

The Ups and Downs of Cognitive Enhancers

A Study of Common Cognitive Enhancers

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The human brain is an exceptionally plastic structure, able to form and re-form connections in response to individual experiences and interactions with the outside world. One of the most important ways in which humans are able to control their mental experience today is through the use of cognitive enhancers—substances that noticeably alter and improve function in specific areas of the brain. While a plethora of experiences and drugs have been noted to alter one's cognitive ability, only a few well-defined and documented cognitive enhancers seem to dominate recent academic study and today's commercial market. Among these drugs known to enhance focus and attention in the short-term are such stimulants as those used to treat attention deficit disorder (e.g. Ritalin and Adderall), caffeine, and even illegal substances like cocaine. While mainstream cognitive enhancers have been the subject of most scientific study, the spectrum of substances that can be classified as cognitive enhancers is far more broad. The class of chemicals that interfere with normal brain functions is incredibly varied and the effect of these substances on the human brain is near impossible to entirely predict or identify. Thus, research regarding all types of cognitive enhancers continues to develop.

Ritalin

Ritalin is one of the more controversial classes of cognitive enhancers widely used today. Commonly prescribed to treat attention deficit disorder (ADD) and attention deficit hyperactivity disorder (ADHD), Ritalin is a member of a class of drugs known as stimulants. More specifically, Ritalin, along with other ADD drugs like Adderall or Dexedrine, is classified as an amphetamine. In particular, Ritalin is the brand name of the generic chemical methylphenidate, a direct derivative of amphetamine (1). Amphetamines have been shown to function more effectively as short-term cognitive enhancers than other stimulants, like caffeine. In a paper by Bernard Weiss and Victor Laties in the



Image courtesy of Julius Schorzman. Retrieved from http://en.wikipedia.org/wiki/File:A_small_cup_of_coffee.JPG (accessed 25 October 2012)

Figure 1: A cup of coffee has around 100mg of caffeine. Caffeine remains one of the most common cognitive enhancers consumed around the world.

early 1960s, amphetamines were found to be “vastly superior to caffeine at improving human performance in a variety of mental and physical activities” (1). Even in people who do not experience any form of ADD, amphetamines can help to improve focus and efficiency while performing tasks. Quite simply, appropriate doses of amphetamines like Ritalin, Adderall, or even methamphetamine (a commonly abused street drug), administered over a short period of time can enhance cognitive function for nearly all activities. However, amphetamine use over the long-term can have serious negative consequences. In the short term, the side effects are few and manageable—insomnia and decreased appetite are the most commonly noted short-term side effects of amphetamine use. Side effects of long-term amphetamine use are more pronounced and include addiction and increasing tolerance for the drug, which imply a psychological need to take more frequent and larger doses as amphetamine use progresses.

Diller describes the appeal of Ritalin

and drugs like it as “feelings of euphoria; a sense of power, alertness, excitement, or heightened clarity; an ability to deny the need for rest” (1). Ritalin is classified as a Schedule II stimulant under the Federal Controlled Substances Act (CSA). In order to be classified as such, a drug like Ritalin must exhibit “a high potential for abuse [...] have currently accepted medical use in treatment in the United States, and [...] show that abuse may lead to severe psychologic or physical dependence” (2). The feeling of focus and control associated with Ritalin, as well as its availability through medical prescription, makes it highly susceptible to abuse. Currently, the high risk for abuse of Ritalin makes it both more difficult to get and less commonly used than other cognitive enhancers.

Caffeine

Caffeine is perhaps the most popular and widely used of drugs that alter cognition. It occurs naturally in over 60 species of plants, and has been consumed

by humans for centuries in different forms (3). Many people use caffeine every day for its effects as a mild stimulant. Most of the world's caffeine consumption is in the form of coffee, tea and soft drinks. In the U.S., coffee accounts for about 75 percent of caffeine consumption, tea for about 15 percent, and caffeinated sodas for about 10 percent (3). Caffeine is unique in that few regard it as a “drug” due to its relatively mild effects when compared with other more potent stimulants. However, many praise caffeine as a significant cognitive enhancer, with the ability to enhance focus, increase alertness, and generally improve psychological functioning. According to Barry Smith and Kenneth Tola, the popularity of caffeine today is “typically attributed to its stimulant effects, though its role in slowing and smoothing habituation and in enhancing and sustaining attentional focus may also be factors” (3).

The effects of caffeine on cognitive performance have been studied in several different areas, including information processing, memory, and complex cognitive functioning. The vast array of ways that caffeine can affect these different forms of mental functioning can quickly complicate the role of caffeine as a “cognitive enhancer.” For example, while many studies have shown that caffeine “enhances problem-solving and improves logical reasoning,” it remains largely unclear whether caffeine has a positive or negative overall impact on memory, an important part of learning and, therefore, daily cognitive functioning (3). When considering caffeine, it is important to remember that all chemicals that are presumed to enhance cognitive function, have—either directly or indirectly—a drawback to their use. This may seem obvious—a cognitive enhancer with no negative side effects would be overwhelmingly popular. No such drug

currently exists, and the use of cognitive enhancers such as caffeine requires analysis of the drug's positive and negative effects.

Even cognitive functions typically found to benefit from caffeine use can suffer sometimes. An example of this can be seen in the impact of caffeine on information processing. As mentioned previously, caffeine has often been found to improve problem solving, enhance logical reasoning, and even partially reverse age-related deficits in cognitive functioning (3). However, Smith and Tola note that: “most of the studies reporting positive effects of caffeine in information-processing tasks have used primarily or exclusively male subjects” (3). Studies involving the impact of caffeine on both males and females were more frequently associated with no effect or even detrimental effect on information processing. The confounding role of gender in some caffeine studies is just one example of the difficulties of establishing a clear cognitive benefit of any drug. Cognitive enhancers such as caffeine often impact different people in different ways. Moreover, the method of administration, the dose, and the frequency of consumption also play a large role in determining the overall effect of the drug in enhancing cognitive function. For example, some studies have shown that high doses of caffeine can actually interfere with performance during complex tasks (3).

The effect of caffeine has also been studied with regard to memory. Like information-processing experiments, caffeine's impact on memory formation and recall has been studied with mixed results. Confounding variables such as gender, age, and dose taken play a large role in determining the outcomes of each of these individual studies as well. In the case of the interaction between caffeine and memory, the “memory assessment method” (i.e. recall or recognition,) as well as the time frame (whether the memory is assessed immediately or following some time delay), seems to play a significant role in determining the results (3). Experimental trends indicate that caffeine seems to be most effective at enhancing delayed recall, recognition memory, and verbal memory. However, caffeine has also been shown to decrease immediate recall in some cases, such as with word lists (3).

dealt with one-time tests of subjects who had consumed or abstained from the drug. The issue of controlling for previous exposure to the drug, or of predicting the future impact of the drug through continued, regular use remains a significant one. Since most people in developed parts of the world have been exposed to caffeine or consume it regularly, it can be very difficult to establish a strong control group on whom caffeine has had no significant impact. As the daily influences on the brain are many, it can also be very difficult to tell whether other confounding variables impact the cognitive functioning of a routine caffeine user. In fact, they almost certainly do. For example, the amount of sleep that one gets can very easily affect cognitive functioning, and while caffeine can offset the effects of a lack of sleep in the short-term, over a longer period of time these effects may begin to more clearly manifest, regardless of the presence or absence of caffeine.

Caffeine tolerance and the decreasing benefit to cognitive marginal functioning with prolonged caffeine use is also of concern. In fact, some researchers claim that caffeine has the potential to be highly addictive and to be abused by some users (3). Tolerance can be a good measure of whether a drug is actually “addictive” or not. Some studies maintain that regular or heavy caffeine use does not lead to a tolerance—that the effect of caffeine on non-users and regular users is much the same (3). However, other studies have shown that caffeine tolerance is, in fact, a real problem and can develop “perhaps in as little as five days” (3).

Just as the positive impacts of caffeine use are hotly debated, the negative impacts seem uncertain at this point. While some of this can be attributed to a lack of proper research regarding caffeine tolerance and addiction, much of the problem results from an inability to account for the myriad of confounding variables that are a constant in research regarding cognitive function. It is impossible to isolate two individuals with an identical cognitive experience, and it is therefore difficult to establish a true control group. From this perspective, it is best to consider cognitive enhancers as a part of a larger scheme—the goal of research on this front is not to isolate a single, direct influence of any chemical with the potential to enhance cognitive function, but instead to establish a general positive or negative correlation between cognitive output and the use of a substance.



Image courtesy of Patrick Mallahan III. Retrieved from http://en.wikipedia.org/wiki/File:Adderall_XR_20mg.jpg (accessed 25 October 2012)

Figure 2: Adderall XR 20mg capsules. Adderall is a prescription drug, commonly abused for their cognitive effects

Current Research Limitations

All of the discussed studies on caffeine



Image courtesy of Wmahon. Retrieved from http://commons.wikimedia.org/wiki/File:Ginseng_in_Korea.jpg (accessed 25 October 2012)

Figure 3: Ginseng on sale in a South Korean market. Ginseng is popular in Asia for its purported medicinal properties, such as enhancing cognitive functioning. Scientists have classified it as a nootropic.

Nootropics

Research regarding attention deficit drugs like Ritalin and common stimulants like caffeine, while incomplete, has been fairly extensive. However, there are other chemicals with the potential to enhance cognitive function that are less well represented in the scientific literature. For an overview on these types of substances, it is best to look at the relatively newly-established field of “nootropics.” Dwivedi *et al.* describes nootropics as: “drugs, supplements, nutraceuticals, and functional foods that are purported to improve mental functions such as cognition, memory, intelligence, motivation, attention, and concentration” (5). This definition is quite broad and would include all classes of cognitive enhancers. However, the term “nootropic” is generally reserved for use in the description of less traditional substances. In many ways, the most defining aspect of a true nootropic is that it has not been well-defined. The prototypical example would be ginseng, a naturally occurring root with strong cultural significance. Nootropics are “purported” to enhance cognitive functioning, but as in the case of caffeine and Ritalin, an abundance of confounding variables and (especially in the case of nootropics) a lack of research makes it difficult to tell just how effective these substances may be (5).

Nonetheless, the use of nootropics is

developing rapidly. Yet many researchers are hesitant to associate themselves with it because to do so seems as if they are stepping away from hard scientific research into the realm of traditional natural medicine. Nootropics have been employed as alternative treatments in cases of degenerative brain disorders such as Alzheimer’s or Parkinson’s disease, with some success (4). Ultimately, the struggle to identify substances that might enhance brain function is a very difficult one, but one that some researchers are excited to pursue. Malik *et al.* notes that: “many academic researchers are dedicating their efforts to identify compounds that can help in restoring impaired cognitive functions, either directly or through the cure of the pathologies that produce cognitive dysfunction” (4).

Conclusion

While some are more optimistic than others, it is apparent that research regarding the use of cognitive enhancers, especially on a regular basis, is lacking. It is still difficult to identify long-term effects of the use of many cognitive enhancers that are relatively new to the scene, such as attention deficit drugs and various nootropics. Even caffeine, which has been in use for centuries, remains to be fully understood. It seems logical that, for the time being, an appropriate balance is

important in the use of cognitive enhancers. “Too much of a good thing” is very much a concern in the use of cognitive enhancers. This is seen to be true of stimulants such as Ritalin and caffeine, which may lead to tolerance, addiction, and ultimately a negative impact on cognitive functioning. Where enhancers have been most effective is in the treatment of disorders affecting cognitive functioning, as in the case of ADD or degenerative diseases such as Alzheimer’s or Parkinson’s. Especially in the case of neurodegenerative diseases, the risk of using new and relatively unknown cognitive enhancers can be outweighed by their potential to improve the health of the consumer.

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