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A Module for Metaphor? The Site of Imagination in the Architecture of the Mind

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Abstract. An influential position in contemporary psychology is that the mind consists of a constellation of domain-specific, specialized computational mechanisms. Controversy remains about how global, integrative cognitive processes such as the imagination fit into such an architecture. I consider three possible conceptualizations of the imagination; as an operation of a domain-general central process in a Fodorian mind; as an operation of a specialized module in a massively modular mind; and finally as a product of low binding selectivity in Clark Barrett's 'cogzyme' mind. This final approach is much the most promising, as the key to the imagination seems to be the mapping of meaningful representations between dissimilar cognitive domains. I thus argue, partly through the link between imagination and schizotypy, that we should view imagination as a consequence of incomplete insulation between parallel specialized processes. Such de-insulation permits innovation and novelty, but also makes possible psychotic illness and delusional beliefs. Thus imagination, like any other evolutionary development, is likely to have costs as well as benefits.

THE IMAGINATION AND THE DOMAIN-SPECIFIC MIND

THE IMAGINATIVE CAPACITY OF *HOMO SAPIENS* has long been held to be one of that species' most notable features. For Darwin, imagination was 'one of the highest prerogatives of man' (cited in Roth 2003). Archaeologists and palaeoanthropologists have tended to judge the question of when there were people 'like us' less in terms of anatomical similarity, and more by the

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presence of clearly imaginative products such as figurines, decoration, and painted representation (Mithen 1996). As Roth points out, the centrality of imagination to what it is like to be human has not guaranteed its centrality within the models of mind developed by scientific psychology. The subject of this chapter is how we might conceptualize the place of the imagination within the overall architecture of the mind. The background to the ideas developed here is the rise of interest in the concept of the domain-specific, or modular, mind (Fodor 1983; Tooby and Cosmides 1992).

Fodor gave the first detailed elaboration of the thesis that much of human cognition is organized into a number of relatively autonomous subcircuits. The key features of these modules are that they are designed to solve a particular task, and act on a particular type of informational input, automatically, without their internal processes being available to other modules, and without drawing on any 'general' cognitive resources such as attention. Thus, the face perception module works fast and completely automatically whenever visual information fulfilling the criteria of being a face becomes available. It is impossible to look at a familiar face but decide not to recognize it until later on, when you have more time. Moreover, the question of how you recognized it (was it the curve of the chin?) is completely unavailable to, for example, the linguistic system. Face recognition is thus informationally encapsulated. It is unlikely that the circuitry that does the recognition is able to do anything that is not face recognition or some task closely modelled on it (recognizing a dog or a doll for example; Kanwisher 2000). Thus, face recognition is a good candidate for a modular process. In accordance with Fodor's criteria for modularity, this leads to a number of ancillary possibilities; chiefly, that it might be possible for brain damage to abolish face recognition capacities without impairing performance on anything much else, and that there might be brain circuits that are active in all and only face recognition tasks. Both of these predictions turn out to be the case, as reflected in acquired prosopagnosia, which is the selective impairment of face recognition capacity, and in the existence of neurons uniquely responsive to faces in the superior temporal sulcus of both monkey and man (Kanwisher 2000; Desimone 1991).

Fodor's model of the mind is a two-tiered one. Whereas a number of specialist tasks such as perception and language are handled by modules, there is also a general-purpose cognitive system that takes the output of the various modules and does characteristically human things with them such as planning, problem-solving, writing books, and so on (Figure 12.1). These processes have all the converse characteristics to modular cognition; slow, voluntary, effortful, and attentionally demanding. Processes within the general-purpose system are unencapsulated, which means in principle that you could write a book about how you deciphered Linear A (using general-purpose cognition) more easily that one about how you parse a sentence of ordinary spoken English (using a language module). Within the Fodorian mind, the imagination, ranging as it does across multiple domains and modalities, cannot itself be a module. The other possibility, then, is to locate it in the general-purpose system with all the other difficult-to-study, important and uniquely human characteristics such as reasoning.

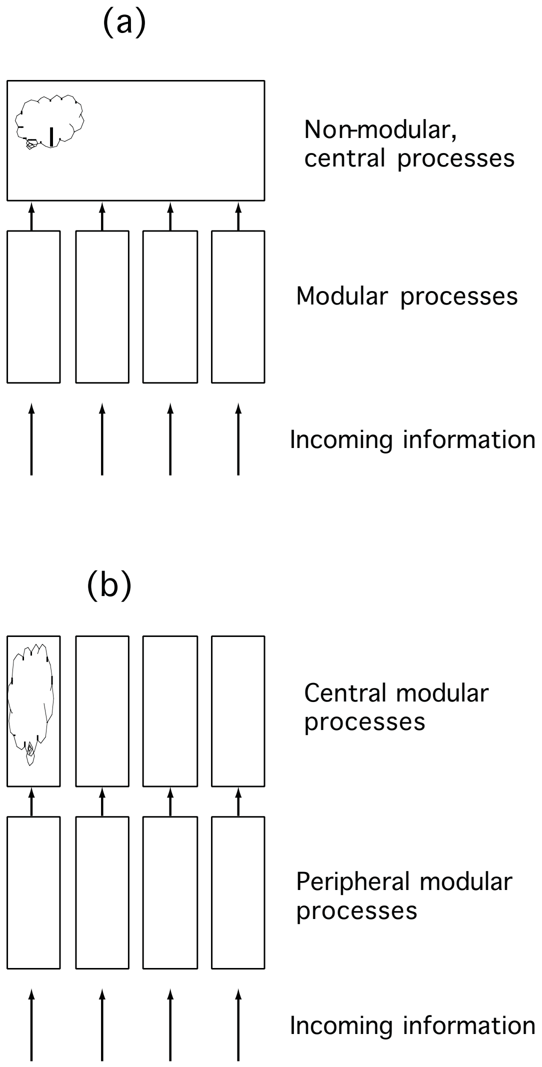

Figure 12.1. Two possible sites of the faculty of imagination in the architecture of the mind. (a) In a Fodorian mind, imagination is a property of domain-general central processes. (b) In a massively modular mind, imagination is a property of some domain-specific central module, designed for some function such as planning or problem-solving.

If this view is adopted, then imagination falls victim to what Fodor himself, with characteristic iconoclasm, calls the First Law of the Nonexistence of Cognitive Science (Fodor 1983). The thrust of this law is that cognitive science produces good, well-grounded models of basic processes that were not of much interest anyway, and shoves really key human processes such as imagination into the general-purpose system, the workings of which it is hard to get any kind of methodological handle on. Thus, the parts that are scientific are not very cognitive, and the parts that are really cognitive are in a box which might as well say 'And then a miracle happens'. If imagination is a general process, then there is almost nothing we can say about it beyond what it is not, namely localized, specialized, showing evidence of evolutionary design, and so on.

A more recent alternative to the Fodorian architecture is the so-called massive modularity hypothesis (Samuels 1998; Tooby and Cosmides 1992). According to Tooby and Cosmides, the whole mind is organized into a system of specialized processes. These cover not just low-level tasks like Fodor's modules, but all the major cognitive operations humans must perform in order to survive and reproduce. Thus, there would be a module for selecting a mate, one for tracking cooperative interactions with other people, one for thinking about plants and potential foods, one for thinking about the physical movements of objects, one for avoiding being murdered, and so on. The primary argumentation for such pervasive modularity is theoretical. Since the architecture of the mind has been shaped by Darwinian selection, it will end up optimized for solving the recurrent adaptive challenges human beings have faced. Each of those adaptive challenges—feeding, mating, avoiding predation, cooperation—has a different set of rules and constraints, and thus requires specialized cognitive machinery. The things you learn about feeding are really no help in finding a mate, and any system designed to be able to learn the two equally well would be inferior to two specialized systems in the same head, each triggered by the relevant scenarios. Thus, any mind consisting of a general-purpose computer whose resources and algorithms were equipotentially relevant to all the different adaptive domains would always be outcompeted by one that divided up its resources into specialized modules (Cosmides and Tooby 1992, p. 112).

The massive modularity hypothesis, as stated, would naturally lead to the view that the imagination is a module, designed by natural selection for some important task or other, perhaps advanced planning or problem-solving. However, such a view—in which imagination is domain-specific and specialized—seems completely at odds with what imaginative cognition is like, as I shall argue in the next section.

The massive modularity hypothesis, though influential, has raised scepticism, in particular about whether the globality, flexibility, and context-sensitivity of (at least some) human thought could originate from a mind entirely composed of autonomous and specialized devices (Over 2003; Stanovich and West 2003). Clark Barrett has recently outlined a model that satisfies Tooby and Cosmides' stipulation that natural selection produces specialized mechanisms, and yet preserves the fluidity and context-sensitivity of Fodor's central processes (Figure 12.2; Barrett 2005). He proposes that specialized cognitive mechanisms should not be seen as separate channels in the mind, but instead are more like enzymes in the chemical soup of the human cell. That is, they have affinities to particular kinds of information, which they bind to and transform in certain ways, just as enzymes have affinities for particular chemical substrates which they catalyse. Thus, for example, there may be a mate selection mechanism that has an affinity for cues of attractiveness in a member of the opposite sex, and turns these into a representation of a mating opportunity. However, crucially, information within the system is not partitioned into separate containers, as in a modular mind, but instead resides in a common mental pool of representations. Individual 'cogzymes' (i.e. specialized mental processes) take representations and transform them in ways specified by their design, but then return them to the common pool, where they are available to other cogzymes. Moreover, one cogzyme may uprate or inhibit another, just as happens with enzymes in complex chemical reactions. What previously appeared to be 'domain-general' processes such as reasoning may instead be complex central processes in the pool of representations that drawn on many different, interacting cogzymes. Barrett's model appears persuasive, and also offers a more satisfying conceptualization of the imagination than either Fodor's ill-defined central processes, or a modular account, as I shall outline in below.

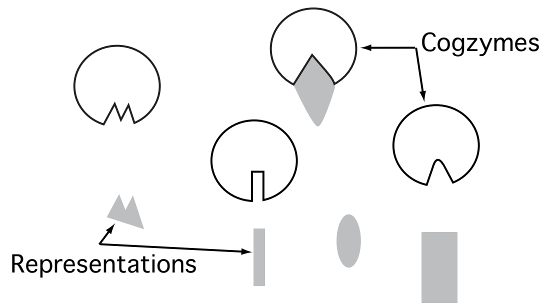

Figure 12.2. A Barrettian mind. Representations of information are in a common mental pool, where they interact with specialist cognitive processes or 'cogzymes', which have affinities for particular types of information. Imagination emerges as a consequence of incomplete binding selectivity between representation types and cogzymes.

THE BASIS OF THE IMAGINATION

As the Introduction to this volume notes, imagination is clearly a multi-faceted, family resemblance term. One ordinary-language meaning of the imagination is essentially visual imagery ('seeing in the mind's eye'), while another is counter-factual thinking ('in my imagination, I can see what will happen if the bridge collapses'). Both of these kinds of imagination could easily turn out to be capacities of particular domain-specific processes. For example, cognition about objects in the physical world could usefully make use of both visual imagery and counterfactual reasoning. Indeed, each of these two topics has proved relatively amenable to experimental investigation, suggesting, in accordance with the first law of the non-existence of cognitive science, that they are probably not the phenomena of greatest interest. However, there is another sense of imagination, which seems closer to the sense in which imagination is a true hallmark of modern human cognition. This is the sense in which a poem, a scientific theory, or a mathematical proof could be said to have required a leap of the imagination.

The key to imagination in this sense seems to be the production of a novel representation from an input by bringing to bear information from another domain. Let me illustrate this point with two brief examples that would by common consensus be considered highly imaginative. First, consider Sylvia Plath's poem *Old Ladies' Home*. Plath describes the residents of an elderly persons' home as, 'Frail as antique earthenware/One breath might shiver to bits'. We have an intuitive, evolved, specialized way of thinking about persons (social intelligence), and the natural currency of that intuitive process is things like beliefs, desires, and intentions. For physical objects, there is a different intuitive processing (physical intelligence) centred around spatial position, physical integrity and object permanence. Plath here uses the language of the latter to talk about the former, drawing out the isomorphism that the death of an agent is in the domain of social cognition what the loss of object integrity is in cognition about physical objects.

Describing the activity of the ladies, the poet writes, 'Needles knit in a bird-beaked/Counterpoint to their voices'. One can almost hear the click-click of the needles in the sound of the first of these two lines, through the repeated initial *n* sound followed by repeated *b*. However, we are normally unaware of the acoustic resemblances of language to non-linguistic sounds, since an automatic domain-specific process intervenes to turn speech into meaning. Writing and reading poetry generally, as here, requires taking the line and treating it not just as language, but also as a non-linguistic stream of sound. In other words, the signal must be allocated *both* to linguistic processing, and to non-linguistic sound processing, yielding in both cases some representation of the knitting process, namely the linguistic semantics of knitting and something like its actual sound.

Plath finishes the poem 'And Death, that bald-headed buzzard/Stalls in halls where the lamp wick/Shortens with each breath drawn.' Once again, the meaning of this sequence involves taking a subject that would normally be allocated to social cognition (the ladies), and using schemas to do with predation or scavenging (the buzzard), and combustion, which is part of intuitive physics, to reframe their impending mortality.

As a second example, consider the development of game theory by Nobel prize winner John Nasar (1998). Game theory is a framework for considering the likely evolution of behaviours, in scenarios where the payoff to an actor depends not only on his or her own behaviour but on that of others with whom he or she interacts. A classic game-theoretic scenario would be the decision how long fishermen should wait before re-fishing a depleted salmon river. The individually rational decision might be to wait until the salmon are completely grown and fish them then. However, a rational person, realizing that the others will realize that it is rational to wait until the salmon are full-grown, will wait until a month *before* this, and fish without competition. However, a rational person, realizing that the others will work this out and start fishing one month before the salmon are full-grown, will only wait until *two* months before. And so on.

Modelling the outcome of these types of interaction turns out to be quite simply done using some basic mathematics. You simply treat the actors as a physical system governed by a matrix of payoffs and a maximization function. Nash's work is imaginative because this is not the usual way of thinking about people. Game theory fundamentally concerns human social interactions. Again, we would normally think about these with an intuitive belief/desire psychology—what the fishermen *want*, when they *intend* to fish and so on. Thinking about the salmon problem, folk psychology just tells us that the fishermen *want* and *intend* to wait, but game theory tells us that the salmon will get fished early despite everyone's intentions to the contrary. (Natural selection, of course, 'knows' this, which is why it has given us such emotions as moralistic outrage, anger and guilt.) Thus, Nash's imaginative leap lies in applying mathematics, an outgrowth presumably of specialized cognition for thinking about objects in the physical world, to the social domain, where normally another, quite different, specialized process would be in force.

The common thread in poetry and game theory is metaphor, in the broad sense of 'a mapping or transfer of meaning between dissimilar domains' (Modell 2003). The imaginative creations involve seeing that a problem within one domain (of language or social interaction) can actually be processed, perhaps simultaneously, in another (sound or physical systems).

This results in a novel representation that would not have been available by following the normal algorithms internal to the domain in which the problem was first conceived (Chiappe 2000).

It is unclear that insights such as Plath's or Nash's can be produced by the application of deliberate cognitive effort. Indeed, it is unclear that the imaginative leap, as distinct from the solving of the details, need be slow or voluntary. It seems more likely that this kind of cognition arises where cognitive operations from one domain spontaneously interact with the information that properly belongs to another. In Barrett's (2005) terms, the cogzymes designed to take information relating to, say, naive physics, interact with representations of the social world, or vice versa. This 'non-selectivity' in the cogzyme pool could well reduce average efficiency in carrying out everyday cognitive tasks, but it produces occasional moments of arresting creativity. The appropriate metaphor for capturing the basis of the imagination using the cogzyme model would be that of 'binding selectivity'. In biochemical systems, enzymes with high binding selectivity only interact with a very narrow range of substrate molecules. Enzymes with lower binding selectivity would react to some degree with a much wider range of molecules. Lowering average binding selectivity in a system would increase the number and complexity of different reactions in response to different chemical inputs, though it might also render more chaotic and inefficient the production of key reactions.

Steven Mithen has been a champion of the view that truly modern cognition, with its symbolic and artistic capacities, arises not from the development of additional domain-specific capacities, but from the partial breakdown of inter-domain cognitive barriers (Mithen 1996). Within the Barrett model, we might rephrase this by saying that in the modern mind, binding selectivity of cogzymes to different information types has become lower, producing creative imagination of the type we have discussed. This hypothesis seems compelling, but has scarcely been studied in the experimental psychology laboratory, in part due to the difficulty of getting an experimental handle on the types of cognitive processes required. One fruitful source of evidence for the informational fluidity model is to be found in studies of psychopathology, particularly schizophrenia. This requires, first of all, an explanation of the link between psychopathology and creative imagination.

IMAGINATION AND PSYCHOPATHOLOGY

It may seem a leap to move from imagination to cognitive functioning in schizophrenia, but there are reasons for doing so. A full review is beyond the scope of this chapter (see Nettle 2001). Suffice it here to say that there is evidence of increased rates of psychopathology, including psychosis, in individuals judged by society to be highly creative (Ludwig 1988; Richards *et al.* 1988), and in their first degree relatives (Heston 1966; Karlson 1970; Richards *et al*. 1988). Moreover, the contents of psychotic states can only be described as imaginative. Patients often have elaborate systems of delusional beliefs, in which real events and facts will be minutely and consistently interwoven with non-veridical constructions, often fantastical or paranormal in nature. Paranoid thinking contrives to discover ingenious connections between apparently disparate domains, and the characteristic 'crooked logic' of thought disorder involves generating novel connections in much the way that the imaginative examples given in the previous section do. (On the connection between positive symptoms of psychosis and the imagination, see also Currie 2000.) Nash himself was of course affected by psychosis for many years.

Perhaps most importantly, there is evidence of a shared cognitive style in what we would recognize as imaginative cognition and in psychosis. People diagnosed with schizophrenia show relative impairments on a wide variety of psychological tasks. One exception is those tasks that have been proposed as measures of creativity. An example is the alternate uses test, in which the participant has to come up with as many different uses for an everyday object as possible. As the banal uses are soon exhausted, much of the variation on this task arises from the person's ability to draw possible uses from completely different domains than that for which the object is designed. Schizophrenia patients show a large advantage on this task compared with controls, and indeed, when a group of 'highly creative' normals were tested, their performance was essentially indistinguishable from that of the patients (Keefe and Magaro 1980). A similar pattern is found on a task where non-standard, novel criteria for sorting objects must be devised by the subject (Dykes and McGhie 1976). The performance of schizophrenia patients is enhanced. This is in sharp contrast to tasks where more obvious sorting criteria set by the experimenter must be discovered and adhered to, such as the Wisconsin card sorting task, where patients are impaired relative to controls.

Researchers studying schizophrenia distinguish between the condition itself, and the cognitive or personality style that underlies it. For the former to develop requires the presence of the latter, but the latter may also be found in subclinical or even benign form, and only in some cases is converted into frank psychotic illness. The underlying personality configuration is known as schizotypy (Claridge 1997). Schizotypy is conceptualized as a continuous trait. It can thus be measured within the general population using standard personality scale designs (Mason *et al.* 1995). Psychotic (bipolar as well as schizophrenic) patients are reliably high scorers on these scales, but there are also high scorers with no history of treated mental illness (Nettle 2006).

Factor analysis of schizotypy scales reveals several independent subdimensions (Claridge *et al*. 1996). In particular, a factor relating to unusual ideas, beliefs and experiences (which are the positive symptoms of schizophrenia) can be reliably separated from a factor characterized by anhedonia (say what this means) and social withdrawal. This latter factor corresponds to the negative symptoms of schizophrenia. It is the positive, unusual ideas factor that has generally been related to creativity or imagination (Schuldberg 2000). For example, poets and visual artists score higher than controls, and as highly as schizophrenia patients, on the Unusual Experiences schizotypy scale (Nettle 2006).

Schizotypes (by which it is meant high scorers on schizotypy scales who are psychiatrically normal) have often been used in research as models for schizophrenia (Claridge 1997). This is because they are presumed to show many of the cognitive hallmarks of schizophrenia without the medication, negative symptoms, institutionalization, stigma, and frank psychosis that make cognition in schizophrenia hard to study. However, schizotypes can also be used as a model of highly active imagination. There are several justifications for so using them. First, there are the conceptual similarities and epidemiological links between serious mental illness and imaginative creativity, as noted above, and schizotypy is the linking construct. Second, schizotypy scores are elevated among arts students (O'Reilly *et al.*, 2001), and among poets and visual artists (Nettle 2006), relative to the general population. Third, scores on the positive dimensions of schizotypy scales (those which measure unusual beliefs and experiences) correlate with performance on tasks that have been proposed as measures of creativity (Green and Williams 1999; Weinstein and Graves 2002). One such task is the Remote Associates Test (Mednick 1962). Here, participants have to find a word that links three others presented to them, such as Manners–Round–Tennis, where the link word is Table. The solution requires accessing simultaneously a number of competing meanings in disparate semantic domains. Other tasks correlated with positive schizotypy include generating as many words as possible beginning with a given letter, completing a partial diagram in as many ways as possible, or generating as many different or original instances or uses for a stimulus as possible. Thus schizotypes seem, from multiple perspectives, to represent the workings of an active imagination.

COGNITIVE MECHANISMS IN SCHIZOTYPY

It has long been known that schizophrenia patients show a marked impairment on tasks where one source of information has to be ignored and another attended to. They show more intrusions and interference from the ignored channel in dichotic listening experiments than controls (Wishner and Wahl 1974). This has been interpreted as a defect in the mechanism that limits the flow of information into conscious awareness to that which is the current object of attention. However, the account could just as easily be framed in terms of an inherently low binding selectivity of specialized processing mechanisms.

Support for this view also comes from various types of priming experiment. In normal volunteers, pre-exposure to a word such as DOG decreases reaction time to recognize a word such as CAT. There is some evidence that in schizophrenia patients and in schizotypes, this priming is abnormally quick and potent (Spitzer *et al.* 1993, Evans 1997). Of particular interest here is the suggestion that the performance of some patients is particularly enhanced compared to controls when the semantic relationship between prime and target is indirect, as in LION-STRIPES (Spitzer *et al*. 1993). The priming seen here is best explained by the prime activating the representation of TIGER, which activates the representation of STRIPES. One is tempted to say that this is a rather imaginative association, and the schizotypal enhancement presumably arises from their semantic representations interacting rather more freely than in controls. Schizotypes judge two loosely associated words to be more closely related in meaning than controls do (Mohr *et al.* 2001), though their associations do not become completely indiscriminate.

Priming can also be negative. In general, subjects show a reaction time *increase* to name a word when, in the previous phase of the experiment, they have had to ignore the same word. This is presumed to occur because in the 'ignoring' phase, the representation of the stimulus is inhibited, and this inhibition has then to be overcome when, in the next phase, the same representation needs to be accessed. High schizotypes, however, show reduced inhibition (Beech and Claridge 1987; Beech *et al.* 1989). If anything they show some facilitation from having seen the word before. When the ignored word in the priming phase is semantically related to (rather than identical to) the word they then have to name (e.g. CAT–DOG), high schizotypes are clearly facilitated, whereas low schizotypes are inhibited (Beech *et al.* 1991). The best interpretation of these effects is that streams of processing that should be inhibited by attentional set are not inhibited in high schizotypes; instead, multiple processing streams remain active and can affect each other.

The core feature of schizotypal cognition thus has been described as 'an inability to exclude from intrusion into consciousness material from either external stimuli or internally stored associations . . . [which would be] normally excluded because of their irrelevance to ongoing activity' (Maher 1983). The positive symptoms of psychosis, delusions and hallucinations, are of course the examples *par excellence* of this leaky filter (Frith 1979). The view can be rephrased in the terms of Barrett's cogzyme model. Schizotypal cognition, then, involves a broader range of interactions between mental representations and cogzymes than would otherwise be observed, and consequently there is a broader set of cogzyme–representation pairings, both above and below the level of consciousness.

Priming effects related to schizotypy occur at very fast presentation speeds, when the participant may not even be consciously aware of the prime (Beech *et al.* 1989). In the indirect priming example, the semantic circuit for LION should not, in a sense, activate the meaning of STRIPES. Semantic activation should spread laterally only a small distance, and be subject to sharp inhibition beyond this. The alternative is a world of chaotic and numinous associations. However, in schizotypy, the leakage or facilitation of part-connected semantic representations is super-normal. The negative priming and dichotic listening examples can be interpreted in the following way. Attention should inhibit certain specialized and automatic processing streams (for reading or monitoring a sound source, for example) when they are not useful to the current task demand (which is to ignore them). However, in schizotypes, these inhibitory processes are reduced in effectiveness.

This formulation explains perfectly the double dissociation with schizophrenia patients in divergent versus convergent tasks. They are relatively impaired when they have to follow an experimenter's criteria for sorting items/cards into groups or categories, and relatively enhanced when they have to come up with their own idiosyncratic ones. They are impaired on IQ tests, but have an advantage on the novel uses task. Increasing the number of cogzyme–representation interactions is bound to reduce the efficiency of a convergent task in which only one interaction is actually needed. On the other hand, it will increase the fecundity of precisely that set of tasks where it is the number or richness of different interactions that is measured—namely, tasks of divergent thinking. It also explains some of the brain imaging findings with respect to schizophrenia. Imaging studies have reliably found differences in activity in the schizophrenic and non-schizophrenic brain. However, the nature of the difference depends very much upon the task. No single area reveals itself as consistently hyper-active or hypo-active. Instead, there is a marked tendency for multiple areas to remain active in the patients, even in tasks which in normal subjects would shift the locus of activation to one particular (specialized) brain region. Thus, the underlying abnormality may be one of how a whole circuit of brain regions allocate their activity appropriately for a given situation (Andreasen *et al.* 1998).

Given that we have defined the essence of imagination as a mapping of meaning between dissimilar domains, and taking schizotypy as a model of the imagination at its most productive, we can thus define imagination as the often simultaneous interaction of multiple cogzyme–representation pairings.

CONCLUSIONS: IMAGINATION AS LOW BINDING SELECTIVITY

We have examined some evidence for a tentative hypothesis that the cognitive basis of the imagination is enhanced cross-talk between different specialized processing types. The psychological effect of this cross-talk is an enhanced ability to process one type of thing as if it were another, or to make semantic links between apparently unrelated entities. Some caveats are in order, though. Many of the experimental examples reviewed, such as semantic priming or dichotic listening, have concerned lateral activation and inhibition *within* the same processing domain (word meaning or hearing). The examples of imaginative thought we have reviewed concern making a mapping *between* quite different domains, for example, seeing people as physical systems, or language as non-linguistic sound. It would be illuminating to investigate whether high schizotypes are enhanced on a task where a problem normally allocated to one domain has to be processed using another. If schizotypy is related to some general systemic property of the brain, then within-domain fluidity may correlate with between-domain fluidity, but this has not yet been demonstrated.

To return to the overall picture of cognitive architecture presented at the outset, it is clear from this view that imagination is neither a domain-specific process itself, nor a domain-general capacity that operates on the output of domain-specific processes. Instead, it is a product of incomplete informational encapsulation between processes that themselves show evidence of specialized design. In other words, specialized mechanisms show lowered or incomplete selectivity for particular types of information.

Steven Mithen may well be right (Mithen 1996) to argue that the key to the truly modern human mind was not the addition of new specialized abilities but the partial breakdown of the barriers between the existing ones. This is generally viewed as a highly adaptive change, permitting a flowering of new creative behaviours and innovations. However, it is worth remembering that all evolutionary changes have costs as well as benefits. The effective insulation of different cognitive processes from each other has functional advantages in terms of the convergent efficiency of those processes within their proper domain. The breakdown of separation between them may reduce their efficiency, and lead to some other non-adaptive results. For one thing, around 1% of the human population, those individuals, perhaps in which the binding selectivity is lowest, is afflicted by socially and practically impairing psychotic illness. More generally, the breakdown of processing separation between natural history, intuitive physics, and social cognition has some odd and not necessarily functional consequences. Most human beings believe in supernatural agents whose desires and intentions affect natural forces; many believe in astrological systems whereby natural cycles affect human motives;

many believe in telepathy, animism, shamanic possession, or Cabbalistic speculation. These strange cross-modal beliefs—in which implausible associations between events in one domain and consequences in another are considered as real—may reflect a real cost of the low binding selectivity mind. What the compensatory benefit may be is beyond the scope of this paper, but whatever it is, it has been sufficient to allow *Homo sapiens,* the imaginative ape, to dominate the globe in a manner achieved by no other primate.

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