Starbucks and Spider Webs

By Julianna LeMieux — May 19, 2017

Recently, a teenager died from ingesting too much caffeine in too short a time period. At first, this may sound shocking.

But, caffeine is known to be toxic in very high quantities. An old, fascinating, science experiment tested, in a very unique way, just how toxic certain chemicals are - including caffeine. The results show the effect of caffeine (and other drugs) on our brains by using an uncommon scientific assay -- spider web spinning.

This idea was first proposed by Peter Witt and Charles Reed, in an article published in Science in 1965 called "Spider-web building". In it, they state that because orb-weaving spiders spin webs of varying designs - even under non-ideal circumstances (with a leg missing or when the nervous system is not functioning properly) - web building could be used to understand the effects of certain insults to the nervous system.

This is exactly what was done by a group of scientists at NASA in 1995. They describe their results in a one page write up that is not peer-reviewed, as far as I can tell. Nevertheless, it is too cool not to write about.

The group sought to test if the toxicity of certain substances could be tested on house spiders (Araneus diadematus), by observing the patterns of their webs. The hypothesis was that spiders would be given either no compound or compounds that vary in their toxicity, and asked to spin a web. The more toxic a compound is, the more the geometry of the web would stray from a normal web.

Shown below are some of their data. They conclude that "It appears that one of the most telling measures of toxicity is a decrease, in comparison with a normal web, of the numbers of completed
sides in the cells: the greater the toxicity, the more sides the spider fails to complete." In looking closely at the webs, and using that criteria, caffeine leads the pack in toxicity - its web even more disorganized than the one made by a spider given Benzedrine (an amphetamine.)

This same type of experiment has since been repeated and peer reviewed. One example is an article entitled, "The Effects of Neurotoxins on web-geometry and web-building behaviour in Araneus diadematus." In this paper, they analyze spider webs to define web building as a behavioral pattern that can be used to test the effect of neurotoxins. In the below figure, A) and B) are before and after the administration of a control solution, C) and D) are before and after administration of amphetamine, E) and F) are before and after the administration of caffeine.
The researchers go on to quantify the differences in these webs by taking thirteen different measurements of the webs. The parameters measured can be found below, in the notes section.

I am writing about this work for two reasons. The first is because people may not realize that caffeine can be toxic and, although you cannot cross a street in NYC without seeing a Starbucks, it is a drug that we need to consider how much and how quickly we are consuming. The second is to make sure that you never look the same way at a spider web again.

**NOTES**

Parameters measured

- Radii length—total length of all radii.
- Capture length—total lengths of all capture spiral threads.
- Capture area—the area covered by the capture spiral, excluding the hub and free zone.
- No. of reverses per centimeter of spiral thread—During capture spiral construction, the spider reverses its direction of thread laying several times, most often in the southern quadrant where more spiral turns are laid. A reverse was identified when two spiral threads joined together in a V shape.
- Proportion of irregular radii—The number of Y-shaped (radii that splits into two inside the capture area) and distorted radii as a percentage of total number of radii.
- Mesh size—Average mesh size
- Eccentricity—a measure of the shape of the web
- Total building time—the total time elapsed from the spider creating the first radii until finishing the last capture spiral. Pauses during which the spider sits motionless were included in this time.
- Pauses—capture spiral. Number of times the spider was motionless longer than 20 s during construction of the capture spiral.
- Speed (auxiliary spiral)—the average building speed of the spider when constructing the auxiliary spiral not including pauses.
- Speed (capture spiral)—the average building speed of the spider when constructing the capture spiral not including pauses.
- Pause from aux to cap—the pause between finishing the auxiliary spiral and starting on the first capture spiral turn. This pause is seen in all orb weavers and could be a necessary break used to change from normal silk to gluey silk.
- Building efficiency—the efficiency exhibited by the spider during capture spiral construction.

**SOURCES**

