Massive Redeployment and the Evolution of Cognition

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Introduction

Part of understanding the functional organization of the brain is understanding how it evolved. This talk presents evidence suggesting that while the brain may have originally emerged as an organ with functionally dedicated regions, the creative re-use of these regions has played a significant role in its evolutionary development. This would parallel the evolution of other capabilities wherein existing structures, evolved for other purposes, are re-used and built upon in the course of continuing evolutionary development ("exaptation": Gould & Vrba 1982). There is psychological support for exaptation in cognition (e.g. Cosmides 1989), theoretical reason to expect it (Anderson 2003; 2007-b; in press) and neuroanatomic evidence that the brain evolved by preserving, extending, and combining existing network components, rather than by generating complex structures *de novo* (Sporns & Kötter 2004). However, there has been little evidence that integrates these perspectives, bringing such an account of the evolution of cognitive function into the realm of cognitive neuroscience (although see, e.g., Barsalou 1999).

The Massive Redeployment Hypothesis

One recent hypothesis along these lines—that combines a story about the evolution of the brain based on the re-use and extension of existing elements with an exaptive account of cognitive functions—is the massive redeployment hypothesis (Anderson 2006; 2007-a; 2007-c). The massive redeployment hypothesis proposes that cognitive evolution proceeds in a way analogous to component reuse in software engineering, whereby existing components—originally developed to serve some specific purpose—are used for new purposes and combined to support new capacities, without disrupting their participation in existing programs. If cognitive functions evolved in this way, then we should be able to make some specific empirical predictions regarding the resulting functional topography of the brain; in this talk I discuss and provide evidence in support of three.

Supported Predictions

First, I found that a typical brain region supports numerous cognitive functions in diverse task categories. If this were not the case, if a typical brain region in fact served a very limited set of cognitive functions, then this would suggest instead a localization-based hypothesis, whereby the brain evolved by generating new, dedicated regions for each new purpose.

Second, I found a correlation between the phylogenetic age of a brain area and the frequency with which it is deployed in various cognitive functions. This is presumably because the longer an area has been around the more likely it will have proved useful to some evolving cognitive capacity, and be incorporated into the functional network of brain regions supporting the new task. Again, this outcome would not be predicted by the localization-based evolutionary hypothesis.

Third and finally, I found a correlation between the phylogenetic age of a cognitive function and its degree of localization. That is, more recent functions generally use more, and more widely scattered brain areas than evolutionarily older functions. Again, the reason is simple: the more established neural components there are when a given cognitive capacity is evolving, the more likely that one of them will already serve some purpose useful for the emerging capacity, and there is little reason to suppose that the most useful areas will be grouped together (and less reason to suppose this as evolutionary time passes, making available more functions supported by more areas). A localization-based hypothesis would predict no difference in degree of localization.

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