ALTERED PERCEPTIONS: HOW VARIOUS SUBSTANCES INFLUENCE OUR PERCEPTION OF TIME

BY AAYA ABDELSHAFY



Do you ever feel as though you are stuck in time, or as if there are just never enough hours in a day? Our sense of time is unlike any other sense we experience. It is physically intangible and yet is sustained throughout our lives from the moment we are born, unless a brain disorder presents itself. As opposed to our other senses, we do not have an organ that is specifically dedicated to time perception.[6] Instead, this elusive awareness is ruled by a complex interplay of variable representations.[6] For example, the brain's cerebellum and basal ganglia (BG) are largely known to be involved in this interplay. The cerebellum is responsible for precise representations of time and temporal reproductions (in milliseconds). It is also responsible for our internal clock, which regards temporal discrimination tasks (separate from our sleep cycle).[10, 20] On the other hand, the BG is linked with our internal pacemaker, which keeps track of time relative to regular rhythmic intervals (regards millisecond-second durations).[6, 17] The structure contains the greatest amount of dopamine (DA) neurons in the brain.[16] DA is a neurotransmitter that plays an active role in our reward system.[9] However, it also strongly influences time perception by affecting the internal pacemaker. DA agonists (stimulate its action) slow our perception of time down, while antagonists (inhibit its action) speed it up.[6,13] Some of the most widely used illicit and non-illicit substances such as caffeine, alcohol, marijuana, and "magic mushrooms" influence these complex representations and produce significant alterations in our perception of time. With these alterations, our awareness of the world is disturbed—thusly tying into the great mystery that is Consciousness.

CAFFEINE

Let us begin with the drug that most of us have tried at least once to enhance our attention and help us tackle our busy schedules: caffeine. Although it is rarely treated as such, caffeine is indeed a psychoactive drug and is regularly consumed by about 80% of the US population, primarily in the form of coffee.[12] A previous study conducted on rats showed that low doses of caffeine may slow down our perception of time, while high doses may have an opposite effect.[4] This may be due to how caffeine interacts with adenosine receptors in the central nervous system, which includes our brain and spine. It primarily acts as an adenosine antagonist, which indirectly enhances DA production.[19, 21] Since caffeine does not directly act on our DA receptors, it makes sense that its effects on our time perception are inconstant. McClellan Stine et al. further examined such effects by inquiring about several participants' caffeine consumption and testing their ability to correctly assess specific durations of time.[12] They witnessed a similar u-shaped pattern wherein only moderate doses of caffeine



(approximately one 6 oz. cup of coffee) yield accurate time perception. The greatest amount of inaccuracies occurs with larger time intervals.[4]

MARIJUANA

While caffeine may be the most popular non-illicit substance, marijuana holds a similar rank in the realm of illicit substances.[11] Tetrahydrocannabinol (THC) is the primary psychoactive ingredient in marijuana, and it works by attaching to the brain's cannabinoid receptors.[8] Like caffeine, THC indirectly acts upon DA transmission.[3] By blocking GABA (our main inhibitory neurotransmitter), dopaminergic neurons are released and concentrate in the brain's striatum.[3, 15, 18] Just as with high doses of caffeine, infrequent marijuana users tend to estimate time as passing more quickly than it actually has, but they also they also experience a slowing down of time when asked to produce time intervals between 2 seconds-3 minutes.[11, 14, 18] This means that THC causes an overestimation of external time meanwhile our internal time seems to be passing more slowly, which is likely due to an increase in the speed of our cerebellum's internal clock.[11, 14, 18] These results are in tune with the inaccurate time perceptions produced by caffeine at longer intervals.

> "In contrast with caffeine and marijuana, frequent alcohol usage does not damper its impact on our perception of time."

ALCOHOL

In the same manner as caffeine and THC, alcohol (ethanol) also indirectly yields an increase in DA activity.[1,3] It primarily does so by directly affecting the GABA system (like THC), whose neurons then extend to our reward pathway and stimulate DA release.[1] However, the pleasures we get from alcohol likely stem from the released endorphins (our feel-good opioid hormones) as opposed to DA.[1] In contrast with caffeine and marijuana, frequent alcohol usage does not damper its impact on our perception of time.[7] Alcohol dependency is linked with impulsive behavior, which is linked with a faster internal clock.[2] Like infrequent THC consumption, this fast-paced cerebellar internal clock results in an overestimation of time intervals.[7] A study conducted by Lapp et al. explored how healthy men's expectations of their alcohol consumption altered their subjective sense of time, and found that the subjects perceive time as passing more quickly in order to compensate for the presumed effects of alcohol.[7] As with all aforementioned studies, this effect mostly just occurred with longer intervals of time.[7]

PSILOCYBIN

Thus far, we have only looked at how dopaminergic substances influence how we perceive time—but increasing evidence has shown that drugs working within the serotonergic system (involves the neurotransmitter serotonin, which influences our mood) also alter our sense

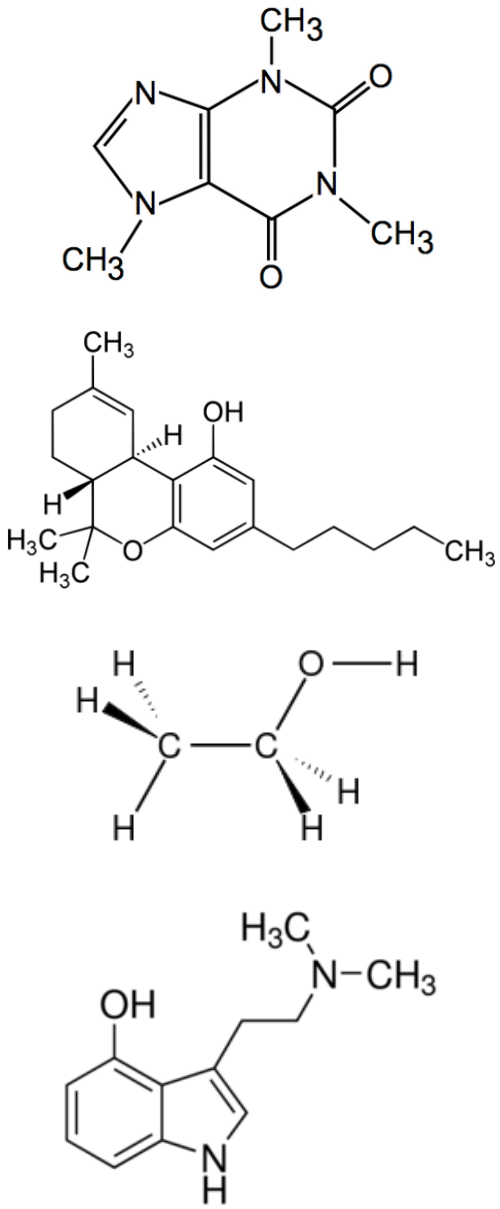

Figure A: Caffeine, THC, Ethanol, and Psilocin molecules, respectively

"Now, in addition to the cerebellum and BG, we can see that the PFC also plays a role in our time perception."

of time—"magic mushrooms," for example. These fungi contain psilocybin, which is an inactive precursor to psilocin: the culprit of their hallucinogenic effects.[5] In contrast with the aforementioned time dilation effects, psilocin seems to slow time down when binding to serotonin receptors.[5] This serotonergic activity is linked with the brain's prefrontal cortex (PFC). [22] Now, in addition to the cerebellum and BG, we can see that the PFC also plays a role in our time perception.[22] Wittmann et al. explored how various doses of psilocybin impacted how healthy college students perceive time. For time durations longer than 2-3 seconds, the subjects experienced time as passing more slowly than it truly was; with shorter time durations, however, their sense of time was accurate.[22] This was true of both temporal reproduction and synchronization tasks.[22] These results show us that even serotonergic substances only truly impact our time perception when it regards protracted durations.

FINAL REMARKS

Taking all of these findings into account, we can see that these substances all influence our time perception for longer durations. Such alterations could lead to harmful limitations in anticipatory planning.[22] It is crucial for us to perceive longer durations of time accurately, as this sort of temporal processing is involved in several other daily tasks including driving, using tools, and anything that relies on our working memory.[18] It is interesting to note that although the mentioned substances vary in terms of their legality, they all may produce disadvantageous effects (often through similar neural systems). Although these effects are reduced with regular caffeine and marijuana use, regular consumption may cause other unwanted side effects that obstruct our engagement with our environment. Despite being regarded as pleasurable (often owing to DA transmission), caffeine, THC, alcohol, and psilocybin all negatively impact our conscious awareness of the world.

REFERENCES

1. Alcohol and dopamine. (2012).
2. Cangemi, S., Giorgi, I., Bonfiglio, N. S., Renati, R., & Vittadini, G. (2010). 32, 3.
3. Dubuc, B. (n.d.). THE BRAIN FROM TOP TO BOTTOM [Scholarly project]. In The Brain.
4. Fry, T. (2014). Caffeine and Human Perception of Time.
5. How Psilocybin Works: Addition by Subtraction - Psychedelic Frontier. (2013, May 15).
6. Ivry, R. B., & Spencer, R. M. (2004). 14(2), 225-232.
7. Lapp, W. M., et.al. (1994). 55(1), 96-112.
8. Learn About Marijuana: Factsheets: Cannabinoids. (2013, June).
9. "Marijuana and Dopamine: The Science Behind It." Leaf Science. N.p., 10 May 2014. Web. 3 Nov. 2016.
10. Mastin, Luke. "Biopsychology." Exactly What Is Time. N.p., 2016. Web.
11. Mathew, R. J., et.al. (1998). Cerebellar activity and disturbed time sense after THC. Brain research, 797(2), 183-189.
12. McClellan Stine, et.al. (2002). Evidence for a relationship between daily caffeine consumption and accuracy of time estimation. Human Psychopharmacology: Clinical and Experimental, 17(7), 361-367.
13. Meck, W. H. (2005). Neuropsychology of timing and time perception. Brain and cognition, 58(1), 1-8.
14. Ogden, R., & Montgomery, C. (2012). High time. PSYCHOLOGIST, 25(8), 590-592.
15. Oleson, E. B., & Cheer, J. F. (2012). A brain on cannabinoids: the role of dopamine release in reward seeking. Cold Spring Harbor perspectives in medicine, 2(8), a012229.
16. Perez-Costas, E., Melendez-Ferro, M., & Roberts, R. C. (2010). 113(2), 287–302.
17. Rhythm and the Perception of Time. (2011, March 10). Retrieved November 4, 2016.
18. Sewell, R. A., Schnakenberg, A., Elander, J., Radhakrishnan, R., Williams, A., Skosnik, P. D., … D'Souza, D. C. (2013). 226(2), 401–413.
19. Solinas, M., et.al.(2002). 22(15), 6321-6324.
20. Teixeira, S., et.al. (2013). 12(5), 567-582.
21. Volkow, N. D., et.al.(2015). 5(4), e549.
22. Wittmann, M., et.al. (2007).

IMAGE SOURCES

23. http://img10.deviantart.net/f6bb/i/2013/023/1/5/caffeine_molecule_by_txtcla55-d5sfkw6.png
24. http://24.media.tumblr.com/tumblr_lfaxflTbER1qdl9bfo1_r3_500.png
25. https://upload.wikimedia.org/wikipedia/commons/thumb/1/11/Ethanol-3d-stick-structure.svg/220px-Ethanol-3d-stick-structure.svg.png
26. http://www.sigmaaldrich.com/content/dam/sigma-aldrich/structure2/073/mfcd00079228.eps/_jcr_content/renditions/mfcd00079228-medium.png
27. http://iasos.com/artists/alexgrey/Theologue-3.jpg
28. http://androidjones.com/