Caffeine and Memory

A digest of reports of research into the direct and indirect effects of caffeine on cognitive performance.

Summary

It seems clear that caffeine improves alertness and reaction time, but evidence is inconclusive for its effect on higher memory and reasoning processes. It is possible that caffeine may in fact impede memory, where the information is complex or ambiguous.

Caffeine can be helpful in ameliorating the effects of time of day and sleep deprivation on cognitive performance. In normal circumstances (i.e., not prolonged sleep deprivation, or extreme stress), caffeine seems to be more helpful to older adults, in helping them overcome time-of-day effects.

Recent research has demonstrated that caffeine affects blood flow in the brain. It is not yet clear what the implications of this may be.

Caffeine has been implicated in raising blood pressure. High blood pressure is undoubtedly a risk factor for cognitive decline and dementia for those over 60. However, recent studies suggest that, while it is clear that coffee raises blood pressure, it is not clear that caffeine is the culprit.

Brewed coffee raises homocysteine levels. High homocysteine levels in older adults increase the risk of cognitive decline and dementia. Recent research suggests however that caffeine is not the sole ingredient in coffee responsible for the homocysteine-raising effect.

Evidence for the effect of caffeine on glucose regulation is inconclusive as yet, but there is some suggestion that caffeine may be a risk factor for impaired glucose tolerance. Impaired glucose tolerance is a risk factor for cardiovascular disease (and thus, by implication, cognitive decline, since research now indicates that “what is good for the heart is good for the brain”). More direct evidence also suggests that impaired glucose tolerance in older adults is associated with memory problems.

While people clearly build up a tolerance to some of the effects of caffeine, it is not yet clear what the long-term effects of regular caffeine use are. Nor can we say, as yet, what factors are important in determining those long-term effects, although we can speculate that gender, metabolic factors, cardiovascular health, alcohol and tobacco use are all possible influences.

Conclusion: Clearly, caffeine has both good and bad effects, both of which may impact on cognitive performance. Moreover, the main vehicle for caffeine — coffee — contains active ingredients other than caffeine which may, directly or indirectly, impact on cognitive performance. Caffeine does appear to be of greater potential significance to older adults. Overall, the evidence suggests that, while caffeine may help older adults in the later part of the day, those with hypertension, diabetes, impaired glucose tolerance, or high homocysteine levels, would be wiser to
avoid coffee, even if decaffeinated. In general, while caffeine may help you overcome factors that lower your cognitive performance, it does not seem that caffeine has any significant direct effect on memory, although it may well help you pay attention.

### Caffeine and cognitive performance

Caffeine helps ameliorate factors that lower cognitive performance

Caffeine and blood pressure

Caffeine and homocysteine levels

Caffeine and glucose levels

Habituation to caffeine

### Caffeine and cognitive performance

**Summary**

A study of older adults found higher lifetime consumption of caffeinated coffee was associated with better performance on several cognitive tests — for women, but not men.

Four cups of caffeinated coffee led to increased alertness and improved performance on several simple cognitive tasks.

Low doses of caffeine, more typical of tea and cola drinks, are also associated with improved cognitive performance.

However, while caffeine undoubtedly improves reaction time, facilitating those cognitive tasks which are measured in terms of speed, it is not clear that caffeine improves tasks that involve more complex cognitive processes.

**Conclusion:** Caffeine improves alertness and reaction time, but evidence is inconclusive for its effect on higher memory and reasoning processes.

### Reports

November 2002

Coffee consumption associated with higher cognitive performance in older women

A study of 1528 older adults compared cognitive function (assessed by 12 standardized tests), and lifetime and current coffee consumption (self-reported).
Higher lifetime coffee consumption in women was associated with better performance on six of 12 tests; current caffeinated coffee intake was associated with better performance on two tests. Among women aged 80 or more years, lifetime coffee intake was associated with better performance on 11 of the 12 tests, but the results did not reach statistical significance. There was no relation between cognitive function and decaffeinated coffee intake.

No relation was found between coffee intake and cognitive function among men.

A study investigating the effects of caffeine on homocysteine levels (below) also found that the effects of caffeine were stronger in women.


**Older studies**


Two experiments examined the effects of a cooked breakfast, a cereal/toast breakfast, and caffeine (4 mg/kg). Breakfast improved performance on free recall and recognition memory tasks, but had no effect on a semantic memory task and lowered performance on a logical reasoning task. Caffeine improved performance on all of these cognitive tasks.


Some 9000 British adults were surveyed to investigate the relationship between habitual coffee and tea consumption and cognitive performance, measured by tests of simple reaction time, choice reaction time, incidental verbal memory, and visuo-spatial reasoning.

For all tests, higher levels of coffee consumption were association with higher performance. Similar but weaker associations were found for tea consumption, but these were significant only for simple reaction time and visuo-spatial reasoning. Caffeine appeared to benefit older people more than younger people.


The effects of caffeine on several study-related tasks were investigated in 25 students (6 males, 19 females). The tasks involved short-term memory, mental arithmetic, reading comprehension, serial search and verbal reasoning, and took place in eight sessions, at four times of day (1am, 7am,
1pm, 7pm), after participants were given caffeine (4 mg/kg) or a placebo. Participants were classified according to their self-reported caffeine consumption.

Caffeine improved performance on all speed-related tasks. High caffeine users performed more poorly than the others on the verbal reasoning task. Interactions between caffeine, time of day, and user history, support the view that different cognitive processes are affected differently by these three factors.


The effects of caffeine on mid-morning cognitive performance were investigated in 32 male subjects. Participants were given drinks containing either no caffeine, 125 mg caffeine, or 250 mg caffeine. They were then tested on three tasks: 1) free recall of word lists, 2) a response time task, and 3) a numerical Stroop task.

There were no significant effects of caffeine on the recall task or in response times, but those who were given the higher caffeine dose were seriously impaired on the Stroop test, making particularly slow responses.

The researchers suggest that caffeine may have a deleterious effect on the rapid processing of ambiguous or confusing stimuli.

**Everyday use of caffeine**

November 2002

Study confirms validity of laboratory tests to naturalistic settings

The study investigated whether a more realistic coffee-drinking regime (4 doses of 65 mg over a 5 hour period) produced the same effects as a single large dose of caffeine (200 mg). The smaller doses produce an equivalent amount of caffeine present in the body after 5 hours. 24 participants attended four sessions. On two of the sessions, coffee was consumed at 10am, 11am, 12 noon and 1pm. In one of these sessions 65 mg caffeine was added to the decaffeinated coffee. In the other two sessions, the coffee was consumed at 1pm and 200 mg caffeine was added in one of the sessions. Participants completed a battery of mood and performance tests at 9.30am and 3pm.

Regardless of whether the caffeine was consumed in one big hit or in several, smaller doses, caffeine led to increased alertness, increased anxiety, and improved performance on a variety of cognitive tasks: simple and choice reaction tasks, a cognitive vigilance task, a task requiring sustained response and a dual task involving tracking and target detection.

October 2000

The effect of low doses of caffeine on cognition

This study looked at the effects of low doses of caffeine, more typical of tea or cola drinks. The 23 participants were given either 0, 12.5, 25, 50 or 100 mg of caffeine. Their performance was tested once before and three times after the placebo or caffeine.

All doses of caffeine significantly affected cognitive performance, with little difference between the sizes of dose. The effects were more marked in those with a higher level of habitual caffeine intake.


November 1998

The effects of caffeine in doses typical of one cup of tea

There is little evidence concerning the effects of caffeine in doses typical of one cup of tea. The present study investigated the effect of 60 mg caffeine, consumed in either tea or hot water, on cognitive performance in 8 males. Over four test sessions, participants consumed a different hot beverage (tea or hot water, either caffeinated or not), and then completed some nine tests.

Reaction time on pattern recognition, delayed match to sample, and match to sample visual search, was significantly faster for those who had caffeine.


**Caffeine helps ameliorate factors that lower cognitive performance**

**Summary**

Caffeinated drinks can largely overcome the declining cognitive performance seen over the course of the day, most particularly in older people. However, such effects are not thought to be solely due to caffeine, nor are the effects necessarily any better that any stimulant would produce, such as sugar, or exercise.

High doses of caffeine improved vigilance, choice reaction time, and motor learning, in fit young men who were sleep deprived and stressed. In another study, a high dose of caffeine improved some cognitive functions for some of a 64-hour sleep deprivation period, and improved others for all the 64 hour period.
Caffeine in a carbohydrate electrolyte solution improved cognitive performance in male athletes after strenuous exercise.

**Conclusion:** Caffeine is helpful in ameliorating the effects of time of day and sleep deprivation on cognitive performance. In normal circumstances (i.e., not prolonged sleep deprivation, or extreme stress), caffeine seems to be more helpful to older adults.

**Reports:**

**Circadian Rhythm**

January 2002

Coffee helps older adults retain mental sharpness later in the day

Memory in most older adults often depends on the time of day, with memory typically optimal early in the morning and declining during the late afternoon. A study of 40 older adults (over 65) confirmed the popular belief in the value of caffeine in helping overcome this decline in mental sharpness later in the afternoon. All the participants (like three-quarters of all people in that age group, studies suggest) described themselves as "morning people". Testing confirmed that they were less alert later in the day.

The participants, who were already regular coffee drinkers (and were asked to abstain before arriving for the test), were given the California Verbal Learning Test at 8 a.m. and again at 4 p.m., on two days, separated by an interval of 5 to 11 days. During these sessions, some were given a mug of regular coffee, and others a mug of decaffeinated coffee. Interestingly, those given regular coffee performed a little better in the morning than those who had decaffeinated, but the really striking result was that those on regular coffee performed as well on the afternoon tests as they had done in the morning.

While it is good news that this daily decline can be overcome so easily, we cannot conclude from this that the caffeine was responsible. As the researcher noted, any stimulant may work as effectively. Anything that supplies a boost in energy, such as having sugar, or going for a brisk walk, may have the same effect.

http://www.clickondetroit.com/sh/health/stories/health-143668420020506-130555.html

http://www.wral.com/health/1436684/detail.html

http://www.newswise.com/articles/2001/12/JAVAJOLT.UAZ.html

http://www.nytimes.com/2002/01/01/health/psychology/01AGIN.html?rd=hcmcp?p=041sRh041sTt436WO012000mo9Sho9mk

July 1999

This study assessed the influence of age on the effects of caffeine on a variety of psychomotor, cognitive and subjective tests. The 48 participants, of both sexes, were from two different age groups: 20-25 years and 50-65 years. They were all regular moderate caffeine drinkers. Half of each group was given a placebo, and the other half 250 mg of caffeine. A range of tests was used to assess psychomotor, cognitive and subjective functioning before treatment and 1 hour after.

Unsurprisingly, before treatment, the younger participants generally performed better than the older on psychomotor and cognitive tests. After taking the placebo, performance and alertness improved in the younger group but declined in the older. After caffeine, both groups showed an improvement in psychomotor and cognitive performance, particularly in offsetting the declining performance over time in the older participants.


October 1998

Nineteen volunteers drank black tea, coffee, caffeinated water, decaffeinated tea or plain water on three occasions through the day (at 9am, 2pm, and 7pm). A variety of psychometric tests, including a short-term memory test, were carried out at regular intervals through the day.

The drinking of tea rather than water, and of caffeinated compared to decaffeinated beverages, largely prevented the steady decline in alertness and cognitive capacity observed among those drinking plain water. In other words, caffeinated drinks largely overcame normal time-of-day effects. However, the benefit of decaffeinated tea suggests that this is not simply due to the caffeine. Other factors may involve other substances in the drinks, or psychological factors.


Sleep Deprivation

November 2002

Caffeine’s value in mitigating the effects of stress and sleep deprivation on cognitive performance
A study of 68 U.S. Navy Sea-Air-Land (SEAL) trainees examined whether moderate doses of caffeine would reduce adverse effects of sleep deprivation and exposure to severe environmental and operational stress on cognitive performance.

The participants were given capsules of either 100, 200, or 300 mg caffeine or placebo, after 72 hours of sleep deprivation and continuous exposure to other stressors. A variety of cognitive tests were administered, involving vigilance, reaction time, working memory and motor learning.

As expected, sleep deprivation and environmental stress had an adverse effect on performance. The higher doses of caffeine (200 and 300 mg) significantly improved visual vigilance, choice reaction time, and motor learning, with the greatest effects on tests of vigilance and reaction time. The greatest effects of caffeine were present after an hour, but significant effects persisted for 8 hours.


December 2001

The mitigating effects of caffeine on sleep deprivation

Sixteen men participated in this study to determine whether slow-release caffeine (SRC) could mitigate the effects of sleep deprivation on vigilance and cognitive performance. Participants were kept awake for 64 hours, and given either a 300mg SRC or a placebo twice a day.

Cognitive function was assessed using a variety of tests. It was found that those receiving the caffeine were more vigilant throughout the period of sleep deprivation, while the cognitive functions showed a variety of patterns: some improved up until the 33rd hour; others were ameliorated through the entire period; alertness was better from the thirteenth hour.


Strenuous Exercise

August 1999

Caffeine improves cognitive performance after strenuous physical exercise

On five separate occasions, 15 male athletes were given either one of three carbohydrate electrolyte solutions (CES), a CES placebo, or water. They drank part of the drink before, and the
rest during, an all-out 1 hour time trial on a bicycle ergometer. The three CES drinks contained various levels of caffeine (150, 225 and 320 mg/l). Cognitive tests were carried out immediately before and after the exercise.

Before the exercise, the low dose caffeine CES improved long-term memory. Immediately after the vigorous exercise, all cognitive functions were improved by the low- and medium-dose caffeine drinks.


**Caffeine and blood pressure**

**Summary**

High blood pressure in older adults (58 years and older) is associated with an increased risk of age-related cognitive impairment, of severe cognitive decline, of dementia and Alzheimer’s.

A study found that caffeine intake equivalent to four or five cups of coffee raised blood pressure an average of five points.

More recently, research suggests that it may be something other than caffeine in the coffee, that raises blood pressure.

**Conclusion:** High blood pressure is undoubtedly a risk factor for cognitive decline and dementia for those over 60. While coffee raises blood pressure, it is not clear that caffeine is the culprit. Older adults with blood pressure problems should therefore also avoid decaffeinated coffee.

**Reports**

November 2002

Coffee’s effect on blood pressure doesn’t depend on caffeine content

A Swiss study of 15 volunteers aged 27-38, of whom 6 were habitual coffee drinkers, found that an intravenous injection of caffeine increased blood pressure and muscle sympathetic nervous activity (MSA) in both habitual and nonhabitual coffee drinkers (by 29% after 30 minutes and 53% after 60 minutes). (Sympathetic nervous system activity plays an important role in the regulation of blood pressure and over-activation has been linked with high blood pressure.)

Nonhabitual coffee drinkers had a similar result an hour after drinking a triple espresso, whether regular or decaffeinated. However, habitual coffee drinkers experienced only the increase in MSA, without the increase in blood pressure.

The effect of decaffeinated coffee on nonhabitual coffee drinkers suggests that some ingredient or ingredients other than caffeine is responsible for the cardiovascular activation.
The lack of BP effect on habitual coffee drinkers indicates that a tolerance to the effects of coffee occurs, but the fact that sympathetic nerve activation still occurred in this group indicates that the tolerance is to other ingredients in the coffee, not caffeine.

Recent epidemiological studies have produced conflicting results on whether or not regular coffee drinking is good for the cardiovascular system. This study suggests that, if coffee is indeed beneficial for the heart and arteries, it is not an effect of the caffeine.

The researchers suggest that coffee drinking may not be hazardous for those with normal blood pressure, but more importantly, the results suggest that those with hypertension should avoid decaffeinated coffee as well as regular coffee.


http://www.americanheart.org/presenter.jhtml?identifier=3006582


May 1998

Moderate Caffeine Use Boosts Blood Pressure

Laboratory studies have made it clear that caffeine raises blood pressure, but the current study demonstrates what happens in real life. 19 habitual coffee drinkers wore blood-pressure monitors while they went about their normal working routine. It was found that caffeine intake equivalent to four or five cups of coffee raised blood pressure an average of five points, compared to days when they only had one cup. The effect occurred within an hour of consumption, and the subjects' blood pressure remained elevated throughout the day. Participants also reported higher levels of stress during the day when they received the higher caffeine dose, and they showed a corresponding increase in heart rate.

A review of nine major studies of blood-pressure and cardiovascular-disease risk showed that a 5-point difference in diastolic blood pressure was associated with at least a 34% increase in the incidence of stroke and a 21% increase in the incidence of coronary heart disease.


**Background: The connection between high blood pressure and cognitive performance**

Treatment to lower blood pressure reduces risk of cognitive decline in stroke patients.

"White-matter lesions" start to appear in the brain from around 60 years, and are responsible for some of the decline in cognitive function related to aging. Such lesions are also linked with circulatory problems, including hypertension.

Raised systolic blood pressure, particularly in conjunction with high cholesterol levels, increases the risk of Alzheimer’s.

High blood pressure is a risk factor for cognitive decline in those aged 58 or older.

Those with untreated high blood pressure are at greater risk of severe cognitive decline.

May 2003

High blood pressure and stroke are associated with increased risks of dementia and cognitive impairment. A study of those with cerebrovascular disease, found a greater risk of cognitive decline in those who were actively treated with blood pressure lowering drugs.

http://archinte.ama-assn.org/cgi/content/abstract/163/9/1069

The PROGRESS Collaborative Group. 2003. Effects of Blood Pressure Lowering With Perindopril and Indapamide Therapy on Dementia and Cognitive Decline in Patients With Cerebrovascular Disease. *Archives of Internal Medicine, 163*, 1069-1075.

March 2003

From around age 60, "white-matter lesions" appear in the brain, significantly affecting cognitive function. Although white-matter lesions are viewed as a normal part of aging, they are linked with other health problems, in particular to circulatory problems (including hypertension, diabetes, heart disease and cardiovascular risk factors).

Full text of the article is available at


July 2001

A large-scale Finnish study found that raised systolic blood pressure and high serum cholesterol concentration, particularly in combination, in midlife, increase the risk of Alzheimer's disease in later life. Raised diastolic blood pressure had no significant effect.

http://www.bmj.com/cgi/content/full/322/7300/1447

January 2001

A large-scale six-year study of people aged 40 to 70 years old found that people with diabetes and high blood pressure are more likely to experience cognitive decline. Diabetes was associated with greater cognitive decline for those younger than 58 as well as those older than 58, but high blood pressure was a risk factor only for the 58 and older group.


December 1999

A large-scale study of French people aged 59 to 71 found that, after four years, 21.7% of those with untreated high blood pressure experienced severe cognitive decline. Of those with high blood pressure whose treatment didn't bring the blood pressure down to normal, 12.5% had severe cognitive decline. Of those whose high blood pressure was successfully treated, 7.8% had severe cognitive decline. Only 7.3% of those with normal blood pressure had severe cognitive decline. The study appeared in the December 10 issue of *Neurology*.


---

**Caffeine and Homocysteine levels**

**Summary**

Older adults with very high homocysteine levels perform more poorly on cognitive tests, and are at significantly greater risk of a stroke, of developing vascular dementia, and Alzheimer’s.

Brewed coffee raises homocysteine levels.

A recent study suggests that caffeine is only one of the substances in brewed coffee that raises homocysteine levels.

**Conclusion:** High homocysteine levels in older adults increase the risk of cognitive decline and dementia. Coffee raises homocysteine levels, but, as caffeine doesn’t appear to be the only ingredient in coffee responsible for this effect, it would seem wise to avoid decaffeinated brewed coffee as well.
Contribution of caffeine to the homocysteine-raising effect of coffee

Coffee drinking raises homocysteine levels. Elevated levels of homocysteine are associated with a greater risk of stroke, vascular dementia, and Alzheimer's disease.

While it is known that brewed coffee raises homocysteine levels, it is unclear which ingredients are responsible. In this study, 48 heavy coffee drinkers, of both sexes and ranging in age from 19 to 65, were given either: (1) 6 capsules providing 870mg of caffeine, (2) 4 cups of strong filtered coffee that contained 870 mg of caffeine, or (3) 6 placebo capsules. Each treatment lasted two weeks. Blood samples were drawn fasting and four hours after 2 cups of coffee or 3 capsules. (“Heavy” is defined as consuming 6 or more cups of coffee a day). 31% of the subjects were smokers, who are known to metabolize caffeine more rapidly than non-smokers.

Compared to placebo, the caffeine capsules raised the average fasting homocysteine level by 5%, while the brewed coffee lifted the level 11%. Four hours after consumption of two cups of brewed coffee, homocysteine levels had risen 19%, compared to only 4% for the caffeine capsules. The effects of caffeine were stronger in women, but there was no significant gender difference for coffee.

It would appear then, that while caffeine is partly responsible for the homocysteine-raising effect of coffee, it is by no means the primary factor.


Background: The connection between homocysteine levels and cognitive performance

Elevated levels of homocysteine in older adults have been found to be associated with a more than five-fold increase in the risk for stroke, a nearly five-fold risk for vascular dementia, and almost triple the risk for Alzheimer's disease.

A large-scale study found older adults with very high homocysteine levels performed more poorly on cognitive tests.
five-fold increase in the risk for stroke, a nearly five-fold risk for vascular dementia, and almost triple the risk for Alzheimer's disease. High blood levels of homocysteine have been found to be associated with an increased heart attack risk in several studies. High levels of homocysteine have been found to be associated with deficiencies in vitamin B12 and folate, and also with smoking. 


February 2002

Findings from the long-running Framingham study found people with elevated levels of homocysteine in the blood had nearly double the risk of developing Alzheimer’s disease (AD). This study is the first to tie homocysteine levels measured several years before with later diagnosis of AD and other dementias, and provides the most powerful evidence yet of the link between high homocysteine levels and AD.


May 2001

Recent studies have linked Alzheimer disease and dementia after multiple strokes to extremely high serum homocysteine concentrations. A survey of 1299 men and women aged 60 and over, none of who had previously had a stroke, found an independent relationship between very high homocysteine levels and poor performance on cognitive tests. The folate status of the participants was checked as folate has been shown to significantly modify homocysteine levels. Story recall was worse among subjects with a combination of low folate and high homocysteine than in those whose homocysteine levels were normal or low. Homocysteine levels increased with age and were accompanied by a comparable decline in folate status. The researchers found independent associations between the highest levels of homocysteine and poorer recall. Among subjects with the highest level of homocysteine, the odds of passing a word delayed-recall test were identical whether their folate status was high or low. This study appeared in the.


Caffeine and glucose levels

Summary
Evidence for the effect of caffeine on glucose regulation is inconclusive as yet, and I would not include this section except that it throws a somewhat murky light on the complexity of the caffeine — cognition relationship. In particular:

The suggestion that caffeine may be a risk factor for impaired glucose tolerance is interesting in light of recent discoveries into the relationship between glucose and the brain (see below).

The suggestion that coffee has a different effect on habitual users, who may have built up tolerance to certain factors, than it does on non-habitual users.

The suggestion that coffee may contain some substances that have a beneficial effect, and others that have a negative effect.

The evidence that glucose can have a beneficial or a negative effect on cognitive function, depending on dosage and the individual.

Reports
November 2002

The possible association between coffee consumption and type 2 diabetes was investigated in a large population-based study of 17,111 Dutch people aged 30-60 years. It was found that those who drank at least seven cups a day were only half as likely to develop type 2 diabetes as those who drank two cups or fewer. The risk of type 2 diabetes decreased with higher coffee consumption in a graded manner.

Consumption of tea was lower than that of coffee, and was not associated with diabetes risk. Consumption of decaffeinated coffee was too low to study separately.

The association remained after removal of possible confounding factors. Moreover, higher coffee consumption was associated with generally unfavourable factors: a low educational level, a higher body-mass index, cigarette smoking, alcohol use, less leisure time physical activity, and a generally less favourable diet.

While caffeine acutely lowers insulin sensitivity, tolerance could develop. The long-term effects are unknown. In an intervention study, increased coffee consumption for 14 days reduced fasting plasma glucose, whereas substitution of regular coffee for decaffeinated coffee for 20 days did not affect plasma glucose. That study did not include a control group, but the results suggested that components of coffee other than caffeine could be beneficial for glucose metabolism.

As well as caffeine, coffee contains substantial amounts of magnesium, which has been associated with a lower risk of type 2 diabetes.


March 2002

On two occasions, seven men performed one-legged knee extensor exercises for an hour, before being given, two hours later, either caffeine (5 mg/kg) or a placebo. An hour later, glucose uptake was tested.

Insulin-stimulated glucose uptake was significantly reduced in those who had caffeine. However, this could be offset to some extent by exercise.


February 2002

Caffeine may decrease insulin sensitivity

Caffeine or placebo was administered intravenously to 12 healthy volunteers. Caffeine was found to decrease insulin sensitivity by 15%.


November 1998

Caffeine may increase glucose levels

A study of the effects of caffeine on glucose tolerance involved 30 nonsmoking healthy adults aged 26-32 who abstained from coffee and all other foods containing caffeine for at least four weeks. Participants were then given either 50 mL of decaffeinated cold coffee without sugar or 50 mL of the same decaffeinated coffee with 200 mg of caffeine added (no change in taste or color).
Two weeks later, those who had previously received the caffeine were given the placebo and vice versa. The coffee was followed by 75g of oral glucose.

The 200 mg of caffeine increased blood glucose levels at the third and fourth hour of the oral glucose tolerance test (OGTT).


**Background: The connection between blood sugar levels and cognitive performance**

The brain runs on glucose. It used to be thought that, unless a person is starving, the brain always received an ample supply of glucose. However, recent research has now demonstrated that glucose levels fall in those parts of the brain that are active during particular tasks.

The drop in glucose levels appears to be greater in older subjects, and also takes longer to recover.

The ability to get glucose from the blood to the tissues (including the brain) is reduced in diabetes.

Impaired glucose tolerance (IGT) refers to a condition in which blood sugar levels are higher than normal, but are not high enough to be classified as diabetes. In the U.S., about 40-45% of older adults (65 years or older) have either type 2 diabetes or IGT.

Impaired glucose tolerance is a risk factor for cardiovascular disease.

A study of non-diabetic middle-aged and elderly people found that those with impaired glucose tolerance had a smaller hippocampus and scored worse on tests for recent memory.

It is speculated that in individuals with impaired glucose tolerance, during periods of increased metabolic demand (such as while trying to remember something), glucose levels drop in the parts of the brain doing the work, leading to memory problems.

Glucose has been shown to help memory for prose in healthy older adults. While this has been less clear in younger adults, it now appears that glucose can aid memory in younger adults if the task is sufficiently difficult.

However, it appears that the effective dose range is rather narrow, with too much glucose impairing, rather than enhancing, cognitive functions. The effective amount depends on the individual — their metabolism and the glucose level in their brains at the time.

February 2003

High sugar blood levels linked to poor memory
A new study takes an important step in explaining cognitive impairment in diabetics, and suggests a possible cause for some age-related memory impairment. The study assessed non-diabetic middle-aged and elderly people. Those with impaired glucose tolerance (a pre-diabetic condition) had a smaller hippocampus and scored worse on tests for recent memory. These results were independent of age or overall cognitive performance.

The study raises the possibility that exercise and weight loss, which help control blood sugar levels, may be able to reverse some of the memory loss that accompanies aging. [http://www.eurekalert.org/pub_releases/2003-02/nyum-hsb013003.php](http://www.eurekalert.org/pub_releases/2003-02/nyum-hsb013003.php)


June 1998

Glucose improves semantic memory in older adults

On four sessions separated by a week, healthy older adults were given glucose or saccharin immediately before hearing a narrative prose passage, or immediately before being tested for recall of the passage (24 hours after training).

Participants recalled significantly more information after taking the glucose rather than saccharin, irrespective of whether the glucose was given before learning or before recall.


April 1998

Glucose can help semantic memory in younger adults

Although earlier evidence suggested that glucose does not enhance cognitive function in healthy young adults, more recent findings suggest that glucose can be effective when the tests are sufficiently difficult. In college students, glucose consumption significantly enhanced memory of a prose passage. Glucose also appeared to enhance attentional processes in these students. Neither face and word recognition nor working memory was influenced by glucose treatment.


Additional references:


Habituation to caffeine

Summary

Caffeine reduces blood flow in the brain. The size of the reduction is greater in heavy coffee drinkers. Caffeine withdrawal increases blood flow, and again, the effect is greater in heavy drinkers.

The beneficial effect of caffeine on exercise endurance was substantially greater for nonhabitual users.

Nonhabitual coffee drinkers needed a low dose of caffeine for their optimal performance on cognitive tasks while coffee drinkers and smokers needed a higher dose.

Caffeine increased blood pressure in nonhabitual coffee drinkers, but not habitual coffee drinkers, indicating that a tolerance to the effects of coffee occurs. (see above)

High caffeine users performed more poorly on a verbal reasoning task. Interactions between caffeine, time of day, and user history, support the view that different cognitive processes are affected differently by these three factors (see above).

All doses of caffeine significantly affected cognitive performance, with little difference between the sizes of dose. The effects were more marked in those with a higher level of habitual caffeine intake. (see above)

A study of older adults found higher lifetime consumption of caffeinated coffee was associated with better performance on several cognitive tests — for women, but not men. (see above)

Conclusion: While people clearly build up a tolerance to some of the effects of caffeine, it is not yet clear what the long-term effects of regular caffeine use are. Nor can we say, as yet, what factors are important in determining those long-term effects, although we can speculate that gender, age, metabolic factors, cardiovascular health, alcohol and tobacco use are all possible influences.
A recent imaging study of 20 healthy adults, half of whom were classified as heavy caffeine users, has demonstrated that an amount of caffeine equal to what's in two to three cups of coffee can constrict blood vessels and reduce blood flow in the gray matter areas of the brain.

In heavy caffeine users blood flow was reduced by 26% and in light caffeine users, by 19%. During withdrawal (achieved by abstention from caffeine for at least 30 hours), the blood flow in the heavy caffeine users was more than 30% greater than in the light caffeine users experiencing withdrawal.


Caffeine increases exercise endurance, especially for nonhabitual users

Many studies have demonstrated that caffeine ingested before physical activity causes rapid and significant improvement in performance, especially in aerobic exercise capacity. Because most researchers have assumed the effect is related to the circulating level of the caffeine in the bloodstream, it has been assumed that the maximum effects are found one hour after consumption.

In the present study, 21 volunteers of both sexes, with a mean age of 32, and active in aerobic events, rode a cycle ergometer to exhaustion on six occasions, after being given either a placebo or 5 mg/kg of caffeine. Exercise to exhaustion was completed once per week at either one, three or six hours after taking either the placebo or caffeine. Participants were asked to refrain from heavy exercise and alcohol for 24 hours before each trial, and to refrain from caffeine for 12 hours beforehand.

It was found that caffeine significantly improved the time to exhaustion for all participants, but the effect was distinctly greater for those unaccustomed to caffeine (e.g., at one hour, average exercise time was some 27.4 minutes for users having caffeine, compared to 23.3 for users on placebo; and 32.7 minutes for non-users having caffeine, compared to 24.2 for non-users on placebo). Exercise times were greater for users at both one and three hours after taking caffeine, but not at six hours. For non-users, however, the effects of caffeine were still found six hours after ingestion.

Heart rates were consistently higher for non-users, and increased further after caffeine consumption. Caffeine produced a small but significant increase in oxygen consumption after 15 minutes of exercise for both users and non-users, and in non-users, also slightly raised glucose levels (already slightly higher than that of users).


May 2002

More caffeine needed for habituated users

Sixteen volunteers who were classified as either non-smokers and non-coffee drinkers; smokers and coffee drinkers; non-smokers and coffee drinkers, participated in a Greek study of the effect of caffeine on the central nervous system and cardiorespiratory system. Cognitive tasks were undertaken after taking 90 and 250 mg of caffeine on two separate days. Participants abstained from caffeine for a week before the study.

The study found that non-coffee drinkers needed a low dose of caffeine for their optimal performance while coffee drinkers and smokers needed a higher dose of caffeine for optimal performance. A higher dose significantly increased the blood pressure for non-coffee drinkers.


**Glossary**

The Stroop test is a method of studying automatic processing, and is one of the most commonly used diagnostic tools when determining an attention problem. In the most common form of the test, participants see color words (e.g., blue) printed in either the color the word refers to, or in another color, such as red. When the print color is different from the word, participants usually take longer to name the print color than when word and color match.

Vigilance is perceptual rather than cognitive, and has been defined as the simultaneous preconscious monitoring of all sensory channels for events that will require a shift in attention, as attention to those stimuli of relevance to you, and as the ability to disregard much of the stimulation one receives.

**References**


The PROGRESS Collaborative Group. 2003. Effects of Blood Pressure Lowering With Perindopril and Indapamide Therapy on Dementia and Cognitive Decline in Patients With Cerebrovascular Disease. *Archives of Internal Medicine, 163*, 1069-1075.


