Organization for Human Brain Mapping

OHBM Council Statement on Neuroimaging Research and Data Integrity

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On behalf of the 2014 OHBM Council:

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Preamble:

Neuroimaging research into the form, function, and connectivity of the living human brain has grown remarkably in the last twenty years. This includes advances in neuroimaging physics, a deeper understanding of neuroanatomical processes in development and disease, and the ability to classify signatures of brain activity. Accompanying these advances have been increases in the numbers of neuroimaging investigators, conferences, journals, as well as neuroimaging-specific training programs. Such activities are exciting and encouraging in the context of scientific growth and the possibilities for obtaining new neuroscientific knowledge using neuroimaging methods. Yet, as in all other fields of science, such growth comes with challenges to ensure and maintain the quality of the science being conducted. Recently, concerns have been raised about scientific quality in many different scientific communities and even in the high-profile lay press (e.g. “How Science Goes Wrong”, *The Economist*, Oct.19th, 2013). While some of the issues are generalizable to “all science” other issues are quite characteristic for certain scientific fields. It is, therefore, incumbent upon us as an organization to recognize and bring forth certain recommendations for conducting our work, in which all can contribute, in order to ensure the integrity and maturity of our rapidly growing research enterprise.

Revised May 24, 2014

Indeed, as the OHBM embarks on its third decade, it is an appropriate time for its membership to embrace a collective effort toward enhancing solid experimental rigor, study management and provenance practices, and an openness with regards to data sharing.

While it is always easy to suggest what "should" be done, many impediments must be overcome in setting the stage for what “can” be achieved to ensure a high quality of publishable and actionable research. That said, for a diverse and multi-faceted community such as the OHBM membership, however, no one-size-fits all set of guidelines may be possible. Moreover, demands requiring compliance with standards and/or policy directives may well be counter-productive. However, a failure to recognize and address the range of possible options openly supposes that brain mapping is immune to errors in analysis, reasoning, and interpretation which would only serve to undermine the validity and, hence, credibility of our reported findings.

Example Challenges of Research Quality and Data Integrity:

Despite an increasing number of research articles appearing in leading journals and growing conference attendance rates, neuroimaging scientific rigor is presented with challenges. If recommendations could be made as to which of the range of solutions is most viable, robust, resilient, etc, - or certainly how to critically evaluate such solutions - then the OHBM community could be better informed and take-up use of mature resources for improving data and scientific integrity.

With this in mind, we outline here several example challenge areas and potential solutions with regards to maintaining the high standards of neuroimaging research:

Challenge: The problem of publication bias (publishing significant results despite very low sample size) and the “File-Drawer Problem” (failure to publish non-significant findings) have been documented to exist for neuroimaging as they have in other fields. Such biases affect the collected body of knowledge and make accurate assessment of effects present in the literature difficult.

Potential Solutions:

- Replications and failures to replicate should be encouraged and published by journals in special sections therein with links to the original papers.
- Online resources containing appropriately powered null data and results should be encouraged and appropriate journals recommended (Neuroimage? Human Brain Mapping? PLoS ONE? Frontiers?)

Challenge: Despite prior and extant attempts to encourage the sharing of raw neuroimaging data, processed or derived data, and their statistical results, the open access to the data in the majority of published research articles remains severely limited.

Potential Solutions:

- Open publication of data sets into independent data archives should be encouraged for all peer-reviewed papers through special rewards for papers that meet this high standard (e.g. waived page costs for color figures).
- Data acquisition by consortia should be encouraged so as to ensure a solid empirical basis for addressing key questions of neuroscientific and clinical interest. Such data should be published, with a validation set held out for the evaluation of different hypotheses put forward by the community analyzing the data.
- Publication of data sets from well-motivated experiments without analyses should be encouraged and mechanisms for crediting the authors established (e.g. while other less strict options likely exist, some have gone so far as to suggest a co-authorship option on papers based on the data set that are submitted within 1 year of publication of the data set).

Challenge: Reduced space for research methods in journal articles means that data acquisition procedures and analysis methods cannot be fully reported or, as a result, independently reproduced.

Potential Solutions:

- The further development of existing methods for detailing of data processing provenance should be encouraged and these used as supplemental materials for all papers in the form of formal workflow specifications, study schema, name-space ontologies, etc. (e.g. INCF NI-DM, LONI Pipeline, etc). Such approaches are growing in their use and would have value for providing extra detail on data processing choices made which underlie published results, for example. Journals such as the *Journal of Neuroscience* (JNS), which encourage data and methods availability (http://www.jneurosci.org/site/misc/ifa_policies.xhtml) but do not currently accept or provide supplemental materials themselves, could be approached about endorsing the use of such study provenance information.

Challenge: It has been noted that neuroimaging analyses suffer generally limited statistical robustness, poor predictive performance, from low statistical power.

Potential Solutions:

- Online resources for the testing of predictive performance of models on held-out data should be strongly encouraged and eventually promoted. This is the only mechanism to put all assumptions to the test and prevent circularity and model misspecification bias. (Replications cannot serve this purpose, because incorrect conclusions caused by incorrect assumptions will replicate.)

- Prediction challenges/contests/hackathons should be developed across different subfields of neuroimaging. They should include the decoding of representational content and the prediction of subject covariates, but also predictive tests of effective connectivity models.
-Websites pertaining to the computation of statistical power and/or reproducibility of results should be encouraged and their usage noted in discussion sections of articles accepted for publication wherever possible.

Challenge: Though not often admitted, many studies are performed without specific a priori hypotheses. Analyses might be performed in an exploratory manner ("just to see") and the justification for them crafted post hoc.
Potential Solutions:
- A system for pre-registration of studies might be developed and preregistered studies published regardless of the results. Such systems exist now and might be required of larger multi-site or clinical trials (e.g. clinicaltrials.gov) as has recently been recommended by the *International Community of Medical Journal Editors (ICMJE)*
- Journals might expect that papers should include a table of hypotheses in their methods sections to be tested via a detailed framework, stating for each (1) the test employed, (2) its assumptions and (3) why they are valid. For Bayesian analyses, papers should explicate all the hypotheses and include results from model checking, i.e. evidence that the total model (including all hypotheses weighted by the prior) is consistent with the data. This idea might conflict, however, with the reduced space for research methods in journal articles noted above.
- Purely explorative software resources can be highly valuable and, indeed, necessary in many instances; they should clearly be developed for guided hypothesis-generation. Studies using such tools should cite them explicitly and state that their study is meant for data exploration and the generation of novel, testable hypotheses.

While far from an exhaustive list of challenges, this set seeks to illustrate the point that while there are numerous obstacles to ensuring that quality research is pursued, one or more solution might exist to any given challenge. Some challenges are more challenging than others. Each such solution may have strengths, weaknesses, or unintended consequences. In most all cases, such challenges can be addresses by appropriate online community-driven research and data resources. The question is then, from a number of possible solutions, which might the OHBM single out and recommend to its membership in a thoughtful and principled manner? Given a diversity of extant solutions and resources, a careful, conscientious, and clinical evaluation process must be in place for an organization like OHBM to understand and recommend which solutions are robust, mature enough, and viable for improving research and data quality.

Taking Steps Forward

The OHBM has previously recognized that research and data integrity were something to be valued and cultivated. In the late 1990's, the OHBM founded a "neuroinformatics sub-committee" to explore the use of databases for published neuroimaging studies with a view toward improving data sharing, active interaction among investigators, and for promoting the development of new analytic methods. However, this early effort struggled to successfully find its footing and ultimately was discontinued in ~2002.

The OHBM Council has determined that now is the time to re-implement and re-investigate its needs involving such activities. The Council has recently established a "new" task-force committee which will serve the OHBM over the next calendar year (from June 2014 until June 2015) and be specifically charged with exploring the range of possible solutions to the above and other challenges which presently face quality neuroimaging science. Rather than seek to "define the standards" themselves, such a committee would perform a useful function of reviewing the landscape of these challenges, their sources, extents, their range of viable solutions, and the potential utility these solutions may or may not have for the OHBM community. For instance, they might organize these into distinct categories of neuroimaging informatics including but not limited to minimal information reporting standards, neuroimaging database architectures, workflow technologies, data sharing and dissemination practices. The exact set of categories can contain any number of instances where research or data challenges exist, but a focused collection of thematic areas where, if properly adjudicated, advocated, and promoted, would help to ensure that brain mapping science continues to improve over time.

Forming such an exploratory committee seems the most appropriate means for pursuing such a task on behalf of the OHBM. A special interest group (SIG), by contrast, is a group of members having a shared scientific interest which may vary as the field does. It is open-ended with no particular responsibility to produce deliverables. An exploratory committee or task-force, on the other hand, with the specific purpose of examining research and data integrity resources, would be focused entirely upon this task, have its activities directly answerable to the OHBM council, and complete its examinations in a specific time frame.

The OHBM Council has asked Dr. Tom Nichols to serve as the chair of the committee. Suggestions from the OHBM membership for additional committee members are welcomed, will be selected for their own documented track records in promoting such activities, and approved by the OHBM Council. We expect that most interaction among the committee will take place via email, conference calls, video conference, and other electronic methods. The committee membership will formally meet in-person at the June 2015 annual meeting in order to finalize their report to Council. This report will serve as the basis of a white paper with the

possibilities of, upon approval by the OHBM council, being posted on the OHBM website for further community comment and critique, and/or forming the basis of a peer-reviewed publication in a leading neuroimaging periodical.

The chair of the committee will provide the OHBM Council with progress reports at future Council and Program Committee Meetings, including the following:

- Conference Call: Tuesday, November 18, 2014 (9:30-Noon US-Central Time)
- In-Person Meeting: Thursday, February 26, 2015 and Friday, February 27, 2015, Amsterdam, Netherlands
- In-Person Meeting: Wednesday, June 17, 2015 (11:45 am-2:40 p.m. Hawaii)

Additional progress reports from the committee will be made available to the OHBM Council upon request and as needed. To provide the OHBM Council with sufficient time to review the recommendations in advance of the 2015 Annual Meeting, the committee's final report on data and research integrity best-practices shall be delivered to the OHBM Council no later than June 1st, 2015. Discussions of the recommendations will occur via email in advance of the Annual Meeting. Finally, the committee chair will present the recommendations directly to the OHBM Council meeting during the 2015 Annual Meeting. The final report from the committee will be posted on the OHBM website as soon as is practicable thereafter for community inspection, examination, and comment.

Conclusions

To grow, expand, and mature as a discipline, neuroimaging must be continually vigilant in its efforts to promote and encourage the highest standards of research and data integrity. This cannot happen independently of taking an active role in fostering solutions to challenges such as those listed above. The action to establish and empower an OHBM-sanctioned exploratory committee to carefully and critically evaluate the efforts of its members and affiliated communities working to provide such solutions, will serve several purposes. It will act as a recognition that our community itself is well-equipped to address how best to maximize the quality of its own science. It will encourage innovation and the development of new ideas for research and data resources. It will provide the OHBM community with insights into emerging standards and for how we collectively decide what efforts should be supported. It will explore the acceptance and adoption of not a single solution or resource but of many which will provide choice and flexibility rather than a one-size-fits-all compliance approach. The exploratory committee will provide a critical overview and its own "best practices" for what further steps the OHBM should take next, all in order to ensure that our mutual efforts in brain science continue to maintain high internal quality, provide maximal utility, and are able to evolve in kind as the field evolves.

This effort on behalf of the OHBM seeks not to hinder innovation or research creativity but to provide a new and hopefully positive direction for quality brain imaging investigation. However, we believe that considerations for how best to ensure high research and data quality only makes sense to the extent that this community can support them with direct and conscientious action. Upon the report and public release of the committees report, we invite you, the OHBM membership, to thoughtfully discuss the eventual recommendations, consider them in the context of your own research programs, and provide your feedback as appropriate.

Through the active attention to these issues and by the forming of this exploratory committee, we can be assured that OHBM members, their fellows, and trainees will be working to position themselves for undertaking and practicing only the most rigorous, reproducible, and high-quality neuroimaging science. In so doing now, as brain imaging enjoys unprecedented growth and excitement, we can collectively ensure a rigorous scientific future for our valued OHBM organization.