A Pointers Hypothesis of General Intelligence Evolved from Domain-Specific Demands

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Abstract: A higher-order function may evolve if it is demanded by multiple domain-specific modules. Task-specificity to solve a unique adaptive problem (e.g., foraging or mating) should be distinguished from function-specificity to deal with a common computational demand (e.g., numeracy, verbal or emotional communication, etc.) required by many tasks. A localized brain function is likely a result of such common demand.

As an extension of an excellent discussion on evolution of human intelligence by the authors of the target article, I propose a novel hypothesis of the evolution of general intelligence from domain-specific modules. Paradoxically, general intelligence seems evolutionarily implausible since the mind is populated by a large number of adaptive specializations which are functionally organized to solve evolutionarily typical and recurrent problems of survival and reproduction (Cosmides, Barrett, & Tooby, 2010; Wang, 1996). To resolve this paradox, the authors proposed a model that construes the mind as a mix of truly modular skills and seemingly modular skills that are ontogenetically constructed using general intelligence abilities. The authors refer to them as primary and secondary modules.

If general intelligence consists of a set of secondary modules, each secondary module may be an evolved programing solution for a function that could be shared by multiple primary modules. From this perspective, these secondary modules of general intelligence can be either ontogenetically constructed or phylogenetically evolved. Imagine that a computer architect was creating a system called Unix using the programming language C. At the beginning, the operating system was written in assembly where nearly every line of which would contain
memory addresses. Would it be possible to program the system for its input/output devices without repetitively stating these tedious memory addresses? The problem has been solved by creating a pointer variable, whose value specifies the address of a memory location. If a particular memory address is used repeatedly, it is more efficient to create a pointer to store the value of that memory address. For the same reason, if a random number generator is used repeatedly by many local modules, it would be more efficient to make it globally accessible by connecting a single random generator to each of the modules by a pointer.

Now imaging you are a user of a computer who have created many folders for different papers. At the beginning, you included a copy of a word processor in each folder. You then realized that all these papers in progress require a word processor. It would be more efficient if you place a single copy of a generic word processor in a visible place that is accessible by all the papers in progress. This word processor has then become a general tool for a common requirement of different tasks. Similarly, numeracy as a component of general intelligence may be evolved as a result of a common demand by multiple specific adaptations (e.g., counting foraging outcomes; gauging social exchanges, assessing mate values, and tracking reciprocity activities). From a design viewpoint, a general-purpose device would be more cognitively efficient if it serves for multiple tasks. These general mechanisms thus can be viewed as secondary modules, each is shared by a set of primary modules. General intelligence comes as a solution for overlapping components of modular specifications. From this perspective, task-specificity to solve a unique adaptive problem (e.g., foraging, hunting, or mating) should be distinguished from function-specificity to deal with a common computational demand (e.g., numeracy, verbal communication, emotional reactions, etc.)

For the same token, if a particular emotion is a common component of many specific adaptations, this basic emotion would become a general mechanism shared by these adaptations. For instance, anger is the expression of a neuro-computational system that evolved to adaptively regulate behavior in the context of resolving conflicts of interest in favor of the angry individual (Cosmides & Tooby, 2013). Anger can be triggered by multiple task-specific adaptations, such as territory defense, mating competition, sibling rivalry, and cheater detection. Once triggered, the anger system would produce one of two outputs: threatening to inflict costs (aggression) or threatening to withdraw expected benefits (Cosmides & Tooby, 2013). Similarly, fear as a basic emotion that plays a role in multiple adaptations and has its brain center mainly located in the amygdala. This localized brain function allows the organism to react not only to the specific and typical fear-inducing stimuli but also learn to react to non-specific stimuli with fear via fear conditioning (e.g., Phelps & LeDoux, 2005).

General intelligence and basic emotions may both be solutions for multiple primary modules that demand some common functions. This pointers hypothesis of general intelligence challenges a couple of assumptions in the research literature of cognitive evolution. As pointed out by the authors in the first section of the target article, many previous accounts of evolution of human intelligence assume that domain-specific modules ought to be cheaper and simpler than domain-general cognitive mechanisms. However, being specific does not necessarily mean that the mechanism is simple or cognitively economical. Since a domain-specific mechanism is designed for solving a specific problem, its design purpose is to do whatever it takes to solve the problem instead of achieving structural simplicity, computational economy, or functional
efficiency. Such designs can be either as delicate as human visual system or as patchy and lousy as male’s reproductive system, revised and modified from the Wolffian duct. Thus, these adaptive specializations can either be cheap and simple or costly and complex. Unlike engineering designs, evolutionary designs cannot afford to erase existing blueprints and start from scratch. Evolutionary efficiency is inevitably an efficiency under phylogenetic constraints.

The pointers hypothesis also challenges another assumption commonly implied in the discussion of the brain substrates of evolutionary adaptations: Domain-specific mechanisms are more localized in the brain than domain-general mechanisms. However, on the one hand, a specific adaptation can be implemented by a distributed neural network. On the other hand, a localized brain function is likely a result of a common demand of multiple primary modules. Thus, a more general-purpose mechanism may be implemented by allocating a localized brain region to perform a function shared by multiple primary modules. For instance, localized motor cortex (the precentral gyrus) for motor controls in foraging, hunting, gathering, intra-sex mating competition, inter-sex copulation, etc. Similarly, localized brain regions for language processing serve as a general-purpose system for all the tasks that require information exchange and communication.

References


Blank-slate theories of human intelligence propose that reasoning is carried out by general-purpose operations applied uniformly across contents. An evolutionary approach implies a different model of human intelligence. The task demands of different adaptive problems select for functionally specialized problem-solving strategies, unleashing massive increases in problem-solving power for ancestrally recurrent adaptive problems. Which is an evolutionary impossibility according to some evolutionary biologists and psychologists (see Cosmides, L., Barrett, H. C., & Tooby, J. (2010)).

Ref.: Ms. No. BBS-D-16-00542R1
A Pointers Hypothesis of General Intelligence Evolved from Domain-Specific Demands (Commentary Proposal on Burkart et al) Behavioral and Brain Sciences
Dear Professor Wang,

Your invited commentary on "The evolution of general intelligence" has been officially accepted for publication in BBS.

In the next three to four months the BBS Production Editor will email an MSWord copy of your accepted commentary with copy edited corrections and author queries for you to review and answer. The copy editor will utilize the "track changes" tool in MSWord which will enable you to answer the queries and make updates directly to the file. The file can then be saved and emailed back to the Production Editor. The Production Editor will also send a PDF file containing a Copyright Transfer Agreement and an Offprint Order form.

With kind regards,

Paul Bloom
Editor
Behavioral and Brain Sciences

Ref.: Ms. No. BBS-D-16-00542
A Pointers Hypothesis of General Intelligence Evolved from Domain-Specific Demands (Commentary Proposal on Burkart et al) Behavioral and Brain Sciences

Dear Professor Wang,

Thanks for submitting your invited commentary on the manuscript by Burkart et al. The editor is asking you to please revise and resubmit your commentary. The editor sent the following note:

This is a very interesting discussion, but it's not a commentary on the target article -- in fact, it doesn't even mention the target article. So I'm afraid that you need to rewrite it so that you engage with the ideas and arguments of the article that you are commenting on.

Please submit your revised commentary by Friday October 28th.

When your revision is ready, log in as an author at www.EditorialManager.com/bbs. At the main menu, click on the link that reads "Submissions Needing Revision." Under the Action Links menu, choose "Revise Submission." Then follow the on-screen instructions to upload your revised commentary.

If you have any questions, please email bbsjournal@cambridge.org.

Thank you,

Gennifer Levey
Managing Editor
BBS
Dear Professor Wang,

The commentary invitation list has now been finalized and we are pleased to invite you to submit a commentary on the following target article: "The evolution of general intelligence" by Judith M. Burkart, Michèle N. Schubiger, and Carel P. van Schaik.

The deadline for commentary submission is Monday October 24, 2016. Please accept or decline this invitation by September 26, 2016.

VIEWING TARGET ARTICLE and ACCOUNT INFORMATION: To view the updated target article before you reply to this invitation, please log on as an author to http://bbs.edmgr.com/. Your User Name is xtwang and your password is available at this link http://bbs.edmgr.com/Default.aspx?pg=accountFinder.aspx&firstname=XT&lastname=Wang&email_address=xtwang@usd.edu. At the main menu, click on "My New Invitations" and then click "View Submission Requiring Commentary." Then click "Agree to Submit" or "Decline to Submit" from the menu items.

You may also reply by selecting the appropriate link below. If you accept, you will be directed to your Accepted Invitations folder where the target article manuscript may be viewed.

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If you have any questions, don't hesitate to contact us at bbsjournal@cambridge.org.

Many thanks for your cooperation,

Paul Bloom -- Editor
Barbara Finlay -- Editor
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Please do not devote the limited space in your commentary to repeating the contents of the accompanying target article. Portions of commentaries redundant with the target article or with other accepted commentaries may have to be deleted by the editor. BBS also reserves the right to edit commentaries for relevance and style. All commentaries are editorially reviewed; where necessary, they may also be formally refereed.

Please provide an informative, indexable title for your commentary. As many commentators will address the same general topic, your title should be a distinctive one that reflects the gist of your specific contribution and that is suitable for the kind of keyword indexing used in modern bibliographic retrieval systems. With many active commentaries at any one time, it is also extremely helpful to us if you indicate at the very top of your commentary the name of the target-article authors on whose article you are commenting.

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Invited commentaries can only be accepted in the following format:

A. DOC(X) or RTF file submitted through the BBS Editorial Manager peer review system at http://bbs.edmgr.com/. Your username and password are available in this commentary invitation letter.

B. FIGURES may be in JPEG, GIF, TIFF or EPS format. However, TIFF or EPS format may be required for publication.

C. All figures, tables and equations must be placed where you would like them to appear in print, at the proper location in the document with the corresponding figure captions below. In addition, please make sure your commentary has ALL of the following in this order:

01. THE NAME OF THE AUTHOR(S) OF THE TARGET ARTICLE
02. FOUR SEPARATE WORD COUNTS (ABSTRACT, MAIN TEXT, REFERENCES, ENTIRE TEXT (TOTAL + ADDRESSES etc.)
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You may check the status of your manuscript by logging onto Editorial Manager at (http://bbs.edmgr.com/).

Kind regards,

Dear Professor Wang,
Many thanks for the submission of your manuscript, "Commentary proposal in Burkart et al." to the journal Behavioral and Brain Sciences.

You will be able to check on the progress of your submission by logging on to Editorial Manager as an author. The URL is http://bbs.edmgr.com/.

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Thank you for submitting your work to this journal.

Kind regards,

Editorial Office Staff
Behavioral and Brain Sciences
http://bbs.edmgr.com/

Ref.: Ms. No. BBS-D-16-00388
Commentary proposal in Burkart et al.
Behavioral and Brain Sciences

Dear Professor Wang,

Your Commentary Proposal has been processed and your name has been added to the list of potential commentators. This is a preliminary list only. Please DO NOT prepare a commentary unless you receive a formal invitation, indicating that it was possible to include your name on the final list, which is constructed so as to balance areas of expertise and frequency of prior commentaries in BBS.

Next, you will receive an email with a formal response to your commentary proposal. (Depending on when you submit your proposal, it could take several weeks to receive this email.)

Sincerely,

Paul Bloom
Editor
Behavioral and Brain Sciences
bbsjournal@cambridge.org

Dear Editor,

Thank you for the invitation. I would like to write a commentary on the target article by Burkart, Schubiger, and van Schaik. As requested, we first provide author’s information with my relevant expertise below:

X.T. (Xiao-Tian) Wang, Professor of Psychology and BBS associate
University of South Dakota, Vermillion SD. 57069, USA