On the Role of Brain-Imaging Technologies in the Calibration of Learning Strategies

Lars Hall
Lund University Cognitive Science
lars.hall@lucs.lu.se

Petter Johansson
Lund University Cognitive Science
petter.johansson@lucs.lu.se

Abstract

In this article we discuss the process of calibration and verification of learning strategies, and argue that a careful consideration of data from brain-imaging methodologies, as well as a systematic treatment of first-person subjective reports, is the most promising route for educational researchers to answer the age-old question about what a learning strategy really amounts to. In addition we argue that such considerations may pave the ground for a future breed of ICT learning applications based on a refined concept of neurofeedback.

1. Introduction

No matter how mobile and pervasive ICT-applications we may construct; no matter how powerful our computer-mediated learning environments may become; and no matter how intelligent the agents and interfaces of the near future may be, the remarkable flexibility and adaptivity of the human brain/mind will still remain the most important variable in the study of favorable learning outcomes.

It has recently been argued that the standard experimental brain-imaging paradigm of the cognitive neurosciences habitually overlooks crucial first-person introspective data [1], thus missing out on a cheap and abundantly available source of information to help in the construction of experiments, and in the interpretation of brain-activation profiles. In this article we explore the flip side of this argument, namely that educational research into the nature of learning strategies and learning styles generally have failed to incorporate results from brain-imaging methodologies, thus missing out on a great opportunity to calibrate, validate or falsify the introspectively derived concepts they work with.

We argue that a careful consideration of these issues will allow productive answers to be given to the age-old question about what the nature of individual learning strategies are, how we employ them, and why they work as they do, thus opening up new grounds for validating and calibrating such strategies.

2. Calibration and Validation of Learning Strategies

In this section we provide an overview of the problem of validating and calibrating learning strategies.

There are many problems inherent in the study of learning strategies and learning styles. On the one hand we find theories that classify people into broad categories of learning styles (alternatively called cognitive styles, or thinking styles). Such theories may contain great insights, but due to the abstract nature of the categories they are not good candidates for fine-grained functional level elaboration. On the other hand we have theories poised at a very low level of abstraction - i.e. theories that look for some basic parameter of ‘mental-speed’ to explain learning performance. Again, while there might be insight to be found in such approaches, it is at present wholly unclear how they can be meaningfully related to research on strategic learning processes, and the realities of teaching practice.

Instead, we contend, it is in the middle range of abstraction that the most promising candidates can be found for a theory of ‘micro-manageable’ learning strategies. Many of these strategies have their roots in cognitive psychology (i.e. things like ‘semantic elaboration’ or ‘phonological rehearsal’ in memory research), but most also have some kind of underpinning from subjective, everyday experience (i.e. things like mental imagery or associative mnemonics). As we see it, getting to grips with the nature of such strategic processing is perhaps the single most pressing problem for educational psychology to solve.

In the following sections we provide three case studies that illustrate different aspects of the basic interplay between first-person subjective reports and third-person data that must be explicated in order to provide a complete characterization of what a learning strategy really is.

2.1. Attention

---

1 To access full paper, see http://www.lucs.lu.se/People/Lars.Hall/
In this section we use a recent study [2] to provide an example and a discussion of the use of imaging technologies to corroborate mental strategies. In this study subjects were trained extensively on a simple perceptual task (to resolve illusionary 3D depth in a random dot stereogram). In addition to this, brain activity of the subjects was measured by EEG (electroencephalogram). The interesting finding of this study [2] was that for each subject they were able to find a strong and clear correlation between a categorization of the verbal reports of the subjects (the degree of mental preparation, or attention of the subjects) and the EEG-response profiles. These correlations were stable over several recording sessions, in effect providing “a consistent signature of a subject’s cognitive strategy” (p. 1590).

We discuss the inferences that can be drawn from [2] and other similar studies, and argue that the main power of such results lies in the prospect of eventually finding a generally agreed upon match - a shared functional language - between first-person and third-person data.

2.2. Inhibition

In this section we use the case of inhibition (a central component of most mental strategies, most importantly emotion-regulation and self-control) to provide an example of an attempted reduction of subjective strategies to a ‘fundamental psychobiological mechanism’ [3]. We discuss the many pitfalls and hazards of making reductions across subjective and scientific boundaries, and use recent brain-imaging data to argue that the conclusion of [3] is premature, and ought to give away to a wider process of calibration, where mutual constraints arising from each source of evidence can be explored.

2.3. Memory Encoding

It is a well known fact that there can be wide discrepancies between what people think and believe that they are doing when executing a strategy or performing a task, and what really goes on in their minds [4]. In this section we provide examples of theoretically motivated enumeration of strategic processes, which lack adequate counterparts in phenomenological experience.

Memory encoding and memory performance is such an example. While encoding and remembering may seem like processes that are too complex not to be conscious (or even self-conscious), this is a misguided intuition. As far as cognitive operations go, there is no systematic relation between the complexity of a process and whether it is executed in a conscious manner or not.

3. Discovery and Creation of Learning Strategies

The outcomes described in the studies above are important not only because they reveal to us the power of the process and instruments needed to verify and/or calibrate subjective strategies of self-regulation, but also because they open up new avenues for the creation and teaching of learning strategies.

In this final section we turn to a discussion of the potential of a refined form of neurofeedback to support a whole new breed of ICT-based learning applications.

With neurofeedback, complex ‘strategic’ operations of a semi-conscious nature can be elevated to a personal level, and manipulated according to need [5]. Take for example the concept of cognitive control, which regularly is depicted as a strategic, metacognitive function, and thought to consist of several components, of which ‘conflict monitoring’ is an central part. Recently it has been shown that conflict monitoring is an important component of general intelligence [6]. However, ‘conflict monitoring’ is a process almost entirely devoid of phenomenology (it is a ‘quasi-phenomenological’ concept as [1] would put it). The only straightforward way to put it under conscious cognitive control would be to feedback a representation of the neural activation-levels to the subject to see if and how they could do something to influence it (and in turn see whether this would improve performance on the task). As we see it, once real-time processing models of fMRI & EEG have been refined [7] such applications promises to provide exiting prospect for personal modification and influence over learning strategies and mental operations.