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Computers, Persons, and the Chinese Room. Part 2: The Man Who Understood

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This paper is a follow-up of the first part of the persons reply to the Chinese Room Argument. The first part claims that the mental properties of the person appearing in that argument are what matter to whether computational cognitive science is true. This paper tries to discern what those mental properties are by applying a series of hypothetical psychological and strengthened Turing tests to the person, and argues that the results support the thesis that the Man performing the computations characteristic of understanding Chinese actually understands Chinese. The supposition that the Man does not understand Chinese has gone virtually unquestioned in this foundational debate. The persons reply acknowledges the intuitive power behind that supposition, but knows that brute intuitions are not epistemically sacrosanct. Like many intuitions humans have had, and later deposed, this intuition does not withstand experimental scrutiny. The second part of the persons reply consequently holds that computational cognitive science is confirmed by the Chinese Room thought experiment.

Keywords: Chinese Room, psycholinguistics, Turing test

The debate about the Chinese Room Argument is one of the most prominent lines of inquiry for computational cognitive science. Positions around this argument consolidated quickly since Searle introduced it in his classic 1980 “Minds, Brains, and Programs,” and it might now appear that everything has been said for and against the argument, leaving interested parties with the task of merely choosing from the available positions. Earlier, I provided, however, new arguments against a central thesis of key responses to Searle’s thought experiment, from which one of the two central theses of the persons reply emerges (Restrepo, 2012a). By depicting a person implementing a program for understanding Chinese who “undoubtedly” does not understand Chinese, Searle aimed to show that the

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theory of computational cognitive science is false. Computational cognitive science theorises that some computations by themselves are sufficient for having certain mental properties. So if Searle is right that the Man implements the computations at issue but does not have the mental properties in question, then computational cognitive science cannot be correct.[1] Searle's main detractors have all claimed that the mental properties of the Man who figures in the argument are irrelevant to whether computational cognitive science is true or false. The first central thesis of the persons reply is that this is not the case. It sustains that the key arguments of Searle's main detractors have significant holes, that there are sufficient reasons emanating from our conceptions of what a computer is to think that the Man is the Computer whose mental properties matter to whether computational cognitive science is true or false, and that to deny this renders an important portion of psychological theories unverifiable. In this regard, the persons reply provides a new way of siding with Searle's much-questioned stance on this issue. However, neither Searle nor virtually any of his detractors question that the Man does not in fact understand Chinese when he implements the program for understanding it. But if the first thesis of the persons reply is correct and the Man does not understand Chinese, then computational cognitive science must indeed be false. Abelson (1980) was the notable exception to having accepted the view that the Man does not understand Chinese. The thought Abelson had, however, has been largely ignored and has remained far from fully developed, explored, and justified. This paper aims to fill many of these gaps in order to develop the second thesis of the persons reply.

The persons reply takes Searle's claim to heart that cognitive scientists should uphold scientific realist standards and be "interested in the fact of . . . mental states, not in the external appearance" (2002, p. 61). With this focus in mind, the Man in the Chinese Room is taken to be a participant in an experiment designed to test computational cognitive science, and the external appearances are taken as mere symptoms of their inner causes. Experimentally structured appearances are the empirical basis of scientific knowledge, and the present paper aims to bring this basis to judgments on the supposed understanding or lack of understanding of the Man in the Chinese Room. If the Man provides robust experimental evidence that he understands Chinese, then we can say that he understands Chinese and computational cognitive science is confirmed. If the Man, on balance, displays evidence that he does not understand, then it would be correct to say that the Man does not understand, and that computational cognitive science is false. The result of applying this elementary scientific realist method, I will try to demonstrate, is the second thesis of the persons reply: that the Man mentioned in the Chinese Room Argument understands Chinese when he implements the

[1]Formalizations of both the Chinese Room Argument and computational cognitive science are found in Restrepo (2009, 2012a).

program for understanding Chinese, and consequently, that computational cognitive science receives confirmation. I must note from the beginning that not all evidence for or against a scientific theory is of equal strength, and that there may be consequences of a correct theory which are not at all intuitive. The proposed theory is no exception. However, what matters in theory choice is that the balance of evidence is distributed more heavily toward one theory rather than the others. Evidence is the data of how things seem to be. Theory choice is determined by putting all the available data together and seeing what, on balance, they are more likely to be an appearance of. In the following discussion, there will be evidence of varying degrees of strength, and no one piece of data is definitive. The cumulative effect, however, is robust support for the persons reply.

In a certain sense, we know from the outset what the result of a battery of tests applied to the Man will be. After all, it is known by hypothesis that the Man is computationally and behaviorally identical with a genuine Chinese speaker, so he will, in tests, perform indistinguishably from such a genuine speaker of Chinese. However, I believe applying the tests reveals details of the implication of this supposition which are otherwise obscured. Applying these tests shows how contrary to scientific realist expectations it is to suppose that the Man behaves as he does under the experimental set-up, while not understanding the target language. The tasks are not trivial and the way in which the Man performs, quite plausibly requires picking up the semantics of the Chinese symbols. Like in a psychological experiment operating with random participants to detect their psychology, the proposal is to take the Man to be a random participant in an experimental environment designed to see what can be learned about his linguistic psychology.

It should be noted that implementing the experimental set-up immanent in the Chinese Room Argument is practically impossible. The Man would have to be moving around the Room, reading and writing much faster than a normal human ever could, in order for his computational actions and deliverances to be indistinguishable from those of a genuine speaker of Chinese. Estimates of the computational power of the brain (in this case, one that understands Chinese), would indicate this, since they range in the astronomical.[2] Nevertheless, we can ask, what would the application of a battery of tests designed to test the

[2]For an index of estimates of computational powers of brains see Sandberg and Bostrom (2008), Appendix A. For illustration: Dix (2005) calculates that a brain with 10 billion neurons could perform 10^{16} computational operations per second (given many assumptions). Perhaps the operations of the Man, corresponding to his Chinese simulation activity, would comparably correspond to the work performed by 10 billion neurons in the brain of a Chinese speaker (a fraction of his total number of neurons). Supposing the Man used all his capacity and each operation (conservatively) corresponded to one centimetre in the movement of his body, he would move 10^{11} kilometres each second, which is significantly faster than the speed of light.

theory that the Man understands Chinese tell us about the psychology of the Man? We can perform experiments on the Man as we would on any other person to ascertain the properties of her psychology. The hypothesis proposed here is that the performance of the Man in the envisaged experimental set-up would lend evidence to the theory that he does what a human does in virtue of which she understands.

I would like to make available to the ensuing discussion a version of the Chinese Room Argument in which the relevant languages are switched. Suppose, instead of the Man being an otherwise monolingual English speaker, that the Man is an otherwise monolingual Chinese speaker. The Chinese Man enters the Room, which contains baskets of English symbols and a rule-book, which the Man uses to manipulate the symbols in accordance with the program for understanding English. The resulting version of the Chinese Room Argument preserves all its relevant logical features. Call this resulting argument the *English Room Argument*. The same relevant question can be put forth. Does the Chinese Man understand English? If the Man in the English Room Argument understands English, then the Man in the Chinese Room Argument understands Chinese. The two are in exactly analogous positions.

One reason I make this version available is for expositional ease. The experimental research in psychology to be applied was conducted in English, and readers of this present paper speak English, while infrequently speaking Chinese, so it makes sense to use the common symbols we ourselves recognize. Perhaps more importantly, I make this version available because it might help deconstruct misleading presuppositions I believe drive the intuition that the Man does not understand the language he computationally simulates. Consideration of this version might lend greater reliability to judgments about whether the Man understands the language he simulates. It is to be expected that we are better at telling the difference between a person who understands and one who does not understand a language we ourselves understand, than at telling the difference between a person who does not understand and a person who does understand a language we ourselves do not understand. The English Room Argument eliminates the possibility of basing the judgment that the Man does not understand Chinese on our own condition. Because most people in the debate over the Chinese Room Argument do not understand Chinese, to most people in this debate, Chinese symbols look meaningless. In fact, this is why Searle has substituted them for combinations of SQUIGGLE SQUOGGLES. But the fact that Chinese symbols look meaningless now, without running the program for understanding Chinese, does not imply that under the conditions supposed by the Chinese Room Argument, we would not understand. We might very well change our view that we do not understand Chinese were we to be running the program. This would not be more surprising than the fact that if some movements of molecules in our brains were changed, we would understand languages we don't currently understand and we would have conscious experiences we don't currently enjoy.

The Man Can Disambiguate Symbols that Look the Same

A key feature of understanding the semantics of a language is the ability to disambiguate polysemous symbols. Can the Chinese Man do this with English symbols? Let us look at some disambiguation tasks. The symbol for financial banks and for the sides of water systems has the same shape: "banks." One way to tell whether the Chinese Man can disambiguate the symbol is to see whether he reliably uses the symbol appropriately. If the Man does not, then this lends credence to the idea that he does not understand, and if he does, then this supports the idea that he does understand English.

Suppose the Chinese Man received the set of symbols "Let's go sailing at the bank." A genuine English speaker would answer "Cool, let's do it" or "I don't want to get wet in that cold water," for example. So would the Chinese Man. Like the genuine English speaker, the Chinese Man in the English Room Argument would not output symbols like "That's crazy. The bank guards will kick you out, thinking you are a menace to the safety of the clients."

The Chinese Man is supposed to be behaviorally indistinguishable from a real English speaker. Minimally, normal persons would exhibit appropriate verbal behavior requiring the disambiguation of polysemous symbols like the present one. One could also ask the Chinese Man directly, "What is the meaning of 'bank'?" This question would be on a par with any other normal question that could be put to him, which would be answered as an authentic speaker of English would. Given that he is behaviorally equivalent to a true speaker of English and that his rule-book is complete, he could answer something like this: "There are two meanings of 'bank.' One refers to the sides of water systems and the other is about institutions where people keep money and take out loans."

On the flip-side, suppose someone asked the Chinese Man the same question in Chinese (maintaining the "bank" symbol in English), his otherwise only language. We can expect him to answer appropriately. In line with Searle's design, what would enable him to say this is that the rule-book would contain a complex set of commands such that if asked for the meaning of "bank" he would be guided to say things like the mentioned response example. Further, understanding the semantics of symbols provides us with the ability to make correct inferences. Take, for example, the following inference:

1. All banks are financial institutions.
2. All banks are along the edges of waterways.
3. Therefore, all banks are financial institutions along the edges of waterways.

We all agree that the premises are true and the logical syntax seems to be validly applied. But this, however, by no means convinces anyone committed to the premises that they are committed to the conclusion. Rather, it is easy to respond that the word "bank" is being used in different senses and that consequently, the truth of the premises, under the plausibly true interpretation, does not logically imply the conclusion. The Chinese Man would respond to such an argument in an equivalent way.

Consider another example. Read closely the story of *The Wrestler*:

> Rocky slowly got up from the mat, planning his escape. He hesitated a moment and thought. Things were not going well. What bothered him most was being held, especially since the charge against him had been weak. He considered his present situation. The lock that held him was strong but he thought he could break it. (Anderson, Reynolds, Schallert, and Goetz, 1977, p. 372)

The passage seems clear. In understanding it, certain computational channels are activated in readers, and certain inferences can be drawn from it which enable readers to answer questions. Like other readers, the Chinese person would be able to answer the question of who the wrestler in the story is: Rocky.

But now, answer the following question with respect to the text: "Who is the inmate?" Your answer is probably something like this: "There are no mentioned inmates in the text — there is a wrestler, not an inmate!" The Chinese Man would answer the same. Now read the passage again with close understanding and think of it as a description of a prison escape, titling it *The Prisoner*. Here too, there is a clear and distinct meaning, which will be associated with the activation of another computational passage and other behaviors. Now you can answer the question above: "Rocky is the inmate." The Chinese Man would exhibit the same response patterns.

Intuitively, without much theory in place, the Chinese Man's competence at respecting the semantic boundaries and conditions of application of symbols that look the same is some evidence that the Man really understands the semantics of the text at issue. Now, take the structure building framework theory of understanding (Gernsbarcher, Varner, and Faust, 1990). Perhaps this specific psychological theory is correct, and perhaps not. Let us, for a moment, suppose that it is right, as a proxy for whichever is truly correct. The structure building framework theory says that we understand a text by establishing a frame or structure onto which new information is mapped. If we do not map the information, we build a new structure onto which further information can be mapped. The behavior of an unquestionably genuine English speaker (you, in this case) would be explained by structure building framework theory: the two instances of reading the text about Rocky had titles which established distinct general subject-matters or "structures," onto which the rest of the narrative was mapped. Before reading the passage under the title of *The Prisoner*, the subject relevant to the subsequent question was not aptly fixed, and thus, the reader did not know what prisoner was being inquired about. The structure building framework theory could explain the pattern of your behavior; and since the Chinese Man displays the same pattern of behavior, there is a prima facie case that he understands English through similar mechanisms.

Whichever theory of understanding truly explains your lexical disambiguation behavior patterns, it will posit mental properties which would seem to similarly explain the Chinese Man's behavior patterns. Thus, given that your understanding explains your behavior, the Chinese Man's understanding would similarly explain the Chinese Man's behavior.

The Symbols Seem to Elicit Comprehension-Mediated Responses

A key feature of the human mind is that it has a set of concepts with semantic contents, whose relations help humans remember, perceive, and orient themselves in their environment. The degree of strength of the semantic relations between concepts varies. Semantic priming is a mechanism hypothesized to be one by which this web of ideas operates (Neely, 1976; Whitney, 1998, pp. 92–93). The basic mechanisms posited by the theory of semantic priming are the facilitation and the inhibition of the processing of incoming information depending on their semantic ties. For example, in a lexical decision task, a person decides as fast as she can whether a second string of letters is a word. The person might be shown the string ROBIN or XXXX, and then BIRD. BIRD is obviously more semantically connected to ROBIN than to XXXX. Persons are consistently faster at deciding whether BIRD is a word when the first shown string is ROBIN than when the first string is XXXX. There is a facilitation effect from ROBIN to BIRD; the person is semantically primed for BIRD. Glenberg (1997) suggests that semantic priming is an instance of the operation of a mesh, where a mesh is the encoding of possible interactions between our embodied selves and the rest of the world. Further, in Glenberg's scheme, a person's understanding of a lexical item crucially involves the person's encoding of a set of actions that might be taken in response to the reference of meaningful fragments. Glenberg believes that such a conception erases some of the experimental embarrassments of the theory of semantic priming. In particular, semantic priming theory is challenged by evidence showing that priming may be due to non-permanent links, as early semantic priming theories denied (Glenberg 1997, p. 14 cites McKoon and Ratcliff, 1986) and that priming is observed between strings which are not related by their presumed semantics (Glenberg, 1997, p. 14 cites Shelton and Martin, 1992).

Nevertheless, whether semantic priming is true as originally envisaged or as envisaged by mesh theory, it still involves mental structures which have semantic content in that it involves mental structures *about* the way the world is, and it is the relations between items in those mental structures which drive the observed priming effects. With this in mind, the operation of a mesh is itself the operation of a semantic relation — that is, the operation of a relation between elements with intentionality in a mental structure. Glenberg simply has a particular conception of the semantics of such mental structures, with an emphasis on perception and action.[3] Further, the effects of semantic priming are in response to observed strings of lexical items. People who understand a language need to have appropriate links between their lexical items and their mental structure in order to generate the observed responses.

The response times the Chinese Man would display would be indistinguishable from those of an authentic English speaker. In fact, all observations relevantly made in the semantic priming literature and the mesh literature will be observed in the Chinese Man, because as Searle supposes, the two are behaviorally identical. The hypothesis that these cases are explained by the idea that the Chinese Man, like other humans, has a mental structure representing the world, including himself, that mediates between his different observations and responses, should not be underestimated. The degree of detailed symmetry in expected responses between the Chinese Man and those of a genuine English speaker is impressive.

The Chinese Man Seems to Form an Intentional Mental Representation

A core feature of a person who understands a meaningful declarative text is that she forms an intentional mental representation of what the world would be like if the text were true. There is a consensus among psychologists that there are various stages in text processing, each stage dealing with a distinctive aspect (Whitney, 1998, p. 259), and at some point in the processing of a text, the reader forms a mental representation of what the sentence is about. This is a common understanding amongst neutral, nativist, and non-nativist views of language. Thus, truth-conditional semantics (e.g., Frege, 1879), conceptual semantics (e.g., Jackendoff, 1992), and cognitive grammar theory (e.g., Lakoff, 1987) accept this. It is also accepted by minimalist and constructivist theories (e.g., Kintsch, 1988, 1992; McKoon and Ratcliff, 1992). Minimalism theorizes that understanding a text involves conceptual connections with structures close to the form of the text itself and involves minimal connections to information from areas of the mind which are not specifically linguistic. The constructivist view takes it that the use of areas not specific to language is an important part of understanding. The mental representation studied within these theories would

[3]In psychology, "semantic" and "episodic memory" are typically distinguished. The intended use of "semantic" here primarily involves the philosopher's notion that an item of memory has semantics if it has referential meaning. This philosophical notion is akin to the psychologist's declarative memory.

seem to be the one in which Searle (1980) is interested. Whichever theories in this domain turn out to be true, the Chinese Man would provide equal experimental evidence for them as any English-speaking person would. Here is one example of the kind of evidence that might be put forth:

> Roger broke up with his long-time girlfriend and moved in with Gail. The ex-girlfriend is quite upset and is trying to win Roger back and convince him to leave Gail. He'd left her for Gail before, she thought, and he might leave Gail for her now.
>
> Roger was invited to a party with old friends, and was happy to see Haruna, Elizabeth, Emily, Matt and Sagar. Gail, however, could not go to the party as she was feeling sick, so she stayed home. Roger, on the other hand, having a better time than expected, stayed until late. When he arrived home, Gail was distressed and asked "Tell me the truth. Was *she* there?" (adapted from Whitney, 1998, pp. 245–246)

Now, in Gail's question, who is *she*? You and everyone who understands the passage knows who it is: the ex-girlfriend. The Chinese Man would respond just as you would. This is quite surprising if he does not understand what is going on.

The Man in the Chinese Room Argument Seems to Know the Reference of the Symbols

Let us consider the original Chinese Room Argument again. Experimenters might want to determine whether the Man has the capacity to match Chinese symbols to the things to which they refer. If he could, this would support the claim that the Man is picking up the referential meaning of the Chinese language. Thus, they might ask the Man, in English and in Chinese on different occasions, to identify a 笔 (which means PENCIL). The experimenters would find that in both cases the Man will identify a pencil, for example, by pointing at one or by saying in Chinese, or English if required, that it is the object in his hand with which he writes. The Chinese Room Argument asks us to suppose that the Man is behaviorally equivalent to a man who understands Chinese. Thus, when the Man is asked in English, he will look in his rule-book and find a command taking him from his wish to identify a 笔, to the identification of a pencil. Commands will enable him to answer appropriately.

Someone outside the Room might hand the Man a pencil and ask him to say what it is in Chinese. Some might be surprised to know that he would answer correctly, with the 笔 symbol. How can this be? The answer is that if the rule-book is complete, the Man's behavior in response to the question will be based on a command functionally equivalent to "If asked to name a pencil in Chinese, output 笔." This is so whether the question is asked in English or Chinese. The Chinese Room Argument already supposes that while the Man computes and behaves as a person who understands Chinese, he speaks English, for this is the language in which the rule-book is written.

Another evidentially relevant case is one in which experimenters tested the Man's ability to apply color terms correctly. The conscious experiences associated with colors are a key aspect of our understanding of color terms. The conscious experience associated with each color determines the semantics of our color terms and are a key aspect of what enables us to apply them correctly. Does the Man apply color terms correctly?

Let us focus on the English Room Argument version to look at this potential experiment. Experimenters could ask the Chinese Man (in English or Chinese) to identify green, orange, magenta, red, and black items in the Room. The Chinese Man is behaviorally equivalent to a man who really understands English. A man who genuinely understands English would, under normal circumstances, be able to identify green, orange, magenta, red, and black objects. The Chinese Man would be enabled to find and differentiate the differently colored objects by a command in the rule-book which would instruct him, like in the PENCIL case, to identify objects of the desired color. For example, an available command would be functionally equivalent to: "if asked to identify 绿色, identify green." Given that he can identify green things just as he can visually identify the symbols, this should not be a problem.

Naturally, this surprising ability of the Chinese Man in the English Room Argument lends credence to the hypothesis that he understands English. The Chinese Man consistently applies the term "green" to green items; as with the rest of the terms and the colors to which they refer. Further, the Man does this in quite a flexible and fine-grained manner. Consider Heider's (1972) classic refutation of a strong version of the Sapir–Whorf hypothesis (Hunt and Agnoli, 1991). According to this version of the theory, we cannot cognize outside the basic categories of our language. Heider studied the Dani tribe in New Guinea, which has only two basic terms to name colors. Heider showed people of the Dani tribe chips of one color (say, focal red). Sometime later she showed them chips of many colors, including a shade of the previously shown color (say, an off-shade red), and asked them what color she had showed them before. The Dani, like English speakers, remembered focal colors better than off-shade colors, and distinguished between colors for which there was only one basic term. The Dani understood that each of their terms could refer to various kinds of colors, even if they were grouped together under one term.

Similarly, the Chinese Man might be shown a focal red chip at one time, and subsequently be asked, in English and in Chinese on different occasions, to identify chips with the same color. Like the Dani, the Chinese Man would reliably identify the chips with the correct color. This suggests that the Man understands that there are various colors to which "red" applies and knows which colors those are. This is an important part of understanding the meaning of "red." The task normally requires appropriate interactions between a person's perceptual, linguistic, and mnemonic systems, which is part of what enables people who understand a language to understand it.

A "Psychological Version" of the Turing Test

The Turing test is a recognized high-standard test designed to detect the existence of a target entity's intelligence. Originally, it was meant to be applied to an artificial machine, and involved the idea that if a non-expert person could not tell the difference between when she talked with the machine or with a human being, then the artificial machine would have provided sufficient evidence to conclude that it thinks. In the Chinese Room Argument, the Man takes the place of the artificial machine. The Man is behaviorally indistinguishable from a man who genuinely speaks Chinese. Thus, the Man passes a highly demanding test for understanding Chinese, one which no artificial computer has ever passed.

As Copeland (2004, p. 435) notes, there is evidence that Turing did not intend to *define* thinking in terms of the ability to pass the imitation game, which has come to be known as the Turing test. Rather, Turing intended to set it up as a sufficient condition. However, it is not true that no textual evidence exists that Turing intended to give a behaviorist definition of thinking since Turing explicitly stated that he wished to *replace* the question of the possibility of a thinking machine with the question of the machine's ability to be behaviorally indistinguishable from a person questioned by an interrogator under the conditions of the Turing test (Turing, 1950/2004, p. 441; cf. Copeland, 2004, p. 435). Out of a general scepticism about the ability to speak meaningfully about such inner "unobservable" states, behaviorist definitions of mentality were in vogue in Turing's day (see for instance, Hempel, 1949). Turing also claimed that the question, "Can machines think?" would be too susceptible to be analyzed and answered by a Gallup poll, which he considered absurd. However, this argument is like saying that the question of whether the Earth orbits around the Sun should be replaced by the question of whether an observer would see the position of the Sun as would be expected if the Earth orbited around it, because the former question would be answered by a Gallup poll, which would be absurd. The argument as a whole is not convincing.

The correct form of the argument is, in my view, that a machine's ability to pass the Turing test constitutes significant evidence that the machine thinks, just as an observer's seeing the systematic position of the Sun from the Earth as if the Earth orbited around it is strong evidence that the Earth indeed orbits around the Sun — Gallup polls and replacements of questions being irrelevant.

Let us, however, raise the bar; let us test whether the Man passes more exacting versions of the Turing test next.[4] Unlike what is allowed in the original Turing test, suppose a psychologist took the role of the interrogator. She might want to try distinguishing the Man by adding experimental conditions used to identify the ways in which a person who truly understands does in fact understand. For example, she might perform Chinese versions of the tests relevant to language understanding of the kind we considered above. The entity that performs outside the norm would be identified as the Man, and consequently, the Man would not pass the psychological version of the Turing test.

The problem is that the Man is, by hypothesis, behaviorally equivalent to a real Chinese speaker, and consequently would pass this version of the Turing test. The Man would display in minute detail the behavioral grounds which would justify the attribution of Chinese understanding to genuine Chinese-understanding humans. Timing provides insight into various aspects of the processing characteristic of understanding and is consequently used in various psychological experiments. Here also, the Man would display the same timing as someone who was processing in the way human understanding exhibits (cf. Dennett, 1987).

French (1990), however, thinks an artificial computer could not show such timings. Considering the lexical decision task used to detect semantic priming, for concreteness, he states:

> The machine would invariably fail this type of test because there is no a priori way of determining associative strengths . . . . Virtually the only way a machine could determine, even on average, all of the associative strengths between human concepts is to have experienced the world as the human candidate and the interviewers had. (cited in Copeland, 2000a, p. 535)

Mutatis mutandis, it might be argued that the Man could not display those timings either. But the argument is weak. For one, the associative strengths are part of

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[4]Notice, however, that the issues of thinking and relevantly, of understanding, are still in question. To try to deflect the force of the Chinese Room Argument by saying that Searle is "merely exploring facts about the English word *understand*" (Pinker, 1997, p. 95) is as convincing as being told that finding a place where there is no light but there is electromagnetism does not refute the electromagnetic theory of light because we are just exploring the stereotypical meaning of the word *light*. There are four possible explanations of such a scenario compatible with the truth of a version of the electromagnetic theory of light: (i) to the contrary, that in such a putative case there is light, but it is just that there is not enough or of the right frequency for us to see; or (ii) that, in fact, there is no electromagnetism in the supposed place; or (iii) that "light" refers to the visible portion of electromagnetic waves, and that consequently, electromagnetic waves of the different kind present in the case at issue are not of the relevant kind; or (iv) a combination of the above. Otherwise, the electromagnetic theory of light would be refuted (compare Churchland and Churchland, 1990; Turing, 1950/2004; Turing, Braithwaite, Jefferson, and Newman, 1952). By hypothesis, in the Chinese Room Argument there are the right kinds of computations implemented, so if there is no understanding, the computational theory of mind is refuted. Pinker simply fails to address Searle's challenge.

the computational dynamics a Chinese speaker displays. On the supposition that a machine could mimic the computational processes of the Chinese speaker, the maker of the machine would link various symbols to other internal processes functionally equivalent to their mental semantics, and not to others. French proposes his "limit" on the Turing test on the basis of the idea that semantic associative strength could not be determined by something other than having had certain human experiences, which by hypothesis the machine has not had. But by that reasoning, no machine could ever pass the original (without an expert interrogator) version of the Turing test, since the machine would have to display behavior normally determined by having had certain human experiences, which by hypothesis, the machine has not had. By French's standards, the fact that a machine has not had the human experiences which normally enable a human to think and understand certain things prevents the machine from making associative semantic links. By this standard, the machine could not even generate a credible answer to the relatively undemanding question "How was your morning coffee?" because it has never had a morning coffee, which must, in my view, be wrong. A psychologist interrogator in the Turing test would not reliably be able to detect the Chinese Man. Consequently, the Man would pass a very demanding Turing test for understanding Chinese.

The "Mathematical Version" of the Turing Test

Penrose (1990, 1994) has been a consistent critic of computational cognitive science precisely because Gödel's and others' results indicate that the outputs of mathematicians are different from the outputs of Turing machines, and that consequently, people are not computers. Suppose Penrose spoke Chinese and was the expert interrogator. He might inquire into whether the people in the other rooms could arrive at uncomputable results, using Chinese symbols. The person who cannot is the Man. He might say to them in Chinese, "tell me whether *pi* has a last decimal." Both respondents would answer the same: "否" (No). Most people have not worked this out in detail, but take it on authority that this is so, or use mathematical induction after a sufficiently high, but finite and Turing-computable, number of checks. Similarly, the Man would have encoded or processed equivalent information. Why should we have a higher standard for the Man?

On the other hand, suppose Penrose was the interrogator and Gödel was the other person in one of the rooms. Gödel is well-known for proving that there are some mathematical truths which cannot be proved by a finite set of rules. Turing's (1936/2004) work itself involved this claim, and addressed it as the Mathematical Objection (Piccinini, 2003; Turing, 1950/2004). Perhaps Penrose would be able to differentiate (a Chinese-speaking) Gödel from the Man. The standard of such a test was pointed out by Max Newman in his discussions with

Turing and others (Turing, Braithwaite, Jefferson, and Newman, 1952, p. 505). If we add Newman's standard to that of the Turing test, we get the Mathematical Version of the Turing test.

But the fact that Penrose would be able to differentiate the Man from Gödel should prove nothing. First, Penrose would be able to differentiate Gödel from any probable genuine Chinese speaker, given Gödel's exceptional mathematical sophistication. By the considered standards, Penrose would only let a handful of people, if any, of the Chinese population pass the test for understanding Chinese. Secondly, as Copeland has noted, it might well be that a human computer is not equivalent to a Turing machine, but to another sort of computing machine Turing designed in his Ph.D. thesis: an O-machine (Turing, 1939; see Copeland, 1998, 2000b). Supposing this is so, if Penrose could design a reliable method for weeding out Turing machine-equivalent persons, and keeping O-machine-equivalent people, then perhaps this could hamper the Man's ability to pass this version of the Turing test. However, the operation of the Man in accordance with the rule-book might well be such that it allows him to instantiate an O-machine. To introduce a random element characteristic of O-machines (Copeland, 1998), the rule-book may contain an instruction of the form "If φ, then take symbols from basket 33 and 249, copy them, shuffle the copies, put them in basket 841 and pick any out." Simulating a Chinese mathematician, the Man could conceivably return the values for Turing's Halting function H (x,y) (Copeland, 1998, p. 130; Turing, 1936/2004).

The "Interactive Version" of the Turing Test

In the Interactive Version of the Turing test, in addition to text, the interrogator and the entities he tries to distinguish can exchange other things. For example, the interrogator may introduce a beetle, pass it to the Man and ask what it is, in Chinese. As with the case of PENCIL above, provided the Man knows that it is a beetle, the Man will be able to follow a rule which will provide him with adequate Chinese labels and descriptions as answers to questions, which will make him behaviorally indistinguishable from a Chinese speaker who also receives the beetle.

Now, suppose the interrogator introduced some unspecified objects in three boxes, kept one and handed each of the other two boxes to the other two people in the Turing test, and told them in Chinese that they will call the thing in the box a "甲蟲" (BEETLE) [cf. Wittgenstein, 1953]. Notice that if they had different kinds of objects, they could figure this out by a series of answers and questions in Chinese about whether the object is biological, its color, the number of legs it has, what it eats, whether it flies, and so forth. The Man would display a competence for communicating in Chinese and exhibit behavior equivalent to that characteristic of coming to know that he has the same kind or a different kind of object in the box as the interrogator, despite the label. The Man would pass this very stringent version of the Turing test. This is surprising if he does not understand.

The Persons Reply

The first central thesis of the persons reply is that the Man is the entity implementing the computational properties characteristic of understanding Chinese, and that consequently, the Man is the Computer whose mental properties are relevant to the testing of computational cognitive science (Restrepo, 2012a). Exploring the considerations that warrant this judgment and the apparent relative weakness of the rationales of the opposing view, the persons reply is in sharp contrast to the logical (Copeland, 2002) and systems replies (Block, 1980, 1995, 2002). Although Searle does not use the same arguments as the persons reply, we agree on this. We also agree that there is a real and important question of whether the Man understands Chinese (cf. Pinker, 1997).

Scientific realism implies that scientific inquiry is a reliable truth-seeking operation. The methods of science are particularly good at telling us about nature and its causal structure. Knowledge of the causal powers of different types of things differentiated by the sciences is what enables us to increasingly explain and predict nature, as well as to create new technology. Psychology has its own way of sorting elements in nature, which focuses on the properties and causal powers of the things in which it is interested: mental things. This involves the claim that some properties of things are relevant to psychology and some are not. For example, thinking is an interesting property for psychology, and to it there corresponds a characteristic set of causal powers. The brain might have the consistency of cold porridge, but in trying to duplicate the properties and causal powers of the brain which are relevant to psychology, duplicating the consistency of cold porridge is misguided (see also Restrepo, 2012b; Turing et al., 1952, p. 495). It is thinking that we are interested in.

There is an important class of properties and causal powers which are hard to directly observe and interpret. Having a negative charge, being radioactive, various aspects of other people's and even our own mental lives are not directly epistemically accessible. However, we do have reason to believe various things have a negative charge, are radioactive, other people have thoughts, and we have various psychological properties we are aware of and others we are not. A particularly good way of discovering these things is through experimental methods, which help filter out the properties we are not interested in and provide us with results that can give us reason to know the character of those properties and causal powers of interest. In the case of the Man, the experimentally selected external appearance Searle demeans is important because it gives us evidence of the internal structure which gives rise to it. The best explanation for the explanatory, predictive, and technological success of well confirmed scientific theories is that they are (approximately) true. The theory that the Man understands Chinese receives robust confirmation from all of the psychological and artificial intelligence tests performed on him, and we are consequently warranted in believing its truth, which is the second thesis of the persons reply. Given that the theory of computational cognitive science successfully overcomes the experimental risk represented by the Chinese Room scenario, this foundational theory itself receives confirmation from the proposed proper understanding of the Chinese Room Argument.

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A Theory of Hemispheric Specialization Based on Cortical Columns

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Hemispheric function specialization and associated neuroanatomical characteristics have been a topic of interest for many years. In this regard, mechanisms of cortical processing and memory storage have proven elusive. The current paper proposes that a model of cortical processing based on the column has the potential for explaining laterality of function and memory. Memory formation is defined as the strengthening of synaptic connections in any given circuit of cortical columns, while forgetting is defined as weakened synaptic connections with failure to activate downstream columns in any given circuit. Following a discussion of the cortical column, it is suggested that speed and quantity of columnar activation can explain laterality findings. However, several additional aspects of columnar interaction patterns must be considered to explain the regional differences within each of the hemispheres. The paper concludes with a discussion of current approaches that offer a means to test the model's validity.

Keywords: laterality, cortical column, memory, dimensional systems model

Cerebral hemispheric asymmetry of function has been the subject of research for many years using a variety of techniques (Hellige, 2002). In addition to gross structural asymmetries (e.g., planum temporale), there are indications of cytoarchitectonic and biochemical differences. However, it has recently been suggested that a more promising way to organize human cortical function is along the lines of dorsal and ventral systems. Borst, Thompson, and Kosslyn, (2011) noted that the two hemispheres seem to have redundant functions,

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with most differences appearing to be quantitative (e.g., speed) as opposed to qualitative.

The search for the neural code of processing and memory in the cortex has proven elusive. There has been ongoing debate about just how functionally specialized are the regions of the brain, with disagreement about whether only basic sensory and motor functions are functionally specialized (Kanwisher, 2010). Highlighting such controversy was a recent series of articles in *Psychological Review*. Bowers (2009, 2010) took the position that "grandmother cells" (i.e., localist model) represented a biologically plausible manner of information storage in the cortex, while this was criticized in two other papers (Plaut and McClelland, 2010; Quian Quiroga and Kreiman, 2010) as lacking sufficient explanation as to exactly how the cortex stores such information as opposed to a more distributed pattern.

In a thought provoking article, Gazzaniga (2010) provides insight as to how scientists tend to miss an important concept — the need for the correct level of explanation for understanding the mind. The article's conclusion is that the brain is a decision-making device and should be understood in those terms. Bassett and Gazzaniga (2011) provided further elaboration on investigating the complexity of the mind/brain interface. In the article, they mentioned the existence of minicolumns and columns, but offered no suggestions on the manner in which these could feasibly interact to create higher cortical functions. One of the questions posed at the conclusion of the article is "What theories need to be developed to guide further research?" (p. 208) The current paper takes the position that the theory needed is one which identifies the manner in which cortical processing occurs and memories are stored. In this case, the correct level of explanation involves identifying the binary unit (bit) and how the interconnection of those units (i.e., the brain) can lead to higher cortical functions (i.e., the mind).

The idea that the cortical column is relevant in the understanding in cortical processing is certainly a controversial issue in its own right. In their review of 50 years of research, Horton and Adams (2005) came "to the disappointing realization that the column may have no function" (p. 837). They reviewed research starting with the 1957 article by Mountcastle who originally hypothesized the column was the "elementary unit organization in the somatic cortex" (p. 430). Although Horton and Adams acknowledge the existence of columns and the numerous models which have emerged based on the concept, they emphasize that no tangible progress has been made. They believe the column has failed to be a unifying principle for the understanding of cortical function. The disappointing aspect is based on the fact that if it were possible to understand one part of the cortex which was representative of the whole, the task of explaining cortical functioning would be simplified immensely. In the closing paragraph, they suggest the column may be a "spandrel" as the term was used by Gould (1997) to describe non-adaptive structures which later in some species become harnessed secondarily for some purpose. As explained, a spandrel is an architectural term used to describe the remaining triangular space when an arch cuts through the surrounding rectangular framework. Despite being present, spandrels are functionally irrelevant.

In an opposite view, a paper by Moss (2006) proposed the dimensional systems model of cortical organization and function. It was suggested that the cortical column (macrocolumn) is the bit at which all cognitive knowledge is coded. As opposed to suggesting a single dichotomy based on identified functions, several cortical dimensions were proposed based on patterns of columnar interactions. In relation to hemispheric asymmetry, it was suggested that processing speed and the numbers of involved columns from the point of sensory input to the point of behavioral output were responsible, though there were other dimensions within each of the hemispheres. For example, the aforementioned dorsal and ventral systems discussed by Borst et al. (2011) were included in the simultaneous–sequential columnar dimension of the dimensional systems model, though these were viewed as intrahemispheric processing modes used by both the right and left hemispheres.

Over the past six years, there have been a number of studies which would appear to support the cortical aspects of that theory and the current paper will discuss these. There is also a discussion of some revisions and additions to the cortical aspects of the model based on the additional data. Prior to discussing the model in relation to laterality, information on columns is presented.

Cortical Columns

Mountcastle (1957) was the first to describe the existence of cortical columns. Two levels of vertical organization of columns have been identified (Calvin, 1995). These are minicolumns and columns (also referred to as "macrocolumns," though the current paper will use the term columns). Calvin indicates minicolumns contain between 100 and 200 neurons and have a diameter of about 30 μm. Columns contain at most several hundred minicolumns and have a diameter ranging from 0.4 to 1.0 mm.

In considering the possible level at which the cortical bit might exist, Moss (2006) suggested it could be at the level of the single neuron, minicolumn, or macrocolumn. It was concluded the column would be the best candidate as the basic unit since it would be resistant to damage, and overlapping columns (i.e., sharing neurons within minicolumns) would allow for the large volume of information contained in the cortex. Calvin (1995) discussed the unusual pattern of superficial pyramidal neurons that suggest a columnar organizing principle. The collateral axon travels a characteristic lateral distance without giving off any terminal branches, but then produces a tight terminal cluster. The distance to the center of the terminal cluster is approximately 0.43 mm in the primary visual cortex, 0.65 mm in the secondary visual areas, 0.73 mm in the somatosensory strip, and 0.85 mm in the motor cortex. It may then continue for an identical distance and produce another cluster, in some cases continuing for several millimeters. This suggests the size of each column is determined by the cluster distances.

Moss (2006) also suggested that the millions of minicolumns were "hardwired" at birth. The columns of the primary receiving areas would be the first to form based on sensory relay from the thalamo–cortical connections. The primary receiving columns would project outward. The intersection points where axonal terminal bundles of two or more primary receiving columns' efferent projections meet would become a new column ("information bit") composed of a similar number of minicolumns. New columns would pass along efferent information in similar fashion with each intersecting bundle of minicolumns forming additional columns.

In an interesting study, Perin, Berger, and Markram (2011) did whole cell recordings of layer 5 pyramidal neurons in rat somatosensory cortical slices. The animals were 14 to 16 days postnatal. Perin et al. found synaptic clusters of neurons in which the highest number of connections were separated by a mean distance of 100 to 125 μm, extending beyond individual minicolumns. However, these extended across distances equivalent to the diameter of a functional neocortical column. Thus, cell assemblies are not arranged randomly or in a lattice, but as small world networks without hubs. Perin et al. noted that the findings are inconsistent with a "clean slate" on which any configuration could be molded. They believed the results suggested that experience could mold overall neuronal circuitry by combining elementary assemblies. Moreover, they believed this could allow for vast memory storage capacity, but also ensure the stability of memories in the face of ongoing activity.

These results provide support for two aspects of the dimensional systems model and add another very interesting possibility. The hardwiring at birth of connections at distances 100 to 125 μm (i.e., corresponding to the size of minicolumns) is consistent with the suggestion of Moss (2006). Additionally, the columnar-sized diameter that these extend is consistent with a column being the level of the information bit. However, the fact that all the neighboring cells within a minicolumn do not project as a unitary cell assembly may indicate that not only do columns overlap and share neurons, so also do minicolumns.

Hebb's (1949) postulate was originally formulated as an explanation for the cellular basis of learning and memory. The hypothesis was that the coordinated activity of pre- and post-synaptic membranes strengthens the connection between them. Moss (2006) proposed that memory could be defined based on columnar connections. A formal definition of memory formation is the strengthening of synaptic connections in any given circuit of cortical columns. The strengthening occurs due to ongoing reactivation of the circuit with resultant increased probability of downstream synaptic activation initially being the result of neurochemical factors (e.g., ionic concentrations, neurotransmitter stores), followed by gradual synaptic structural growth (increased axonal boutons and dendritic spines). Forgetting is the result of weakened synaptic connections with failure to activate downstream columns in any given circuit. In this case, the probability of a column's activation by one or more other columns fails to be maintained. However, with structural changes such as axonal sprouting and increased dendritic spines between neurons of columns, then the likelihood of "forgetting" is greatly reduced.

Columnar organization occurs in the somatosensory, auditory, and visual primary receiving areas of the cortex (Cechetto and Topolovec, 2002). There are also columnar aggregates in the human motor cortex (Mountcastle, 1997). In monkeys, there have been studies showing columnar organization in the inferior temporal cortex (Fujita, Tanaka, Ito, and Cheng, 1992; Kreiman, Hung, Kraskov, Quian Quiroga, Poggio, and DiCarlo, 2006; Sato, Uchida, and Tanifuji, 2009; Tamura, Kaneko, and Fujita, 2005; Tanaka, 2000; Tsunoda, Yamane, Nishizaki, and Tanifuji, 2001) and the dorsolateral prefrontal cortex (Hirata and Sawaguchi, 2008). Thus, there is sufficient evidence that a columnar organizational pattern exists in non-human cortex. In reference to human cortex, recent refinement in fMRI methods have allowed identification of columns for ocular dominance (Yacoub, Shmuel, Logothetis, and Ugurbil, 2007), temporal frequency (Sun et al., 2007), and orientation (Yacoub, Harel, and Ugurbil, 2008), in V1, as well as motion columns in MT (Zimmerman et al., 2011).

Three studies are of particular interest in relation to the overlapping columnar arrangement suggested by Moss (2006). Wang, Tanaka, and Tanifuji (1996) were the first to report findings consistent with overlapping columns tied to object recognition in inferior temporal cortex. Tanaka (2000) provided further support that area TE appeared to use columns as an organizational structure and the columns partially overlap. Using optical imaging in vitro, Hirata and Sawaguchi (2008) noted functional columns in the dorsolateral prefrontal cortex of the macaque. The columnar activity was evoked by stimulating the middle layer of the prefrontal cortex. The activity did not spread horizontally beyond a certain width, even in the presence of strong electrical stimulation. Hirata and Sawaguchi cite their own and others' research indicating that GABAergic inhibition limits the horizontal spread of activity, and lateral inhibition by GABAergic interneurons may work between neighboring functional columns. Finally, they showed that different columnar activities with only slight overlaps were induced by stimulation at different sites in the same slice. Thus, the existence of overlapping columns with surround inhibition has been supported.

Columnar surround inhibition may provide insight into the recent findings of Linke, Vicente–Grabovetsky, and Cusak (2011). In a functional magnetic resonance imaging study, 20 subjects performed a simple change detection task. Multivoxel pattern analysis of the auditory cortex and Heschl's Gyrus demonstrated robust frequency-specific activations during the encoding phase. This was consistent with the expected tonotopic organization. In contrast, these areas showed frequency-specific suppression during the maintenance period. Linke et al. proposed that such suppression in the early sensory regions may act as a natural gate-keeping mechanism to prevent irrelevant stimuli from overwriting the information currently stored.

The dimensional systems model explanation of these findings is that the primary receiving columns are activated in a frequency-specific manner. As the information stream proceeds, the higher order columns are activated. However, these columns have a strong surround inhibition. As noted by Moss (2006), "The inhibitory fields around the columns of the new memory would strengthen (i.e., signal) the new columnar array since all but the immediately adjacent or overlapping columns (i.e., noise) are being activated in that region" (p. 235). Thus, only the columns tied to the memory would be active with a pronounced inhibition, or suppression, of the adjacent areas around those columns. Consistent with this interpretation, Linke et al. (2011) stated, "One possibility, given that high-resolution scanning sequences still sample voxels containing many neurons, is that the neurons tuned to the information held in memory still fire during maintenance, whereas closely surrounding, differently tuned neurons are suppressed" (p. 12964).

Using a dynamic computational model, Lucke (2009) evaluated receptive field self-organization possibilities in V1 cortical columns. Based on the fine-scale structure of columns, the model involved subpopulations of excitatory neurons and their interaction with systems of inhibitory neurons. The model gave rise to specific types of computations that result in self-organization of afferents to the column. It was found that for a given type of input, self-organization reliably extracts the basic input components represented by neuronal receptive fields. It was noted that such self-organizing columns' receptive fields were superior to other algorithms, including independent component analysis and sparse coding.

The foregoing discussion would appear to support the contention that a columnar organization pattern exists. In relation to dynamic formation of columns, a study by Muir and Douglas (2011) is relevant. They note that the cortex shows surprising regularity in its repeated motifs of network design. The "superficial patch system," or "daisy architecture," is one such motif described in mapping connections of cortical tissue by the injection of the neuronal tracer horseradish peroxidase (i.e., an enzyme allowing the visualization from the axon terminal to the cell body). Originally described by Rockland and Lund (1982), the motif refers to a series of bands or patches of dense label from the injection site, separated by regions of weak label. Muir and Douglas (2011) note this pattern has been demonstrated across cortical regions of various species. They contend that such universality may indicate this system "can be adapted to many tasks and forms part of the fundamental substrate for cortical computation" (p. 1118). They note there is a common assumption that labeled patches are composed of clustered axonal projections arising from the pyramidal cells of superficial layers, spreading for several millimeters within a cortical area.

Testing several geometric organizational rules, Muir and Douglas (2011) felt the best fit was one that used information distributed across the cortical sheet to generate axonal projections. They concluded that single neuron information cannot account for such a system, and that information shared across the population of patch-projecting neurons is required. Moreover, the evidence of preferential projections within a cortical area for regions of similar function would be consistent with functional units defined by static neural connectivity. One possible manner in which they believed the patch system could develop across the cortex is by neural activity. Such an explanation is consistent with the dynamic column formation pattern proposed in the dimensional systems model. It is also in line with a study on the horseradish peroxidase in the cat visual cortex by Alekseenko, Toporova, and Makarov (2005). These authors concluded that the initial stages of visual space representation in the cortex can be identified on the basis of data on the topography of direct connections between individual columns in fields 17, 18, 19, and 21a.

Jones and Rakic (2010) posit that columnar-based input may lead to columnar-based output although this has not received much consideration in the past. One article has provided evidence of such dynamic column formation in cortical development: Kaschube, Schnabel, Wolf, and Lowel (2009) showed that columnar architectures of different areas of cat visual cortex develop in a coordinated manner. Orientation columns were analyzed during the critical development period of six to 15 weeks in areas V1 and V2 in both hemispheres. The results were consistent with column-size matching of V1 and V2 both within and between hemispheres, with progressive improvement during the late phase of the critical period. They hypothesized that the emergence of column-size matching is brought about by activity-dependent interactions mediated by interareal connections. Kaschube et al. ended the article with the following comment which is consistent with the dimensional systems model: "Because cortical processing in general takes place in networks distributed across many areas, it is conceivable that a progressive matching of local circuits serving different submodalities is a general characteristic of cortical network formation" (p. 17209).

One last point tied to the column involves cortical layers. Moss (2006) suggested that all layers are involved within the column. Layer 2 was discussed as potentially having inhibitory vertical control over neurons in other layers. Brown et al. (2011) found that neocortical inhibitory interneurons were produced as spatially organized clonal units which were not randomly dispersed. Instead, the inhibitory interneurons formed spatially isolated clusters in the neocortex with clear vertical and horizontal organization. Similarly, Meyer et al. (2011)

found that inhibitory interneuron distribution within columns indicate a cylindrical outline of a cortical column in supragranular layers. This led to the conclusion that cortical columns are relevant functional units beyond input layer 4.

In conflict with the predominant dichotomous view of explicit versus implicit memory, Moss (2006) proposed that all cortical memories are the result of the same basic rules of columnar interactions. In this regard it is suggested that similar neurochemical and neurostructural changes of cortical columns explain all memories. A similar proposal was supported by a recent paper by Reder, Park, and Kieffaber (2009). They provided a thoughtful review and critique of the literature with the proposition that explicit and implicit memories are not a function of separate systems. Reder et al. employed the generic term "node" assuming a localist (as opposed to a distributed) memory representation that is connected to other nodes. Using a computational model called source of activation confusion, they explained how this supports their view that implicit and explicit memory utilize the same memory representations, or nodes. Obviously, the thesis of the current paper is that the column is in fact the cortical node.

One other aspect of the dimensional systems model is that the columns involved in original processing are the same as those involved with the actual memory. In a recent article, Nosofsky, Little, and James (2012) noted that some models of cognition view perceptual categorization and recognition as recruiting the same memory system, while the prevailing view in cognitive neuroscience appears to be that separate neural systems mediate these processes. Employing fMRI and controlling for stimulus and parameter-related differences, they found little indication that categorization and recognition recruit different memory systems.

To understand how the same columnar processes occur in what would appear to be very different forms of processing and memory, Moss (2006) proposed several ways (called dimensions) that cortical columns can be arranged. These were: unorganized–organized; simultaneous–sequential; sensory–nonsensory; and analytical–global. Additionally, two types of cortical memory storage were discussed, one being factual–generic and the other personal–episodic. Following a discussion of the unorganized–organized dimension, the lateralization dimension of analytical–global will be presented. The other dimensions will then be discussed within the lateralization domain. Only a brief description of each dimension will be presented since the full explanation of each was provided in the original article.

Unorganized–Organized

The dimension of unorganized–organized will always be present in the processing of sensory information at the cortical level. In this case, columns representing more basic, or lower-order, information interconnect to higher-order (more-organized) columns. This is along the lines of an "AND-gate" in which two or more lower-order columns lead to the activation of a single higher-order column. When this occurs, the single higher-order column now represents all the information of its lower-order inputs in a feed-forward manner. It appears that such gating mechanisms are likely seen at all levels of the nervous system since simple logic operations such as OR-gates and AND–NOT-gates have computationally been shown in the spines of dendrites (Shepherd, 2008).

Moss (2006) used the example of language development to explain this concept. In brief, columns which represent specific component phonemes activate when a spoken word is heard and these, in turn, activate the word column. The sequential pattern required for phoneme columns to activate the new location of a word column is determined spatially. Since the axonal projections of all phoneme columns that form a word are activated in a specific order, the first activated will have its efferent activity travel further than the next one activated. The spatial location of the new word column will be determined by the efferent travel distance associated with the location where the two or more phoneme column terminal branches meet. Importantly, if the phonemes of the newly formed word column are presented in a different sequence, the word column is not activated. This is due to the different sequence resulting in a different spatial location of the column being activated. Biederman (1987) noted there are 44 phonemes which compose the English language, which certainly appears to make the foregoing hypothesis feasible since only 44 columns would be necessary. However, this does not exclude the possibility of additional forms of basic speech units (e.g., syllables) being stored at the cortical level as well, which have the capacity to activate purported word columns.

The foregoing description appears compatible with Nourski and Brugge's (2011) discussion of temporal sound features in the human auditory cortex. The core auditory cortex is composed of a primary field and one or more primary-like fields which receive direct input from the ventral medial geniculate nucleus of the thalamus. The core region is surrounded by as many as seven to eight fields comprising the belt region, receiving input from the dorsal medial geniculate nucleus and adjacent core areas. Studies suggest the core region can maintain robust explicit temporal representation of repetitive stimuli up to 200 Hz and beyond which encompasses adult male and female voices. The posterolateral superior temporal region tends to have a considerably lower phase locking capacity suggesting that at higher modulation frequencies, temporal information is transformed into different representations based on discharge rate, or cortical place, or both. The authors note this transformation would be consistent with a hierarchical core belt to parabelt serial or parallel processing model of primate auditory cortex.

There have been recent results indicating hierarchical organization for intelligent speech (Okada et al., 2010). Using fMRI, results consistent with core auditory low-level feature coding which are then combined at higher levels in the auditory system for greater abstraction were obtained. In this regard, core auditory regions exhibited high levels of sensitivity to acoustic features, while downstream auditory regions in the anterior and posterior superior temporal sulcus bilaterally showed greater sensitivity to speech intelligibility and less sensitivity to acoustic variation (acoustic invariance). Since acoustic invariance was most pronounced in more posterior regions of both hemispheres, the authors believed this supported phonological level representations.

An anterior superior temporal response pattern consistent with hierarchical arrangement was also reported in relation to other aspects of acoustic features of auditory objects (Leaver and Rauschecker, 2010). As with the Okada et al. (2010) study, Leaver and Rauschecker identified regions along the superior temporal plane closer to the primary auditory cortex were not sensitive to stimulus category, responding to specific acoustic features embedded in natural sounds. They found single phonemes or two-phoneme strings activated the left middle superior temporal sulcus to be optimally sensitive to human speech, with the authors suggesting this is a sub-region for acoustic-phonetic speech and not semantic or lexical content. The right anterior superior temporal plane responded preferentially to musical instrument sounds.

In addition to auditory stimuli, all other sensory processing of columnar information is purported to move from less-organized to more-organized. In relation to somatosensory processing, Reed et al. (2008) examined the interaction of neurons of anesthetized owl monkeys at different hand locations. The results indicated spike timing correlations between neurons separated by millimeters of cortex, extending beyond the representation of the palm pad location. This was felt to reflect functional connectivity. They postulated:

> Synchrony in unconscious animals implies specific anatomical connectivity between neurons, and population of neurons, and emphasizes that higher levels of integration must consider low-level integration . . . . We propose that neurons, even at the first level of somatosensory cortex, participate in global aspects of stimulus processing, on which higher-level processing is based. (p. 10236)

Similarly, there is evidence that visual processing of faces is hierarchically arranged. In relation to four of the six interconnected face-selective regions of the macaque monkey, Freiwald and Tsao (2010) found that neurons in two middle patches were view specific. In the anterior lateral patch, neurons were tuned to identify mirror-symmetrically across views, achieving partial view invariance. Neurons in anterior medial, the most anterior patch, achieved almost full view invariance. This was consistent with results of Tsunoda et al. (2001) in which an object is represented by the combined activation of columns, each responding to a specific visual feature of an object.

In the human visual cortex, Kubilius, Wagemans, and Op de Beeck (2011) employed fMRI to study the behavioral configural-superiority effect. This effect refers to the fact that a visual search for an odd element is more efficient when that element is part of a configuration as opposed to being presented in isolation. They found evidence supporting a feed-forward cortical shape processing hierarchy in a bottom–up fashion which is consistent with the unorganized–organized dimension of the dimensional systems model. In the same manner that only a very limited number of phonemes are involved in language, Biederman (1987) suggested that there are about 36 basic elements which can be combined to form any complex design. Again, this means only a few lower-order columns would be required to allow more complex configurations in the higher-order columns.

In relation to motor output, the information moves from more-organized to less-organized in relation to the columns. Therefore, one higher-order cortical column activates more numerous lower-order columns. This allows a planned movement represented by a single column to occur since multiple primary motor columns are required to accomplish the movement. The non-motor columns of the frontal lobe would be expected to follow the same higher-order to lower-order principle.

In a study supporting a hierarchical organization of the prefrontal cortex along a rostro-caudal axis, Badre and D'Esposito (2007) conducted four mini-experiments across two fMRI sessions. Each mini-experiment varied competition at one of four hierarchical levels of representation (i.e., manual responses, feature-to-response mappings, perceptual dimensions that comprise a set of relevant perceptual features, and contextual cue-to-dimension mappings). Results indicated that dorsal premotor cortex is sensitive to response competition, anterior dorsal premotor cortex is sensitive to feature competition, inferior frontal sulcus is sensitive to dimension competition, and frontal polar cortex is sensitive to context competition. The authors concluded that the results provide strong support for cognitive control being organized in a rostro-caudal representational hierarchy.

Global–Analytical

The lateralized dimension of the cortical system is global–analytical. The distinction between these types of processing can be understood at two levels: the area containing the information units (i.e., cortical columns) and the total number of available units in any given circuit that can be processed. In contrasting the two processing types, global processing would utilize fewer total columns between stimulus input and the associated response than would analytical processing.

An indication of greater interconnectivity would be increased white matter consistent with myelination. Penhune, Zatorre, MacDonald, and Evans (1996) employed MRI to demonstrate that in the region of the primary auditory cortex of the human brain there is greater white but not gray matter in the left hemisphere. Using histological data from 21 postmortem human cases, Harasty, Seldon, Chan, Halliday, and Harding (2003) found that the volumes of the left and right planum temporale were approximately equal. However, the left planum temporale was long and thin with the corresponding right area being short and thick. Based on previous studies in the context of their findings, the authors felt the left cortical region was stretched by greater white matter growth which would result in greater distances between columns.

Another histological study of the temporal lobes involved Brodmann area 22 of seven postmortem subjects (Galuske, Schlote, Bratzke, and Singer, 2000). Neuronal tract tracing revealed a modular pattern of connections linking regularly spaced clusters of neurons. The authors believed the clustering was consistent with interdigitating subsystems of selectively interconnected columns. Cluster sizes were similar in both hemispheres, though there was a wider spacing between clusters on the left. This was interpreted as allowing more subsystems existing per surface unit in the left than the right area 22. Calculations based on the measured cluster size and spacing suggested the left can contain about 30% more distinct subsystems within the same volume of tissue.

In their review on hemispheric asymmetries, Hutsler and Galuske (2003) cite their own (e.g., Hutsler, 2003) and others' studies demonstrating significantly larger spacing between interconnected clusters of neurons on the left, though having the same size on both sides. The data indicate there are a greater number of selectively interconnected columns in the left hemisphere. Hutsler and Galuske believe an attractive hypothesis is that structural asymmetries guide functional asymmetries. In this regard, they state that genetically or early ontogenetic events may lead to a structural minicolumn asymmetry which guides functional lateralization. The lateralization might then shape columns to optimize them for language relevant processing.

More recent studies have supported the existence of structural asymmetries. Using diffusion-weighted MRI, Iturria–Medina et al. (2011) investigated whether both hemispheres demonstrate dissimilar general structural attributes that imply different principles on organization of the information flow in human and nonhuman primates. The results showed that the left hemisphere had more central or indispensable regions for the whole-brain structural network than the right hemisphere. It was also found that the right hemisphere is significantly more efficient and interconnected than the left hemisphere. Since the findings were true of both the human dataset and the single macaque dataset, the authors suggested this may indicate a general organizational strategy which is broadly similar between the species. In terms of functional principles, Iturria–Medina et al. believed the results supported two facts: the left hemisphere has a leading role for highly demanding specific processes requiring dedicated specialized networks, while the right hemisphere has a leading role for more general processes requiring a relatively greater general level of interconnectivity.

Kang, Herron, and Woods (2011) used diffusion tensor imaging and magnetization transfer imaging measurements of pericortical white matter tissue and observed greater fiber coherence and increased myelination of fibers in left hemispheric regions. Highly consistent hemispheric asymmetries in fractional anisotropy and magnetic transfer ratio were observed. The authors suggested that the greater fiber coherence and increased myelination of fibers in left hemisphere perisylvian regions may provide a structural basis for left-hemisphere language dominance.

Using MRI gray matter *R*1 mapping, which is a property related to myelin content, Sigalovsky, Fischl, and Melcher (2006) found indications of greater gray matter myelination in left compared to right auditory cortex in living humans. The areas assessed included Heschl's gyrus, planum temporale, superior temporal gyrus, and superior temporal sulcus. This was interpreted as being consistent with the left hemisphere being preferentially involved in the processing of rapid temporal changes in acoustic signals, including speech.

In an assessment of music processing, Perani et al. (2010) assessed one- to two-day-old newborns using fMRI while the infants heard music and altered versions of the same excerpts. When music was played, right-hemispheric activation was seen in both the primary and higher-order auditory cortex. When the music was altered, the activation reduced in the right auditory cortex, and emerged in the left inferior frontal cortex and limbic structures. The results were considered to demonstrate that the infant brain has hemispheric specialization in processing music as early as the first postnatal hours. Perani et al. believed results also indicated the neural architecture for music processing is sensitive to changes in tonal key. Overall, they noted the hierarchical organization of music processing very early in life is complementary to previous research which supported an interpretation of complex hierarchical organization of auditory language in infants.

Morillon et al. (2010) provided data that supported intrinsic lateralized language network activity as a result of human cerebral asymmetry for language. They found that in the absence of language-related processing, left auditory, somatosensory, articulatory motor, and inferior parietal cortices show specific, lateralized, speech-related physiological properties. Morillon et al. believed the results support theories for intrinsic, hardwired perceptual motor processing in syllabic parsing. Specifically, they concluded there appears to be an inherent auditory-motor tuning at the syllabic rate, as well as an acquired tuning at the phonemic rate which would be consistent with two recognized stages of language development in infants.

The parallel processing view of the hemispheres of the dimensional systems model has also led to the proposition that the hemisphere arriving at a solution the fastest is the one which controls the ensuing response (Moss, 2006). Ratinckx and Fias (2007) investigated processing speed in a number comparison study. They concluded that the results could be interpreted in a simple race model in which two independent and parallel hemispheric processes compete for the control of response. In this case, the faster process wins.

In summary, the foregoing discussion provides support for the column as the basic cortical information bit arranged hierarchically within each hemisphere, with the left's analytical processing style resulting from a larger number of interconnected columns which, in turn, results in slower processing speed compared to the right hemisphere. The discussion will now shift to explaining the hypothesized intrahemispheric dimensions.

Simultaneous–Sequential

Simultaneous processing simply means that a number of columns are being activated at the same time. In this manner, more-organized, or higher-order, information depends upon lower-order columns being simultaneously activated. Sequential processing reflects one column being activated at a given time. For a higher-order column to be activated, the inputs from its lower-order columns must be received in a specific temporal pattern. Thus, if the order of stimulus input is altered, even though the same stimulus input occurs, a different higher-order column will be activated.

Moss (2006) proposed that different types of sensory input require different processing patterns. Based on the processing required, the proximal cortical regions perpetuate the same mode of processing. Somatosensory information requires simultaneous processing, while auditory information relies on sequential processing. Vision requires both modes. This organizational pattern would result in the more dorsal cortical regions following a simultaneous pattern, with the more ventral areas following a sequential pattern. The intermediate areas would combine both modes.

When a task involving highly processed information involving one mode of operation also requires the addition of highly processed information from a different mode, the two areas connect directly. For example, visual input involves both simultaneous and sequential information. If the task at hand requires spatial features (requiring all aspects be appreciated at the same time), the processing stream goes toward the parietal area which involves simultaneous processing. On the other hand, if information requires sequential patterning (i.e., only one final aspect be appreciated), it proceeds toward the temporal lobe. These correspond to the "where" and "what" pathways, respectively. If the task requires both processing types, the higher-order (i.e., more highly organized information being represented by that column) columns in the occipito-parietal and posterior temporal regions would interconnect directly with higher-order anterior and inferior temporal columns. The location where this interconnection occurs is the medial temporal lobe cortex as has been suggested by Diana, Yonelinas, and Ranganath (2007).

Let us assume a task in which a subject is shown a picture of five familiar individuals and then subsequently asked to state from memory where in the picture a particular person was located. This requires the individual to use simultaneous processing (i.e., spatial information) in visualizing the picture. While temporarily "holding" this image, there must be a sequential analysis to locate the specific individual. This would theoretically result in posterior cortical activation in the occipito-parietal (columns associated with visualizing the picture) and anterior–inferior temporal regions (columns associated with the target individual's identity), in addition to the corresponding frontal columns (ventral columns associated with self-talk of the task directions, dorsolateral columns selecting the individual based on the temporal lobe column identity, and the more dorsal columns activating the occiptio-parietal columns related to the spatial visualization).

In situations requiring rapid, ongoing updating of information, processing would occur in convergence zones. For example, area MT involved with motion detection involves both simultaneous (entire visual space) and sequential processing (moving object) in conjunction and columns in this region would allow rapid information updates.

The foregoing discussion highlights another point in relation to the so-called "functionally specialized" regions of the cortex. The dimensional systems model indicates these regions are simply the location of specific columns representing the final (i.e., highest-order) representation of all associated lower-order columns. For instance, a column in inferior temporal cortex representing the face of a particular individual is the last one of a number of lower-order columns starting in V1 and progressing along the cortex. Thus, there is distributed processing along the ventral stream required for each "face" column in inferior temporal cortex.

In relation to the frontal lobes, the processing mode of a posterior cortical column would lead to the same processing mode in the frontal column to which it connects. Thus, the same dorsal (simultaneous processing) and ventral (sequential processing) distinction would occur in the frontal lobe. The intermediate areas would involve both types of processing. If accurate, this would lead to a better understanding of working memory in various tasks, as well as the role of the supplemental motor cortex involvement in sequential motor tasks. In each case, the dorsal simultaneous processing is required to maintain all aspects of the sequential information contained in the ventral columns.

Consistent with dorsally located simultaneous processing, Harrison, Jolicouer, and Marois (2010) found that the intraparietal sulcus was involved only in response to spatial location information in a visual short-term memory task. There was no effect in relation to object identification which the current model would indicate is related to ventrally located sequential processing.

As was previously discussed, the dimensional systems model suggests that when a task involving highly processed information from one mode of operation also requires the addition of highly processed information from a different mode, the two areas connect directly. In support of this contention, Monosov, Sheinberg, and Thompson (2010) collected data from two monkeys performing a covert search task. In this study, the monkey maintained fixation on a central stimulus and, using a lever, reported the identity of the learned target object among distractors. Simultaneous single neuron recordings were taken in the frontal eye fields and inferior temporal cortex. The frontal eye fields are parts of the dorsal frontoparietal attention network and play a role in the visual–spatial selection process. Results showed that neural activity specifying location was evident in frontal eye fields before neural activity specifying target identity in inferior temporal cortex. The authors suggested this implied a functional linkage between the end stages of "where" and "what" visual processing.

Recording from neurons in the dorsal and lateral prefrontal cortex in four rhesus monkeys, Meyer, Qi, Stanford, and Constantinidis (2011) evaluated patterns before and at multiple stages of training on visual working memory tasks. Eye saccades to either a green or a blue choice target were the required responses in a match versus nonmatch task. Two monkeys were trained on a spatial working memory task, while two others were trained in three working memory tasks as follows: spatial working memory, feature working memory, and conjunction of locations and features working memory. Prior to training there were substantial functional differences between the two regions. Dorsal prefrontal cortex was more responsive to visual stimuli and preferentially selective for spatial information. The spatial bias remained higher for the dorsal region after training, though stimulus selectively generally decreased. Ventral areas were biased toward non-spatial information, although they were more influenced by training in terms of activation and changes in stimulus selectivity. The authors cited the literature demonstrating anatomical connections between posterior parietal to dorsal prefrontal areas 8 and 46, and between inferior temporal cortex and ventral visual stream to areas 12 and 45 of the ventral prefrontal cortex. Meyer et al. believed the results demonstrated functional differences in addition to the anatomical connections between the dorsal and ventral prefrontal regions, though the domain-specific organization is not absolute.

In their review of data on a rostro-caudal hierarchical arrangement in the frontal lobes, Badre and D'Esposito (2009) noted there is support for a distinction between dorsal and ventral rostro-caudal gradients of the frontal lobes, such that each acts as a coherent functional network. They drew the same conclusion in relation to regions of the parietal and lateral temporal cortices. This is consistent with the dimension of simultaneous (dorsal) and sequential (ventral) modes of columnar processing in relation to the previously discussed unorganized–organized dimension.

The dorsal simultaneous and ventral sequential differentiation has also been shown related to language. Saur et al. (2008) conducted two experiments employing fMRI with diffusion tensor imaging. The first involved overt repetition of aurally presented pseudo words as opposed to real words, with the second requiring attentive listening to meaningful speech versus meaningless pseudo speech. The most probable anatomical pathways were identified. Sublexical repetition appears to involve a dorsal pathway connecting the superior temporal lobe and frontal premotor cortices, while higher-level language comprehension involves a ventral pathway connecting the middle temporal lobe and ventrolateral prefrontal cortex. Saur et al. suggested the dorsal route is mainly restricted to sensory-motor mapping of sound to articulation, while the linguistic processing of sound involves the ventral route.

Reception–Action (Formerly Called Sensory–Nonsensory)

The third dimension described by Moss (2006) was that of sensory–nonsensory. Based on the current model, any memory of action involves columns of the frontal lobe. Actions can refer to motor functions, but can also refer to nonsensory columns interacting without motor functions (e.g., working memory, planning, and analysis). Any receptive sensory memories, including those associated with specific actions, would involve columns in the posterior lobes. Since sensory information is integral to the accurate production of many actions, simultaneous activation of columns interconnecting posterior and frontal cortex would commonly occur. The columns involved in the original processing of information are the same columns involved in the memory storage.

Consistent with the current model, there appears to be some consensus that long-term sensory memories are stored in the relevant cortical regions subserving the given modalities (Doron and Rosenblum, 2010). Baumann, Endestad, Magnussen, and Greenlee (2008) provided support for a model of perceptual memory in which both discrimination and retention of basic stimulus dimensions is a function of low-level perceptual memory stores located at an early stage in the visual process. They found activation of low-level visual areas, in the absence of prefrontal and parietal activation, during delayed discrimination of orientation and spatial frequency.

Winkler et al. (2002) used an experimental model of implicit recognition and testing in relation to auditory memory. Event-related brain potentials demonstrated an accurate representation of tone pitch in the auditory cortex after brief presentation. Winkler et al. interpreted their findings as providing a link between short duration buffering and permanent storage of acoustic information.

In a study involving the rat, Doron and Rosenblum (2010) found that GABAergic interneurons are activated in gustatory cortex in correlation with novel taste learning. They interpreted the results as providing evidence for a local cortical circuit not only during acquisition, but also during off-line processing and consolidation of taste information.

Vaillancourt, Thulborn, and Corcos (2003) conducted a study in which visuomotor and motor memory processes were separated from only-visual and only-motor activation. Their findings provided evidence of a distributed network across cortical and subcortical regions that were involved in the visuomotor process used during visually guided tasks. In contrast, in the prefrontal cortex alone was there activation of a localized network tied to retrieval of force output (i.e., grip force) from memory during internally guided actions. This is consistent with motor memory being restricted to the frontal lobe.

Three studies have provided evidence that left ventral premotor cortex is involved not only in speech production, but also speech perception. Kotz et al. (2010) used transcranial magnetic stimulation (TMS) and fMRI to show Broca's area plays a significant role in speech perception that is lexically based. Using a different experimental approach, Tremblay and Small (2011) explored the nature of the interface between speech production and perception. They noted two possible explanations have been proposed, one of which is that the motor circuits involved in producing a perceived action are enacting the action without causing movement (covert simulation). The other view is that there is not any involvement of motor representations in perception, or the role is simply supportive and does not use the identical circuits. Kotz et al. found the left ventral premotor cortex was significantly active in speech perception as it was in production, supporting the covert simulation hypothesis.

Menenti, Gierhan, Segaert, and Hagoort (2011) used fMRI during speech comprehension and production in 24 subjects. Consistent with Tremblay and Small's findings, this study reported cortical areas involved in semantic, lexical, and syntactic processing were basically the same for speaking and for listening. The overlap included auditory cortex and left inferior frontal cortex, with motor cortex being involved only while speaking.

Factual–Generic and Personal–Episodic Memories

One other aspect of the dimensional systems model suggested by Moss (2006) is that there are two different types of memory stores involving distinct cortical areas. Making a distinction between factual–generic and personal–episodic memories has value in a clinical sense, such as explaining "flashbulb memories" in posttraumatic stress disorder (Moss, 2007). However, during the process of the current review, such a distinction obscures an important point. Based on the purported columnar processing model, memory is simply the columns involved in the original processing of stimuli. As a result, it seems more reasonable to define the memory on the basis of those columns involved. Therefore, episodic memory would refer to sequential processing since this would be necessary for any temporal information. As discussed below, personal memory would refer to the columns involved medially and close in proximity to the somatosensory area. Generic memories would involve more simultaneous processing and columns in the posterior cortex reflecting less-organized information.

As a case in point, Sajonz et al. (2010) provided evidence that self-referential processing can be distinguished from episodic memory. In an fMRI study involving the use of pictorial stimuli, self-relatedness and episodic aspects were varied. Self-referential processing was found to activate the posterior cingulate–anterior precuneus, medial prefrontal cortex, and an inferior portion of the parietal lobe. Episodic memory involved the posterior precuneus, right anterior prefrontal cortex, and a superior portion of the inferior parietal lobe. Common to both were activations in the intermediate regions within the precuneus and inferior parietal lobe.

In another study which demonstrated the distributed nature of various aspects of autobiographical memory, Daselaar et al. (2008) evaluated a time course across brain regions utilizing fMRI. Subjects signaled during recall of personal memories in response to auditory word cues. Initial versus late period aspects were differentiated. In relation to accessing and maintaining memory, the initial period involved hippocampal, retrosplenial, medial prefrontal, and right prefrontal activity, while the later period activated visual, precuneus, and left frontal activity. Emotional intensity ratings were associated with amygdala and hippocampus activity. The reliving ratings had associated activity in visual cortex, as well as ventromedial inferior prefrontal regions during the later periods. Frontopolar cortex activity was associated with emotional intensity across both periods.

It was proposed by Moss (2006) that thalamic association nuclei interconnected with association cortex provided the means to allow maintenance of activation in the columns of the association cortex. This in turn leads to enhanced synaptic connectivity between the involved columns and memory formation. Enhanced arousal was suggested to increase memory consolidation via increased excitation of the thalamo-cortical circuits. This purported thalamo-cortical circuit leading to strengthening of columnar connections (i.e., memory) may also explain sleep's role in consolidating recently formed memories (Stickgold, 2005). In this case, increased thalamo-cortical activity during sleep would further strengthen the newly formed columnar neuronal connections.

A discussion of the role of the hippocampus in memory was basically omitted in the paper by Moss (2006). When the theory was originally conceived in 1984, it was unclear as to what role the hippocampus and associated medial temporal areas could play in memory storage of cortical columns located at a distance. However, it is now clear that the hippocampus is involved with the storage of new memories.

A theoretical proposal which is consistent with the dimensional systems model is that the hippocampus promotes the process of the gradual integration of newly acquired information into cortical associative networks via binding, reactivating, and strengthening connections (Rasch and Born, 2007; Sutherland and McNaughton, 2000). Within this context the hippocampal cells are considered to have a "starter" and "pacemaker" role in the activation of the long-term memory formation involving columns. The fact that hippocampal cells have long-term potentiation ability and connections to thalamic association nuclei can feasibly lead to a thalamo–cortical–hippocampal–thalamo activity loop leading to consolidation. As the cortical memories become consolidated, hippocampal involvement would no longer be required. If this is the case, anatomical hippocampal connections to the thalamic nuclei (Saunders, Mishkin, and Aggleton, 2005) would suggest hippocampal involvement in all forms of memory.

The involvement of such an activity loop is suggested by the results of a study by Sperling et al. (2001). Using fMRI during the encoding of face–name associations, a consistent pattern of activation was observed in the hippocampus, pulvinar, fusiform cortex, and dorsolateral prefrontal cortex. The authors suggested the data support a distributed network of brain regions in associative learning.

Based on the current model, perhaps the best way to define memory is on the basis of the type of columnar processing occurring in each region involved. In other words, many memories employ areas distributed across the cortex and each area's cortical columns represent specific and unique properties. There appear to be two additional dimensions related to the type of information processed and stored in the cortex.

Internal–External Stimulus Coding

During times between experimental conditions and associated active responding in fMRI studies, it was discovered that a characteristic pattern of brain activity occurred. Since the pattern was seen when no externally directed goal was involved, it was commonly referred to as the "default network" (Christoff, Gordon, Smallwood, Smith, and Schooler, 2009). The most consistent regions associated with stimulus-independent thought are medial prefrontal, posterior cingulate–precuneus, and posterior temporoparietal cortex. In a different aspect of cortical functioning, emotions have also been evaluated by neuroimaging. Medial, orbital, and inferior lateral frontal cortices appear to be consistently activated independent of type of emotion (Kober, Barrett, Joseph, Bliss–Moreau, Lindquist, and Wager, 2008). Based on such information, it is speculated that the medial cortical columns are involved with memories related internally (i.e., oneself). The default network temporoparietal involvement appears related to ongoing proximal somatosensory information which is explained in the next subsection.

If accurate, then cortical columns in regions closer in proximity to the diencephalon and limbic structures would contain memories tied to oneself, with a gradual transition to information related to external stimuli as the cortex proceeds further away from the midline. The insular temporal area in close proximity and anterior to primary auditory cortex would contain sequential sensory information related to the internal representation of oneself, with a transition toward sequential–simultaneous proceeding toward the posterior insula. Similarly, the dorsal medial parietal region would contain simultaneous, self-information, with the parietal insular area reflecting a combination of simultaneous-sequential processing.

Proximal (To Body) versus Distal Coding

The primary motor and somatosensory areas involve the most proximal-to-body columns. As the cortex proceeds away from these areas, the information becomes progressively more involved in coding distally related information. In relation to sensory information, vision and audition are the senses involved with stimuli away from one's body. In relation to the frontal cortex, there is an expected transition from columns acting upon proximal information (e.g., premotor acts upon motor columns). This would indicate the most anterior columns would be those involved with the highest order processing of non-body related information, acting upon less-organized frontal, as well as posterior cortical columns. This appears consistent with the results of a study of a reasoning paradigm adapted from Raven's progressive matrices. Golde, von Cramon, and Schubotz (2010) found that the premotor cortex became engaged in the sequential concatenation of relations, while the anterior prefrontal was involved in their integration. The authors concluded that the results support hierarchical models of frontal function.

In another study, Ranganath, Johnson, and D'Esposito (2000) found that left anterior middle prefrontal activation increased with the demands (i.e., size judgment versus old–new recognition) to recall specific perceptual information. In a study involving an analogy task, Krawczyk, McClelland, and Donovan (2011) reported the results were consistent with a hierarchical organization for relational reasoning across domains in which posterior frontal cortex is active across concrete reasoning tasks, while progressively more anterior regions are recruited to process increasingly abstract representations in reasoning.

Badre and D'Esposito (2009) indicated neurons in progressively rostral regions of the frontal cortex seem distinguished by their ability to support more abstract representations and more complex rules. This is consistent with the proximal–distal dimension and the organized-to-unorganized decoding aspect of the frontal lobe action columns as described in the dimensional systems model.

Cortical Columns as the Common Denominator in Synchronicity

Gamma-band synchronization has been an area of interest as a psychophysical hypothesis in perceptual binding since the late 1980's (Fries, 2009). The binding-by-synchronization hypothesis as discussed by Fries considers both neuronal synchronization and neuronal interactions. However, the hypothesis suggests the patterns of neural communication links allowing cortical computation are a function of segmentation and selection of input based on gamma-frequency and low-frequency rhythm. The currently proposed theory that the cortical column is the level at which cortical memory occurs provides an alternative explanation. That is, gamma-frequency input at the cortical level dynamically leads to column activation which, in its connection to other columns, is responsible for cortical computation and memory storage.

The mechanism behind this column-sized activation pattern appears to relate to active inhibition. Llinas, Ribary, Contreras, and Pedroarena (1998) used optical data from guinea-pig visual cortex using either a single electrode or two electrodes placed 2 to 6 mm apart. Stimulation with two electrodes at low frequency (10 Hz) gave rise to two waves of excitation moving horizontally and showing close to linear summation at the center of the tissue slice where they fused. Thus, the area of excitation spanned the cortical distance between electrodes. At gamma-frequency (40 Hz) stimulation, a restricted area approximately a cortical column in width was observed for each of the stimulating electrodes separated by a gap of reduced activity between the activated regions. Notably, in the presence of GABA blockade, the spatial gap activity reduction disappears. This would suggest gamma-frequency activity may well result in column activation while lower frequency stimulation results in generalized cortical activity. The end result is one which can increase the signal (column) to noise (surrounding cortex) in that gamma activity is observed in the context of low frequency (e.g., theta) recordings (Fries, 2009). The Llinas et al. findings are consistent with the previously mentioned study by Hirata and Sawaguchi (2008) in which different columns with only slight overlaps were induced by stimulation at different sites in the same cortical slice. The brief electrical stimulation leading to dynamic columnar activation would be in the gamma frequency range (50 to 60 Hz).

Another study provides support for the manner in which large neuronal assemblies can interconnect with near zero time lag synchrony. It also suggests another mechanism by which column size damage resistance can be obtained using only a limited number of neurons contained within a column. Vicente, Gollo, Mirasso, Fischer, and Pipa (2008) employed a model in which two neuronal populations relay their activities to a third population in the gamma oscillation range. The expectation was that the redistribution of the dynamics performed by this unit would lead to self-organized zero lag synchrony among the outer populations. Vicente et al. conducted simulations with networks of Hodgkins–Huxley neurons in integrate and fire models to reflect the influence of long conduction delays. The results showed the development of the expected synchrony of the outer neurons for both a three cell circuit and a three network population circuit. The inner neurons were asynchronous. Not only does this study speak to activation speed, it also suggests that only the outermost neurons are involved once synchrony develops. This suggests that individual minicolumns and columns, when activated, synchronize only the outermost neurons while the interior neurons remain asynchronous. If correct, overlapping minicolumns which compose columns, and overlapping columns which are proposed to represent the actual information bit, can attain the required information volume to be the cortical information bit.

If the purpose of gamma frequency input is to activate a discrete cortical column, it would be expected that there should be early developmental evidence based on input from sensory thalamus. There is evidence supporting columnar activation via gamma-frequency input in the developing thalamus and somatosensory cortex. Minlebaev, Colonnese, Tsintsadze, Sirota, and Khazipov (2011) found that in postnatal days 2 to 7 with the rat, brief single whisker deflections evoke gamma band oscillatory local field potential responses in the corresponding cortical barrel. These early gamma oscillations allowed vertical synchronization between topographically aligned thalamic and cortical neurons. At the end of the second postnatal week the "adult" gamma oscillations emerge and allow horizontal synchronization in the cortex.

Moss (2006) theorized that in a feed-forward manner the location where output from lower-order columns crosses, a new column forms and then represents information from the lower-order columns. Gamma-frequency oscillations can logically be responsible for a column activating at that crossing. Repeated activation of the downstream column by the upstream columns can lead to strengthening of synaptic connections. There is some support that gamma frequency input does result in column activation across the cortex. Eckhorn et al. (1988) used fiber-microelectrodes to measure responses in areas 17 and 18 of the cat visual cortex to stimulus-evoked resonances in the gamma range. Coherent resonances were found at the minicolumn and column levels. These were also observed between two different cortical areas. In the macaque visual cortex, Berens, Keliris, Ecker, Logothetis, and Tolias (2008) also found results suggestive of columnar size activation when there was a strong correlation between local field potential in the gamma-band range and multi-unit recordings. In another study using monkeys, Liu and Newsome (2006) evaluated local field potentials and multi-unit activity in area MT in relation to motion direction and speed. Their results showed strong tuning for local field potential frequencies above 40 Hz reflects neural activity that is local on a spatial scale equivalent to or smaller than that of cortical columns.

If cortical memory involves a strengthening of synaptic connections between associated columns and, as has been suggested, the hippocampus acts to maintain cortical activity to allow that strengthening, it would be expected that hippocampal cells would synchronize the in-line cortical columns. Obviously, gamma-band output would be necessary to maintain column-sized activity. Sirota et al. (2008) recorded local field potentials and unit activity from multiple neocortical areas (i.e., parietal, anterior cingulated, and medial prefrontal) and the CA1 pyramidal layer of the dorsal hippocampus in mice and rats. The major finding was that a fraction of neurons in different neocortical areas, in addition to spatially localized and frequency-specific gamma oscillations, were phase locked hippocampal theta oscillations. The authors believed that the data supported the conclusion that theta oscillation entrainment provides a way that activity in widespread cortical and hippocampal networks can be temporally coordinated. Another finding was that gamma oscillators were often localized to either a single cortical layer and/or a putative column. Finally, the findings were interpreted as demonstrating that hippocampal theta oscillations can effectively link the sporadic and spatially distinct local gamma oscillations.

Similar findings were obtained in the macaque in a study by Jutras, Fries, and Buffalo (2009). While recording with microelectrodes from the left hippocampus, a visual memory recognition task was performed. During the encoding phase, gamma-band synchronization was observed in hippocampal neurons and enhanced synchronization was predictive of greater subsequent recognition memory performance. It was concluded that the synchronization may facilitate synaptic changes necessary for successful memory encoding.

Using depth-EEG recordings within the hippocampus and rhinal cortex of the same nine epilepsy patients during a single-trial word memory task, Fell et al. (2001, 2003) reported on both gamma and lower frequency (e.g., theta) interactions. They investigated whether these interactions were important in encoding declarative memory. In the case of successful encoding, both structures appeared to be functionally linked by increased phase synchronization of induced gamma activity, in addition to increased phase and amplitude coupling in the lower frequency ranges. The authors suggest that rhinal-hippocampal theta coherence interacts with gamma synchronization during declarative memory formation.

In their binding of item and context model, Diana et al. (2007) provided a more precise account of the areas involved in recognition memory. Based on combined findings in fMRI studies, they proposed several aspects. First, the perirhinal cortex receives information from other cortical areas related to “what” information (i.e., specific items) needed for familiarity judgments. Second, parahippocampal cortex receives information about “where” information (i.e., context) useful for recollection judgments. Third, hippocampus receives the “where” and “what” information and binds these together to form item context associations that permit recollection. Based on the dimensional systems model, the cortical columns which project to the medial temporal lobe cortex would contain the “what” and “where” information. Although the “what” and “where” information columns represent a high level of consolidation of lower-order columns in their respective information streams, these would be considered lower-order columns relative to the combined information contained in the medial temporal lobe columns.

Moss (2006) suggested the mechanisms, including the role of frontal cortical attention centers, by which any stimulus requiring attention is subsequently stored in long-term memory in the cortex. Based on the foregoing discussions, this can now be further elaborated to include the medial temporal lobe structures. Moreover, it has been suggested how the stimulation frequency being mediated by the hippocampus can create ongoing localized cortical tissue alterations which allow the strengthening of synaptic connections of the involved cortical columns.

It is also possible to use the gamma oscillation studies to give further insight into laterality of function. The purported global organization of columns in the right hemisphere allows less detailed and faster processing of novel stimuli. Via the interhemispheric connections, the global columns activate corresponding left hemisphere columns which can then serve as the "skeleton" outline of the developing analytical processing. The columns in the left hemisphere skeleton design can then begin the process of entraining interconnecting columns which will allow the more detailed processing characteristic of the analytical mode. Once well learned, activation of the right hemisphere columns still occurs, though the left hemisphere assumes primary control of the detailed response unless speed demands of the task negate this possibility. This would explain the observation by Borst et al. (2011) that the two hemispheres seem to have redundant functions, with most differences appearing to be quantitative (e.g., speed) as opposed to qualitative.

Integrating the Cortical Dimensions and Future Research

The relevant dimensions of cortical columnar functioning as specified by the current dimensional systems model are: unorganized–organized; simultaneous–sequential; reception–action; global–analytical; internal–external; and proximal–distal. It is now suggested that applying each of these dimensions should reveal the type of information represented in columns of specific regions. Again, there is always a distributed system going from less- to more-organized in the posterior cortex, so that columns representing lower-order information may be shared by multiple higher-order columns. The closer in proximity to the primary receiving areas, the more the columns will be shared by higher-order columns.

Information in the primary receiving areas is obviously the most unorganized. As the information stream moves outward, organization is expected to be predictable. Raw visual information in the left cortex moving dorsally along the lateral cortex would involve progressively organizing analytical, simultaneous, external reception which will become more proximal to one's body the closer in proximity to the parietal somatosensory area. If the information stream progresses along a more medial cortical path, the columns involve internal (i.e., self-referential) information. If the information stream proceeds ventrally along a lateral cortical path, it is progressively organized and becomes more distal to one's body the closer in proximity to the temporal pole. The more medial the information stream, the more it is self-referential, but still distal. If the information moves in a horizontal direction, the columnar processing would involve both simultaneous and sequential characteristics.

Based on the foregoing descriptions, it is believed that the dimensional systems model can provide specific a priori predictions about columnar processing modes. Hopefully, this can be of benefit to researchers utilizing imaging procedures in evaluating results of their studies. Moreover, it seems possible to design studies to support or refute the model.

The probability of fMRI being used to analyze columnar processes in a more direct fashion is improving. As previously mentioned, recent refinement in fMRI methods have allowed identification of columns for ocular dominance (Yacoub, Shmuel, Logothetis, and Ugurbil, 2007), temporal frequency (Sun et al., 2007), and orientation (Yacoub, Harel, and Ugurbil, 2008), in V1, as well as motion columns in MT (Zimmerman et al., 2011). Chaimow, Yacoub, Ugurbil, and Shmuel (2011) provided further refinement in a model which can potentially be used for decoding information conveyed by cortical columns. If this is eventually accomplished, as it appears it will be, then there can be direct evaluation of the currently proposed dimensional systems model.

As was stated by Horton and Adams (2005), if it were possible to understand one part of the cortex which was representative of the whole, the task of explaining cortical functioning would be simplified immensely. We have attempted to provide a convincing argument that over 50 years ago, Mountcastle (1957) got it right. The cortical column is the basic cortical unit and it is the unifying principle for understanding cortical functioning.

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Dreaming: Physiological Sources, Biological Functions, Psychological Implications

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Dreaming is an enigmatic phenomenon. Although research over the previous fifty years has increased our knowledge of dreaming significantly, fundamental questions lack definitive answers. This paper reviews contemporary literature to explore the physiological sources, biological functions, and psychological implications of dreaming. During rapid eye movement sleep, the brain generates stimuli. It then processes the internally generated information, organizes it, and interprets it. The result is a form of mentation called a dream. Divergent opinions exist about why we dream. It is either an epiphenomenal byproduct or an evolutionary adaptation, the purpose of which is not entirely known. Psychologically, dreaming is a cognitive phenomenon. A dream, no less than waking mentation, articulates how an individual organizes experience and expresses central psychological features. Clinically, working with dreams in psychotherapy can provide an additional opportunity for psychological development.

Keywords: dreaming, dream, psychology, interpretation

Scientists know more about DNA, atomic fission, and Loch Ness than a basic human activity: dreaming. It is not that they are uninterested. In the last fifty years, research into the nature of dreaming has increased our knowledge dramatically. Dreaming occurs four or five times every night at roughly 90 minute intervals. Dreams last for ten to 40 minutes with the last episode of dreaming being the longest; and the brain is very active while it dreams — as active as when we are awake — but in a chemically different way (Barušs, 2003; Moorcroft, 2003). Yet fundamental questions remain.

In the first section of this paper, I examine the physiology of dreaming. Brain imaging techniques, animal microstimulation experiments, and stroke victim lesion studies provide scientists an increasingly clear window through which to view the workings of the dreaming brain. Using this data, I present a physiological

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model of dreaming and describe what may happen in the brain while it dreams. In the second section, I explore possible biological explanations for why humans experience dreams during sleep. There are essentially two schools of thought: dreaming is either an epiphenomenal byproduct of a chemically-activated brain, or it is an evolutionary adaptation, the purpose of which is not entirely known. In the third section, a psychology of dreaming is presented as well as a method for analyzing dreams. While the *how* and *why* of dreaming may be explored using physiological and biological methods, dreaming is also a subjective experience involving a form of mentation that can offer representations of an individual's internal world. Thus, any study of dreaming also lends itself to psychological scrutiny and clinical application.

The paper provides a concise yet comprehensive review of contemporary literature on the nature of dreaming. Typical research into the phenomenon focuses narrowly on particular aspects. This paper integrates findings from diverse disciplines, including neurophysiology, evolutionary biology, cognitive psychology, and clinical psychology, and develops explanations that are logically related to available data. It may be of particular interest to clinical psychologists. Dreams were once considered the "royal road" in psychotherapy. In current practice, however, dreams are utilized only occasionally and most psychotherapists do not feel competent working with clients' dreams (Cartwright, 1993; Crook and Hill, 2003; Fox, 2002; Keller et al., 1995; Schredl, Bohusch, Kahl, Mader, and Somesan, 2000). This paper identifies dreams as meaningful cognitions, and argues that dream work is a valid and valuable therapeutic activity. The paper also presents an accessible method for working with dreams in psychotherapy and includes clinical examples.

Physiological Sources

In 1951, a University of Chicago physiology graduate student named Eugene Aserinsky attached electrodes to the head and eyes of his eight-year-old son, Armond, and watched him fall asleep. About 90 minutes later, Aserinsky's primitive electro-oculagraph and electroencephalograph machines sprang to life, recording his son's eye movements and brain activity. The data suggested Armond was awake, yet he was sound asleep. Eugene Aserinsky had just "discovered" rapid eye movement (REM) sleep (Brown, 2003).

While the most observable signs of REM sleep (e.g., eye twitches) were probably first noticed by a Late Pleistocene-era *homo sapien*, and certainly described by ancient Greek philosophers and Hindu poets (Stevens, 1995), Aserinsky's experiment provided neurophysiologic indicators of a particular state of sleep during which the brain seemed to be doing something. Subsequent experiments in the 1950s and 1960s demonstrated that the movements made by the eyes during REM sleep were associated with some kind of intense mental activity. Studies showed that when subjects were awakened during and after REM sleep, dreams were reported 74% to 95% of the time (Aserinsky and Kleitman, 1953; Hobson, Pace–Schott, and Stickgold, 2000). A review of 35 studies of mentation produced during sleep found a mean REM dream recall rate of 82% (Nielsen, 2000).

The discovery of REM sleep and its strong relationship with dreaming initially led to the belief that dreaming occurred *only* during REM sleep. Experiments which demonstrated mentation could occur during non-rapid eye movement (NREM) sleep challenged this hypothesis (Foulkes, 1962). Even if dreams are not the exclusive property of REM sleep, there exist qualitative differences between reports of dreams produced during REM versus NREM sleep and physiological differences between the two sleep states. These differences are significant enough that REM sleep may be considered the physiological concomitant of dreaming.

REM dream reports are so qualitatively different from NREM reports that judges can easily distinguish between them (Foulkes and Schmidt, 1983; Reinsel, Antrobus, and Wollman, 1992). Antrobus (1983) found that when judges evaluated 154 REM and NREM reports, they correctly identified the sleep state in which the dream was produced 93% of the time. First, subjective reports from dreams that occur during REM sleep are more dreamlike, bizarre, and vivid than those produced during NREM sleep (Antrobus, 1983; Revonsuo and Salmivalli, 1995; Williams, Merritt, Rittenhouse, and Hobson, 1992). In Nielsen's (2000) review of 35 dream studies, 43% of NREM reports qualified as dreams, although vivid dreams occurred only 7% of the time. Next, REM dream reports are significantly longer than NREM reports, with a median length of 148 words for REM dreams compared to 21 words for NREM dreams (Stickgold, Pace–Schott, and Hobson, 1994). NREM reports are longest when they occur within 15 minutes of a REM sleep episode (Antrobus, 1983; Gordon, Frooman, and Lavie, 1982; Stickgold et al., 1994). Stickgold et al. (1994) concluded that NREM dream reports "reflect transitional periods when some aspects of REM physiology continue to exert an influence" (p. 25). That is, REM sleep processes "covertly" contribute to NREM dreaming (Nielsen, 2000).

REM sleep is physiologically different from NREM sleep. REM sleep is characterized by a low-voltage, desynchronized pattern of cerebral electrical activity, the distinctive movements of the eyes, and sporadic and spastic activity in certain groups of muscles together with an absence of tone in the large muscles of the legs, back, and neck. Also, the pulse and respiration are irregular; both male and female genitalia may become tumescent; and blood pressure, brain temperature, and cerebral metabolic rate are all raised (Moorcroft, 2003). In contrast, the body and brain behave much differently during NREM sleep. In NREM sleep, also known as "quiet" or "slow-wave" sleep, a person's breathing and heart rate are regular. Also, while neurons in the brainstem are quite active during REM sleep, they slow down or stop firing completely during NREM sleep (Siegel, 2003). Positron emission tomography (PET) studies demonstrated significant decreases in regional cerebral blood flow throughout the cortex during NREM sleep (Braun et al., 1997).

What causes a person to fall asleep, enter NREM sleep, then REM sleep, is not yet fully understood. What is clear is that the chemistry of the brain changes. By 1960, it was known that the noradrenaline and serotonin output of brainstem cells in animals changed when the animals went to sleep, and again when they entered REM sleep. Currently, it is known that noradrenaline and serotonin outputs fall by half during NREM sleep, and then shut off completely during REM sleep (Hobson, 2002).

As the brain's noradrenaline and serotonin levels fall, acetylcholine becomes the predominant neurotransmitter. During the waking state and NREM sleep, acetylcholine appears modulated and partly inhibited by noradrenaline and serotonin. Since cortical activation is maintained during REM sleep in the absence of noradrenergic and serotonergic activity, the cholinergic system appears capable of influencing the cortex. Research suggests that it may be the combined actions of acetylcholine and glutamate that contribute to cortical activation and operation during REM sleep (Perry, Walker, Grace, and Perry, 1999).

According to Perry et al. (1999), "one of the most important neurophysiologic events that trigger REM sleep or dreaming is the firing of cholinergic neurons in the pontine brainstem" (p. 276). Chemical microstimulation experiments in cats confirmed the relationship between acetylcholine, the pontine brainstem, and REM sleep: when a cholinergic drug was injected into a feline's pons, REM sleep began. If the drug was placed in the reticular formation, an area of the pontine brainstem, then the cats entered REM sleep sooner and stayed in it longer than injections into other areas of the pons (Hobson, 2002). Thus, cholinergic agents injected into the pontine brainstem seemed to produce all the activities of REM sleep, providing a possible pharmacological model of REM sleep (Steriade and Biesold, 1991; Steriade and McCarley, 1990).

The only monoaminergic neurotransmitter which continues to function during REM sleep is dopamine (Gottesman, 2007). Solms (2000) argued that a dopaminergic mechanism — distinct from the cholinergic one — is capable of producing the same quality of dreams in REM and NREM sleep. Dreaming can be artificially induced by dopaminergic agents and damage to the dopamine circuits in the ventral tegmental area of the forebrain stops dreaming completely. Solms concluded that while REM sleep may be initiated by a cholinergic-activated brainstem, dreaming may be influenced by dopaminergic-activated forebrain.

Advances in the field of brain imaging using PET technology make it possible to document localized cerebral activation patterns during REM sleep. PET studies identify the activation during dreaming of many cortical and subcortical regions. The basal ganglia, basal forebrain, and the midline anterior cerebellum and vermis are all activated. Significant activity was also evident in all regions of the brainstem, particularly in the pontine tegmentum. Dreaming is also characterized by activation of paralimbic and limbic areas, including the hippocampal formations, parahippocampal gyri, and anterior cingulate cortices (Braun et al., 1997). Prominent arousal was also found in the amygdala (Maquet et al., 1996). And despite the general deactivation of much of the parietal lobe, Maquet et al. reported activation of the right inferior parietal lobe.

Also of interest from the PET studies was information about what areas were not activated during REM sleep. Most noticeable was a vast area of the dorsolateral prefrontal cortex (Braun et al., 1997; Maquet et al., 1996). This indicates that a considerable portion of the executive cortex, active during waking, is far less active during REM sleep (Hobson et al., 2000).

A Physiological Model of Dreaming

A dream is an affect-laden, multi-dimensional, visual-motor, cognitive experience; it is full of images and emotion as the dreamer moves through three-dimensional dream "space." How might the brain create such a phenomenon? I draw upon Hobson's (2002) "activation–synthesis" model to integrate and conceptualize the abundant information about cerebral activation. Using this model, I describe how a dream may originate, and how such things as dream motion, emotion, and a sense of dream "space" may be created by the brain while we sleep.

Certain assumptions must necessarily be made when attempting to model any complex system. This model implies a certain progression in the development of a dream, although the flow of information between regions is probably "multidirectional with abundant feedback and feedforward loops" (Hobson et al., 2000, p. 827). Also, it is assumed that activated regions of the brain operate much as they might during waking (Antrobus and Conroy, 1999; Llinas and Pare, 1991).

Physiological data suggest that the process of dreaming may originate in the brainstem. The previously mentioned chemical change in the brainstem that may contribute to the onset of REM sleep may also act as a stimulus to dreaming. Specifically, the shift in brain chemistry from aminergic and serotonergic dominance in waking to cholinergic dominance in REM sleep appears to stimulate the pons. Braun et al. (1997) showed that when the brain enters REM sleep, the pontine tegmentum (the core area of which is occupied by the reticular formation) becomes the most active area of the brain, functioning at a level higher than it does during either NREM sleep or waking. This activity in the pons seems to start a chain reaction that the rest of the brain follows.

The now-stimulated brainstem behaves as it would during waking: it attempts to exert its effects upon the forebrain. There appear to be two major routes, or ascending arousal systems: a dorsal branch projecting into the thalamus and a ventral branch which goes to the basal forebrain and the hypothalamus (Hobson et al., 2000). Braun et al. (1997) found increased activity during REM sleep in both dorsal and ventral ascending routes, although activity in the brainstem and forebrain area was considerably elevated above waking levels while activity in the thalamus was not. This increased ventral activity is consistent with the cholinergic instigation hypothesis since the basal forebrain has widespread cholinergic projections to the neocortex and paralimbic regions of the brain. Indeed, Braun et al. argued that this "preferential activation" (p. 1185) of the ventral pathway was a distinctive feature of REM sleep, and hence, dreaming.

Since our eyes are closed while we sleep, no external visual information is transmitted to the primary visual cortex. Further, the striate cortex — the projection region for the retina in waking — is inactive. Although PET data now confirm this fact, in one study from the 1960s, the eyes of sleepers were taped open when they entered REM sleep and objects were placed before them. The sleepers were awakened several seconds later and no evidence of object recognition was found (Rechtschaffen and Foulkes, 1965). Therefore, the images that we "see" in our dreams likely originate in the brain and are based on something previously experienced (Antrobus and Conroy, 1999). PET data show that the extrastriate ventral occipital area, which creates complex structures of visual perceptions while we are awake, is active during REM sleep (Hobson et al., 2000). This appears to be the region in which basic visual dream images are created. The thalamus may also contribute to the perceptual features of dreaming by transmitting ponto-geniculo-occipital (PGO) waves to the visual cortex (Hobson et al., 2000). The activated extrastriate system in REM sleep is also associated with activation of the limbic-related projection area and parahippocampal cortices, areas that support emotional and memory processes. Thus, the dream image is constructed from memory and laden with affect (Antrobus and Conroy, 1999).

In waking, emotions are generated by the limbic and paralimbic systems: an interconnected group of cortical and subcortical structures. These are consistently found to be active in REM sleep. Braun et al.'s (1997) PET data showed "profound activation of both the paralimbic belt and limbic core" (p. 1188). In particular, the amygdala likely plays a pivotal role in the modulation of dream emotion (Maquet et al., 1996). The brainstem and forebrain may also be involved in dreams that feature primitive feelings of rage, terror, or sexual arousal. (Hobson and McCarley, 1977). Thus, most researchers believe these regions contribute to the often reported emotional quality of dreams (Domhoff, 2001; Merritt, Stickgold, Pace–Schott, Williams, and Hobson, 1994).

The basal ganglia, thalamus, and cerebellum likely play the most prominent roles in portraying dream movement. Release of acetylcholine in the basal ganglia has shown to decrease significantly during NREM and then increase to levels higher than wakefulness during REM sleep (Braun et al., 1997). The basal ganglia are a collection of neurons belonging to the forebrain; it is believed the basal ganglia are involved in complex patterns of motor activity. While a variety of names are applied to different combinations of components of the basal ganglia, usually the caudate nucleus, putamen, and globus pallidus are included. During waking, the basal ganglia are constantly informed about most aspects of cortical functioning. The putamen is probably centrally involved in most motor functions. The caudate nucleus transmits information via the globus pallidus mostly to pre-frontal areas. Next, the thalamus sits atop the brainstem and is situated between it and the cerebral cortex. In waking, the thalamus plays an important role in the sensorimotor relay system: instinctual motor commands generated by the brainstem are transmitted via the thalamus to the cortex. Finally, the cerebellum may refine dream movements with specific features.

Much of the parietal lobe is deactivated while we sleep. PET data show, however, that the right inferior parietal lobe is active (Maquet et al., 1996). This brain region is important for spatial organization and integration, and may generate the three dimensional feeling of dream "space" necessary for the total experience of dreaming. This region's importance to dreaming should not be underestimated. In Solms's (2000) lesion study, damage to the area appeared to result in the cessation of dreaming.

Waking consciousness does not exist in any particular region of the brain. During REM sleep, the influence of acetylcholine, the stimulation of the brainstem and forebrain, and the close relationship between the thalamus and the cerebral cortex may contribute to the sense of verisimilitude that exists in dreaming (Pare and Llinas, 1995). Furthermore, increased gamma wave frequencies during REM sleep indicate inter-hemispheric binding, which may be necessary to join together the internally-generated stimuli in a manner that is experienced as dream consciousness (McNamara, Nunn, Barton, Harris, and Capellini, 2007).

The activation of many cortical and sub-cortical regions during REM sleep contrasts sharply with the prominent deactivation of the "executive" portions of the frontal cortex, particularly the dorsolateral prefrontal cortex. In waking, this area is involved in reasoning, self-reflection, directed thought, and working memory tasks. Dreams are frequently described upon waking as illogical (e.g., "I was flying"), and disorienting (e.g., "The location suddenly shifted to my childhood home"). During a dream, however, the content is typically experienced without such critical evaluation. The deactivation of prefrontal cortex areas may contribute to the uncritical acceptance of dream content as reality while we are dreaming (Hobson et al., 2000).

Biological Functions

In this section, I present multiple hypotheses concerning the function of dreaming. Possible explanations cluster around two views. One view is that dreaming serves no purpose. A dream is merely the byproduct of neurochemical transitions that occur while we sleep. The other view is that dreaming is a product of our evolution. Functions of dreaming may be deduced by understanding the environmental context within which our species evolved.

Epiphenomenon

It is possible that dreaming “was not selected for (or against) during our evolutionary history but was dragged along because the feature to which it was coupled [REM sleep] was actively selected for” (Revonsuo, 2000, p. 879). Thus, dreaming may serve no particular biological purpose. This is not a new opinion; most of Sigmund Freud’s contemporaries believed dreams were “foam.” Proponents of this view believe dreams are simply the incidental results of the brain’s thermoregulatory chemical transitions. The cortex creates a random story from the random messages it receives from the brainstem. Thus, a dream is the best fit the cortex can provide (Moorcroft, 2003). Dreams are “noise in the machine.” Because dreams have no function, the content is meaningless.

That people can remember dreams is balanced, if not outweighed, by the fact that it appears as if humans were physiologically programmed to forget their dreams. In one study, only 14% of people reported dreaming every night and 6% reported never remembering their dreams (Strauch and Meier, 1996). Poor or no dream recall by many people is a function of the abolition of memory during brain-activated phases of sleep. Neurochemical systems that are responsible for recent memory are completely turned off when the brain is activated during sleep, making recall difficult (Hobson, 2002). If dreams had a purpose, would it not be more functional and adaptive to remember rather than forget them?

Evolutionary Adaptation

Humanity’s evolutionary history has taken place mostly in a Hobbesian world in which life was nasty, brutish, and short. Anthropologists speculate that a Paleolithic hominid’s life expectancy would have been no more than 30 years (Fortey, 1997). Daily threats to an early human’s survival included predatory animals, disease, weather, and poisonous plants. Thus, sickness, injury, and death were common and would have generated intense natural selection pressures. If dreaming serves a biological function, then it must have enhanced our species’ evolutionary fitness in some way. Specifically, dreaming must have provided our ancestors with a method for surviving better in an often hostile environment. This would have increased an individual hominid’s odds for surviving and more importantly, reproducing. Reproduction would have allowed the mechanisms that produced dreaming to persevere (Revonsuo, 2000). Possible evolutionary adaptations of dreaming include threat simulation, memory consolidation, memory dumping, trauma processing, and costly signaling.

Threat simulation. A biological function of dreaming may be to simulate events that might have threatened the reproductive success of our ancestors, in order to improve the probability that corresponding real events would be negotiated successfully (Revonsuo, 2000). Dreams allow us to “rehearse threat-avoidance skills in the simulated environment of dreams so as to lead to improved performance in real threat-avoidance situations in exactly the same way as mental training and implicit learning have shown to lead to improved performance on a wide variety of tasks" (Revonsuo, 2000, p. 891). It is not necessary to completely remember the dream, for the purpose of the simulations is to rehearse skills, and such rehearsal results in faster and improved skills rather than a set of explicitly accessible memories. Furthermore, due to the conditions under which dreaming evolved, it is doubtful that any biological function of dreaming could be based on remembering or reflecting upon dreams. Because most humans now live in relative safety from environmental dangers, the threat-simulating function of dreaming rarely gets activated fully. Instead, the contents of modern dreams are usually prompted by recent events that are associated to related "traumatic" emotions drawn from long-term memories (Revonsuo, 2000).

Memory consolidation. An association between dreaming and remembering is apparent in experiments on both animal and human subjects: REM sleep deprivation impairs the capacity to remember tasks from one day to the next (Stevens, 1995). Winson (1990) believed that dreaming may be a memory-processing mechanism in which information important for survival is processed during REM sleep. The clue, according to Winson (1985), lies in hippocampal theta rhythms. The brain's electrical activity can be classified into frequency bands. Waves of frequency greater than 13 cycles per second (cps) are called beta waves, those 8 to 13 cps are called alpha waves, those 4 to 7 cps are theta waves, and those less than 4 cps are called delta waves (Barušs, 2003). Experiments in most mammals have detected theta rhythms in the hippocampus on two occasions: whenever the animals performed survival-important behavior, and during REM sleep. The hippocampus is an old structure, phylogentically, and has a number of important functions, one of which is to fix experiences in memory, thus enabling an organism to learn and store new and valuable information.

Since theta rhythms are involved in both dreaming and in the performance of important survival behaviors, Winson (1990) concluded that "theta rhythm reflected a neural process whereby information essential to the survival of the species — gathered during the day — was reprocessed into memory during REM sleep" (p. 44). Early mammals had to perform all their "reasoning" on the spot. In particular they had to integrate new information (sensory data) with old information (memories) immediately to work out their strategies. Winson (1985) speculated that at some point in human evolution, the brain invented a way to postpone processing sensory information by taking advantage of the hippocampus: REM sleep. Theta rhythm is the pace at which that processing happens. Instead of taking input from the sensory system, the brain takes input from memory. But the kind of processing during REM sleep is the same as during the waking state, so this REM sleep processing is merging new information with old memories. From an evolutionary point of view, REM sleep helps the brain "remember" important facts without having to add cortical tissues. A dream lets us "see" some of the processing.

Memory dumping. Crick and Mitchison (1983), based upon research on mammalian brains, hypothesized that "reverse learning" or "unlearning" took place during REM sleep when unwanted and/or useless information acquired during the awake state was removed. They argued that while we dream during REM sleep, the brain eliminates potentially unnecessary or damaging patterns of brain functioning. The brain's network of interconnected cells is so dense, so complex, and so sensitive that "unwanted or 'parasitic' modes of behavior" (p. 111) can easily take hold when the brain is disturbed either by natural growth or by external experience. To perform as well as it does, the brain must have some way of ridding itself of unwanted, unnecessary, or harmful information. Using this hypothesis, the process of dreaming makes memory space available for newer information to be encoded (Gulyani, Majumdar, and Mallick, 2000). Thus, for proponents of the memory dump hypothesis, trying to remember dreams is not encouraged since this just maintains information the brain was trying to purge.

Emotion processing. According to Hartmann (2007), dreams diffuse emotions and serve a kind of "quasi-therapeutic" function. A recent emotional experience during waking, typically one capable of disrupting an individual's emotional equilibrium (e.g., a traumatic event), is diluted through a dream. Dreaming connects the new emotional material to older memories; by weaving in a current emotional experience with older ones, the intensity of affect is spread out.

Hartmann (2007) collected numerous dream reports, over a period of months, from people who experienced traumas. This allowed him to track and assess any qualitative changes in content. Over time, the dreams followed a pattern. Initially, the trauma typically manifested as a natural disaster (e.g., tidal wave, tornado, or avalanche). According to Hartmann, such a dream produced intense feelings of helplessness, terror, and vulnerability, which facilitated verbal expression of the trauma upon waking. Within days to weeks, the dreamer's mind began to connect the traumatic experience with older memories. Connecting the trauma with older material from the dreamer's life gradually diluted its intensity and the event occupied a diminishing role in the individual's waking life and dreams. Dreams processed the intense emotions and contributed to integrating the trauma into the dreamer's waking life.

Costly signaling. Neurochemical changes, brain activation, increased cardiac and respiratory rates, and muscle twitches are metabolically "costly." McNamara, Harris, and Kookoolis (2007), using evolutionary theory, argued that these features of REM sleep and dreaming are likely to have been selected and serve a purpose that justifies the expense. In nature, certain characteristics or behaviors evolve because they signal health and strength to members of the species. The costlier the trait, "the more honest is the advertisement of 'having good genes' " (Valli and Revonsuo, 2007, p. 103). A signal that is metabolically costly serves as a "certification of honesty" (McNamara, Harris, and Kookoolis, 2007, p. 117).

Dreams, which are often emotionally charged, can influence an individual upon waking. In particular, they produce memories and feelings that are then used by the individual in social interactions. When these thoughts and feelings are conveyed either subtly or overtly to another person, they are considered "honest" and "hard to fake" signals. According to McNamara, Harris, and Kookoolis (2007), "the audience who hears the dream knows that regardless of content, the dream will convey important emotional and social information about the mind of the dreamer" (p. 118). Dreams, therefore, are a form of communication and important for our species' social behavior.

Psychological Implications

While a dream likely has physiological sources, and may have biological functions, it is also a form of mentation and an experience through which an individual has lived. Hunt (1989) wondered if it is even possible to study the activity of dreaming without recognizing it as "a lived story with rich imaginistic properties and powerfully felt meanings" (p. 18). Mancia (1999) argued that dreaming "transcends the brain and occupies an epistemological level very different from that of brain functions" (p. 1211). Thus, dreaming may be studied as an empirical, meaningful, cognitive phenomenon (Kramer, 2007; McNamara, Nunn, Barton, Harris, and Cappellini, 2007). Dreams also have clinical applications. The images in a dream are drawn from an individual's personal history and express core features of his psychology. By clarifying dream images and connecting them to the dreamer's waking life, a meaning for the dream can emerge. Such explication of a dream can lead to understanding personality dynamics and promote behavioral change.

When the brain is activated during REM sleep, it operates as it does when awake. That is, the brain processes information, organizes it, and interprets it (Fosshage, 2000; Hartmann, 2007). Since external sensations are limited during sleep, the brain focuses on internally generated stimuli. Dreams represent this process, using the cognitive abilities that are accessible to the brain in its REM state (Beck, 1969; Llinas and Pare, 1991). The result is a dream; a form of mentation that uses schemas, expresses emotions, and incorporates procedural, semantic, declarative, and episodic memories (Bucci, 1997; Domhoff, 2003).

A dream's most striking features are verisimilitude and narrative cohesion. Both the poet and the scientist capture these qualities. Edgar Allen Poe asked "Is all that we see or seem but a dream within a dream?" David Foulkes (1985) wrote "dreams are credible multimodal world analogs that are experienced as life. The simulation of what life is likely to be like is so nearly perfect, the real question may be, why shouldn't we believe this is real" (p. 37)? Because dreams feel real and usually tell a story, we often impart meaning to them and seek to understand the imagery they contain.

The first known recording of a dream was found on a Babylonian clay tablet dating to 3,000 BCE (Hoffman, 2004). Stevens (1995) asserted that "every society known to anthropology has had theories about dreams and techniques for interpreting them" (p. 9). In the twentieth century, the most prominent Western approach to dream interpretation was Freud's psychoanalytic theory. According to Freud (1900), a dream was a type of unconscious thought in which the images that appeared (manifest content) represented the disguised expression of a repressed wish (latent content). Freud believed that when something occurred during the day that stimulated a libidinal or aggressive wish, it was typically repressed because awareness of the wish was too disturbing for the conscious mind. Since the wish still pushed for gratification even when repressed, it was incorporated safely into a dream in a disguised form through the defensive processes of condensation and displacement.

Freud's scientific peers paid little attention to the phenomenon of dreaming and the lay public often considered dreams to be supernatural messages. Thus, Freud's theory of dream formation, rooted firmly in the science of his day and the psychology of the dreamer, represented a significant departure that has "proved essential for our modern view of dreams and dreaming (Trosman, 1995, p. 163). Freud's insights into the psychology of dreaming also had an innovative clinical implication. By thinking freely about the manifest images in a dream and following the chain of associated thoughts, memories, and feelings, Freud believed the manifest content could eventually be connected to the latent content. Thus, dream analysis could play an important role in a process of working through conflicted emotional experiences that influenced an individual through neurotic symptoms (Da Rocha Barros, 2002; Freud, 1900).

While Freud's dream theory and clinical method were revolutionary, and elements of both endure, contemporary research has led to the revision of many core psychoanalytic tenets concerning dreams. It does not appear that dreams are deliberately disguised repressed thoughts; nor do they always represent instinctual wishes (Barrett, 2007; Bucci, 1997; Cartwright, 2006; Fosshage, 2000; Trosman, 1995). Rather, dreams are the result of the brain's cognitive processing of internally generated stimuli during REM sleep cycles. In particular, a dream's organization and content are likely due to nonverbal, figurative processing mechanisms and the loss of logic resulting from the deactivation of the dorsolateral prefrontal cortex (Bucci, 1997).

The images that end up in a dream effectively and efficiently represent the self, other people, events, and relationships, as well as ideas and feelings (Cartwright, 2006; Fosshage, 2000). While image selection likely assumes a probabilistic nature, the process is based both on the activation of memories and the use of figurative thinking. First, hippocampal and amygdalar activity during

REM sleep suggests a recent waking event likely stimulates memories because the thoughts and feelings evoked in the present are similar to those associated in memory. Since memories are linked by a shared potential to evoke similar experiences (Rovee–Collier and Cuevas, 2009), the content of a dream can draw upon numerous procedural, semantic, declarative, and episodic memories (Bucci, 1997; Da Rocha Barros, 2002).

Next, given the deactivation of the prefrontal cortex and the lack of verbal mediation, the mind visually represents content using its nonverbal, figurative thought processes, such as metaphor (association by similarity) and metonymy (association by contiguity). While metaphors and metonymies are typically considered literary devices, they are fundamental to how the mind organizes and interprets information. Through a metaphor, items that are similar in form or function can be associated. One concept or image can replace another or multiple concepts or images can be condensed into one. Through a metonymy, items that are linked temporally or connected physically can be associated. People, events, and/or objects that have been experienced closely in time can stand for the other; also, a whole can stand for a part or a part for the whole.

Metaphors and metonymies allow for textured and flexible thoughts. They "connect ostensibly separate aspects of human experience, linking body and mind, emotion and memory, past and present, unconscious and conscious" (Bornstein and Becker–Matero, 2011, p. 172). Through metaphor and metonymy, complex feelings, experiences, and concepts can be represented powerfully and efficiently by a single visual image (Domhoff, 2003; Lakoff and Johnson, 2003).

A dream, no less than waking mentation, articulates how an individual organizes experience and expresses central features of his psychology (Domhoff, 2003, Fosshage, 2000). A dream offers representations of a client's internal world, in particular, schemas of self, others, events, and relationships. Clinically, since dreams flow from emotional history, they can also lead to issues that play a central role in a client's psychological difficulties (Da Rocha Barros, 2002). Working with dreams in psychotherapy can provide an opportunity for psychological development (Cartwright, 1993; Hill, 2004).

A Cognitive–Experiential Model of Dream Analysis

When dreaming is viewed as a psychologically meaningful cognitive phenomenon, the task is to clarify, through the dreamer's associations and elaborations, the organization and meaning of the dream's images. Explication of the images leads to an understanding of the underlying schemas and the possibility of promoting change. Furthermore, the experience of talking about a dream also has therapeutic properties.

Hill (2004) developed an approach to using dreams in psychotherapy that clients found helpful and fits well with the data presented in this paper. Hill assumes that: a dream is a form of cognition; dreams involve affective, behavioral, and cognitive components; a dream's meaning is personal; dreams are a useful tool for promoting insight and change; and working with dreams is a collaborative process. Theoretically, the model is rooted in both psychodynamic and cognitive psychology. It incorporates Freudian and Jungian principles and techniques when they are consistent with contemporary knowledge concerning how the mind works during its waking and REM sleep states. For example, from Freudian psychoanalytic theory comes the idea that dream images are shaped by condensation and displacement (although not for defensive purposes). Condensation works by the metaphorical cognitive mode and displacement works by the metonymic one. From Jungian analytical psychology come the dream analysis techniques of active imagination, associating close to the image, and having a component that uses the dream to facilitate change in the client's daily life. Also, psychoanalytic object relations and Jungian archetypes are expressed as schematic representations of a client's internal world.

In Hill's (2004) approach, there are three stages to analyzing a dream: exploration, insight, and action. These stages mirror the typical sequence of psychotherapy itself. That is, most clients begin therapy by exploring those issues that initially brought them to treatment. Gradually, the therapist helps a client make sense of underlying personality dynamics that generate symptoms and conflicts. Finally, therapist and client collaborate on how to do things differently and make changes in the client's life. By mirroring the broader psychotherapeutic sequence, the task of analyzing a dream fits easily within the broader process. Furthermore, clients can apply what they learn from how to work with dreams to other aspects of the therapy and their life.

Exploration stage. When a client shares a dream, it is likely that neither the client nor the therapist knows immediately what it means. Even if a therapist has some interpretive ideas, she should refrain from sharing them at this point. During this stage, description precedes judgment, interpretation, and explanation. Therapist and client identify five to 10 prominent images and explore them as they appear sequentially in the dream. A selected image can be a person, object, behavior, thought, or feeling.

To facilitate the exploratory process, the therapist uses open-ended questions to help the client describe each image. (The client describes an image as it appears in the dream, rather than how it may exist in the individual's waking life.) Detailed image description immerses the client in the dream so that experiences in the dream "become more immediate, real, and significant for the client" (Hill, 2004, p. 27). The therapist then gathers the client's associations to each image. Associations are one of the principle sources of information about the client's underlying schemas. According to Hill (2004), the therapist helps the client stay close to the image rather than free associating away from the image. Finally, since each image is connected to an issue or concern in the client's waking life, the therapist helps the client to explore what may have occurred recently to trigger the selection of a particular image.

Insight stage. Therapist and client integrate the descriptions and associations gathered in the exploration stage to formulate an understanding of the dream, which may include several possible interpretations. The goal is to generate interpretations that make sense, fitting the descriptions and associations gathered during the exploration stage with knowledge of the client's present life and past history. In general, the focus is on understanding how the dream reflects aspects of the client's waking life and personality dynamics (i.e., schemas, object relations, attachment patterns, archetypes) rather than any stereotypical or fixed interpretation (e.g., a rocket symbolizing a phallus or a spider representing the pre-oedipal mother). The meaning of each image is determined by the client's associations, and the image's connection to other images in the dream. As with the previous stage, the therapist is not an "expert" who dispenses answers; rather, the therapist asks the client for his initial impressions about what a dream may mean and then collaborates on expanding the understanding of the dream.

Dreams typically range from being fairly literal with little cryptic imagery to being very figurative and full of bizarre images. Most dreams contain rather straightforward content that includes familiar people and locations; the bizarreness ratings are surprisingly low (Domhoff, 2007). Dreams with little embellishment do not require extensive interpretation to understand because the images are relatively transparent. For example, a 25-year-old male client dreams of driving down a highway and being "cut off" by another car. The dreamer feels furious, tries to catch up, but is unable to do so. In the exploration phase, the client describes the make and model of the other car and associates it to his older brother's car. The client then remembers that the previous day he was at a family picnic. The client's brother, who he described as "a natural raconteur," dominated the event with his anecdotes and the client felt frustrated that he was not able to talk (being "cut off"). The client also reported always feeling competitive with his brother and never being able to match his accomplishments (unable to "catch up").

When dream images are more bizarre and/or cryptic, the mind's nonverbal, figurative processes are used to greater effect. Again, this is not done to deliberately disguise anything; it is just how the mind works during REM sleep. As mentioned, dreams use metaphors and metonymies to portray ideas, feelings, events, people, and relationships. The focus remains on what the images might represent in the client's waking life and how they may reflect aspects of the client's personality dynamics. For example, a 27-year-old male client dreams of flying toward Tallahassee, Florida in a "Jetson's-like" flying car. He pulls into an amphitheater. As he walks through the amphitheater, something tugs at his legs. He turns around and sees a woman wearing a skull mask trying to pull him down. The client pulls off the mask and the woman is wearing another mask;

he pulls off the second mask to reveal a third mask! Upon removing the third mask, he sees the face of a female childhood acquaintance covered in blood. The dream woke the client up and he felt confused by the images and disturbed by the bloody face.

Through exploration, the client generated satisfactory descriptions and associations to Tallahassee, the flying car, the amphitheater, the woman wearing multiple masks, and the childhood acquaintance. Furthermore, the client reported having an argument with his girlfriend the previous day and this was likely the precipitating event for the dream. The primary insights gained from the dream were: frustration with his current girlfriend (as well as a previous relationship); and difficulty expressing certain feelings, particularly anger, toward women.

Knowledge of the client's associations and the dream's meaning allows it to be "reverse engineered." That is, working backward from what the dream conveys, it can be shown why the particular images may have been selected to construct the specific narrative. The central issues for this dream were the client's frustration toward women, particularly his current girlfriend, and his difficulty expressing negative feelings toward them. The mind tries to express these thoughts and feelings using visual metaphors and metonymies drawn from the memories and schemas available to it. Why was the dream set in Tallahassee versus any other location? The client had an ex-girlfriend who lived in Tallahassee and the relationship did not end amicably. In the client's memory, there were associations via temporal contiguity (i.e., a metonymy) between Tallahassee, his ex-girlfriend, and feeling frustrated and angry. The three were so closely linked in time that Tallahassee stood in for both his ex-girlfriend and his feelings toward her. We know the client felt frustrated and angry toward his current girlfriend. Thus, in the client's mind, there was no difference between Tallahassee and his current relationship. Tallahassee effectively and efficiently represented his present circumstances; that is to say, his psychological "location." The selection of the amphitheater was due to an association via similarity (i.e., a metaphor). The dreamer's argument with his girlfriend occurred in a public place and he felt awkward about being "on display." Functionally, the amphitheater and the public place in which the argument occurred were similar in the client's mind. Thus, one replaced the other in the dream. Finally, in waking life, during the argument, the client did not say something he felt would be "mean" and hurt his girlfriend's feelings: the relationship was "bringing him down." In the dream, physically being pulled down by the female figure, the skull mask, and bloody face of a childhood acquaintance captured these sentiments through metaphors. The name of the childhood acquaintance in the dream was the same as his current girlfriend. In childhood, the girl was often subject to teasing by classmates. The skull mask and blood symbolized his girlfriend being hurt. The client feared that if he expressed his frustration and anger toward his girlfriend, then she would be hurt.

Action stage. Understanding a dream can promote psychological development when it leads to the client thinking and behaving differently. The therapist helps the client use what was learned in the insight stage to consider what changes could be made and how to implement them. If the client decides to make a change, the therapist collaborates on generating specific change tactics. In particular, the therapist explores the client's options, evaluates advantages and disadvantages, provides necessary component skills (e.g., assertiveness training), and offers encouragement. The therapist does not push the client to make a change or tell the client what to do; rather, the therapist helps the client to think about how the dream may be used to change habits and attitudes in order to foster different outcomes in his life. How a client reacts to ideas of change also permits a therapist to assess readiness and motivation for change. Some clients welcome the possibility and others are more resistant. Regardless of the client's reaction, it becomes part of the dream work and psychotherapy processes.

One way to facilitate change is to ask the client to modify particular images in the dream, alter its plot, or give it a different ending. Hill (2004) believed this helps the client feel like an active agent capable of directing his life story, rather than like a passive recipient. The therapist then identifies how changes the client made to the dream could translate to the client's waking life. For example, a 41-year-old female client dreams of floating comfortably in a swimming pool when someone tells her she needs to prepare an elaborate dinner for her family. The client does not want to spend hours cooking; she wants to do something simple like order a pizza. The client secretly orders take-out food from a fancy restaurant for her family and a pizza for herself. When she goes to pick up the food, she is nervous throughout and afraid that she will be caught for "going behind their backs." Upon exploration and insight, the client determined that she often ignored her own needs and preferences for the sake of "keeping the peace" in her family.

During the action stage, the client changed the plot of the dream: when she was told to prepare dinner, she responded by saying she was enjoying her time in the pool and when she was finished she would be happy to order a pizza for dinner tonight. If the family wanted something else, they could prepare it themselves. The therapist then translated the change in the dream to the client's waking life by helping her identify a preference (e.g., taking some time for herself), as well as how to express and pursue it without feeling exceedingly guilty.

Conclusions

Dreaming is not a disembodied phenomenon. While what causes a person to dream is not fully understood, what is known is that the chemistry of the brain changes when we enter REM sleep. A neurochemical change in the brain may act as a stimulus for dreaming. Specifically, a shift from aminergic and serotonergic dominance in waking to cholinergic and glutamatergic dominance in REM sleep seems to start a chain reaction in the brainstem that the rest of the brain follows. The activation of many sub-cortical and cortical regions may provide a neurological platform for cognition. The brain can then use those cognitive functions available to it during REM sleep to create mentation based on internally generated stimuli.

Most current hypotheses concerning the function of dreaming are either too dismissive or focus too narrowly on one purpose. First, the dream as "noisy byproduct" explanation is a poor fit for what we know about human evolution and how the brain works. Given the metabolic costs involved in dreaming, as well as its continued existence over the course of our species' evolution, the phenomenon may have facilitated our environmental adaptation. If a dream is just "noise," it is far more likely that it would make no sense at all. Revonsuo (2000) provided the example of migraine auras to demonstrate how actual "noise" in the brain manifests. Next, Barrett (2007) suggested that even if some waking thoughts focus on potential dangers, we do not assume "threat management is the sole function of thought — we tend to assume it's one of many" (p. 138). Thus, dreaming likely has multiple functions that facilitate adaptation, as does waking thought, including solving problems, simulating threats, fulfilling wishes, processing emotions, and serving as forms of communication.

The physiological sources and possible biological functions of dreaming are likely important but insufficient components of a comprehensive understanding of the phenomenon. A dream is also a form of cognition and a subjective experience. During REM sleep, the brain interprets internally generated stimuli using the cognitive abilities that are available in its REM state. The result is a dream; a form of mentation that visually represents the self, other people, events, and relationships, as well as ideas and feelings using nonverbal, figurative thought processes. Thus, a dream, no less than waking mentation, is psychologically meaningful. Because of this, dreaming also has important clinical implications. Since dreams are idiographic products of an individual's memories and schemas, they reveal how an individual organizes experience and identifies core psychological issues. Working with dreams in psychotherapy can provide a valuable contribution to a client's psychological development.

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Counterfactuals, Belief, and Inquiry by Thought Experiment

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The case is presented that counterfactual thinking evolved from trial of action for inquiry into current problems. Counterfactual thinking is regulated by belief. It is activated automatically by the belief that there is a problem, and terminated by the belief that a satisfactory response is found or cannot be found. The evaluation of bad outcomes is a special case, being one among many classes of problem. The other uses of counterfactual thinking, including its extension to other applications, and its prevention of repeating the same mistake, are secondary benefits. This unified view of counterfactual thinking is seen more clearly with the original definition of counterfactual from philosophy, which allows the inclusion of future-directed conditionals.

Keywords: counterfactual, belief, inquiry, reason

This paper defines a counterfactual as an "if *p,* then *q*" or "*q* if *p*" conditional where the antecedent *p* is, or is presupposed to be, false. Allowing the falsity of the antecedent to be presupposed permits the inclusion of future-directed or forward-looking conditionals. The definition is from philosophy and philosophers have often included forward-looking conditionals as counterfactuals (for examples see Blackburn, 2008; Chisholm, 1946; McDermott, 1999). The definition is necessary for my purpose, which makes use of forward-looking conditionals. I will argue that the definition is psychologically sound. For convenience I will call this the original definition. Many psychologists use the stricter definition advocated by Kahneman and by Roese, by which a counterfactual is an "if *p,* then *q*" conditional where the antecedent *p* is known to be false. I will call this the newer definition. It restricts counterfactuals to backward-looking or past-directed conditionals, since the future is not known. I will comment further on the difficult nomenclature of conditionals in the final section of this article.

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The Congruence of Future-directed and Past-directed Counterfactuals

Daniel Kahneman (1995, p. 378) has argued that "There is no psychologically interesting difference between the counterfactual conditional 'If you had loaded one more suitcase on this cart, it would have tipped over' and the conditional warning 'If you load one more suitcase on this cart it will tip over." This is the view I wish to justify, to demonstrate that the original definition of counterfactual is psychologically sound. In this instance the two conditionals, both counterfactuals by the original definition, express essentially the same thought, derived from the same unstated background knowledge. The likely context is that they are unasked-for comments by an observer to an experienced porter, the second made as the cart is loaded, the first when it is ready to be unloaded. They are both activated by closeness or near miss, from the cue of seeing the particularly fully loaded cart. They may be idle comments, or, if the porter is a novice, they may be for instruction. The forward-looking observer may feel anxious, and the backward-looking observer may feel slight relief, but it is likely that neither speaker feels any definite emotion, they may even be amused.

Backward-looking counterfactual thoughts are often involved in attributing causes, while forward-looking counterfactuals are often involved in prediction, planning, decision-making, and actions. I will return to the question of function later, to propose that both types have the same primary purpose. At first sight the different types of counterfactuals seem to be accompanied by different emotions. Backward-looking thoughts are typically accompanied by backward-looking emotions such as regret, relief, and consolation, while forward-looking thoughts are typically accompanied by forward-looking emotions such as anxiety, fear, and hope. On closer examination, it is clearly not past and future direction that determines the emotion, it is certainty or uncertainty in the thinker's mind. It just happens that the future is uncertain and the past is often known. The football fan who thinks "I hope we will win this game, if we lose our season is over" will continue to hope until he hears the result, perhaps days after the match. A prisoner may feel regret as he thinks counterfactually of the pleasures he will forgo, knowing what his future holds. There is no necessary link between counterfactual thinking and emotion. Counterfactual thoughts that are purely hypothetical, or about matters of no personal concern, are often not accompanied by any emotions.

The Evolution of Counterfactual Thinking

My proposal begins with the conjecture that counterfactual thinking evolved from trials of action. Trial of action is the most primitive form of inquiry. It is part of conditioning behavior in simple animals, with the trying of alternatives when a previous response has had bad or neutral consequences. It is how a laboratory rat solves a maze, and thirsty cattle that find one gate to the water trough closed move along the fence to the next gate. Humans retain this old ability to use rather automatic trials of action, as a man doing a jigsaw puzzle tries the unplaced pieces and a man with an unfamiliar set of keys fiddles and experiments to open an obstinate lock. The purpose of trial of action is to find a solution for the problem that is confronting the animal or person at the time, which for convenience I will call a current problem. Trials of action are like unspoken counterfactual thoughts: if I go to the other gate, then I may get through. If I fiddle the key out a tiny bit and try again, then the door might open. It seems a small step from trials of action to counterfactual thinking. My suggestion is that human evolution has taken this step, initially because of the better ability to solve current problems that it confers.[1]

The ability to conduct inquiry by thought experiment or mental simulation, which often involves raising and testing counterfactual alternatives, is a recent development in evolution, perhaps unique to humans (Suddendorf and Corballis, 1997). Chimpanzees are good at learning but poor at making discoveries through imagination (Povinelli, 2000). The human ability with thought experiments is presumably due to the great development of the frontal lobes in evolution from ape to human. Counterfactual thinking is a frontal lobe function, and is defective in patients with frontal lobe damage (Epstude and Roese, 2008; Knight and Grabowecky, 1995). Once evolved, this new ability greatly extended the scope and power of inquiry. Trials of action deal only with the current problem. Thought experiments can also consider the distant past, the distant future, and even the purely fantastical. Though evolved as a form of thinking that aids inquiry, counterfactual expressions are used for communication in discourse.

Counterfactual Thinking and Belief

The proposal is that in a typical instance counterfactual thinking is activated automatically when a person believes that a pertinent problem has arisen, and is terminated automatically when the inquirer believes the question is answered, the problem solved, or the best alternative found (Leicester, 2008). The stronger the belief, the more compelling its effect. These automatic processes are swift and effortless and have an unconscious component. Inquiry can also be deliberate, and can be extended deliberately. Such extensions, which override the natural response, are slow and effortful. Some people use them more than others do, depending on their intelligence and cognitive style, but it is impractical to attempt them for more than a small fraction of our thinking.

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[1]Kahneman (1995) proposed that automatic counterfactual thinking developed from the orienting reflex seen in lower animals and infants. His example is that when the doorbell makes an unusual sound this activates the counterfactual image of its normal ring. Another example is the small problem of noticing that one's shoelace has come untied. It is part of how counterfactual thoughts are activated, a topic discussed later in this article.

Pertinent problems that initiate inquiry have many forms. These include indecision about what to do, threatening situations, planning to achieve a goal, impediments to goals and plans, bad events and bad outcomes, matters of curiosity and interest, failed expectations, disappointments, tasks and questions set by other people or advice asked for, perceptions and propositions that cause doubt or surprise, and unexpected, unexplained, or unwelcome emotional feelings.

I will comment particularly on thinking about outcomes, because this has been so thoroughly studied as a separate topic. I propose that it is a special case of the general function of thinking about problems. Bad outcomes, like other problems, automatically activate inquiry with a new search for counterfactual alternatives. Since the outcome is past, the counterfactuals will usually be backward-looking. Nevertheless, the reason the counterfactuals are activated is to seek a way to fix the current problem, which they may do by identifying a mutable cause of the bad outcome. The alternatives raised are relevant to the particular outcome, and are often not useful for the future. The inquiry sometimes succeeds: some bad outcomes can be overcome or nullified. When inquiry finds that there was a better alternative but the outcome is now past remedy, then backward-looking regret, remorse, guilt, or shame may follow, or consolation, if no better alternative is found. When a better alternative is found and the problem is one that may occur again, then the counterfactual thinking can confer future benefits, but that is not its primary purpose, it is an incidental gain.

The purpose of counterfactual thinking proposed here is consistent with the main findings from studies of responses to outcomes. These findings are that bad outcomes activate counterfactual thinking much more than good outcomes do, and that the counterfactuals raised usually focus on the most mutable events and causes in the sequence that led to the bad outcome and often suggest how the outcome might have been better.

Counterfactual thinking has other applications. It is used to attribute cause and assign responsibility. This is not what it was evolved to do, and it often yields only mutable enabling causes (Byrne, 2005). People deliberately seek counterfactuals to give consolation to themselves or to others. They do sometimes reflect on good outcomes, often when the event was one they had anticipated anxiously, or when they have the strong cue of a close shave with disaster. They sometimes think counterfactually about other people's problems and other issues that do not concern them, as well as during idle wishful thinking and reverie. People are aware of the issue of prevention, and they tend to think harder about how the outcome might have been better when they expect the situation to occur again (Markman, Gavanski, Sherman, and McMullen, 1993). I propose that these applications are secondary benefits that became available once the capacity for counterfactual thinking had evolved.

Epstude and Roese (2008), in a less general application than mine, have proposed that the recognition of a problem and the negative emotions that accompany that recognition are the key determinants that activate counterfactual thinking. Their concern was with past-directed counterfactual evaluation of outcomes and its effect on regulation of future behavior.

The Process of Counterfactual Thinking: Its Unconscious Components and Limitations

Counterfactual thinking begins with the belief that there is a problem. This step involves processing perceptions and relevant memories and expectations, and seems to begin preconsciously. Some events automatically activate the orienting reflex, drawing attention to the problem. Often the process is more subtle, the thinker may not be fully alert to the fact he has identified the problem, which he may not express in inner speech. Problems are not always recognized promptly. The next step, if the problem requires inquiry by thought experiment, is to activate or bring to conscious mind an alternative or counterfactual antecedent for testing. This is a key step, because it is preconscious and fallible. It depends on cues and association of ideas or priming, which makes how the problem is framed important, and may explain why usual, normal and routine acts and events, and the thinker's prejudices, overvalued ideas, and strongly held prior beliefs are all so readily available. The stronger the cues, the more likely the activation (crossword puzzles depend on this for their effect). There is no control over which alternatives are activated, even during deliberate inquiry, and the inquirer may be unaware of the cues he has used. The next step is to test the counterfactual possibility that has emerged, using the Ramsey test, the inquirer hypothetically adding *p* to his stock of knowledge and evaluating his belief in the satisfactory or target outcome *q,* given *p*. When he finds a counterfactual where he believes "If *p,* then probably *q,*" inquiry will stop, depending on the (closely related) strength of his belief and his judgement of the probability. In this process the emergence of belief is effortless and involuntary and its effect in terminating inquiry is automatic, though in special contexts it may be deliberately overridden. The final step, when it is applicable, is to actualize *p* to obtain *q*.

Counterfactual reasoning often fails to consider some of the most pertinent alternatives — it stops too soon. One commonly suggested reason for this is the limited capacity of working memory. I have proposed that another important reason is that the process is regulated by belief, giving speed and economy to inquiry and decision, but with some sacrifice of accuracy (Leicester, 2008). Another cause of fallibility is that even humans are simply not very good at raising counterfactual possibilities. Why does the crossword answer, known perfectly well, not emerge until the cues of some of its letters are revealed, when it pops out?

The importance of cues and the unconscious element in their use was beautifully shown in an experiment by Norman Maier (1931). Maier hung two cords from the ceiling of his laboratory. His subjects were told to tie the cords together. The difficulty was that the two cords were too far apart to reach one while holding the other. Various objects were around the room, such as poles, clamps, extension cords, and chairs, which the subject was allowed use. The process involves a counterfactual thought experiment leading to a trial of action. Subjects found some of the solutions easily, such as tying the extension cord to the end of one of the ceiling cords. After each solution Maier told the subject "Now do it a different way." Most of the subjects failed to find the pendulum solution of tying a weight to the end of one cord and swinging it at the other cord to catch it while holding the other cord. When these subjects were well and truly out of ideas Maier gave them a cue. Apparently by accident, as he walked to the window he would touch one of the cords to set it in a slight swaying motion. Over half the subjects then found the pendulum solution within the next one minute. When they were asked how they had got the idea of the pendulum solution most said they did not know, and when pressed offered wrong reasons, including one fanciful confabulation.

Conditionals and the Psychology of Reasoning

The modern approach to the psychology of reasoning developed from work by the British psychologist Peter Wason, who showed that most subjects answer incorrectly the seemingly simple reasoning tasks he designed. This is partly because the tasks are not truly simple, but involve relatively complex logic (O'Brien, 1995). Most subjects fail to activate relevant considerations, often because of premature mistaken beliefs that the solution is found.

The dual-process theory of reasoning proposes that belief belongs to the Type 1 or System 1 process, the system that is rapid, automatic, effortless, associative, and partly preconscious. It has become appreciated that conditionals are not simply true or false, they have probabilities of being true. Belief bias refers to the tendency to endorse conclusions on the basis of believability rather than on validity. It is consistent with and perhaps predictable from the process of inquiry described above.

How people use, understand, and draw inferences from counterfactuals during discourse is less relevant to this article, though pertinent to the next section on nomenclature. It is a complex topic. People commonly make logical errors, often from understanding "if" as "if and only if" — which can lead to justifiable inferences. People sometimes use conditional expressions to give emphasis or humor to strong assertions, or courtesy to otherwise blunt instructions: these uses are unrelated to conditional reasoning.

A Note on the Classification of Conditionals

The inherent difficulty of the subject, the indefiniteness of mood in English grammar, the desire for accurate descriptive names, and a bias to choose the definition best suited to each author's own interest have led to a confused nomenclature of conditionals. A particular conditional that is counterfactual by the original definition may be semifactual, factual, or prefactual by other definitions.

English has the subjunctive mood for sentences that are definitely or possibly hypothetical and the indicative mood for factual sentences. The rule is loosely applied, with the result that many contrary-to-fact conditionals are not expressed in the subjunctive mood and some conditionals that are expressed in this mood are not counterfactual (Chisholm, 1946). This implies, I think correctly, that subjunctive conditionals and counterfactuals are not the same thing, though they are still often so treated. The hypotheticality of a conditional sentence means the degree of probability that the situations it refers to, and more especially in its antecedent, have been or will be actualized. This hypotheticality is a continuum (Comrie, 1986), and the limits of counterfactuality are unclear. With the exception of deontic conditionals expressing in general terms natural or man-made laws, conditionals are not factual: their "if" ensures some hypotheticality of the antecedent (Comrie, 1986), no matter how believable or true they are on Ramsey test, or how factual they sound and look in speech and print. In consequence, if interpreted generously, most conditionals are counterfactual by the original definition.

The main reason that Kahneman and Roese abandoned the original definition seems to have been desire for an accurate descriptive name. Kahneman and Varey (1990, p. 1102) pointed out that "By definition, counterfactual statements refer to events that did not, in fact, occur," and Roese and Olson (1995, p. 1) argued that "The term counterfactual means, literally, contrary to the facts . . . . For present purposes, we restrict our use of the term counterfactual to alternative versions of past or present outcomes, although we are aware that others have also used the term to describe future possibilities." The newer definition serves well for evaluation of outcomes and attribution of causes, and has the merit of being clear to define and apply, but it obscures the commonality of backward-looking with future-directed conditionals. It makes difficulties for studies of prediction or planning, when authors have either retained the original definition or introduced the term "prefactual" for imagined future-directed cases (Gleicher et al., 1995).

Psychologists interested in how people understand and draw inferences from conditionals during discourse often base their nomenclature on the grammatical mood of the conditional, because this affects the inferences likely to be drawn. Subjunctive conditionals have stronger counterfactual implication, and are often equated with counterfactuals, while indicative conditionals are called factual

(Byrne, 2005, pp. 33–34). Byrne adopts a suggestion originally made by Goodman (1947) and treats semifactual conditionals (even if *p,* then still *q*) separately, because, unlike other counterfactuals, semifactuals imply or concede that the actual antecedent did not cause the consequent. My comment is that the counterfactual thinking is identical in each case. Whether or not the hypothetical antecedent being tested would change the consequent emerges after the testing, from the result of the Ramsey test. I believe this justifies the original and usual emphasis on the hypotheticality of the antecedent. The important causal implication of semifactuals could be indicated by calling them concessional counterfactuals. Note that all these terms are problematical as descriptive names. Accurate and satisfactory descriptive names have proved elusive, and I think the quest for them is unnecessary.

Philosophers were initially drawn to counterfactuals by the paradox that something that has not occurred and may never occur can be true. Counterfactuals present challenges to logic and theories of truth. Early authors expected that important benefits would follow from a solution of these challenges. For example, Chisholm (1946, p. 289) contended that "The philosophical problems which this question involves are fundamental to metaphysics, epistemology, and the general philosophy of science," and Goodman (1947, p. 113) posited "A solution to the problem of counterfactuals would give us the answer to critical questions about law, confirmation, and the meaning of potentiality." It may be fair to say that neither the solution nor the benefit have been forthcoming, and to conclude that the reason philosophers separated counterfactuals from other conditionals has lost much of its force.

Furthermore, the validity of the orthodox identification of indicative and subjunctive conditionals has been questioned (DeRose, 2010; Dudman, 1994). DeRose (2010, p. 7) writes in negative tone of the "many who think they can tell what camp a conditional falls in just by quickly looking at its quasi-grammatical features." Blackburn (2008, p. 82) ends his concise entry on counterfactuals in *The Oxford Dictionary of Philosophy* with the sentence "There is a growing awareness that the classification of conditionals is an extremely tricky business, and categorizing them as counterfactual or not may be of limited use." I have some sympathy for this view, and have retreated from "counterfactual" to the simpler "conditional" several times in this article. I have chosen the definition of counterfactual that suits my interest and which I believe is psychologically sound.

Conclusions

The proposal presented is that counterfactual thinking evolved from trials of action *pari passu* with the ability for inquiry by thought experiment and the ability to consider the past and the future. The primary function of counterfactual thinking is to find solutions to current problems. Its future benefit if the same problem recurs is a secondary gain. Counterfactual thinking is regulated by belief. It is activated automatically by belief that there is a pertinent problem, and terminated by belief that a satisfactory response is found or cannot be found. Once evolved, counterfactual thinking has extended to other applications, including consideration of good outcomes, and of problems of no direct concern to the inquirer.

The proposal is shown to be consistent with the main findings from the literatures on counterfactual thinking and on the psychology of reasoning. It involves using the original definition of counterfactual, to include forward-looking conditionals.

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Déjà Vu Explained? A Qualitative Perspective

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St Augustine first referred to déjà vu in c. 400AD as "*false memoriae*." However, since the late nineteenth century, when there was a flurry of research (Wigan, 1844, "the sentiment of persistence"; Jackson, 1880, "mental diplopia"; Bourdon, 1893, "reconnaissance des phénomènes nouveaux"; Arnaud, 1896, "fausse memoire"; Bergson, 1908, "souvenir du present"), the study of déjà vu has largely remained under-researched in mainstream scientific investigation. This article employs qualitative analysis to examine and explain the theories of the causes of déjà vu or stimuli characterised by a feeling of familiarity in the absence of recollection. It also explores a psychological "profile" for the experience of déjà vu and draws inferences about the physiological "purpose" of déjà vu and the evaluative dimensions of the phenomenological experience of it. Qualitative analysis reveals that déjà vu is a commonly occurring normal experience and that while it may be an effect of temporary over-excitation of hippocampal synaptic transmission, it has a purposeful cognitive function by acting as an orientation-reflex to spatial-temporal reflection in experients' momentary consciousness.

Keywords: déjà vu, memory, phenomenology

Explanations of déjà vu or the perceived feeling of "any subjectively inappropriate impression of familiarity of a present experience with an undefined past" (Neppe, 1983, p. 3) is a common lifetime experience among approximately 67% of the population (Brown, 2003, p. 397) occurring on average once yearly amongst people who report experiencing it. The experience is thus consistent with psychological normality. Whilst the subject of déjà vu most obviously belongs to psychology, as the study of a specific happenstance of memory it has long been described in literature, as an "as if" experience that doesn't quite fit.

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I have been here before,
But when or how I cannot tell:
I know the grass beyond the door,
The sweet keen smell,
The sighing sound, the lights around the shore.

Dante Gabriel Rosetti,
"Sudden Light," 1854

Characteristically, déjà vu is often brief in experience, lasting for no-longer than five seconds, although the experience itself is phenomenologically unforgettable. Indeed, Proust's (1913–1927/1992) *À la Recherche du Temps Perdu* is famously a monologue on déjà vu and conscious recollection, running to nearly one and half million words. More recently, Joseph Heller described déjà vu in quasi-psychological terms in *Catch-22* as ". . . just a momentary infinitesimal lag in the operation of two coactive sensory nerve centres that commonly functioned simultaneously" (1961, p. 268). Heller's point might have been to introduce an anthropomorphic fallacy into his famous novel, however, O'Connor and Moulin (2008) identify two types of theory classifications for déjà vu in cognitive psychology. Firstly, progressing from small or subordinate units involving perceptual theories arising from familiarity invoked from a perceptual environment, and secondly, theories suggesting déjà vu result from an over-arching cognitive feeling that is applied to a perceptual input (Moulin and Chauvel, 2010, p. 214). Some psychologists describe the phenomenon as a glitch in the working memory of the system or a problem with how the perceptual world is communicated to the part of consciousness which is interpreting it (Moulin and Chauvel, 2010, p. 214; Seamon, Brody, and Kauff, 1983). At its most fanciful, déjà vu experiences may lead to people believing themselves to be living in a computer simulation (Bostrom, 2003). Furthermore, participants in some psychological experiments of déjà vu report experiencing it within dreams. Kusumi (2006, p. 308) argues that dreams are "compressed past real experiences" that are similar to typical perception of scenes experienced during waking consciousness. Dream fragments evoke sensations of familiarity from their similarity, triggering déjà vu. However, from the perspective of cognitive processing, déjà vu occurrences within the normal range of waking conscious experience are in fact useful — a form of triggering mechanism or "re-alignment" process in the experience of the individual's subjective conscious present. Given that most experiences of déjà vu are parenthetic — an experience of temporal illusion that is recognised — déjà vu may serve to re-orientate the experient to a conscious state that results in an enhanced perceptual awareness, despite the fact that as Neppe suggests, "'inappropriate familiarity' specifies the core component of the déjà experience" (1983, p. 205). This assertion that déjà vu is actually useful is supported by aspects of recognition heuristics. Analogical reasoning in which the cognitive demands of a previous problem provide a solution to a new one is similar to the sense of familiarity caused by a problem in present experience enabling the retrieval of solutions from past experience. However, it is argued that the dissonance of the déjà vu among normal experients actually causes a valuable re-alignment of cognitive functioning within present consciousness, in this sense the useful cognitive experience is phenomenonological rather than semantic in nature.

Déjà vu also has been described as paramnesia of wrong recognition of an experience (Brown, 2003, p. 395). However, the déjà vu phenomenon itself could be seen as paradoxical as it is ostensibly the right recognition of a wrong experience and hence very useful for realigning cognitive processing with both subjective and objective reality. As O'Connor and Moulin suggest, "déjà vu is . . . a benign experience, not a pathological one, and does not lead to a behavioural impairment" (2010, p. 165). The experiences of déjà vu, experiences of "familiarity without identification of their source," occur on a continuum of recollection-based recognition (Cleary, 2008, p. 353). Strong familiarity signals are produced by a high degree of salience between features of a current situation and recollections of previous experiences in memory whereas a low degree of overlap produces a weaker cognitive signal. Thus similarity of experience to previously experienced situations produces a feeling of familiarity. Familiarity increases with resemblance (feature overlap) between situation schema experienced in the subject's present and those that are stored in memory (Cleary, 2008, p. 354). Déjà vu occurs when familiarity is experienced (feature overlap) without the possibility of temporal coincidence of perceived reality. Furthermore, in the déjà vu illusion the source of the feeling of familiarity may not be identifiable. This offers a clue to identifying the experience of déjà vu — bearing in mind that déjà vu occurs when people experience a feeling of familiarity despite evidence to the contrary, this experience may be limited to those in which there is an overlap between, (a) a feeling of familiarity, (b) an inability to identify the source of familiarity, and (c) evidence that objectively the event could not have occurred before. Thus, although almost instantaneous there may be a temporal dislocation that precipitates the déjà vu experience — a feeling of prior experience that is a minute displacement of time perception in cognition of present experience. From this perspective, déjà vu is thus a learning experience — an aid to objectivity.

Definitions

If déjà vu is a device of memory or memory dilemma, it has corollary experiences which are also within the continuum of recollection-based recognition. *Jamais vu*, for example, is a feeling of unfamiliarity with a situation which should be familiar and *presque vu* is the feeling that "one is on the verge of an epiphany" (Cleary, 2008, p. 356). *Presque vu* may be experienced by a sensation of analogical equivalence described as the discordance from having a memory which is detected in the absence of the ability to identify a source analogy for that memory (Cleary, 2008, p. 356). Brown suggests *jamais vu* is related to word alienation (the occurrence of unfamiliarity in a familiar word) and semantic satiation (a word repeated causes a loss of connotative meaning) [2003, p. 402]. Capgras syndrome may also be related to déjà vu. This is an unusual condition in which an individual believes that a familiar friend or relative has been replaced by an imposter. Fregoli syndrome and intermetamorphosis are also related to conditions of memory alteration and identity. Under either condition, the individual may believe that a familiar (intermetamorphosis) or unfamiliar (Fregoli syndrome) individual has been replaced by a friend or relative (Brown, 2003, p. 402). Funkhouser (1983) distinguished between *déjà vecu* (already experienced), *déjà senti* (already felt), and *déjà visite* (already visited). Neppe (1983, p. 10) further distinguished the phenomenon of *déjà fait* (already done), *déjà pensé* (already thought), *déjà raconté* (already recounted), *déjà entendu* (already heard), *déjà éprouvé* (already experienced), *déjà senti* (already felt, smelt), *déjà su* (already intellectually known), *déjà trouvé* (already found, met), and *déjà voulu* (already desired). Clearly, the déjà vu experience occurs on a continuum of separately identifiable experiences that share a semblance of comparative similarity that enables them to be grouped under the one characteristic of memory dilemma. There may be up 30 such phenomenon each describing a specific aspect of the déjà experience referring to sensory, physical, intellectual and somatic experiences (Neppe, 1983, p. 5). This gives rise to the questions of (a) is there a single cognitive cause for all potential déjà vu experiences, and (b) is it possible to reproduce them in experimental conditions? Most of the literature points to a non-uniformity of phenomenon that may or may not have similar causes.

A Common Profile for the Déjà Vu Experience

Brown (2003, p. 394) suggests that 60% of the population has experienced déjà vu, its frequency decreases with age, it appears to be associated with stress and fatigue, and it shows a positive correlation with both education and socioeconomic level. Although it is more common in clinical contexts as a perceptual "aura" (or physiological experience) among patients with temporal lobe epilepsy, a figure of 60–80% for non-pathological occurrence of déjà vu amongst the general population is also confirmed by Brázdil et al. (2012, p. 1240) and Kusumi (2006, p. 312). Most surveys of the experience of déjà vu only ask about incidence rates rather than the qualitative dimensions of the experience. A survey conducted by Kohr in 1980 found that 14% of respondents had one or two lifetime experiences, 19% had three of four, 23% had five to eight, and 44% had nine or more (see Brown, 2003, p. 398). The inference from this might be that if a person has one experience of déjà vu she is likely to have another. Indeed, as Brown claims, 98% of those who have experienced déjà vu once are likely to experience it again. However, due to the qualitative experience of déjà vu, it may be that the familiarity effect is reinforcing, and respondents are more likely to report more incidences than those actually experienced because the experience produces a memorable physiological effect even though there is no actual deficit effect on semantic memory.

Although the experience of déjà vu may be associated with mild stress and anxiety, the reinforcement of the experience is an alignment of the consciousness within a particular spatio-temporal "frame," but, according to Neppe (1983), it is not accompanied by changes in thinking or emotion. The latter is questionable as the experience of déjà vu is clearly separable from the cognitive sensations both before and after its occurrence and thus has the potential to trigger changes in thinking and emotion. Frequently, feelings of mild stress and anxiety are displaced by more intense temporary experience of temporal (and spatial) detachment. Both Neppe (1983) and Brown (2003) found that the déjà vu experience is often triggered by a visual scene and is very brief in duration, the internal reaction is one of surprise, and involves a sense of temporal dislocation — the experience of time as slowing down. However, it is very difficult to repeat a standardised scenario for these experiences in experimental conditions. Thus, many features of the déjà vu experience from the experimental position remain relatively unknown: there is either little data available of qualitative experience or that which exists is taken from very small samples (Neppe, 1983). From the perspective of experimental design, this is partially due to limitations of drawing information from retrospective designs and the fact that from a qualitative perspective, one's memory of the experience of déjà vu is more likely to be dominated by the perceptual experience of it rather than objective knowledge of one's physical, psychological, or neurological state.

What is consistent from the studies which have been conducted is that the incidence with which déjà vu is experienced decreases with age (Bernhard–Leroy, 1898; Brauer, Harrow, and Tucker, 1970). Studies have shown that déjà vu is more prevalent amongst younger people (Chapman and Mensch, 1951, pp. 168–169). Although this may appear counter-intuitive, middle-aged or older people have had a longer time-span of experience and thus by inductive inference should have more opportunity to experience déjà vu than younger people — but data show that the experience of déjà vu occurrence diminishes with age. No consistent sex difference in the occurrence of déjà vu has been found (Brown, 2003, p. 400).

However, there are further reasons why déjà vu is more common in 20–24 year olds. The first of these is neuroplasticty — certain sections of the brain are still developing at that age, leading to more adjustments in speed of neural transmission. It may be that the developing brain is more active in processing new information and so in some circumstances arousal, resulting in déjà vu experience, may be more frequent. This could also in part be influenced by socio-cultural factors. From the socio-cultural perspective, while the upper point of stimulation may change, we all still seek medium levels of sensory arousal (i.e., inverted "U" curve) from experience. However, those that seek more arousal tend to be younger people and the rush of accompanying cognitive stimulus may result in some circumstances of momentary disruptions in neurotransmission as the brain adjusts to process perceptions from both new and familiar situations. A lower level of sensory arousal and hence experience of the déjà vu is then consistent with older age. These disruptions in neurotransmission are likely to take place in the plasticity connections between the hippocampus and the temporal lobes both of which are involved with memory and learning.

A study conducted by Chapman and Mensch (1951) revealed that educated persons aged 20 to 35 years had a higher déjà vu incidence than less-educated persons. These results were replicated by Richardson and Winokur (1967) who found a higher incidence of déjà vu in professional and student groups (47% to 73%) than unemployed and unskilled groups (25% to 43%). Perhaps this is because better-educated people may have a narrower range of information processing: their perceptions of stimuli differences have smaller variation and thus changes in cognitive processing may be more pronounced when attentional frames of reference change. Or it may be that this narrow but intensive range of perceptual experience momentarily produces over-excitation of specific brain regions. There is also evidence that those who frequently travel may have a higher incidence of déjà vu since they encounter more new locations which require increased perceptual arousal (Brown, 2003, p. 401). Chapman and Mensch (1951) found that those who do not travel have a 11% incidence of déjà vu, people who make from one to four trips yearly have a 31% incidence, and those who travel more frequently have a 32% incidence of déjà vu. Titchener reported that déjà vu may occur with physical or psychological distress or in situations of mental fatigue (1924, p. 187). From the physiological perspective, Adachi et al. (1999) stated that déjà vu may be correlated with lower glucose levels in the metabolism of the parietal cortex and mesial temporal lobe. Zuger (1966) reported a relationship between absence of dream memory and experience of déjà vu in waking consciousness, and experience of dream memory and déjà vu in sleep. Consequently, people who remember their dreams are less likely to experience déjà vu. However, even when experienced by a fatigued awakened person, déjà vu can serve to enhance normal conscious experience by reorienting a person to her temporal present experience. As the product of physiological arousal in the temporal lobe and hippocampal neurotransmitters, it is a servant, not a slave of consciousness.

Thus the three components of travel, dreaming, and repeated visual stimulus may result in potential sources of familiarity stored in the memory of people who experience déjà vu. If familiarity is accompanied by an inability to retrieve the memory source, it leads to a sense of having been already experienced (Cleary, Ryals, and Nomi, 2009, p. 1082). Other features of déjà vu include, restricted paramnesia, a failure to recognise a portion of past memory which triggers a perception of present familiarity; redintegration, in which a whole schema of a mental state is imaged on only a part of it; and, pseudo-presentiment, the foretelling of a present situation (Neppe, 1983, pp. 8–9). The latter is reasonably seen as an after-effect of déjà vu, a feeling of familiarity in the absence of recollection produces a sense of foretelling once the déjà vu experience is recognised and integrated within ordinary consciousness. However this sense of foretelling is usually unaccompanied by any content apart from a sense of vague recollection. The effect is to re-establish conscious awareness in the present-time experience.

Explanations of Déjà Vu

Among scientific studies there is little data available about the precise nature of the déjà vu experience (Brown, 2003, p. 398). This may be partly due to the fact that the experience is qualitative, hard to locate in neurological terms, fleeting, not inconsistent with normality, and difficult to describe or replicate in quantitative experiments. According to Brown (2003), Moulin and Chauvel (2010), and Neppe (1983, 2010), explanations of déjà vu fall into four categories. These are (a) dual processing (two cognitive processes that are momentarily out of synchrony), (b) neurological (disruption in neural transmission or seizure), (c) memory-based (implied familiarity with unrecognised stimuli), and (d) attentional issues (unattended perception followed by attended perception; see Table 1).

While there is agreement amongst researchers that déjà vu is a routine cognitive experience unrelated to severe psychological disturbances, it is nevertheless possible that déjà vu, while involuntary, may in fact be a very useful response for objectivity normalisation. Thus while the common déjà vu experience is distinct from depersonalisation, psychopathology, and even ongoing dispositions such as mood fluctuations, working rhythms, and emotional sensitivity, there is some evidence that the experience of déjà vu is longer in duration and higher in frequency amongst people with these disorders (Brown, 2003, p. 396).

Table 1

The Four Categories of Explanation of the Déjà Vu Phenomenon

Dual Processing	Two cognitive processes which normally operate in synchrony become momentarily uncoordinated (out of phase)
Neurological	Brief dysfunction in the nervous system involving either a small seizure or alteration in the normal course of neuronal transmission
Memory	Memory and perception momentarily enfold one-another
Attentional–Inattentional	The ongoing stream of perceptual experience is divided into two separate perceptions through distraction or inattention

Dual-Processing Explanations

The dual-processing explanation asserts that there is a disruption in the operation of two separate but interactive cognitive processes. Mnemonic processes that operate in concert may become momentarily asynchronous with one being activated in the absence of the other (Brown, 2003, p. 402). Familiarity and retrieval are independent cognitive activities usually operating in synchronous parallel; hence recall is accompanied by familiarity of information retrieved. However, in déjà vu, retrieval can be activated in the absence of familiarity to become momentarily unfamiliar (*jamais vu*), or familiarity may be activated in the absence of retrieval (déjà vu). This dual process interpretation is supported by the earlier work of Bergson (1908) who posited that perception and memories are simultaneous events. The dual-process hypothesis is described by Mullarkey and Pearson (2002, p. 144) who asserted that, "memory is never posterior to the formation of perception: it is contemporaneous with it. Step by step, as perception is created, the memory of it is projected beside it, as the shadow falls beside the body." However, this hypothesis may fail to account for the persistence and complexity of memory. It may incompletely describe why any given memory selection may be retained over another or the differences between short- and long-term memory and the selective filtering and assembling of perceptual experiences within cognition. Alternatively, the "memory–perception" hypothesis of déjà vu may account for the cognitive experience of the memory of déjà vu after the experience has passed, unaccompanied by the physiological sensation of déjà vu itself.

Memory encoding and retrieval operate either on the basis of experiencing recollection or storing experience for recollection but seldom both at once. Consequently, when experiencing the déjà vu phenomenon, it is possible that memory encoding and retrieval can both be briefly active simultaneously — new experiences can briefly be encoded as familiar. However, Pashler (1994) has suggested that there is instead a dual mode model of attention, with a single process for memory encoding, memory retrieval, and response selection. Consequently, memory and encoding may not work in parallel, and memory is the outcome of whatever processing occurred as input.

Other theories of dual-processing imply that cognitive resources are usually focused on an out-going event, but distraction, inattention, or fatigue can lead to memory and perception enfolding in on one-another. In support of this, Hughlings–Jackson (1888) suggested that people have two varieties of consciousness — normal (which processes information from the outside world) and parasitic (or introverted — which processes thoughts and reflections of an inner mental world). When the activity of normal, extroverted consciousness is lessened by distraction, fatigue, or temporary seizure, the evaluation of incoming sensory information depends more on internal consciousness, which derives from experiences already held, hence a new experience is misread as an older experience. A problem with this hypothesis is that it is difficult to imagine how a function of consciousness could be parasitic on other parts of consciousness. There are two forms of consciousness operating in parallel that may be combined in a perception of familiarity: straightforward perception of the environment (objective stimulation) and subjective reflection on internal experience (subjective stimulation). For déjà vu to occur, the processing of these two functions is momentarily combined in a state of fatigue, causing an apprehension of temporal displacement.

Neurological Explanations

The basic premise of neurological explanations is that déjà vu relates to brief and temporary neurological dysfunctioning characterised by a change or seizure in the flow of neural transmission from specific receptor sites in the brain: the hippocampus and temporal lobes. Halgren, Walter, Cherlow, and Crandall (1978) hypothesized that déjà vu results not from a decrease but from an increase in the electrical outflow of the hippocampal gyrus (the area of the brain involved in encoding and retrieval) and that this is qualitatively experienced as a misinterpretation of familiarity. Bancaud, Brunet–Bourgin, Chauvel, and Halgren, (1994) proposed that the inappropriate feeling of familiarity results from a nonspecific seizure of activity in the temporal lobe combined with current sensory input (the temporal lobe received information from both the visual and auditory cortices) so possibly either may be involved in the experience of déjà vu if these occurred coincidentally. As Wild (2005, p. 1) suggests, "the perceptual, mnemonic and affective regions of the lateral temporal cortex, hippocampus and amyygdala" are implicated as regions of the brain that are activated in the occurrence of déjà vu. A neural transmission delay from perceptual organs to the higher processing centres in the brain results in a slight increase in the time it takes to transmit a message due to temporary synaptic dysfunction — a slowing in routine processing time of several milliseconds. The experience of this is misinterpreted as what is actually new information experienced as old information (see Grasset, 1904). It is possible that a fatigued state underlies this slowing in neural processing time, which temporarily elongates the time between sensation and perception. A transmission delay involving two neural pathways rather than one seems to be the more cogent explanation.

Neural transmission delay is also the basis of another theory (Ephron, 1963; Humphrey, 1923) which posits that the primary perceptual pathway goes to the dominant brain hemisphere while the secondary pathway routes through the dominant and the non-dominant. When delay from a non-dominant hemisphere is extended, a déjà vu experience may result. Alternatively, an electrical excitation of one pathway in the dominant hemisphere may cause a temporal delay to be experienced in the secondary pathway — causing déjà vu.

Memory Explanations

Memory explanations may serve as the basis for theorising that implicit familiarity is the basis for déjà vu. If an individual processes information without paying conscious attention to the experience of processing information, subsequent processing may give rise to the sensation of objective familiarity in the absence of exact recollection, if the experiential processing conditions are very similar — thus déjà vu may reveal an iterative recursive quality (Corballis, 2011) to the experience of human thought and consciousness. Déjà vu is contrasted to other memory responses through a strong impression of familiarity in absence of explicit recollection.

O'Connor, Lever, and Moulin (2010) describe déjà vu as arising from "erroneous sensation of familiarity" (p. 118). Déjà vu differs from *déjà vecu* in so much as déjà vu experiences do not precipitate actions whereas *déjà vecu* experiences do and are therefore considered to be delusional. The neuropsychological substrates of the experience of déjà vu are considered to be distributed across the two functions of remembering and knowing. As O'Connor et al. suggest, remembering involves recollection from episodic memory and knowing with retrieval from semantic memory, the first requires effort and the second is automatic (2010, p. 119).

O'Connor et al. (2010) state that déjà vu derives from disruptions to the "temporal coding" that are produced by false signals of recall without retrieval, frequently in new perceptual contexts. This sensation follows from dissonance in "firing in hippocampal output neurons relative to the theta oscillation" (p. 118). This increased neural activity causes the sensations associated with retrieval to become dissociated from the act of retrieval itself (p. 119). The hippocampus is involved in reactivating the context associated with an event and recognition and recollection involve theta-coupling between the hippocampus and other neocortical areas. Theta coherence of brain-wave function is associated with the success of encoding and retrieval involving "synchronisation across spatially distributed networks" (p. 135). The basis of the model of neurological functioning causing déjà vu that O'Connor et al. propose is that increased theta coupling occurs both while the hippocampus is encoding and retrieving, producing the dual sensation of recall without retrieval (p. 138). More recently Bartolomei et al. suggest the specific regions involving increased hippocampal "theta coupling" are the anterior subhippocampal structures (involved in knowing) whereas remembering and retrieval require distributed stimulation across the medial temporal lobes (2011, p. 490). Brázdil et al. used a multivate neuroimaging technique termed source-based morphometry which revealed that amongst people who experience frequent non-pathological déjà vu there were mesiotemporal subcortical regions in which significantly less grey matter was present (2012, p. 1240). This is consistent with the findings of both O'Connor et al. (2010) and Bartolomei et al. (2011) that alteration in hippocampal functioning results in changes of volume in transmission.

Speculation concerning implicit familiarity as a foundation for déjà vu was originally proposed by H. F. Osborn in 1884, who suggested that individuals process a considerable amount of information without paying full conscious attention to it and that subsequent reprocessing may occasionally give rise to a sensation of subjective familiarity in the absence of recollection. What sets déjà vu experience apart from other implicit memory responses is an inordinately strong impression of familiarity in the absence of explicit recollection. So, according to Osborn, it is not the specific content of memory encoded which activates the déjà vu but rather an experience of the cognitive processing which occurred on a separate occasion. However, other theories have posited a single element familiarity. One element that is perceived in the present environment may be objectively familiar but is unrecognised because it is experienced in a new or changed context. This gives rise to MacCurdy's (1925) term of restricted paramnesia. Sno and Linszen (1990) suggested a holographic explanation of déjà vu. Memories are stored as holograms; each memory corresponds to a unique pattern of neural activation involving entire cortex, hence memory is not based on storage but a unique wave form of activation. If perceptual elements in a new scene overlap with elements of previous memory, then this has the potential to reactivate an old memory (Brown, 1983, p. 406). MacCurdy (1925) speculated that there are two components of nominal recognition response — affective reaction followed by familiarity (cf. Zajonc, 1980): although two stages follow in quick and seamless succession — indistinguishable as separate processes — déjà vu results when the initial affective stage is not succeeded by a clear cut memory match. Fleminger (1991, p. 1418) suggested that affective and cognitive channels of information processing usually work in concert but that déjà vu results from "aberrant activity in the pathway responsible for affective interpretation of percepts." Linn (1953) suggested that anxiety evoked by some aspect of the present situation disrupts normal functioning of the reticular activitating system. Linn assumed that a change in arousal precipitates déjà vu, rather than a specific affect associated with a stimulus.

Attentional–Inattentional Framework

A fourth framework for déjà vu is that perceptual experience is divided into two separate perceptions as the result of distraction or inattention. Déjà vu is caused when perception under diminished attention is followed by perception under full attention, the juxtaposition of these two experiences results in the diminished perception being attributed to a more distant past (Brown, 2003, p. 407). Leeds (1944) termed this a "split attention phenomenon" and proposed that a physiological reaction as subtle as an eye blink could divide these perceptions. Déjà vu has also been attributed to inattentional blindness (Mack and Rock, 1998). When a target stimulus is in periphery and the extraneous (ignored) stimulus is in the centre of the visual field (fovea), inattentional blindness is more likely to occur when a target stimulus is in the fovea and extraneous stimulus is in the periphery (Brown, 2003, p. 407). Momentary distraction from a stimulus that is later perceived more clearly elicits déjà vu. Dixon (1971, p. 106) suggested that during an initial brief stimulus exposure, inhibition by interference may cause parts of the stimulated field to interfere with the perception of other parts, consequently a second glance of a scene results in initial disinhibituation which then matches present perception. Déjà vu is difficult to re-create in laboratory or field experiments because it is almost impossible to stimulate the over-whelming sense of familiarity within a fleeting moment that needs to be concurrent with the realisation that the stimulus could not have occurred in the context of the present. Furthermore, it is difficult to separate any environmental stimulus on temporal lobe activity from the possibility it may have occurred under any circumstance (Neppe, 1983, p. 7).

Conclusion: The Purpose of Déjà Vu

Déjà vu, rather than only being a feature of memory anomaly, is in fact a purposeful function of cognitive processing. Most studies concentrate on defining déjà vu — either as a phenomenon of experience or as an occurrence of neurological plasticity. However, few of these studies mention that déjà vu is also a useful subjective experience. While the experience of déjà vu may be one of heightened perception of brief temporal displacement within conscious awareness, it re-orientates the experient to the subjective present and heightens the perception of the spatio-temporal experience by the perception of dissonance caused in its brief occurrence. This temporal moment is subjective in so far as the experience is qualitative and different from the normal experience of perceptual flow; it may even be a pleasant experience (the feeling of familiarity usually is). However, the experience of déjà vu is also an aid to objectivity in so far as the experiencer is forced to perform a cognitive "check" at its onset. As O'Connor and Moulin suggest, "the overall evaluation of the déjà vu-eliciting situation sides with the higher-order metacognitive awareness of inappropriate recognition — the outcome is that the experient is able to function normally, does not modify his or her behaviour based on the errant sense of recognition, and can be left with a sense of wonderment at this insight into the normally concealed machinations of his or her mnemonic decision-making processes" (2010, p. 165). The current article does not suggest that déjà vu gives cause for behaviour modification itself — but nevertheless the experience of déjà vu is a phenomenological aid to the framing of consciousness in experients. The value of déjà vu is as a by-product of temporary over-excitation of hippocampal neurotransmission that re-orientates and re-familiarises the conscious state of the individual to a heightened awareness of the perceptual flow of her current physiological experience of environment.

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The Equilibration of the Self and the Sense of Sublation: Spirituality in Thought, Music, and Meditation

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Spirituality is as much a part of everyday experiences, expressed in music, art, or sport, as it is a part of meditative and other mystical states of consciousness. Three loci of development are proposed, relating to representational, presentational, and mystical lines: all of these lines converge on cognitions of spiritual reality, expressed through the mediums of the lines in question. A graded horizontal and vertical progression in the ensemble of lines characterises spiritual presence as both the highest expression of any line and as specific lines of development themselves. Well-confirmed neo-Piagetian dynamics are found to explain many aspects of spiritual development as well as conventional psychological development. Sublation is the atemporal condition of spiritual presence on which all lines converge in their highest forms, which developmental psychology approaches, slightly paradoxically, through the temporalised progression of ontogeny.

Keywords: spirituality, transpersonal, sport, music, meditation

The "sense of sublation" is a resplendent, magisterial, and atemporal appreciation of the fullness of life, which emerges as human potential blooms: it can be glimpsed as the higher unfolding of all human capacities (including thought, sport, and music), and also encompasses entire capacities in their own right which have been developed most fully by the mystics (including meditation). Life is experienced as opening outwards into a seemingly infinite horizon in which finitude appears to have been transcended. The resultant affect is one of happiness (even ecstasy), kindness, and something like wonder. Mystical philosophers have called this enlightenment, and religious teachers, including Christ, have said that it is a glimpse of the fullness of an eternal life to come (c.f. Hunt, 2012). Yet if this condition is really timeless it cannot be ours to find in the future alone but must also be available to us now: individuals discover this initially in their greatest moments and as they share in the greatest moments

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of others, and then as an increasingly continuous sense of buoyancy and insight which accompanies both inspirational and mundane aspects of life.

The "equilibration of the self" is the mutual coallesence of thought and the world through the development of cognition across ontogeny. It has been shown in Piaget's genetic epistemology that the self "equilibrates" (Piaget's term) to physical reality, as demonstrated through increasing mastery of cognitive tasks. Equilibration is the changing relationship between components or "lines" (term explained below) within the individual which influences both the development of the individual, and the emergence of transpersonal potentials (see Dale, 2011).

The transpersonal version of Piaget's ideas outlined in this article may have been closer to Piaget's original vision than the account of development up to formal operations to which his work is simplified in psychology text books. Much of Piaget's early work was concerned with the pursuit of "value," which he considered to be the goal of the religious life. A great deal of research in psychology can be considered a contribution to the process of equilibration of the individual to spiritual reality, although the relevance of psychological research to a spiritual context might only be obvious to those who have attained a degree of equilibration to spiritual reality which is above average in the general population whom psychologists study. In discussing these dynamics more fully it is useful to identify representational, presentational, and mystical loci.

Representational, Presentational, and Mystical Loci

The "lines" of development within the human being can be placed into three groups, or loci, which can be named representational, presentational, and mystical. (The term "line," which may appear strange to those unfamiliar with its usage in psychology, is used to represent any developmental capacity. The concept originates in nineteenth century faculty psychology, and was most famously developed through the related notions of modules, domains, or frames, in the work of Fodor [1983] and Gardner [1983], and then in neo-Piagetian psychology.) The *representational* loci deal with aspects of cognition in which meaning is conveyed through computational symbols. Examples include lines dealing with number, weight, and spatial processing, among others (see Case, 1992). The *presentational* loci deal with aspects of cognition in which meaning is conveyed through absorption in mediums of everyday expression. Examples include all forms of the arts, including music, poetry, and drama (see Shanon, 2008). The *mystical* loci deal with spiritually related altered states of consciousness which do not usually arise in ordinary life at all, like the different techniques of meditation.

If the loci are arranged from left to right, with the representational lines on the left, the presentational lines in the centre, and the mystical lines on the right, then a graded progression of spiritual awareness exists from both top to bottom and from left to right, such that the most intense spiritual presence exists towards the top and towards the right (see Figure 1). The bottom left of the ensemble will be the least likely to produce a feeling of spiritual presence in the individual, and the top right will be the most likely. Hence, the representational lines only find spiritual expression at the very highest levels. The presentational lines find spiritual expression more easily, but still have to be developed to a reasonable degree. The mystical lines induce a sense of spiritual presence very quickly, though they can still intensify through continued vertical development.

Any line of development finds a spiritual expression in its higher forms. The development of the representational lines in very different cultural settings produces recognisably similar cognitions. In the modern West, the development of representational thought in mathematics and physics has led to the study of the interconnected structures of complex systems theory, to a recognition of the possibility of multiple realities, to an awareness of the speeding up and slowing down of time in different situations captured in the "twin paradox," to an acknowledgement of the shifting of observer/observed roles, and to linkage or "entanglement" of objects arbitrarily far apart in space (Laughlin and Throop,

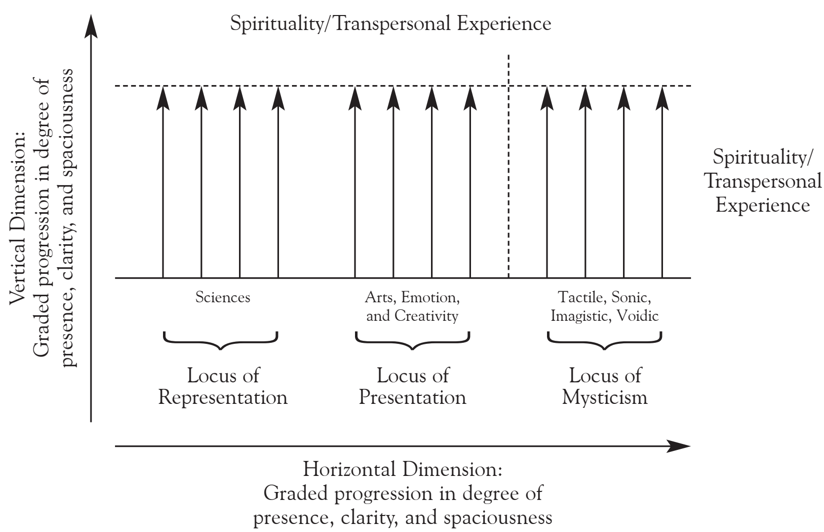

Figure 1: Spirituality is both the higher levels of any developmental line, and specific developmental lines themselves.

2001, 2003; c.f. Hunt, 1995). Physicists do not fully understand these phenomena, much less most psychologists, but recognisable parallels between the representational structures which physics describes and ancient cosmologies are clearly evident. The same structures of representational cognition provide the blueprint for all investigations of cosmology, whether those investigations take place in the modern West and take the data of modern cosmology as their content, or in non-Western indigenous settings and take the phenomenologies of shamanism as their content. There is even some evidence that the contemplation of representational cognition itself can open out into the spacious presence of spiritual consciousness: in the cult of Pythagoras, and the academies of Plato and Hypatia, the contemplation of geometrical axioms was practised as a route to mystical cognitions of the "forms" (Dzielska, 1995).

The presentational lines open out into spiritual presence more frequently and in more obvious manner. The appreciation of music or of poetry can result in an almost meditative or trance-like absorption into the medium of presentation: a musical concert can convey a spiritual or transcendent feeling (Hunt, 1995). This spiritual feeling extends to the performer as well; the sitar musician Ravi Shankar described becoming so immersed in his music that the setting of the concert would be completely forgotten (Shankar, 1997). In theory any form of art, including painting, sculpture, architecture, literature, poetry, or theatrical performance, can potentially induce this kind of reaction.[1] Similarly in sport, descriptions of sporting performances or persons as "divine" in the media, though perhaps overused, reveal the potential of this activity to convey a sense of transcendence to the observer, as well as at times the sports person themselves.[2]

The perception of spiritual presence through the presentational lines is more common than through the representational lines; for extraordinary individuals like Pythagoras, Plato, or Hypatia, such a perception of spiritual presence through the development of representational cognition is possible, but most people do not experience an enhanced spiritual awareness whilst trying to solve mathe-

[1]The appreciation of "natural art" (like landscapes) can produce a similar spiritual feeling. In previous ages, the act of hunting was regarded as sacred, and may have induced a similar "ecstasis" or absorption in the moment, and in the flow of life. Dance is used in ancient cultures and modern subcultures to this effect. Indeed absorption in many traditional activities, like weaving and other crafts, may well have helped to root these cultures in the heightened sense of spiritual awareness they often seem to have activated (Eliade and Couliano, 1991). Music was used in these cultures to raise spiritual presence for ritual purposes, but the natural rhythms of indigenous life-ways may well have continued this immersion in presentational materials through more mundane activities as well.

[2]The English cricketer Geoffrey Boycott (2009) describes an experience, "in the millisecond it took for the ball to leave Chappell's hand, I knew the shot I'd play to it; I knew where the ball was going; I knew it would bring up my century. I saw the delivery in striking clarity, almost in High Definition. And I played it as though I was standing outside myself; actually watching myself get into position for the on-drive." See also Taylor (2002).

matical problems. Deriving a spiritual feeling from presentational experience is much more common, but a high level of development in the line in question is still necessary: a beginner playing an instrument will not induce a spiritual presence in the audience; a professional musician or even an accomplished amateur might induce such a presence. Hence there is a graded increase in the likelihood and ease with which spiritual presence is accessed from the representational lines to the presentational lines.

The mystical lines exist furthest to the right of all of the loci, and therefore most easily and obviously produce a spiritual presence. For a presentational line to reach spiritual heights, years of development are needed; it usually takes at least ten years to master a domain of development (music, literary, etc.) [Piirto, 2004]. Developing such lines to the degree that they can produce a sense of transcendence in others takes time. But, as individuals' statements testify, anyone can derive a sense of spiritual presence through either a few days spent on an intensive meditative retreat, or even more rapidly through the use of indigenous entheogenic preparations like the ayahuasca brew. The mystical lines themselves can still be developed through years of practice and so the purest and most intense spiritual presence is to be found at the highest vertical extent of the mystical lines, and hence the most fertile spiritual ground is the top right-hand corner of the ensemble that has been described; but even a small degree of development of the mystical lines induces a spiritual sensation, as the whole of the right-hand side of the ensemble is directly rooted in potent spiritual currents.

The Neo-Piagetian Dynamics of the Mystical Lines

Neo-Piagetian research has shown that the representational lines unfold through Piaget's stages of development at independent rates. The mystical lines also show evidence of a neo-Piagetian styled dynamic; different lines of meditative development progress through Patanjali's stages of samyoga at different rates, as proposed in Dale (2011).

Lines of meditative development take the form of either contents or techniques, and correspond to the contents and tasks of neo-Piagetian psychology. The contents of introverted spirituality are best broken down into the sensory modalities, and specific Yogas exist which develop each of these sensory modalities. A *tactile* line relates to meditations which develop awareness of the body, including the practices which work with the internal channels and areas of muscular tension (for example Hindu chakra meditations). An *imagistic* line relates to meditations which develop internal imagery (for example the cultivation of light in Christian Hesychasm). A *sonic* line exists which is developed in the Yogas of mantric recitation and the internal intonation of syllables (for example the Hindu shabda Yoga), and a *voidic* line exists which it is claimed taps into pure consciousness, that is, consciousness stripped of any complex representation (for example, in the Sunyavada school of Buddhism).[3]

The development of each line unfolds relatively independently of the others as it must be constructed separately on a neurobiological level. (See Cahn and Polich [2006] for some examples of brain areas involved in different types of meditation.) These different contents or modalities are utilised in different techniques. For example, the Sant Mat school often combines imagistic and sonic lines into the surat shabda Yoga of light and sound. But each technique of meditation can be considered a line of development itself, and again these develop relatively independently (an expert-level grounding in Zen meditation won't automatically transfer to a mastery of Tantra, which involves very different procedures.) Much as musical content can be developed through the tasks of playing either the guitar or the flute, so each meditative content can be developed through multiple specific techniques.

There is evidence that shared, broad stages of meditative development exist. Often, three such stages are identified which correspond to Patanjali's stages of *dharana*, *dhyana*, and *samadhi*. The first two stages have been confirmed in laboratory studies of meditators across traditions, and correspond to synchronised alpha waves and synchronised theta waves respectively, while the neural correlates of samadhi show variation between different groups and different forms of measurement (Cahn and Polich, 2006; West, 1980). The stages of samyoga refer to different stages of mergence with the object of meditation; they are often experienced as distinct transitions by the meditator (see Vivekananda, 1901; Washburn, 1995). Different contents or techniques develop through these stages independently, as the different lines of meditation have to be built independently through neurological adaptations.

Many of the issues debated in comparative religion and transpersonal psychology are clarified when considered from a neo-Piagetian perspective. A neo-Piagetian understanding of the phenomenologies of different spiritual cultures would definitely not predict the universal stages suggested in analyses of spiritual phylogeny, as did Wilber (1982). Instead, different contents and different tasks would see a disparate development between different cultures (and indeed between different individuals) in line with the degree with which a particular spiritual content or task was practised. In neo-Piagetian theory, factors which lead to particularly large differences between the development of different lines include a high degree of exposure to the content or task in question, a high degree of motivation to develop the content or task, and a rich knowledge

[3]The senses of taste and smell are not developed as Yogas as frequently, perhaps because they are the least prominent senses in humans, but there are some attempts to create Yogas of taste and smell in Vajrayana Buddhism (Gyatso, 1991). However, in this article the four lines identified in the main text provide the focus.

base (Case, 1992; Feldman, 1994). These factors are likely to be in place in spiritual communities like monasteries and ashrams where motivation and knowledge base in students will be high, and where the exposure to certain contents or techniques rather than others is likely to be acute — for it is often the case that only the techniques and contents considered relevant by the tradition are encouraged, or even allowed, to be practised. In lay communities of meditators where techniques are more likely to be mixed, or chopped and changed, the degree of independence in the development of different mystical lines will be less pronounced.

The question of whether or not stages apply to spiritual development appears to depend on the nature of the learning environment. A large amount of evidence shows that performance on learning tasks amongst school children progresses continuously rather than in stage-like or discrete jumps in performance level in ordinary class-room environments. In optimal learning conditions on the other hand (for example, conditions in which one-to-one tuition is available), new performance levels are achieved in stage-like jumps (Fischer, Kenny, and Pipp, 1990). If neo-Piagetian dynamics extend to meditative lines then researchers can expect to find stage-like development in the practice of meditation in the optimal learning conditions of monastic or ashramic settings where one-to-one support is available on a daily basis, while in communities of lay meditators where such support is not often available, development will usually be much more continuous (as well as slower overall). Indeed this continuous rather than discrete development in communities of lay meditators is what is reported in anecdotal feedback from students (see Rothberg, 1996), who claim to experience progress over time but do not feel that the stage-like nature of development described in the traditional meditative compendiums composed in monasteries is evident in their own growth.

Although three stages of meditation are commonly reported across both Eastern cultures (from which Patanjali's samyoga stages derived) and Western cultures (where they make up the *scala perfectionis*), as well as in Lewis–Williams and Pearce's (2005) analysis of the progression of trance in Kung bush people, and although three stages have been confirmed through corresponding changes in EEG synchrony in laboratory studies, some techniques and traditions identify a different number of stages. Although four main stages dominate neo-Piagetian frameworks (sensorimotor, preoperational, concrete operational, and formal operational), Piaget himself, as well as more recent theorists, acknowledged that many additional substages were involved and that substages differ from one task to another. Moreover, the substages often *had* to differ as different physical procedures were needed to complete tasks on a balance beam from tasks on a rope pulley, for example (see Inhelder and Piaget, 1958). A direct analogy arises between different cognitive tasks and the performance of different meditative techniques. The more elaborate meditative techniques like Tantra or the visualisation meditations given in the *Gheranda Samhita*, are clearly very different tasks compared to techniques like Zen and Vipassana, which involve a much simpler focus on the breath or the body. It is no surprise then, that different numbers of stages are mentioned in different meditative traditions. Three main stages exist across many meditative techniques, but different technique specific sub-stages also exist, which can make certain compendiums of meditative development appear more detailed.

Interrelations of the Lines

The mystical lines can play an active role in the development of other lines in the self. There is evidence that the presentational lines are initially influenced by the development of representational cognition, and then may fall under the influence of the mystical lines (in those who choose to activate the mystical lines). For example, musical development passes through Piaget's stages up to a formal operational level; in the case of the guitar, the instrument must be learned physically, so the correct way to pluck the strings must be learned (sensorimotor level), then set pieces are learned like scales (concrete operational level), and then the same general riffs, refrains, and turnabouts are applied as generalised or abstract blue prints in a variety of improvised situations (formal operational level). Certain musicians, having developed to this level, will then cite mystical experience, including meditation, as an influence which inspires the creation of more and more impressive pieces of music. Their music will be heightened as a result of their spirituality, which their music conveys (c.f. Shankar, 1997).

Similarly, moral development initially falls under the influence of representational cognition, but its development can be raised to post-conventional levels through the influence of mysticism. In Kohlberg's model, the concrete operational morality of the child, in which loyalties are extended to kin and kind, who share concrete surface features (same family, same school, same neighbourhood, etc.), progresses to a formal operational level in which general principles of equality of rights and values are extended to increasingly abstract groups (all human beings, all human and animal beings, etc.; see Colby, Kohlberg, Abrahami, and Gibbs, 2011). The highest levels of moral development can be conceived of intellectually at a formal operational age (12–16 years), and so, as Kohlberg stressed, the development of morality follows the development of abstract logico-mathematical cognition.

But for Kohlberg the highest stages of moral development were not signified by the representational ability to answer questions on moral judgement tests alone, but by putting that understanding into practice in terms of actual actions in real life situations. In Western mystical traditions, the state of *union*, which involves behaviors similar to Kohlberg's proposed seventh stage of moral development, is induced through years of dedicated mystical prayer, in which the egoic personality is stripped away so that the essence of personhood which remains acts entirely in accord with the universal ethic, or in traditional terms with the "will of God." As Hollenback (1996, pp. 551–552) describes, in the state of union the individual will "become so heedless of his own welfare that he instinctively conforms his actions and his intentions exclusively to God, just as if God's will were his own." Such a state of mind appears to capture what is intended by the integrative unity of Kohlberg's highest stage. The highest stage of moral development appears to be a synesthetic fusion of thought and feeling, in which the individual actually acts upon his or her moral insights (Gandhi, Martin Luther King, and Nelson Mandela are the usual modern examples).[4] Such a state, it seems, can be induced through the synesthetic fusion experienced in meditative mystical prayer, though this activity is not essential in inducing the highest levels of moral development.

The development of ego is also initially closely related to the development of representational cognition (Erikson, 1982; Loevinger, 1976), but higher soft stages of ego development exist, and research has shown that meditation can accelerate the ego development of students into post-conventional levels (Alexander et al., 1990; Radhi, 2002). Meditation (and mindfulness) are also known to be effective in "unfreezing" the development of disadvantaged populations, like prisoners, who had not previously reached conventional levels of moral development, as well as raising affect (Biegel, Brown, Shapiro, and Schubert, 2009; Himelstein, 2011; Khurana and Dhar, 2000; Orme–Johnson and Moore, 2003).

The emerging picture is that many of the presentational lines are initially influenced by representational cognition, but to develop the presentational lines to their peak, the influence of the mystical lines can be useful. The mystical lines themselves provide the metaphor of openness and humanistic expansiveness to which the moral line appears to equilibrate (c.f. Hunt, 1995); the absorptions of meditation produce a sensation of beauty, or of magnificence, which musical and other creative endeavours aspire to replicate.[5]

Spiritual Reality and Sublation

In Piaget's genetic epistemology, the development of representational cognition converges on physical reality. This insight — voluminously confirmed empirically

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[4]Kohlberg eventually abandoned the study of the seventh stage of moral development as actual examples of such individuals were too difficult to find, but the highest stage identified by Fowler (1981) has similar characteristics, and also seems to come close to the Western mystical state of union.

[5]Spirituality is a structural change unfolding across every line in the self. A powerful spiritual equilibrium influences all lines, but can be triggered by developments in any line. Any line of development can produce the necessary perturbation to throw ontogeny down a transpersonal trajectory which finds expression in *every* line (see Dale, 2011).

— can be developed and extended to provide insight into the nature of spiritual development.

Spiritual development converges on spiritual reality; that is, every line of development draws towards spiritual reality and therefore expresses the spiritual in its highest forms. This is not to suggest that there is a pre-given or metaphysical state of "nirvana" which exists in unchanging manner independently of the perception of human individuals, for this has been debunked, firstly by Kant, and then by Piaget himself who set the co-constructed relationship between subject and object on a developmental footing (Von Glaserfield, 1979). Instead, the physical world and the subject mutually coalesce; the testing of the world by the individual (the Piagetian process of "reality testing") changes the internal structures of the subject through the processes of assimilation, accommodation, and equilibration, whilst changes in those internal structures simultaneously alter the appearance of the external world. Development proceeds in this constructive and circular interaction (Piaget, 1972).

Once it is admitted that every line of development can come to a spiritual fruition, the nature of physical reality and spiritual reality conflates, for it becomes clear that what was previously considered physical and separate from the spiritual is really the same as the spiritual. In the realisation of "subject permanence," an equilibration of the self occurring after several years or decades of dedicated meditation which has been confirmed in longitudinal studies of meditation students, the difference between the subject and object is removed, and the experience of a separate external physical world melts away into the unified continuum of the "Self" (see Alexander et al. [1990] for more information). A difference between the physical and spiritual only seems obvious in certain forms of equilibrium, or in certain phases of human development. The nature of physical reality itself and the difference between spiritual and physical reality depend on the developmental equilibrium of the individual. Every aspect of ontogeny can be viewed as a convergence on spiritual reality, and the highest flowering of every developmental line as an expression of spiritual value. What is more, this view of development is more in line with the theoretical basis of much twentieth century psychology than might commonly be realised; Piaget himself had set out to show something similar in the early part of his career.

If he had written in the twentieth-first century, Piaget would probably have been considered a psychologist with transpersonal interests. Piaget certainly showed an interest in religion. For Piaget (1916, 1918, 1928, 1929, 1930), the individual converged on a sense of spiritual value described in his theory of "immanentism." Though the individual could never completely reach spiritual reality, the individual could equilibrate more closely to spiritual reality, in a manner reminiscent of Hegel's work. Spiritual value was experienced as a sense of sublime appreciation and benevolence, rather like Plato's "Good" and did not indicate a belief in the God of the conventional Catholic theology of his up-bringing. God was conceived in a Bergsonian sense and identified with the evolutionary progression of life (Bergson, 1907/1944). Much as representational cognition could equilibrate ever more closely to physical reality, so the experience of value which constituted intuition of the Absolute could constantly be refined.[6] That Piaget cut down his focus on these themes later in his career may have been due to a lack of a developed transpersonal paradigm. At any rate, Piaget maintained some interest in these topics to the end of his career (see Piaget, 1983) as well as in his informal conversations with Bringuier (1980), though he failed to substantiate this interest as competently as his studies in representational cognition.

From the perspective of developmental psychology, subject permanence presents a paradox. Mystics from many different cultures describe a sense of timelessness. Yet subject permanence, or related terms like Fowler's (1981) sixth stage of faith, or the non-dual terminology popular in transpersonal psychology, is increasingly recognised as an equilibrium which can be achieved as a part of a developmental process. Sublation is the philosophical term used by Hegel (1807/2005) to refer to the act of moving beyond a previous level or form whilst simultaneously maintaining that previous form in its entirety; it is also commonly used in translations of Madhyamaka philosophy like Nagarjuna's *Mulamadhyamakakarika* (see Garfield, 1995). The heights of spiritual presence reveal an atemporal cognition, which any line of development can reach; this realisation sublates the developmental process of each and every line once it is achieved. The individuals in the state of subject permanence are simultaneously aware of the passage of conventional time and can interact with the world, but at the same time it is clear to them that the stream of conventional time is subsumed within an unchanging and timeless backdrop with which the greater part of themselves now identifies. This is the paradoxical nature of the state of sublation, which was recognised in many systems of ancient philosophy, and which is emerging again as scientific psychology increasingly arrives at the same insights as the mystical philosophers through the study of the temporalised aspect of reality which constitutes ontogeny.

Average human equilibrations to reality do not usually appear spiritual, particularly in the first half of life, and there is a tendency for individuals to think of the spiritual as something "otherworldly," obscure, or even delusional. But a

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[6]The counter-intuitive developments in physics like the curvature of space-time have shown just how far the nature of physical reality can depart from common sense expectations (see Piaget and Garcia, 1983). Moreover, the curvature of space-time which ensures that travel in any direction will eventually lead back to a central point, reveals a similar cognition of eternity to that which is revealed of consciousness in meditative samadhi: both representational and mystical lines produce knowledge of the same reality, which takes on a spiritual or infinite quality when those lines undergo a certain degree of development.

convergence on spiritual reality follows from the assumptions of genetic epistemology which have been very well confirmed empirically in the research of Piaget and neo-Piagetians. Psychological data are data on spiritual development; one cannot, at any point, either find, or leave the spiritual path, for nothing exists outside of that path.[7]

Conclusion

Every developmental line progresses towards and reflects spiritual reality, though some lines of development reflect spiritual value more readily and obviously than others. The lines of development themselves interact as advances in one line radiate around the entire structure of the self. The lower developments of the lines are simply less accurate equilibrations to spiritual reality; a low level of ability in any line is less obviously spiritual than a higher level of ability, as described in relation to representational, presentational, and mystical loci. Any other definition of spirituality encounters the problem of defining the difference between the spiritual and the nonspiritual which, simple as it might sound, might be impossible: in the final analysis, if spirituality involves notions of infinity and eternity, then no aspect of life can stand outside of the spiritual vista, for infinity and eternity must contain all.

Life can be thought of as a celebration of spirituality — a showcase in which every line of development exhibits some aspect of equilibration to spiritual reality at some level. This sentiment, which sounds New Age (and therefore perhaps suspect) when first encountered, is actually very close to the aims of perhaps the most influential theorist and researcher in psychology's history: Piaget. The sentiment can be explored through analogies with genetic epistemology, a science which engages all of the intricacies of the relationship between subject and object, and between rationalism and empiricism, which have been debated for 2000 years, and which the great modern philosophers like Descartes, Hume, Locke, Kant, and Hegel struggled to come to terms with. Piaget's own answer to these questions, expressed in his constructive theories of development and evolution, and approached through the mutual, dynamic coalescence of the subject and object into an ever-deepening future — see Flavell (1963) and Müller, Carpendale, and Smith (2009) for summaries of Piaget's work — is compatible with the theory of spiritual development outlined. The theory outlined may even contain the potential to illume some of the blind spots which Piaget's own

[7]This equilibration to spiritual reality is not mediated through higher developments in the hard stages of representational cognition, but as a soft stage (or equilibrium) which can come into being at any time in ontogeny, as a result of nonlinear phase transitions in the complex system of the organism. As a systems based equilibrium, rather than as a representational hard stage, children and adolescents can occasionally attain profound awareness of spiritual presence; for more on this systems view of transpersonal development see Dale (2011).

theory set out to address but could not complete, benefiting as it does from several further decades of research and theorising on transpersonal issues.

Spirituality is not only found in the mystical lines, it is found in all human experience. Spirituality is to develop our own abilities to the greatest degree, which is to say, to live spiritually is to live any and all aspects of life as well as we can.

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Critical Notices
Book Reviews
Book Notes

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The Spiritual Gift of Madness: The Failure of Psychiatry and the Rise of the Mad Pride Movement. Seth Farber. Rochester, Vermont: Inner Traditions, 2012, 464 pages, $21.95 softcover.

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Seth Farber's *The Spiritual Gift of Madness: The Failure of Psychiatry and the Rise of the Mad Pride Movement* is a lucidly written and masterful account of an area that is little understood and rarely researched. The book explores the link between madness and the urgent need for a movement of cultural renewal.

Farber is deeply worried about the state of the planet. Runaway climate change is looming and "there is not yet a sense of life and death urgency." Something is missing. Thinking people, who have been following the succession of scientific pronouncements over recent years about the need for immediate action to curb global warming, probably can't help but wonder why we're not already well on the way to solving the problem. Why can't we make some kind of binding global agreement that will avert the looming catastrophe? We know the polar ice caps are melting, we know sea levels are rising, we know it is carbon pollution from burning fossil fuels that is the main problem, we know that life on earth will soon become progressively more difficult for many species, particularly humans, and we know how to replace fossil fuel energy with renewable energy. So what's the problem? Why are we incapable of reaching a international carbon restriction agreement? Such an agreement would cause only minor inconvenience compared to the disruption of progressively worsening climate change. Why don't we listen to reason and why do we still procrastinate?

According to Farber, the political and cultural changes required to solve problems on this scale can't happen without the inspiration of "creatively maladjusted" people acting as catalysts. And these people are currently in very short supply. The shortage is due to an over-active and misguided mental health system. Psychiatrists, he argues, are disrupting a natural process of cultural renewal by capturing and neutralizing messianic-minded people and treating them, often forcibly, with brain damaging drugs. Farber's theory is that mainstream societies follow their cultural trajectories, regardless of warnings about looming dangers, until they are shaken awake by mad men and women who finally persuade them to alter course. The intercession of a dose (or perhaps a demonstration) of madness provides a catalyst for social change and renewal.

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This theory might seem far-fetched at first glance. But this glance is just the way I'm presenting it. Farber is far more subtle and persuasive in the way he unfolds his view. The mental conditions he focuses most of his attention on are the ones psychiatrists call mania and schizophrenia. Who would deny the long associations these conditions have had with mysticism and the arts? And what are mystics and artists, after all, if not catalysts for cultural change?

The Spiritual Gift of Madness begins with a wonderful free-associated foreword by Kate Millett in which she relates anecdotes from her own "loony-bin" experience and recreates, with a short burst of brilliance, the feelings and moods of the long lamented 1960s. From there the book moves quickly into the first of a series of seven interviews. Transcripts of these interviews are scattered throughout the book and together they form the central core insomuch as they provide much of the evidence supporting the thesis.

The first of these interviews is with Peter Stastny. Introducing him, Farber says that since Loren Mosher's death in 2004 Stastny "has been the leading spokesperson for the patient self-help movement" and that he was a "founding member in 2005 of the International Network Toward Alternatives and Recovery (INTAR)." The interview gives Stastny an opportunity to discuss problems with psychiatric drug therapies and the faith he has in the ability of patients to help themselves and each other. The second interview is with David Oaks, director of the human rights and psychiatric survivor advocacy organization, Mind Freedom International (MFI). Farber and Oaks have an association that goes back to 1990 and some of Oaks' interesting personal experience with madness and psychiatry is discussed. Oaks believes that "we are all mad" and that madness is "just culturally relative." Other interviews are with three Mad Pride activists, Chaya Grossberg, Caty Simon, and Sascha DuBrul; former physician turned medical researcher and recovered mad person, Ed Whitney; and former mental patient, author, and psychospiritual healer, Paul Levy.

Interspersed among these interviews are chapters in which Farber discusses subjects raised in the interviews and various aspects of his theory. A number of these chapters have descriptive, self-revealing titles like, "Mental Patients' Liberation," "The Messianic or Postmodern Paradigm?," and "The Relationship of Mad Pride to Messianic Transformation."

To understand the rationale for the many parts of this book it is necessary to understand what Farber needs to prove in order to support his theory. Although the author's perception of a looming global catastrophe is the overall rationale for the book he doesn't feel the need to spend much time in delineating the nature of the problem. In fact, global warming only comes up for discussion in a couple of places and then only for a page or two at a time. The existence of the threat is taken for granted and doesn't require any further evidence from Farber.

Instead, the most urgent point for which strong evidence is provided is the argument that the psychiatric understanding of madness is misguided and that psychiatric treatments are harmful, both to individual patients and to the society at large. This is a constant theme throughout the book and is discussed, at least in part, in all the interviews. This point is necessary to establish early on because if readers were left in any doubt about the unwise habits of psychiatry it would be impossible to further persuade them that madness has spiritual gifts that are essential for collective human well-being.

What should we make of psychiatry? Is there any real science to it, or is it just an art — with all the foibles, jokes, hoaxes, and changing fashions that are essential to the nature of all the arts? Or is psychiatry political, a branch of social control — pest control — perhaps? If it is a true branch of medicine, as is claimed for it, why is it given coercive powers and routinely allowed to treat people against their will? And why do so many former patients complain that their forced treatment did them far more harm than good? Other branches of medicine are bound by the iron rule of informed consent, why not psychiatry?

Farber repeatedly draws on the writings, opinions, and professional practices of three trenchant critics of mainstream psychiatry. Two of them, Thomas Szasz and R.D. Laing, were leaders of the anti-psychiatry movement that began in the 1960s and which Szasz prolonged in his writing almost right up to his recent death. Peter Breggin, the third, doesn't really belong to the anti-psychiatry camp; his position is more specific. Breggin is not necessarily opposed to all psychiatry, he's just very strongly against bio-psychiatry. These three heroes of Farber's complement one another perfectly for his purpose. He needs to persuade readers that there is no such thing as mental illness (Szasz); that mad people are instead spiritually endowed and that any symptoms they might have of distress are just signs of difficulty in coming to terms with their spiritual gifts (Laing); and that normal bio-psychiatric interventions are brain-damaging (Breggin).

But persuading readers that psychiatry does more harm than good is only the beginning. The second leg of Farber's thesis concerns the nature of mad people themselves. After mad people have been rescued from psychiatry, Farber needs to demonstrate that they are up to the task he envisions for them by being both capable and willing to provide inspiration for social change. To establish this he singles out a branch of the psychiatric survivors movement, Mad Pride. Mad Pride exponents, he argues, differ from other former mental patient campaigners in that they are not so much concerned with patients' rights and human rights as with celebrating the experience of madness. The willingness to celebrate madness, it seems, is a pre-requisite for inspiring social change.

It is fairly apparent that in singling out the Mad Pride movement, as the contemporary vehicle for imminent global change and cultural renewal, Farber has stuck his neck out, perhaps a little too far. It would be different if he had argued in a more general way, as others have before him, that prophets and messianic figures, with apparent symptoms of mental disorders, have historically been identified with movements for religious renewal. Indeed, Farber does this himself in a number of places but mainly it is to give support for his faith in Mad Pride. He devotes a whole chapter to the theories of psychiatrists R.D. Laing and John Weir Perry who both developed therapeutic approaches that assumed mad people had spiritual gifts that should be nurtured. However, much of the focus of the book is directed towards an expectation that the fairly narrowly-based Mad Pride movement in the United States will be the soil from which the required messianic movement shoots.

It's clear that at the time Farber conceived and planned his book the Mad Pride movement showed more promise for the fulfillment of this expectation than has come to pass. Over time, Mad Pride seems to have lost a lot of its founding energy and vision. There is something of an air of disappointment in the way Farber contrasts his original enthusiasm for the movement to the way he saw it develop as he watched. His original enthusiasm came from his discovery of The Icarus Project in 2007. This is a web-based forum that publishes the views and writings of Mad Pride adherents. It was founded after a 2002 newspaper article by Sascha DuBrul brought DuBrul together with Ashley McNamara.

Although Mad Pride may not be the right place to look for the required activists, nevertheless, cultural change on a grand scale is still undeniably needed and the input of people with mad gifts may be a pre-requisite for it. Farber's underlying thesis may be sound but it seems to me that it is unlikely these mad catalysts of the future will identify with organizations of former psychiatric patients. The "creatively maladjusted" activists Farber anticipates are more likely to be people whose madness has gone undetected and who have somehow slipped through the psychiatric dragnet and by doing so have kept their minds intact and their brains undamaged.

The Spiritual Gift of Madness is definitely worth reading despite the apparent mismatch between Mad Pride activists and the reality of the challenges confronting creatively maladjusted people who want to jolt the world from its current condition of complacency. Mad Pride activists might have other, more personal, less high-minded, things on their minds but these, too, are worth knowing about. Read the book for the interviews and to hear Farber's cry from the wilderness and don't worry about some of the more doubtful details of his prophecy. We need to hear from prophets. But prophets should always be careful not to be too specific about how their prophecies might come to pass.

BOOKS RECEIVED FOR REVIEW

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