Recent perspectives on the functional organization of frontal cortex highlight its ability to keep track of multiple independent dimensions in order to internally guide thought and action. Such an architecture is important for analogy making. Also, PFC may form abstract representations of the types of relations that will be useful for generating future analogies. However, these abstract PFC representations may be distinct from abstract representations stored elsewhere that form our store of semantic knowledge.

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Are all analogies created equal? Prefrontal cortical functioning may predict types of analogical reasoning

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Abstract: The proposed theory can account for analogies based on learned relationships between elements in the source and target domains. However, its explanatory power regarding the discovery of new relationships during analogical reasoning is limited. We offer an alternative perspective for the role of PFC in analogical thought that may better address different types of analogical mappings.

Analogical thought is often considered the cornerstone of abstract reasoning; it allows one to uncover relationships between a familiar situation in memory (the *source* domain) and a new situation (the *target* domain) that may not be well understood. Notably, analogy does not involve simple retrieval of information about the two domains, but a *mapping* between their surface elements based on shared abstract relationships.

Speed's framework attempts to illuminate the neural mechanisms underlying analogical thinking by specifying how flexible encoding of relational information from experience in prefrontal brain circuits allows for the differentiation between surface and structural features during analogical mappings. Specifically, prefrontal cortex (PFC) neurons represent relationship information between different concepts, features, or actions; these neurons are attuned to relational categories of increasing abstractness following a hierarchical rostrocaudal organization. Upon establishment of successful mappings between a source and a target domain, PFC neurons are selectively activated to represent abstract longer-term relational categories; moreover, the response of PFC neurons persists depending on the behavioral relevance of the activated relationships.

An important product of analogical reasoning in the real world is the understanding of a target domain through the discovery of new relationships that were not previously known outside of the context of the analogy. Although Speed's account may provide a neural framework for understanding how abstract relationships are learned and stored progressively in PFC neurons from experience and how available relational information may be activated during A:B::C:D analogical reasoning problems that have been traditionally used to study analogy in the laboratory (e.g., *brain*:*thought* :: *stomach*: *?*), this presents a question for the current theory: If the target domain is not well understood, how are these new or unlearned relationships between the domain's surface features explicitly represented in PFC neurons?

For example, when one is using an object in a novel way instead of a typical object, to achieve an ad hoc goal (e.g., using a *baseball bat* as *rolling pin*), how is the mapping of the abstract relationship between the objects represented in PFC? When Watson and Crick mapped analogically the known helical structure of the alpha-keratin molecule (source domain), to discover the unknown structure of the DNA molecule (target domain), how was relational information about the source activated without predicting in advance their potential for reward or punishment? How was relational information about the target domain represented, given that it was this very abstract relational information about the DNA structure that was poorly understood? Such analogies may require different representation in PFC neurons relative to analogical mappings between well-understood source and target domains (e.g., the analogy "planet is to sun as electron is to nucleus" refers to *already established* relationships about the structure of the solar system and atom).

We propose here that, instead of representing relational categories of increased abstractness, the PFC functions as a domain-general, biasing mechanism that sculpts the representational response space (Frith, 2000), focusing attention on certain aspects or features of a representation during analogical reasoning, while ignoring others. Such a conceptualization of the PFC may allow for explicit predictions regarding the extent of the involvement of this region depending on the type of analogical reasoning. According to this approach, PFC might be involved in analogies that are based on strong preexisting knowledge of abstract structural relationships in the source and target domains. In such cases, biasing the response space would allow for focus only on the relevant aspects of these relationships for a successful analogical mapping between the source and target domains. In contrast, PFC regions may not be involved to the same extent for analogies that are not based on explicit preexisting knowledge and which—if successful—might lead to new discoveries. In such cases, biasing the response space may be counterproductive, given that one may not know in advance which relationships will become of optimal behavioral relevance (see Chrysikou & Thompson-Schill, in press; Thompson-Schill, Ramscar, & Chrysikou, 2009).

We argue that such an approach to PFC offers a neural framework for analogical reasoning that is able to account for both types of analogy, which may further our understanding of analogical transfer (or its failure) in real-life circumstances.

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Does the PFC model of analogy account for decision making, problem solving, reasoning, flexibility, adaptability, and even creativity?

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Abstract: From everyday cognition to scientific discovery, analogical processes play an important role: bringing connection, integration, and interrelation of information. Recently, a PFC model of analogy has been proposed to explain many cognitive processes and integrate general functional properties of PFC. We argue here that analogical processes do not suffice to explain the cognitive processes and functions of PFC. Moreover the model does not satisfactorily integrate specific explanatory mechanisms required for the different processes involved. Its relevance would be improved if fewer cognitive phenomena were considered and more specific predictions and explanations about those processes were stated.

Speed proposes a novel PFC model of analogical processing. This model explains analogical processes as a progressive integration from posterior to more anterior areas of PFC, during which the information processing increases in abstractness and complexity. The fronto-striatal circuits would bring the basis for analogy formation and persistence, sustained by learning and prediction of reward/punishment. The model is discussed in relation to other approaches to PFC and also to several processes involved, such as explicit and implicit processing, long vs. short-term representations, and cognitive control. More importantly, this model is presented as a useful tool for integrating the multiple functions of PFC in order to understand complex behaviors, such as decision making, problem solving, reasoning, flexibility, adaptability, and even creativity.

In spite of the main merit of this work, which lies in an effort to integrate the different roles of PFC and the analogical processes in order to understand complex behaviors, there are several caveats that raise doubts about the model's usefulness.

Although analogy would be a very important factor in wide-ranging cognitive processes, it is hard to imagine how a general cognitive skill such as analogy could be enough to explain as many cognitive processes as proposed by Speed. Would the same analogical model explain decision making, reasoning, creativity, and other very disparate processes? How is it possible for such a model to achieve this goal? Is there an identical neuronal substrate for all these cognitive processes? No precise description or insight on these main issues can be found in the paper. In the same vein, those complex