Comparative Brain Collections Are an Indispensable Resource for Evolutionary Neurobiology

Andrew N. Iwaniuk

Department of Neuroscience, Canadian Center for Behavioral Neuroscience,
University of Lethbridge, Lethbridge, Alta., Canada

Earlier this year, Dr. John I. Johnson organized a conference in Washington, D.C., USA, as a tribute to the life and works of Wally Welker, a prominent member of the evolutionary neurobiology field [Johnson, 1993]. As part of this tribute, several people contributed talks focused on neuroanatomical collections throughout the world, including the Welker collection currently housed at the National Museum of Health and Medicine (Washington). A wide range of collections was discussed, some of which are well known (e.g. Heinz Stephan's bat, insectivore and primate brain collection and Welker's Wisconsin collection) and others not known at all to most scientists. What became clearly apparent to the conference attendees was that there are many brain collections worldwide and most of them are infrequently used. A potential consequence of this infrequent use is that the collections could be misplaced, destroyed or otherwise lost. Several people have since developed a committee (see <http://braindatabases.wikispaces.com/>) aimed at documenting these collections, increasing awareness of these collections within the scientific community and eventually digitizing these collections to make them more readily available for research and educational purposes.

The underuse of these brain collections by neuroanatomists brought me to question why the collections are so often ignored or overlooked. At a practical level, many people are unaware that these collections exist, which is why the curators of these collections need to be more proactive. Researchers interested in broad comparative analyses also need to be encouraged to explore what is available in natural history museums and other specimen collections. Some museums, such as the National Museum of Natural History (Washington), have large numbers of brain specimens that could be used for neuroanatomical research.

A second possible reason for the poor usage of brain collections is a concern raised by some authors regarding the compilation of neuroanatomical, specifically volumetric, data from a variety of sources. Roth et al. [2010] and Healy and Rowe [2007] have both criticized the use of data from disparate sources. The main reason underlying their criticism is simple: different methods result in different degrees of tissue shrinkage and thereby skewed volumetric measurements. This criticism is fair, but is it reasonable enough to exclude specimens under all circumstances? Should every researcher be expected to generate their own comparative brain col-

lection in order to answer evolutionary questions about the brain? And, if so, how do we justify multiple data sets with overlapping species with respect to permitting and funding agencies? I am not trying to suggest that datasets be combined without any forethought; to do so could definitely yield misleading results. However, failing to incorporate as much data as possible into a comparative analysis can be equally misleading.

Under ideal circumstances, fixation solution and method, specimen storage, histology and brain region boundaries should be consistent across datasets. In many cases, this is not, however, a practical approach. Take, for example, the comparative study of hominid brains. It is extremely unlikely that an individual would successfully procure permits to perfuse orangutans (*Pongo* sp.) in the field, so researchers interested in hominids must rely on zoos and brain collections to access suitable material. In many cases, the animals themselves originate from vastly different backgrounds, and are fixed at variable times post mortem [de Sousa et al., 2010]. To further complicate matters, sex and age differences are often difficult to analyze because of small and/or unequal sample sizes. Studying hominid brains is, however, an essential part of understand-

ing human brain structure, function and evolution. Without compiling data from multiple sources, we would have a very rudimentary understanding of hominid brains.

The notion that datasets should never be compiled is not only impractical for hominids; limited access to the brains of a sufficient number of species for the purposes of comparative analyses is virtually universal. All modern studies of cetacean brains depend on salvage operations to obtain material [Butti et al., 2009] and many other studies have similarly taken advantage of salvaging material [Kalisinska, 2005; Yopak et al., 2007; Yopak and Frank, 2009]. Given the current funding and permitting restrictions, it is going to become increasingly difficult to procure many species, making it even more important to collate datasets, take advantage of existing

brain collections and salvage specimens whenever possible. One means of incorporating data from these disparate sources is to express the relative size of a brain region as percentage or proportion of total brain size [Clark et al., 2001]. This so-called 'cerebrotypes' approach would overcome measurement errors introduced by different laboratory techniques and allow for the inclusion of a much broader range of data thereby providing a more accurate picture of the evolutionary process.

Lastly, I would like to stress that the importance of the various brain collections cannot be overestimated. The brain collections are just as valuable to comparative neuroanatomy as the journal articles and books that are cited. In fact, the collections should be considered as 'brain libraries' that can be mined for a wealth of anatomical data. Volumetrics are just one mea-

surement that can be taken from these collections. Other data include cell types and numbers, surface areas, linear dimensions and cortical gyrification [Hof and Sherwood, 2005; Pillay and Manger, 2007], many of which are not prone to the potential effects of different laboratory methods. If more people took advantage of these collections, we could ensure their future as well as improve our understanding of how the brain evolves by including a broader array of species that encompasses a diversity of life history strategies.

Acknowledgments

I wish to thank Georg Striedter and Jack Johnson for their encouragement and feedback.

References

- Butti C, Sherwood CC, Hakeem AY, Allman JM, Hof PR (2009): Total number and volume of von Economo neurons in the cerebral cortex of cetaceans. *J Comp Neurol* 515:243–259.
- Clark DA, Mitra PP, Wang SS (2001): Scalable architecture in mammalian brains. *Nature* 411:189–193.
- de Sousa AA, Sherwood CC, Mohlberg H, Amunts K, Schleicher A, MacLeod CE, Hof PR, Frahm H, Zilles K (2010): Hominoid visual brain structure volumes and the position of the lunate sulcus. *J Hum Evol* 58:281–292.
- Healy SD, Rowe C (2007): A critique of comparative studies of brain size. *Proc Biol Sci* 274:453–464.
- Hof PR, Sherwood CC (2005): Morphomolecular neuronal phenotypes in the neocortex reflect phylogenetic relationships among certain mammalian orders. *Anat Rec A Discov Mol Cell Evol Biol* 287:1153–1163.
- Johnson JI (1993): Wally Welker: a career in relating brains, behaviors, and evolution. *Brain Behav Evol* 41:51–56.
- Kalisinska E (2005): Anseriform brain and its parts versus taxonomic and ecological categories. *Brain Behav Evol* 65:244–261.
- Pillay P, Manger PR (2007): Order-specific quantitative patterns of cortical gyrification. *Eur J Neurosci* 25:2705–2712.
- Roth TC II, Brodin A, Smulders TV, LaDage LD, Pravosudov VV (2010): Is bigger always better? A critical appraisal of the use of volumetric analysis in the study of the hippocampus. *Phil Trans R Soc Lond B Biol Sci* 365:915–931.
- Yopak KE, Frank LR (2009): Brain size and brain organization of the whale shark, *Rhincodon typus*, using magnetic resonance imaging. *Brain Behav Evol* 74:121–142.
- Yopak KE, Lisney TJ, Collin SP, Montgomery JC (2007): Variation in brain organization and cerebellar foliation in chondrichthyans: sharks and holocephalans. *Brain Behav Evol* 69:280–300.