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Short communication

ABCD: A functional database for the avian brain

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Abstract

Here we present the first database developed for storing, retrieving and cross-referencing neuroscience information about the connectivity of the avian brain. The Avian Brain Circuitry Database (ABCD) contains entries about the new and old terminology of the areas and their hierarchy, data on connections between brain regions, as well as a functional keyword system linked to brain regions and connections. Data were collected from the primary literature and textbooks, and an online submission system was developed to facilitate further data collection directly from researchers. The database aims to help spread the results of avian connectivity studies, the recently revised nomenclature and also to provide data for brain network research. ABCD is freely available at http://www.behav.org/abcd.

Keywords: Bird; Brain; Connectivity; Database; Circuitry

1. Introduction

Avian neuroscience has contributed greatly to the understanding of fundamental neural processes, for example neurogenesis in areas critical in learning (Nottebohm, 1989), biochemical cascade leading to morphological changes in memory formation (Rose, 1991), circuitry involved in song production homologs to human speech (Jarvis, 2004), visual discrimination and motor control capacity of subtelencephalic regions (Kabai and Kovach, 1993) or the plasticity of spatio-temporal coordination (Knudsen et al., 2000).

Interestingly, such breakthrough results have hardly been incorporated into mainstream neuroscience. This is partly because traditional bird brain nomenclature was based on flawed assumptions of homology to mammals. Recently, traditional terminology has been revised to rectify this problem (Reiner et al., 2004; Jarvis et al., 2005), but until new names replace the old ones in the minds of neuroscientists, parallel use of new and old terminology might even add to the present confusion regarding evolutionary homologies.

Another reason of neglect of bird brain studies might be that avian experts are few in number, their studies are focused on particular systems, and integration of such isolated systems is difficult without an intricate knowledge of the primary literature.

The increasingly large amount of information accumulating about avian brain circuits can be retrieved by searching publication databases such as PubMed using simple keywords. However, such a searching strategy is surprisingly ineffective and slow, primarily because the concise information on connectivity is published in figures of series of schematic sections not available for text search. On the other hand, text of an article describing connections between area A and B would contain names of many more areas related to the targeted regions in some way, and text of many articles may contain the names of A and B without information on their connectivity. Difficulties also arise from the increasing resolution of anatomical research, a known connection between A and B may later be described as connection between their subregions under different names. In avian neuroanatomy, text search is further hampered by the changing nomenclature. For example, text search for 'hyperstriatum ventrale AND birds' results in 329 hits in PubMed, whereas the new name of the same region, 'mesopallium AND birds' retrieves 36 papers, the oldest from 2004, the time of nomenclature change. As thesaurus terms for avian neuroscience are unlikely to be worked out for PubMed, old names will have to be searched even years from now, when traditional nomenclature will have faded out.

Described in the present report is the first avian brain database (Avian Brain Circuitry Database or ABCD), incorporating old and new terminology, hierarchy, connectivity and functional

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considerations of brain areas. This database should facilitate the spread of correct terminology and the building of integrative models both at the level of brain areas and, perhaps, also at the level of single neurons. Our aim was to create an easy to use web-based interface, which provides access to a wide range of data on the avian brain and can also be edited and extended by competent, authorised users.

2. Materials

We have applied standard principles of relational database design to organise information on the avian brain using the open source MySQL database and query tools. A web interface to aid accessing the data was written mainly in PHP, and is freely available at http://www.behav.org/abcd.

The Avian Brain Circuitry Database (ABCD) focuses on connections between brain regions, therefore tables containing other information (such as references, functional keywords, cell, synapse, receptor types, studied species) have been designed around the two central tables for regions and connections. An anatomy-based hierarchy was constructed according to *Comparative Vertebrate Neuroanatomy* by Butler and Hodos (1996) and the *Stereotaxic Brain Atlas of the Pigeon Brain* by Karten and Hodos (1967) to store data on brain regions. Additionally, brain structures in finer resolution, alternative names and divisions were also added relying on specific primary publications (e.g specific subdivisions of the hippocampal formation by Szekely, 1999). The hierarchy enables to define sub- and superstructures of the regions and is extendable down to single neuron level. Information on brain structures involves scientific names, abbreviations (old and the revised ones as well (Reiner et al., 2004), English names and mammalian homologues where available.

Connections between two structures are determined between two items in the brain region table: projection or sender area is defined as the location of one or more body of neurons sending their axon to the target or receiver area. Every connection is linked to the source of information (textbook, original article); the table of references contains the names of authors, date of publication and PubMed ID number to ensure precise identification of references.

ABCD currently holds more than 350 (partly overlapping) brain regions and more than 1100 connections with references.

We have been collecting information on the function of brain regions and connections as well, therefore a hierarchical keyword system is being worked out.

Additional attributions, such as cell, synapse and receptor types can be added and linked to either a brain region or a connection. The database is capable to store quantitative data such as size, cell number, synapse density, etc. of any brain region as well.

Apart from this text based information, images can also be stored and linked to connections, brain regions and functional keyword data items.

The PHP-based webpage allows users to read selected information from the tables in a structured manner, and makes possible to add their own data to the database. Users submit database queries and data via HTML forms processed by PHP against the relational database. Submitted data is displayed following confirmation by an invited reviewer.

3. Results and discussion

Visitors to the web page have two search options. Full text searches query the complete database or can be restricted to specific database fields using ‘Quick Search’. Text search is also provided by drop-down menus derived from the database contents. Brain regions can be selectively searched by old or new names and old or new abbreviations. Single connections can be retrieved by either the name of the pathway, or the names of each contributing areas. A query for connection between two particular regions performs a complex search for the pathways between not just the given regions, but also between their substructures.

A page containing information on a brain region consists of the list of the names of the particular region, as well as its mammalian homologue (if such an entry exists in the database), super- and substructures, functional keywords and related images. Via the ‘connection’ link users can navigate to the connection page where outputs and inputs of the particular region published at that resolution are listed. By following the arrow representing the direction of a connection, further details of the chosen connection are provided: proposed functional keywords, species where connection was shown to exist and the primary or secondary publication references to that connection. Most references are hypertext links to the abstracts of the publications in NCBI PubMed database. To help the visualisation of any circuitries, the web page can automatically draw a simple chart from up to 10 connections chosen by the users.

Searching for an author’s name results in a list of publications used for ABCD input and linked to NCBI PubMed database. The page of a functional keyword lists the upper and subcategories of the given keyword, as well as brain regions and connections to which the keyword might be related to. Images help the user to a better understanding of the particular function. On every page the names of brain regions, connections and keywords function as hypertext links to navigate users to the page of the particular item, where detailed information may be available.

Keeping such a database up-to-date would require a large staff, or preferably, direct contributions of researchers. Therefore, online forms were developed to enable submitting data by registered and moderated users. We do hope researchers will upload data to the database altruisticly, but also to generate interest and citations to their work.

To check whether the Avian Brain Database contains unique information which is hard to obtain in publication databases, we randomly chose 50 connections from our database, and performed a query in PubMed using the abbreviations and the scientific names of the two connected areas as search terms (e.g. (archistriatum OR A) AND (lobus parolfactorius OR LPO) AND ‘Birds’ [MeSH]). This type of query resulted in 0–19 abstracts for any connections. Out of the 50 queries 12 cases retrieved abstracts mentioning the connection. In a further 14 cases the full text, but not the abstract of the papers contained the connectivity data. In 24 cases either no articles were found or they did not contain information on connectivity. This simple tenta-

tive query might indicate that such a connectivity database may contain specific data that are described in publications, but are either unobtainable, or cumbersome by searches in publication databases.

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References

Butler AB, Hodos W. Comparative vertebrate neuroanatomy: evolution and adaptation. New York: Wiley-Liss; 1996.

Jarvis ED. Learned birdsong and the neurobiology of human language. Ann NY Acad Sci 2004;1016:749–77.

Jarvis ED, Gunturkun O, Bruce L, Csillag A, Karten H, Kuenzel W, et al. Avian Brain Nomenclature Consortium. Avian brains and a new understanding of vertebrate brain evolution. Nat Rev Neurosci 2005;6(2):151–9.

Kabai P, Kovach JK. Subtelencephalic visual discrimination in selected lines of Japanese quail. Neuroreport 1993;4(3):255–8.

Karten HJ, Hodos W. Stereotaxic atlas of the brain of the pigeon (Columba livia). Baltimore: John Hopkins Press; 1967.

Knudsen EI, Zheng W, DeBello WM. Traces of learning in the auditory localization pathway. Proc Natl Acad Sci USA 2000;97(22):11815–20.

Nottebohm F. From bird song to neurogenesis. Sci Am 1989;260(2): 74–9.

Reiner A, Perkel DJ, Bruce LL, Butler AB, Csillag A, Kuenzel W, et al. Avian Brain Nomenclature Forum. Revised nomenclature for avian telencephalon and some related brainstem nuclei. J Comp Neurol 2004;473(3):377–414 [Erratum in: J. Comp. Neurol. 2004;475(2):288].

Rose SP. How chicks make memories: the cellular cascade from c-fos to dendritic remodeling. Trends Neurosci 1991;14(9):390–7.

Szekely AD. The avian hippocampal formation: subdivisions and connectivity. Behav Brain Res 1999;98(2):219–25.