PSY 149 Psychology of Language
   CD 155 The Young Child’s Development of Language
   CD 195 Developmental Disorders in Language and Reading
   CD 243 Reading, Dyslexia and the Brain

3. COMP 80 Programming Languages
   COMP 135 Machine Learning and Data Mining
   COMP 150 Computational Learning Theory
   COMP 171 Human-Computer Interaction
   COMP 170/PHIL 170 Computation Theory

4. PHIL 117 Philosophy of Mind
   PHIL 126 Theories of Human Nature
   PHIL 133 Philosophy of Language
   PHIL 134 Philosophy of Social Science
   PHIL/PSY/ANTH 132 Cognition of Society and Culture

D. Advanced research experience. 2 options, both of which involve enrolling in Senior Seminar in Cognitive and Brain Science (PSY195), a once a week, year-long meeting of all seniors in this major worth 1 credit for the entire year:
   1. Senior honors thesis in psychology, child development, computer science or philosophy.
   2. A year-long research experience working with a faculty member from either psychology, philosophy, child development, computer science, or the neuroscience department at the medical school. Students pursuing this route will be required to complete a final write-up of their research which they must present during senior seminar.

*Students considering the Cognitive and Brain Science major will also be strongly encouraged to attend the senior seminar during one semester of their sophomore year.

E. Electives. Students are encouraged, after consultation with their advisor, to augment the Cognitive and Brain Science major by taking electives drawn from the following list:
   Anthro (ANTH 150 Human Evolution)
   Biology (Bio 13, 14, Bio 116 General Physiology, Bio 134 Neurobiology)
   Math (Math 11, 12 & 13, Math 150 Mathematical Neuroscience)
   Psychology (all courses, especially: PSY37, 40, 46, 48, 49, Psy107/108)

Note that students majoring in Cognitive and Brain Science cannot double major in any other Psychology major.
Appendix A. Faculty involved in Cognitive and Brain Science Program

Steering Committee: Robert Cook, Psychology
Daniel Dennett, Philosophy
Phillip Holcomb, Psychology
Ray Jackendoff, Philosophy/Psychology
Diane Souvaine, Computer Science

Other faculty: Nalina Ambady, Psychology
Jamshed Bharucha, Psychology
Emily Bushnell, Psychology
Richard Chechile, Psychology
Joseph DeBold, Psychology
Robin Kanerak, Psychology
Gina Kuperberg, Psychology
Keith Maddox, Psychology
Klaus Miczek, Psychology
Halone Schendan, Psychology
Lisa Shin, Psychology
Holly Taylor, Psychology
Heather Urry, Psychology
Kathrin Koslicki, Philosophy
Mark Richard, Philosophy
Maryanne Wolf, Child Development
Calvin Gidney, Child Development
Anselm Blumer, Computer Science
Carla Brodley, Computer Science
Robert Jacob, Computer Science
Roni Khardon, Computer Science
Donna Slonim, Computer Science
Barry Trimmer, Biology
Christoph Börgers, Math
Appendix B. Cognitive Science programs at other institutions

UCSD Cognitive Science

UCSD offers both a B.A. and a B.S. degree in Cognitive Science. There is also an honors program for exceptional students in both degree programs.

Mathematics Requirement

The cognitive science major requires twelve units of mathematics courses (for the B.A. degree) or sixteen units of mathematics courses (for the B.S. degree), chosen from the following list:

Requirements for the BA degree

Lower-division: (Total=6 courses, 24 units)

1. Math (3 courses, 12 units):
   o Select from the mathematics courses listed above.
   o Please note: Students should check with the math department for rules governing duplication of credit between the 10 and 20 series.

2. Cognitive Science (3 courses, 12 units):
   o COGS 1: Introduction
   o COGS 14: Methods
   o COGS 18: Programming

Upper-division: (Total=12 courses, 48 units):

1. Core (9 courses, 36 units):
   Must include two courses in the COGS 101 series, two in the COGS 102 series, two in the COGS 107 series, COGS 109, and two additional courses from any of the core sequences.
   o COGS 101A-B-C: Fundamental Cognitive Phenomena
   o COGS 102A-B-C: Distributed Cognition, Cogn. Ethnography and Engr.
   o COGS 107A-B-C: Cognitive Neuroscience
   o COGS 109, COGS 118A-18B: Computational Models of Cognition

2. Electives (3 courses, 12 units):
   Two of the three electives must be taken within the Cognitive Science Department.
Brown University Cognitive Science

Brown, like UCSD offers two majors. The A.B. program is primarily for students interested in studying human mental processes. The Sc.B. program is intended for students who also have strong interests in an affiliated area such as artificial intelligence, computational modeling, or cognitive neuroscience.

Standard Program for the A.B. Degree: 13 Courses

A. Introduction
   1. CG 001

B. Required core courses
   1. Cognition
   2. Language
   3. Perception
   4. Cognitive Neuroscience

C. Required courses in skills and methodology
   1. Lab course
   2. Basic computation course
   3. Statistics

D. Capstone
   1. Senior Seminar

E. Electives
   Four additional electives. Electives would in most cases include four 100-level courses, and should show coherence and provide the concentrator with depth in one or more focus areas.

Requirements for the Sc.B. Program

A. All of the requirements for the A.B. degree.

B. Independent study

C. A coherent program of at least four additional courses in the life sciences (e.g., cognitive science, psychology, biology), physical sciences, mathematics, and/or applied mathematics that supports the student's area(s) of study. Many acceptable supporting science programs are possible, and the student should work out her/his program in consultation with the concentration advisor.
Johns Hopkins University Cognitive Science

The course work that makes up the undergraduate program combines course offerings in the Department of Cognitive Science with courses in a number of other departments. These courses are divided into five areas of concentration and students are expected to acquire at least some familiarity with each of these areas. While allowing enough flexibility to offer an exposure in some depth to a student's primary area(s) of interest, the major in Cognitive Science is also intended to provide the broader perspective necessary to situate particular research disciplines within the overall study of the mind/brain.

Most of the courses which fulfill the requirements for the five areas of concentration are listed below.

1. Area A: Cognitive Psychology and Cognitive Neuropsychology
2. Area B: Linguistics
3. Area C: Computational Approaches to Cognition
4. Area D: Philosophy of Mind
5. Area E: Neuroscience

Requirements for the B.A. degree

- **Two Introductory Courses**
  - Cognition
  - Language and Mind

- **Three Courses From Each of Two Focal Areas**
  Among the five concentration areas, two are designated by the student as focal areas, the other three are treated as nonfocal areas. At least one course in each focal area must be at the 300-600 level. These courses may not include research, readings, or practical.

- **One Course From Each Nonfocal Area**
  These courses may be at any level. Note: If Area C (Computational Approaches to Cognition) is not a focal area, Computer Literacy or the equivalent is required and should be taken before the other course in this area.

- **Three Additional Courses at 300-600 Level**
  Chosen from any of the five areas of concentration or other offerings in the Department of Cognitive Science. Students may use 3 credits of research to satisfy one of these course requirements.

- **Any Two of the Following Courses:**
  - Calculus I
  - Calculus II
  - Discrete Mathematics
  - Linear Algebra
  - Introduction to Symbolic Logic
  - Formal Methods in Cognitive Science: Language
  - Formal Methods in Cognitive Science: Reasoning
  - Formal Methods in Cognitive Science: Neural Networks
Carnegie Mellon University Cognitive Science

Cognitive Science at CMU is housed in the Psychology department. The B.S. in Cognitive Science has a quite different structure of requirements than the other varieties of Psychology majors. Its focus is upon the study of the human mind as illuminated by psychology, linguistics, artificial intelligence, philosophy, and neuroscience.

Curriculum
Candidates are required to complete before the junior year the two-semester calculus sequence and a statistics sequence. In addition, candidates complete Intermediate/Advanced Programming, as their departmental computing course. Because of the number and sequential nature of required courses, prospective Cognitive Science majors are encouraged to begin course work for the major prior to the junior year.

Computing Prerequisite 10 units
Intermediate/Advanced Programming

Mathematics & Statistics Prerequisites 37-38 units
Differential Calculus/Integral Calculus
and Multivariate Analysis and Approximation
or Differential Calculus/Integral Calculus
and Integration and Differential Equations/Calculus of Approximation
Concepts of Mathematics
Introduction to Statistical Methods
Experimental Design for the Behavioral and Social Sciences

Artificial Intelligence Core (minimum) 33 units
Fundamental Data Structures and Algorithms I
Principles of Programming
Artificial Intelligence: Representation and Problem Solving
or Production System Models of Thought
or Introduction to Parallel Distributed Processing

Cognitive Psychology Core 27 units
Cognitive Psychology or Human Information Processing and AI
Research Methods in Cognitive Psychology
Plus complete one of the following:
Cognitive Modeling, Introduction to Parallel Distributed Processing or Cognitive Development

Cognitive Science Concentration Requirement 36 units
Complete four courses from the following course listing combined into an area of concentration. One example of a concentration area would cognitive neuroscience and could involve four of the following: Perception, Visual Cognition, The Biology of the Brain, Cognitive Neuropsychology, Introduction to Parallel Distributed Processing, Cognitive Brain Imaging, and Cognitive Neuroscience. Other areas that might be chosen include: human-computer interaction, machine learning, psycholinguistics, perception and natural language processing.
Appendix C. Desiderata for strengthening the program.

The curriculum listed above builds on strengths already present at Tufts. However, in order to be truly interdisciplinary and representative of the breadth of the field, i.e. not to be essentially an augmented psychology major, more depth is necessary in Computer Science and Linguistics. The addition of two positions, one in each of these fields, would act as a catalyst to bring the program to a truly distinguished level.

1. Computer Science. The current curriculum is notably deficient in relevant Computer Science courses, especially given the loss of Jim Schmolze. There is significant enthusiasm from Computer Science faculty for collaborating in this program, particularly from those in Machine Learning, Human-Computer Interaction, and Computational Biology. None, however, have a primary research interest in Cognitive Science. A fully successful program in cognitive science will require the appointment of a tenured, senior or at least mid-career computer scientist with the confidence, experience, and credibility to participate fully in the steering committee of senior faculty in Philosophy and Psychology. This new faculty member needs to be a computer scientist who can fill the current gap in Artificial Intelligence and Cognitive Science disciplines within the Computer Science Department, while being truly committed to the goals of understanding cognitive processes in either a human or artificial agent setting and ready to "wear two hats" and to collaborate fully with the other principal figures within this Program. Such a person would be able to attract Computer Science students with an interest in Cognitive Science to Tufts and to secure research funding that builds bridges between the departments involved in cognitive science. Desirable additions to the curriculum, in addition to a standard course in artificial intelligence and the Comp 14 course introduced above, would include courses in computational vision, computational linguistics, computational modeling of neural mechanism for human learning, and/or knowledge representation and reasoning pertaining to both natural and artificial agents.

2. Linguistics. The curriculum includes only three courses in theoretical linguistics and a handful in psycholinguistics. Many programs elsewhere similarly underplay linguistics, and indeed theoretical linguistics has been something of a minor player in cognitive science in the past decade. However, we believe this to be inappropriate for the Tufts program, given the core faculty in psychology who study language (Holcomb, Kuperberg, Taylor) and Jackendoff’s specialization in theoretical linguistics. An important part of RJ’s work has been to reintegrate theoretical linguistics with the rest of cognitive science, and we would like the Tufts program to reflect this emphasis. However, while in some respects language is our greatest strength it also contains our biggest lacuna: the absence of a core set of courses in linguistics that are critical for training our majors (as well as undergraduates and graduate students in psychology, philosophy, and child development).

Courses such as the following would be desirable additions.

- Phonology and phonetics (sound structure), including phonological perception and production. In serious linguistics departments, these are two separate courses.
Combining them into a single course is a stretch but would add depth to the linguistics component, particularly since this is the area of language where the most is known about connections to other basic areas of cognitive science such as audition and motor control.

- **Morphology (word structure).** This forms an important background to studies of both linguistic diversity and psycholinguistics. In the latter area it is central to longstanding disputes about cognitive architecture (symbolic vs. connectionist models) and the nature of language acquisition.
- **Sentence processing,** both in perception and production, a major area of research. This connects to general issues in cognitive science such as the relation between long-term and working memory.
- **RJ would like to be able to offer an advanced course in the architecture of language and its relationship to general cognition,** reflecting as well on questions of the evolution of the language faculty.

(Note that we are not proposing standard linguistics courses such as language typology, linguistic field methods, historical linguistics, language and society, and courses in the grammatical structure of particular languages. These are necessary for a pure linguistics major but are not essential for cognitive science.)

In order to cover these courses at least once every other year, and in order for RJ not to be locked into teaching the elementary courses year after year (this is certainly not what Tufts hired him for!), another position is necessary to enrich the linguistics curriculum. This need not be a theoretical linguist; it could well be an experimental psycholinguist or developmental psycholinguist with sufficient training in theoretical linguistics.

We do not think the program would be well served by staffing these courses with part-timers or temporary lecturers. We need someone who has a commitment to the program and can serve as research advisor for students. Moreover, looking to the mid-term future, RJ is not going to be on the scene forever, and it would be well to have someone in place who is prepared to be the senior representative of linguistics.

As a bonus, a second theoretical linguist would also make possible further curricular enrichment beyond the cognitive science program. Interest has been emerging from applied linguists in Child Development and in Germanic, Russian, and Asian Languages for developing an undergraduate linguistics curriculum. With a solid core of two theoretical linguists on the faculty, it is beginning to look as though a quite respectable linguistics minor could be assembled in short order out of existing courses.