

The Leverhulme Trust
APPLICATION FORM – Early Career Fellowship

Applicant: Dr Corina Logan	ID/Ref: ECF-2014-256
Project Title: What makes a large brain? Drivers of intraspecific variation in brain size	

Applicant Details

Submission Date:	04/03/2014
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General Details

Title	Dr	Gender	Female
First Name(s)	Corina	Date of Birth	08/12/1978
Surname	Logan		
Honours			

Contact Details

Department	SAGE Center for the Study of the Mind		
Institution			
Address	SAGE Center for the Study of the Mind University of California Santa Barbara Building 551 Santa Barbara United States 93106-9660	Telephone Number	001-805-570-6821
		Email	corina.logan@psych.ucsb.edu

Host Institution	University of Cambridge
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Career Details

Employment

Employment 1	09/2012 To
Job Title:	Junior Research Fellow
Employer:	SAGE Center for the Study of the Mind, University of California Santa Barbara

Education Details

Degree/Qualifications

Degree 1	09/2002 To 06/2004
Degree/Qualification : Subject	BSc : Biology
Institution:	The Evergreen State College
Grade:	Excellent written evaluations

Degree 2	09/1999 To 06/2002
Degree/Qualification : Subject	Associate in the Arts : Drama and Biology
Institution:	Skagit Valley College
Grade:	GPA: 3.91 out of 4.00, top 1.8%

Doctoral Degrees

Degree 1	10/2008 To 05/2012
Degree/Qualification : Institution	PhD : University of Cambridge
Title of Thesis:	The sociality, ontogeny, and function of corvid post-conflict affiliation
Supervisor Name:	Professor Nicola Clayton

Further Applicant Details

If you are or have been registered for a doctoral degree has your thesis been examined? : Yes

Date of doctoral viva : 13/12/2011

Current Employment Details

Date current position/funding ends : 31/08/2014

Proposed start date for Fellowship : 01/05/2015

Any other matters you wish to bring to the attention of the Committee

Research and Publications

Long Title	What makes a large brain? Drivers of intraspecific variation in brain size
Main/sub field of study	Zoology & Veterinary sciences

Abstract

Species with larger brains appear capable of more complex tasks, however we cannot infer whether cognitive abilities are responsible for producing brain size variation or vice versa from correlational evidence. To understand what drives variation in brain size, I will investigate how ecological, genetic, behavioural, and cognitive factors mediate the association between brain size and fitness. Using a 1,000+ sample of skulls from individual red deer with known life histories, I will examine the biological drivers of brain size variation to elucidate how complex cognition can evolve.

Details of current and past research

I am a psychologist and zoologist investigating behavior and cognition in the field and lab to understand how socioecological and genetic factors contribute to cognition and influence behavioural flexibility.

During my PhD, I discovered that sociality influences the behavior crows use to support each other after fights. I showed that post-conflict affiliation is a fundamental aspect of the behavioural repertoire wherever conflicts occur, as exemplified by the fact that I detected it in the least social species studied yet: Eurasian jays. The behaviour adjusts to the social environment: rather than making up with each other, former combatants exchange support with their mate (year-round monogamous species), or obtain support from any non-former combatant (seasonally monogamous species). These results contrast monogamous birds, who primarily use bystander affiliation, with polygamous mammals, who primarily make up with former opponents.

My postdoctoral research focuses on how behavioral flexibility arises by investigating cognition in two innovative birds: New Caledonian crows and great-tailed grackles. I found that crows understand cause and effect relationships and learn novel foraging techniques from others, which likely contributes to their ability to innovate. I am currently investigating behavioral flexibility and cognition in grackles using behavioral, genetic, hormonal, immunological, and neuroanatomical approaches.

Detailed statement of proposed research

File: Detailed statement of proposed research

What makes a large brain? Drivers of intraspecific variation in brain size

Corina Logan – Proposed Research

Important breakthroughs have recently documented complex cognitive capabilities in animals (1). Most studies focus on large-brained species, however almost nothing is known about what produces a large brain and whether it influences survival or reproduction in the wild. Variation in brain size across species

is likely tightly linked with variation in cognitive abilities, however direct evidence is lacking. The ecological, genetic, and behavioural factors examined in this study will determine what produces variation in brain sizes and whether large brains provide survival benefits or increased fitness in the wild. To understand cognitive function in context, it is important to identify the relationship between fitness and brain size, for which intraspecies studies are required. While intraspecies investigations exist, those concerning non-genetic factors compare populations from different habitats (2), thus limiting the ability to determine which factors influence brain size within a population experiencing similar selection pressures. To understand the mechanistic factors exerting selection pressure on brain size on a population from a single habitat, I will take advantage of an unprecedented opportunity to analyse brain size data on 1,000+ intact skulls from red deer (*Cervus elaphus*) and relate this variable with reproductive fitness, and socioecological and genetic factors.

I will access the long-term dataset from a red deer research project on the Isle of Rum, Scotland, which contains data on pedigrees, sociality, habitat use, and lifetime breeding records since 1972 (3). Skulls from deceased individuals are available, but have not been analysed for inclusion in the database. Brain size will be estimated using cranial volume, an accurate proxy (4), and inserted into the long-term database for analysis, which will also be made available to the larger scientific community.

This project will address the following questions:

1) What are the costs and benefits of having a large brain? While large brains might provide individuals with cognitive benefits, they are metabolically expensive (5), potentially leading to a trade off in life history factors. I will examine these trade offs to determine whether brain size is related to reproductive rate and longevity, both of which are energetically demanding. Using lifetime breeding records for each individual, I will perform a selection analysis using generalised linear models to determine which factors change relative to brain size.

2) Is brain size, thus potentially cognition, heritable? A common assumption is that brain size is heritable - a necessary element for selection to operate. This is confirmed in laboratory studies (6), however it is unknown to what degree variation in natural populations can be explained by genetic factors. By using complete pedigrees on all skulls, I will calculate the heritability of brain size using the 'animal model' (7).

3) Do maternal effects influence brain size? Maternal genes, behaviour, and environment can provide adaptive benefits to offspring (8,9). To determine how maternal effects influence brain size in offspring, I will use generalised linear mixed models (GLMM) to examine correlating factors including the heritability of brain size, maternal body mass, nutritional status during pregnancy, age at parturition, and dominance rank.

4) Do brains develop flexibly after birth? In addition to genetics (10) and prenatal maternal effects (11), brain size may also be determined by environmental (12) or social (13) factors. Using GLMMs to examine variation in brain size across life stages by including individuals who died at different ages, I will determine which factors influence brain growth rates.

Impact

While the long-term study on red deer has addressed similar questions for other morphological traits (e.g., birth weight [14,15], antler size [16,17]), investigating brain size in this context is important for informing cognitive studies by providing evolutionary reasons why brain sizes should vary. This is particularly relevant for choosing appropriate proxies that correlate with brain size in cross-species comparisons, and developing cognition research in the context of its influential selection factors.

Results should motivate the exploration of natural selection on brain size and cognition in more detail and in other species. Knowing which selection pressures affect brain size will allow us to understand why certain species possess complex cognitive capacities, what fitness benefits might be conferred by having a large brain, and facilitate more appropriate comparisons across species.

Receiving a Leverhulme Early Career Fellowship would greatly impact my career by allowing me the freedom to complete this research crossing traditional disciplinary boundaries, and firmly establish the role of ecology and life history in the evolution of cognition.

References

- 1) Shettleworth SJ. 2010. Cognition, Evolution, and Behavior (2nd ed). Oxford University Press.
- 2) Gonda A, Herczeg G, Merila J. 2011. Population variation in brain size of nine-spined sticklebacks (*Pungitius pungitius*) - local adaptation or environmentally induced variation? *BMC Evol Biol* 11:75.
- 3) Clutton-Brock TH, Guinness FE, Albon SD. 1982. Red deer: behavior and ecology of two sexes. University of Chicago Press.
- 4) Iwaniuk AN, Nelson JE. 2002. Can endocranial volume be used as an estimate of brain size in birds? *Can J Zool* 80:16-23.
- 5) Nilsson G. 1999. The cost of a brain. *Natural History* 108:66-73.
- 6) Rogers J, Kochunov P, Lancaster J, Shelledy W, Glahn D, Blangero J, Fox P. 2007. Heritability of brain volume, surface area and shape: an MRI study in an extended pedigree of baboons. *Human Brain Mapping* 28:576-583.
- 7) Wilson AJ, Réale D, Clements MN, Morrissey MM, Postma E, Walling CA, Kruuk LEB, Nussey DH. 2010. An ecologist's guide to the animal model. *J Anim Ecol* 79:13-26.
- 8) Curley J, Champagne F, Bateson P, Keverne E. 2008. Transgenerational effects of impaired maternal care on behaviour of offspring and grandoffspring. *Anim Behav* 75:1551-1561.
- 9) Curley JP, Davidson S, Bateson P, Champagne FA. 2009. Social enrichment during postnatal development induces transgenerational effects on emotional and reproductive behavior in mice. *Frontiers Behav Neurosci* 3:25.
- 10) Bartley AJ, Jones DW, Weinberger DR. 1997. Genetic variability of human brain size and cortical gyral patterns. *Brain* 120:257-269.
- 11) Martin RD. 1981. Relative brain size and basal metabolic rate in terrestrial vertebrates. *Nature* 293:57-60.
- 12) Rosenzweig MR, Bennett EL. 1969. Effects of differential environments on brain weights and enzyme activities in gerbils, rats, and mice. *Developmental Psychobiology* 2:87-95.
- 13) Smith AR, Seid MA, Jiménez LC, Wcislo WT. 2010. Socially induced brain development in a facultatively eusocial sweat bee *Megalopta genalis* (Halictidae). *Proc Roy Soc B* 277:2157-2163.
- 14) Albon SD, Guinness FE, Clutton-Brock TH. 1983. The Influence Of Climatic Variation On The Birth Weights Of Red Deer (*Cervus elaphus*). *J Zool* 200:295-298.
- 15) Albon SD, Clutton-Brock TH, Guinness FE. 1987. Early Development And Population Dynamics In Red Deer. II. Density-Independent Effects And Cohort Variation. *J Anim Ecol* 56:69-81.
- 16) Kruuk LEB, Slate J, Pemberton JM, Brotherstone S, Guinness F, Clutton-Brock T. 2002. Antler size in red deer: Heritability and selection but no evolution. *Evolution* 56:1683-1695.
- 17) Schmidt KT, Stien A, Albon SD, Guinness FE. 2001. Antler length of yearling red deer is determined by population density, weather and early life-history. *Oecologia* 127:191-197.

Major publications

File: Major Publications

Major Publications - Corina Logan

In preparation

Logan CJ, Taylor AH, Breen AJ, Gray RD, Hoppitt WJE. (*In prep.*) Social learning in New Caledonian crows.

Taylor AH, Jelbert SA, Breen AJ, Gray RD, **Logan CJ**. (*In prep.*) Tool experience produces stone dropping in New Caledonian crows.

Logan CJ, Bassett DS, Jaeggi A, Soto F. (*In prep.*) Removing the distinction between social and physical cognition until evidence warrants separate categories.

Submitted

Logan CJ, Jelbert SA, Breen AJ, Gray RD, Taylor AH. (Submitted). Modifications to the Aesop's Fable paradigm change performances in New Caledonian crows. *PLOS ONE*.

Logan CJ. (Submitted). Making progress in non-human mental time travel. *Frontiers in Psychology*.

Published

O'Donnell S, Kumar A, **Logan C**. 2014. Life zone differences in army ant raid attendance by Nearctic migrant birds in Costa Rican montane forest. *Wilson Journal of Ornithology* in press.

Logan CJ, Longino JT. 2013. Adult male coatis play with a band of juveniles. *Brazilian Journal of Biology* 73:353-355. doi: 10.1590/S1519-69842013000200015

Logan CJ, Ostojic L, Clayton NS. 2013. Rook, but not jackdaw, post-conflict third-party affiliation reduces aggression for aggressors. *Ethology* 119:1-9. doi: 10.1111/eth.12078

Logan CJ, Emery NJ, Clayton NS. 2013. Alternative behavioral measures of post-conflict affiliation. *Behavioral Ecology* 24:98-112. doi: 10.1093/beheco/ars140

Logan CJ, Clutton-Brock TH. 2013. Validating methods for measuring endocranial volume in individual red deer (*Cervus elaphus*). *Behavioural Processes* 92:143-146. doi:10.1016/j.beproc.2012.10.015.

O'Donnell S, **Logan C**, Clayton NS. 2012. Specializations of birds that attend army ant raids: an ecological approach to cognitive and behavioral studies. *Behavioural Processes*. doi:10.1016/j.beproc.2012.09.007.

Logan CJ, O'Donnell S, Clayton NS. 2011. A case of mental time travel in ant-following birds? *Behavioral Ecology* 22(6):1149-1153. doi: 10.1093/beheco/arr104

O'Donnell S, Kumar A, **Logan C**. 2010. Army ant raid attendance and bivouac checking behavior by Neotropical montane forest birds. *Wilson Journal of Ornithology* 122:503-512.

Logan CJ, Montero C. 2009. *Bothrops asper* (Terciopelo) scavenging behavior. *Herpetological Review* 40:352.

Logan CJ, Pepper JW. 2007. Social learning is central to innovation, in primates and beyond. *Behavioral and Brain Sciences* 30:416-417. doi: 10.1017/S0140525X07002476

Duration, Timing and Host Institution

Duration of Fellowship (36 months unless the % dedicated to the Fellowship is less than 100)	36
Percentage of time to be spent on the Fellowship	100

If Percentage of time is less than 100% please answer the following 3 questions:

Reasons why this is appropriate for the range and type of research activities proposed

Reasons why this is appropriate for your career development

Personal reasons for holding the fellowship on a part-time basis

Research relevant to your proposal being carried out in the host department

Professor Tim Clutton-Brock in the Department of Zoology runs a 40+ year study on red deer in Scotland and this is the population on which I will base my project.

Additional reasons for selecting your chosen host department and institution

I have had the great fortune of being based at two highly interdisciplinary institutions for the past six years, the University of Cambridge in the Department of Experimental Psychology and the SAGE Center for the Study of the Mind. My research has greatly benefitted from these environments by allowing me the freedom to collaborate with many different departments and engage with researchers from disparate fields in an informal setting. I wish to continue to reap these benefits, therefore it is ideal to return to Cambridge, while being based in a different department (the Department of Zoology) with new collaborators.

Referees

Referee 1	Professor Michael Gazzaniga
Department : Institution	SAGE Center for the Study of Mind : University of California Santa Barbara
Position:	Professor of Psychology, Director for the SAGE Center for the Study of Mind
Email:	michael.gazzaniga@psych.ucsb.edu

Referee 2	Professor Nicola Clayton
Department : Institution	Psychology : University of Cambridge
Position:	Professor of Comparative Cognition
Email:	nsc22@cam.ac.uk

Referee 3	Dr Alex Thornton
Department : Institution	Centre for Ecology and Conservation : University of Exeter
Position:	BBSRC David Phillips Research Fellow
Email:	alex.thornton@exeter.ac.uk

Previous and Current Applications

Previous Leverhulme awards or pending applications to the Trust

I have never applied for a Leverhulme award and I have no pending applications to the Trust.

Other awards received in the last 12 months related to this project

I have not received any awards in the last 12 months, or previously, related to this project.

Applications you have made or intend to make to other bodies related to this research proposal

I will also apply for the Royal Commission of the Exhibition of 1851 Research Fellowship.

Research Budget

Give an indication of how you would propose to use the annual research allocation of £6000 for each year of the Fellowship. If the application is successful you will have the opportunity to revise these details.

The Trust does not support FEC

I will use the funds to buy materials to measure endocranial volumes, travel to the Isle of Rum in Scotland to collect the endocranial volume data on over 1,000 red deer skulls, travel to the University of Edinburgh to learn how to use the long-term deer database, present at national and international conferences, and pay publication fees to ensure open access for all journal articles resulting from this work.

—Year 1—

£1,000 Materials for measuring endocranial volumes

£2,000 Field work in Scotland

£1,000 Travel and subsistence: University of Edinburgh to learn to use the deer database

£2,000 International Ethological Conference in Australia

Total=£6,000

—Year 2—

£1,000 Travel to the Institute of Zoology to consult on analysis methods

£1,000 Animal Behavior Society meeting in the USA

£2,000 International Society for Behavioral Ecology Conference

£2,000 Publication fees

Total=£6,000

—Year 3—

£4,000 Publication fees

£1,000 International Ethological Conference

£1,000 Animal Behavior Society meeting in the USA

Total=£6,000

Grand total for years 1-3=£18,000

Institutional Approver Details

Important Note: Applicants can view these details to see what information is required from the host institution in order to provide Institutional Approval. Applicants may not complete any of these details themselves but should ensure that their prospective host institution is aware of what details are needed.

Host Institution	University of Cambridge
Head Of Department	Professor Michael Akam
Host Department	Zoology
Contact Email	m.akam@zoo.cam.ac.uk

Why is your department the best place for the applicant to undertake their research project? (100 words)

This project depends on a unique long-term set of skulls from recognisable individuals that can be matched with genetic data and detailed measures of reproductive success. It is the only place where the project could be done.

Why would you like the applicant to be hosted by your department and what are the benefits to your institution by acting as their host? (100 words)

This project will develop valuable links between behavioural research in this Department and Professor Clayton's group in Experimental Psychology. The project represents a good example of work that transcends traditional subject boundaries and Logan would be an ideal person to advance this collaboration.

How will the applicant be mentored by colleagues in your department? (100 words)

The applicant will work closely both with Professor Tim Clutton-Brock and with his collaborators on the long-term deer research at the University of Edinburgh (Professors J Pemberton and L Kruuk).

How might the applicant contribute to teaching and the wider intellectual life of the department? (100 words)

The applicant would be available to contribute to teaching second- and third-year undergraduates. She would be an important addition to behavioural teaching since she is more familiar with cognitive research than any existing members of the Department.

Details of facilities and relevant resources the Fellow will be provided with by the host department (100 words)

Access to Professor Clutton-Brock's database of long-term records of growth, breeding success and survival for more than 2,000 recognisable individual deer; access to associated genetic data; access to the skeletal collections that we hold in behavioural ecology (at Cambridge) and quantitative genetics (in Edinburgh).

Starting salary	33562
Spine/ scale point	45
London allowance	0
National insurance	1356
Superannuation	2779
Total	37697

Source of matching funding (100 words)

I confirm on behalf of the host department and the host institution that:

- The candidate named above will be accepted to work in the host department and will be treated in every respect as a full-time member of the department and as a normal employee
- The host institution will accept the Trust's contribution of 50% (up to £23000 per annum) of the Fellow's total salary cost for the duration of the Fellowship and undertakes to match this for each year of the award.

Name	Thomas O'Neill
Position	Research Support Advisor
Email	tdo23@admin.cam.ac.uk