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Talking while looking: On the encapsulation of output system representations

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The idea that the human mind can be divided into distinct (but interacting) functional modules is an important presupposition in many theories of cognition. While previous research on modularity predominantly studied input domains (e.g., vision) or central processes, the present study focused on cognitive representations of output domains. Specifically, we asked to what extent output domain representations are encapsulated (i.e., immune to influence from other domains, representing a key feature of modularity) by studying determinants of interference between simultaneous action demands (oculomotor and vocal responses). To examine the degree of encapsulation, we compared single- vs. dual-response performance triggered by single stimuli. Experiment 1 addressed the role of stimulus modality under dimensionally overlapping response requirements (stimuli and responses were spatial and compatible throughout). In Experiment 2, we manipulated the presence of dimensional overlap across responses. Substantial performance costs associated with dual-response (vs. single-response) demands were observed across response modalities, conditions, and experiments. Dimensional overlap combined with shared spatial codes across responses enabled response-code priming (i.e., beneficial crosstalk between output domains). Overall, the results are at odds with the idea of strong encapsulation of output system representations and show how processing content determines the extent of interdependency between output domains in cognition.

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1. Introduction

Cognitive psychology has always aimed at specifying contents, processes, and components of the mind. An important part of this endeavor has been the development of theories on information processing and its structural bases. A central characteristic of a broad range of theories about the mind is the modularity assumption, that is, the notion that at least some of the mental phenomena can be explained in terms of the interplay of distinct cognitive modules. However, only little consensus has been reached on the question of what exactly qualifies as a module, or to what extent certain "parts" of the mind can be adequately described as being modular (Barrett & Kurzban, 2006).

1.1. Modularity in cognition

While the assumption of cognitive modules (or mental faculties) can easily be traced back to at least ancient Greek philosophy, the debate about modularity in cognition has been substantially revitalized by Fodor (1983). According to his conceptualization, cognitive modules represent functionally specialized cognitive systems that primarily occur at peripheral processing stages. In addition to functional specialization and peripheral localization, Fodor also proposed further properties of cognitive modules, for example, domain specificity (e.g., the visual system on the input side of processing, see Marr, 1982), and brain localization (i.e., that modules are realized in dedicated parts of the brain, e.g., Friston & Price, 2011). In a subsequent discussion, researchers suggested several candidates for a key feature of modularity, for example, domain specificity (Coltheart, 1999), or functional specialization (Barrett & Kurzban, 2006). However, many other researchers (including Fodor) agreed that probably the most important property of a module is informational encapsulation, which refers to the idea that a module is cognitively impenetrable (i.e., inaccessibility to the influence of other modules or higher cognitive processes) and does not refer to other psychological systems in order to operate (Fodor, 1983; Pylyshyn, 1999).

Fodor's original work has been criticized on a number of fronts (e.g., Buller, 2005). For example, some researchers claimed that modularity may also occur at central processing stages (e.g., Magen & Cohen, 2010; Sternberg, 2011), a view that has also been termed "massive modularity" in the context of a functional (evolutionary) view of cognition (see Carruthers, 2005; Frankenhuis & Ploeger, 2007; Pinker, 2005; Sperber, 2005; Tooby & Cosmides, 1992). Furthermore, it has been argued that many empirical observations are incompatible with the assumption of (both peripheral and central) modularity (e.g., J. J. Prinz, 2006). For example, brain plasticity appears to speak against a fixed localization of modules in the brain, and the many instances of information crosstalk between processing domains (e.g., the McGurk effect, see MacDonald & McGurk, 1978, showing an interaction between vision and audition on the input side of processing) typically count as evidence against strong encapsulation (see also Jiang & Egner, 2013, for more recent evidence). However, it should also be noted that Fodor (1983, p. 37) himself conceded that the notion of modularity "ought to admit of degrees", and should not be judged in terms of an all-or-nothing phenomenon. Thus, cognitive system interdependency could be considered as a research-guiding dimension with the (heuristically valuable) poles of strong modularity/encapsulation on one side and strong crosstalk on the other side. In this way, the crucial research questions no longer refer to the existence (or non-existence) of modularity, but rather to the factors and mechanisms determining the degree of modularity in specific domains. In the present study, we specifically focus on the issue of encapsulation with respect to cognitive representations of output systems.

1.2. Encapsulation and output system modularity

Interestingly, most empirical research on cognitive encapsulation mainly focused on the input side of processing (e.g., vision, see Barrett & Kurzban, 2006, for a review), whereas substantially less research effort has been put into studying cognitive representations of output (action) domains. However, researchers typically used the term "peripheral systems" to comprise both input and output