Cognitive Decision Making
Neuroscience

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Topic: Value

How do we automatically judge the value of different choices?

Article Discussed

Glimcher, P. W. (2014). Chapter 20—Value-Based Decision Making. In P. W. Glimcher & E. Fehr (Eds.), *Neuroeconomics (Second Edition)* (pp. 373–391). https://doi.org/10.1016/B978-0-12-416008-8.00020-6

Brief summary

The topic of this article is moving towards understanding the basic mechanism by which the human brain makes choices. The critical reading questions focused on topics including the different theories on how humans make decisions, different senses involved in decision-making, and different parts of the brain that aid in decision-making. The classroom discussion talked about topics including law of least effort, laziness and how that affects system 1 and 2, and pupil size in human and primates during a task.

This summary document includes all the article questions that were answered during class. There were no unanswered questions left to answer, the class answered all twenty-six questions. After looking over the questions and answers for the document, all questions were answered with an appropriate response.

Cognitive process neuroimaging analysis

Neurosynth term: “decision making”

Top 5 Pubmed articles

1: Battistuzzi L, Franiuk M, Kasparian N, Rania N, Migliorini L, Varesco L.Eur J Cancer Care (Engl). 2019 May 5:e13083. doi: 10.1111/ecc.13083. [Epub ahead of print] PMID: 31056822

2: Lamb CC, Wolfberg A, Lyytinen K. Haemophilia. 2019 May 5. doi: 10.1111/hae.13766. [Epub ahead of print] PMID: 31056808

3: Peahl AF, Tarr EE, Has P, Hampton BS. J Surg Educ. 2019 May 2. pii: S1931-7204(19)30090-X. doi: 10.1016/j.jsurg.2019.04.004. [Epub ahead of print] PMID: 31056465

4: McDougle SD, Butcher PA, Parvin DE, Mushtaq F, Niv Y, Ivry RB, Taylor JA. Curr Biol. 2019 Apr 12. pii: S0960-9822(19)30409-9. doi: 10.1016/j.cub.2019.04.011. [Epub ahead of print] PMID: 31056386

5: Cruz R, Belter L, Wasnock M, Nazarelli A, Jarecki J. Clin Ther. 2019 May 3. pii: S0149-2918(19)30127-4. doi: 10.1016/j.clinthera.2019.03.012. [Epub ahead of print] PMID:31056304

Top5 Neurosynth articles

Causse, M., Péran, P., Dehais, F., Caravasso, C. F., Zeffiro, T., Sabatini, U., & Pastor, J. (2013). Affective decision making under uncertainty during a plausible aviation task: an fMRI study. *NeuroImage*, *71*, 19–29. https://doi.org/10.1016/j.neuroimage.2012.12.060

Hosseini, S. M. H., Rostami, M., Yomogida, Y., Takahashi, M., Tsukiura, T., & Kawashima, R. (2010). Aging and decision making under uncertainty: behavioral and neural evidence for the preservation of decision

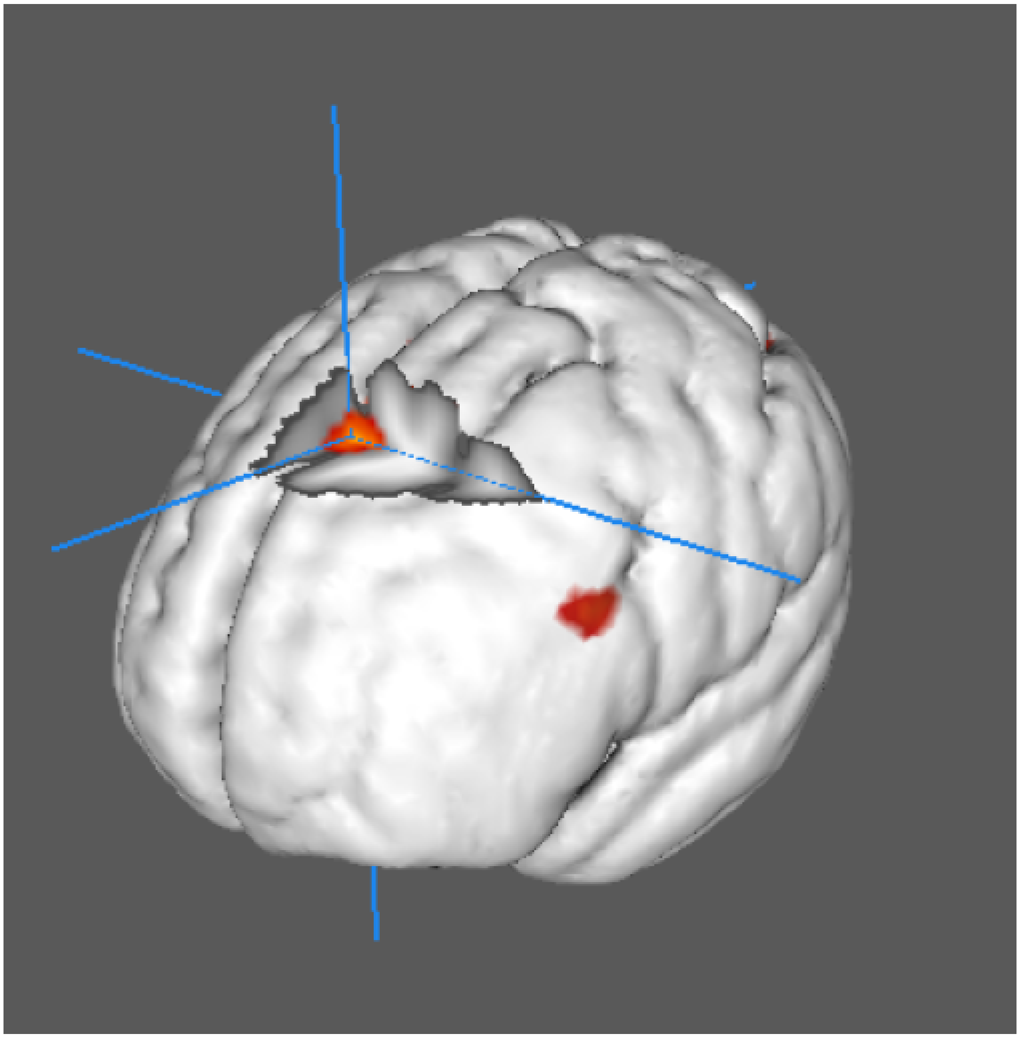
making in the absence of learning in old age. *NeuroImage*, *52*(4), 1514–1520. https://doi.org/10.1016/j.neuroimage.2010.05.008

Madlon-Kay, S., Pesaran, B., & Daw, N. D. (2013). Action selection in multi-effector decision making. *NeuroImage*, *70*, 66–79. https://doi.org/10.1016/j.neuroimage.2012.12.001

Mitchell, D. G. V., Luo, Q., Avny, S. B., Kasprzycki, T., Gupta, K., Chen, G., … Blair, R. J. R. (2009). Adapting to dynamic stimulus-response values: differential contributions of inferior frontal, dorsomedial, and dorsolateral regions of prefrontal cortex to decision making. *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience*, *29*(35), 10827–10834. https://doi.org/10.1523/JNEUROSCI.0963-09.2009

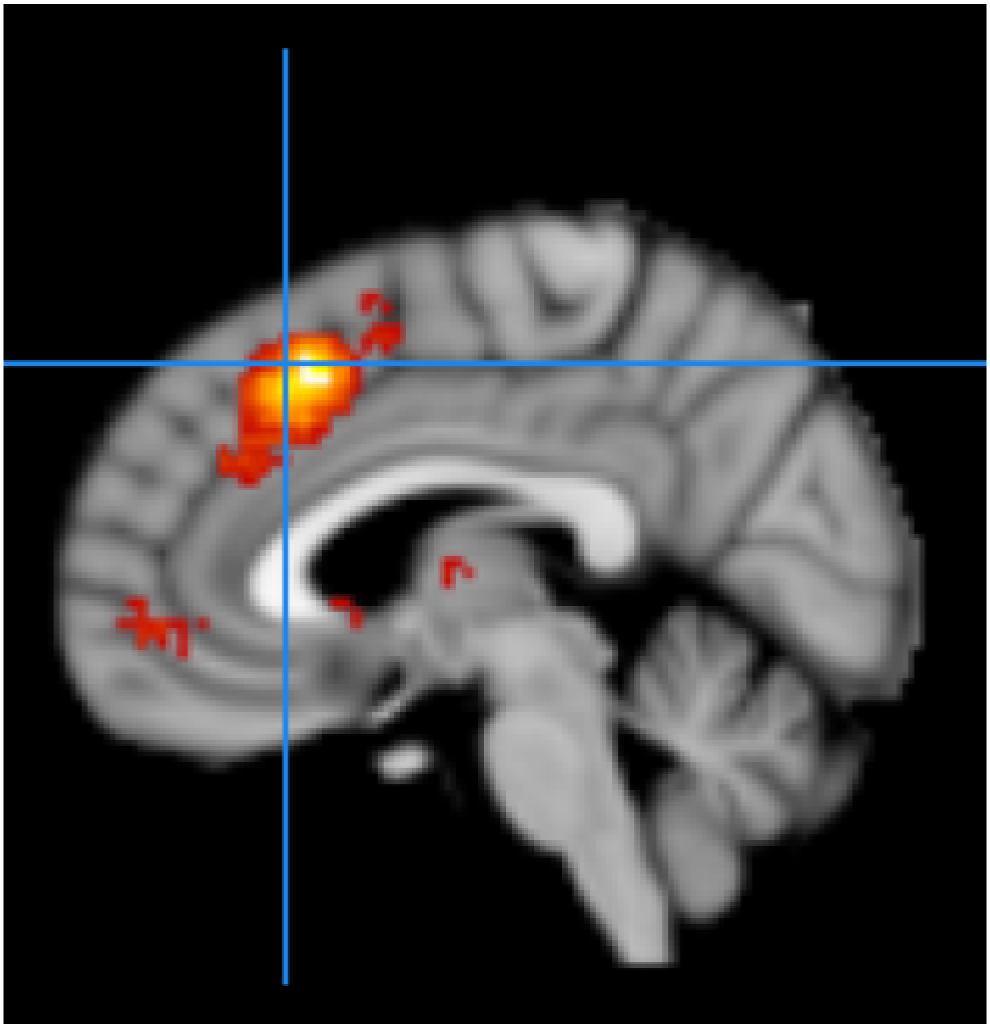
Northoff, G., Grimm, S., Boeker, H., Schmidt, C., Bermpohl, F., Heinzel, A., … Boesiger, P. (2006). Affective judgment and beneficial decision making: ventromedial prefrontal activity correlates with performance in the Iowa Gambling Task. *Human Brain Mapping*, *27*(7), 572–587. https://doi.org/10.1002/hbm.20202

Neurosynth map for the term:



Brain region chosen for the term

Brain region “Sup Frontal Gryus”



Other Neurosynth terms associated with this brain region:

MNI Coordinates: 4,26, 48

	Individual voxel		Seed-based network	
Name	z-score	Posterior prob.	Func. conn. (r)	Meta-analytic coact. (r)
goal	7.08	7.08	0.26	0.51
pre sma	5.84	0.78	0.19	0.29
decision making	5.14	0.69	0.05	0.1
decision	4.9	0.66	0.11	0.24
dorsal anterior	4.59	0.69	0.11	0.13
task	4.53	0.59	0.36	0.53
externally	4.24	0.76	0.04	0.05
medial frontal	4.22	0.66	0.11	0.18
fronto parietal	4.12	0.67	0.21	0.28
parietal network	4.12	0.71	0.15	0.22

Questions posed by the class

Background vocabulary

Q: What does the author mean by the statement “segregation of the decision-making system into two neat components is part pedagogy and part reality”? I am not sure what pedagogy means and in the context of decision-making.

It’s only part reality because the brain works more complexly than to function in neat, organized ways. The segregation of the decision-making system into two neat components is pedagogy because it is mostly used as a theory so that the way the system works can be taught and understood more easily. - VideoSport

Q: What is the Argmax Operation and how is it performed?

- In mathematics, the arguments of the maxima (abbreviated arg max or argmax) are the points of the domain of some function at which the function values are maximized.(“Arg max,” 2018)
- AmbientBenefit

Q: What is the winner-take-all system?

This phenomena describes the outcome of some sort of competition or debate. The winner of the competition gets to take all the rewards, and second or third place receive nothing. So it does no good to try hard unless it's harder than the hardest working individuals there. This sort of competition encourages its participants to cheat or try to cut corners more, compared to trying to do a quality job. As the rewards aren’t divided up depending on the most quality work, but only how you fared in comparison to your opponents.

“Winner Take All Incentive Systems, Competition, and Cheating Teachers, Soccer Players, and Research Subjects.” Psychology Today. Accessed February 5, 2019. http://www.psychologytoday.com/blog/work-matters/201006/winner-take-all-incentive-systems-competition-and-cheating-teachers-soccer.

-AgentCharter

Q: What is a “Gaussian function of distance”

- Every point on the blue graph thing represents the firing rate of a neuron
- Shows two neurons that are active (the one on the right with more color is more active and firing action potentials at higher rate)
- Looks

> like a mound bc GFOD, in LIP neurons are wired, neuron fires action potentials which excites the neighbors and causes them to fire action potentials too

- Gaussian = normal distribution or bell curve
- AmbientBenefit (Reference: a brief summary of things Prof Cate said in class that I wrote down because it was helpful)

Q: What is stochasticity?

Schoasticity is a randomly determined process or probability. (Stochastic. (2019). In *Wikipedia*. Retrieved from https://en.wikipedia.org/w/index.php?title=Stochastic&oldid=877625483) - WindowComrade

Q: What is meant by the term "Behavioral Stochasticity"?

- "Behavioral stochasticity is a term that is used to characterize the randomness or apparent indeterminacy of behavior."
- Jensen, G. (2018). Behavioral Stochasticity. *Encyclopedia of Animal Cognition and Behavior*, 1–5. https://doi.org/10.1007/978-3-319-47829-6_1520-1
- ShelfOpus

Q: What are idiosyncratic preferences?

Idiosyncratic is another word for unique or peculiar. An idiosyncratic preferences, therefore, are the unique preferences that drive decision making for individuals. In the context of the article, researchers can approach studying decision making in a variety of ways, with perceptual decision making and idiosyncratic preferences as two options.

Wikipedia contributors, "Idiosyncrasy," *Wikipedia, The Free Encyclopedia,* https://en.wikipedia.org/w/index.php?title=Idiosyncrasy&oldid=879085703 (accessed February 5, 2019).

MileImport

"a characteristic, habit, mannerism, or the like, that is peculiar to an individual." ("the definition of idiosyncrasy," n.d.) the definition of idiosyncrasy. (n.d.). Retrieved February 5, 2019, from https://www.dictionary.com/browse/idiosyncrasy

This talks about how people's preferences are neither correct or incorrect. They are based on past experiences, therefore emotional decisions are not based on the decision's correctness.

-**IsotopeNirvana**

(Glimcher, 2014)

Theories and Strategies

Q: What is the “expected utility theory” mentioned on page 374?

NitroMotor: “The expected utility theory deals with the analysis of situations where individuals must make a decision without knowing which outcomes may result from that decision, this is, decision making under //uncertainty//. These individuals will choose the act that will result in the highest expected utility, being this the sum of the products of probability and //utility// over all possible outcomes. The decision made will also depend on the agent’s //risk aversion// and the utility of other agents.” Basically, each individual makes decisions based on their perceived utility or value of the probable outcomes. $100 has much higher utility to a homeless person than a millionaire, so that person will choose a conservative behavior that is more likely to get some of the money, rather than taking more risks which may result in no reward. https://policonomics.com/expected-utility-theory/

(“Expected utility theory | Policonomics,” n.d.)

Q: The text mentions a “Mixed Strategy Nash Equilibrium.” What exactly is this and how does it work?

SincereZigzag:

- A Nash equilibrium is a profile of strategies in which each player's strategy is optimal for him, given the strategies of the others.
- It calls for mutual knowledge of the strategy choices that each player know the choices of the others, with no need for the others to know that he knows.
- *Example*: Suppose that each player is rational, knows his own payoff function, and knows the strategy choices of the others. Then the players' choices constitute a Nash equilibrium in the game being played.

(Aumann & Brandenburger, 1995)

US: Prisoners' dilemma shows why trade wars happen

		China: No tariffs	China: Tariffs
United States	No tariffs	US pay-off: +5 China pay-off: +5	US pay-off: -10 China pay-off: +10
United States	Tariffs	US pay-off: +10 China pay-off: -10	US pay-off: -5 China pay-off: -5

Source: Oxford Economics

In the prisoner's dilemma, the Nash equilibrium results from each player's incentive to not cooperate (without knowing how the other player reacts).

Applied to the current trade tensions, it illustrates why there may be a *perceived* incentive to impose tariffs.

Cool Active

Mixed Strategy Nash Equilibrium is a form of game theory that involves calculating payoffs by using "X" by "X" celled tables. Using expected payoffs and probabilities allows the user to analyze the potential choices.

Calculating Payoffs of Mixed Strategy Nash Equilibria – Game Theory 101. (n.d.). Retrieved February 5, 2019, from http://gametheory101.com/courses/game-theory-101/calculating-payoffs-of-mixed-strategy-nash-equilibria/

Q: How do you play "work or shirk"?

- Play a game where you compare the desirability of each action then choose the action that is the most desirable
- "To test the hypothesis that these parietal neurons encode the subjective desirability of making particular movements, we exploited Nash's game theoretic equilibrium, during which the subjective desirability of multiple actions should be equal for human players. Behavior measured during a strategic game suggests that monkeys' choices, like those of humans, are guided by subjective desirability. Under these conditions, activity in the parietal cortex was correlated with the relative subjective desirability of actions irrespective of the specific combination of reward magnitude, reward probability, and response probability associated with each action."
- **DivideSegment**: Dorris, M. C., & Glimcher, P. W. (2004). Activity in posterior parietal cortex is correlated with the relative subjective desirability of action. *Neuron*, *44*(2), 365–378. https://doi.org/10.1016/j.neuron.2004.09.009

Q: Is there a simpler or different analogy than the one that is in the article that can be made about the signal detection theory and the expected utility theory to make it easier to grasp as a concept?

Signal detection theory : Have you ever felt your phone vibrate in your pocket and check your phone and you have no notifications? It’s actually a common occurrence. **Signal detection theory**, which at its most basic, states that the detection of a stimulus depends on both the intensity of the stimulus and the physical/psychological state of the individual. Basically, we notice things based on how strong they are and on how much we're paying attention.

(*Signal detection theory - part 1*, n.d.)

(“Signal Detection Theory,” n.d.)

Expected Utility Theory- Expected utility theory is a major theory of decision making under risk. Decision making under risk is a type of decision-making in which the probability distribution of the results is known. This expected utility theory is assumed in numerous theories of economics

MobileSuper

(Takemura, 2014)

- Signal Detection Theory: Definition & Examples - Video & Lesson Transcript. (n.d.). Retrieved February 5, 2019, from http://study.com/academy/lesson/signal-detection-theory-definition-examples.html
- ShelfOpus

Q: Can someone explain what is being shown in Figure 20.1?

- Figure 20.1 is a visual for the signal detection theory. Signal detection theory provides a general framework to describe and study decisions that are made in uncertain or ambiguous situations. It is most widely applied in psychophysics- the domain of study that investigates the relationship between a physical stimulus and its subjective or psychological effects- but the theory has implications about how any type of decision under uncertainty is made.
- Wickens, T. D. (2002). *Elementary Signal Detection Theory*. Oxford University Press.
- TwinNevada

Areas of the brain

Q: What is area LIP and what are all of the functions it is responsible for?

BanditMeter: Lateral Intraparietal cortex, it is involved in visual movement and attention. The LIP is associated with spatial and temporal attention in vision.

Bisley, James W., and Michael E. Goldberg. "Neuronal Activity in the Lateral Intraparietal Area and Spatial Attention." *Science* 299, no. 5603 (January 3, 2003): 81. https://doi.org/10.1126/science.1077395.

Q: Are so many studies on eye movement because decision-making often (if not always) stems from the senses and that is our primary sense (for the most part)?

- Eye movements do not have a causal effect on preference formation; however through properties inherent to the visual system, such as stimulus-driven attention, eye movements do lead to down-stream effects on decision making.
- It can also be deduced, that the cognitive processes driving eye movements during decision making are not in any consequential way different from those in similar tasks.
- **RespondLlama**

Orquin, J. L., & Mueller Loose, S. (2013). Attention and choice: A review on eye movements in decision making. *Acta Psychologica*, *144*(1), 190–206. https://doi.org/10.1016/j.actpsy.2013.06.003

Q: What are the main functions of the vmPFC and medial prefrontal cortex?

vmPFC sends output to and received input from memory, emotion and reward related structures such as the amygdala, hippocampus, and caudate nucleus.

Wheeler, E. Z. (2006, June 21). Examining Theories of Ventromedial Prefrontal Cortex Function [University of Pittsburgh ETD]. Retrieved February 5, 2019, from http://d-scholarship.pitt.edu/7587/

Medial Prefrontal cortex: some people say it mediates decision making, and other say it is involved in retrieval of long-term memory.

The Role of Medial Prefrontal Cortex in Memory and Decision Making. (n.d.). Retrieved February 5, 2019, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3562704/

SodaOxford

Q: Are the medial prefrontal cortex and striatum limited to around 7 comparison "chunks", as researched in other short term memory related studies?

ExactTulip: "In animal studies, working memory was originally used to explain hippocampal functions 20,21,22,23,24,25,26]. However, working memory has now become the most important concept for interpreting and understanding prefrontal cortical functions in both humans and animals (Funahashi, 2017)."

Funahashi, S. (2017). Working Memory in the Prefrontal Cortex. Brain Sciences, 7(5). https://doi.org/10.3390/brainsci7050049

"According to this "component processes" view of working memory, no processes (and correspondingly no brain structures) are unique or specific to working memory. Rather, working memory results from various combinations of processes that in other constellations can be functionally described in other terms than working memory (Eriksson, Vogel, Lansner, Bergström, & Nyberg, 2015). "

Eriksson, J., Vogel, E. K., Lansner, A., Bergström, F., & Nyberg, L. (2015). Neurocognitive architecture of working memory. *Neuron*, *88*(1), 33–46. https://doi.org/10.1016/j.neuron.2015.09.020

The "chunking" theory of learning is a main component of working memory, considering it enables the user to recall information with greater ease while executing a specific task. When considering both the hypothalamus and prefrontal cortex, in addition to various other regions of the brain, are activated during memory processes, it seems that the chunking method of retaining information is the work of a collective whole rather than individualized brain regions.

Q: How would data in value-based studies of decision making be different for someone with brain damage (more specifically the to the vmPFC and the Dorsolateral Prefrontal cortex)?

RavioliJaguar: the Ventromedial Prefrontal Cortex (vmPFC) plays a major part in human decision making. This region assists in predicting values of the different options in instances of certainty and uncertainty. Those with lesions in the vmPFC showed that they would be able to make decisions based on preferences of the options but their choices were inconsistent.

Fellows, L. K., & Farah, M. J. (2007). The role of ventromedial prefrontal cortex in decision making: judgment under uncertainty or judgment per se? Cerebral Cortex (New York, N.Y.: 1991), 17(11), 2669–2674. https://doi.org/10.1093/cercor/bhl176

The dorsolateral prefrontal cortex (dlPFC) was examined in a study using the Iowa Gambling Task. This tasks takes the form of a card game in which participants select cards from one of four decks in an effort to win play money. Two of the decks are associated with large wins, but occasional even larger losses. The other two conceal smaller wins, but even smaller losses. As the game proceeds, normal individuals generally learn to avoid the risky decks, instead adopting a conservative strategy of accepting smaller wins to avoid large losses (*Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. Cognition, 50(1–3), 7–15.)* They found that damage to dlPFC impairs individuals from being able to play the IGT task and avoid the most losses

Fellows, L. K., & Farah, M. J. (2005). Different Underlying Impairments in Decision-making Following Ventromedial and Dorsolateral Frontal Lobe Damage in Humans. Cerebral Cortex, 15(1), 58–63. //https://doi.org/10.1093/cercor/bhh108//

Neurotransmitters and decision making

Q: Why don't dopamine neurons show increased firing rate when humans/animals receive large rewards? I understand how it could potentially make the receptors less sensitive, but I don't understand why it doesn't affect firing rate.

It appears as if the release of dopamine is more so dependent on the potential for knowing when a reward would be received and less so about the actual size of the reward. For example, more firing would occur if someone was more uncertain about receiving the reward even if the reward itself was large (Anselme & Robinson, 2013).

Anselme, P., & Robinson, M. J. F. (2013). What motivates gambling behavior? Insight into dopamine's role. Frontiers in Behavioral Neuroscience, 7. https://doi.org/10.3389/fnbeh.2013.00182

-TelecomElegant

Q: Is the reward prediction error always going to show that dopamine is not a reward? The article says that when a human/animal expects to receive a large reward and does that dopamine neurons do not show an increase in firing rate.

NitroMotor: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4826767/

"Reward prediction errors consist of the differences between received and predicted rewards. They are crucial for basic forms of learning about rewards and make us strive for more rewards—an evolutionary beneficial trait. Most dopamine neurons in the midbrain of humans, monkeys, and rodents signal a reward prediction error; they are activated by more reward than predicted (positive prediction error), remain at baseline activity for fully predicted rewards, and show depressed activity with less reward than predicted (negative prediction error). The dopamine signal increases nonlinearly with reward value and codes formal economic utility."

(Schultz, 2016) **(Schultz, 2016)**

Q: Given the close relationship between serotonin and dopamine in the brain, how is serotonin incorporated into the dopamine findings concerning value and reward decision making?

ZeroCanary: According to this experiment, subjects who had low levels on serotonin, were significantly less sensitive to rewards compared to the subjects whose serotonin levels were not tampered with (control group).

Seymour, B., Daw, N. D., Roiser, J. P., Dayan, P., & Dolan, R. (2012). Serotonin selectively modulates reward value in human decision-making. *The Journal of Neuroscience : The Official Journal of the Society for Neuroscience*, *32*(17), 5833–5842. https://doi.org/10.1523/JNEUROSCI.0053-12.2012

Gongscratch: Serotonin and dopamine impact different structures in the brain. Dopamine is released in the nucleus accumbens and hippocampus while serotonin is focused more in hypothalamus. While serotonin has more to do with impulsivity and aggression, I would imagine that the data would be similarly correlated to the findings found with dopamine based on their similar relationships with reward and addiction.

Blum, K., Cull, J. G., Braverman, E. R., & Comings, D. E. (1996). Reward Deficiency Syndrome. American Scientist, 84(2), 132–145.

Studies have shown that serotonin levels alter the rate of delayed reward value in both animal and human models, which is associated with impulsive behavior. Low serotonin levels cause impulsive behavior, as proven by the result of more frequent small reward choices when compared to control serotonin levels.

Schweighofer, N., Bertin, M., et al. (2008). Low serotonin levels increase delayed reward discounting in humans. *The Journal of Neuroscience, 28(*17), 4528-4532.

Paint Level

Q: The article stated that dopamine helps to teach value, could that be related

to the addictiveness of drugs that increase dopamine since the increase of dopamine teaches the brain to value taking the drug?

Exposure to drugs can desensitize the brain to dopamine. Addiction is not only related to drugs being reinforced through dopamine release. People will build up a tolerance to the drug and then they will need it to even feel normal, let alone happy. Initially, the drug will give them a huge dopamine release and as they do it more, they need more of the drug to get to that same level. That is what people call “chasing the high” because they are taking more and more of it to try to get that feeling they had at first. This causes addicts to build up such a high tolerance that they have to take a ton of it to feel any dopamine release. Dopamine is definitely related to addiction, but mostly that the drug can desensitize the brain to dopamine so that the addict needs more drugs to be happy and feel that dopamine release.

What Role Does Dopamine Play in Addiction? (2013, September 30). Retrieved February

> 5, 2019, from https://www.inspiremalibu.com/blog/drug-addiction/dopamine-and-addiction/

-PoloBravo

Decision making in non-human animals

Q: The article frequently mentions similarities between human and animal decision making, but never thoroughly the differences. Are our decision-making valuations really so similar?

- Yes, there are many similarities between the decision making processes that both humans and various other animals go through. As we learned in chapter one of the textbook, we know that there are two systems: one that is reflexive and one that requires more complex processes and thinking. We can observe animals displaying these two systems as well by seeing how they interact with rewards. Many studies have set out to see if an animal, such as a mouse, would take a minimal amount of food right away, or if they would understand and go through more advanced cognitive processes to earn a surplus of food. If they take the initial, minimal food, then they are acting on their reflexive system; however, if they think more, then they are using the other cognitive system.
- Exploring Parallels Between Human And Animal Decision-Making. (2016, September 13). Retrieved February 5, 2019, from https://thedecisionlab.com/parallels-between-human-animal-decision-making/

- DecimalSponsor

Q: The article mentions “A tremendous amount is know about how many things are represented in the mammalian brain” (pg 376) (referencing choice processing) and not so much the human brain because of the lack of technology. Are there any studies done on both monkeys and humans that ended with the same conclusion? I’m curious as to just how applicable the choice circuit found in non-human primates will be to humans.

- Methods involving molecular biology demonstrate that there are many physical differences between the brains of non-human primates and humans (Rakic, Ayoub, Breunig, & Dominguez, 2009). Case studies based on human brain lesions have been compared to studies done on non-human primates and some found results for humans and non-human primates that were very similar while others found that in some ways the non-human primates had similar responses and in other ways they differed from humans (Adolphs, 1999). While skimming through my search results it also seems that more studies are being done on humans.
- -VideoSport
- This study done in rhesus monkeys found that choice as a function of probability values are updated based on prior experiences. Therefore it is most likely an adaptive system. This study provides evidence against the idea that decision-making is a function of inflexible computations. This finding is comparable in humans in which accurate decisions require knowledge of prior probabilities.
- Ferrari-Toniolo, S., Bujold, P. M., & Schultz, W. (2019). Probability distortion depends on choice sequence in rhesus monkeys. The Journal of Neuroscience, 1454-18. doi:10.1523/jneurosci.1454-18.2018-**SOCIALANVIL**

Making decisions for others or brands

Q: Many studies about the human decision making process explore what happens in the human body when a person is making a decision for themselves, such as what to wear for the day. How does this process change when a person is making a decision for another person, i.e. a parent making a decision for their child?

PolarisUnique: “Family members, partners, and close friends are sensitive to vulnerabilities of their social partners, but in some domains and according to their partners' age they perceive a greater (or smaller) risk than their partners perceive for themselves.”

(Rolison, Hanoch, & Freund, 2018)

Q: how can the info in this article be applied to how consumers choose between different product brands?

- Using the information from this article can help others to decide which brand will provide the most utility. This can either mean the most use or the best use.

-IsotopeNirvana

- **Optiontemple:** This article talks a lot about lateral intraparietal area (LIP) which has a lot of variation in research about how it affects decision making. The article that I looked at talked about the LIP’s correlation to oculomotor decision making especially decisions that are more system 1 things I believe.
  - Christopoulos, V. N., Kagan, I., & Andersen, R. A. (2018). Lateral intraparietal area (LIP) is largely effector-specific in free-choice decisions. *Scientific Reports*, *8*(1), 8611. https://doi.org/10.1038/s41598-018-26366-9
- Individuals have their idiosyncratic preferences and use those to make decisions, however in relation to marketing and consumer decision making, products that get the most visual attention - aka products on the shelves at eye level in the grocery - are the most purchased items.
  - **DivideSegment:** Christopoulos, V. N., Kagan, I., & Andersen, R. A. (2018). Lateral intraparietal area (LIP) is largely effector-specific in free-choice decisions. *Scientific Reports*, *8*(1), 8611. https://doi.org/10.1038/s41598-018-26366-9

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Aumann, R., & Brandenburger, A. (1995). Epistemic Conditions for Nash Equilibrium. //Econometrica//,

//63//(5), 1161–1180. https://doi.org/10.2307/2171725

Causse, M., Péran, P., Dehais, F., Caravasso, C. F., Zeffiro, T., Sabatini, U., & Pastor, J. (2013). Affective decision making under uncertainty during a plausible aviation task: an fMRI study. *NeuroImage*, *71*, 19–29. https://doi.org/10.1016/j.neuroimage.2012.12.060

Christopoulos, V. N., Kagan, I., & Andersen, R. A. (2018). Lateral intraparietal area (LIP) is largely effector-specific in free-choice decisions. *Scientific Reports*, *8*(1), 8611. https://doi.org/10.1038/s41598-018-26366-9

Dorris, M. C., & Glimcher, P. W. (2004). Activity in posterior parietal cortex is correlated with the relative subjective desirability of action. *Neuron*, *44*(2), 365–378. https://doi.org/10.1016/j.neuron.2004.09.009

Eriksson, J., Vogel, E. K., Lansner, A., Bergström, F., & Nyberg, L. (2015). Neurocognitive architecture of working memory. *Neuron*, *88*(1), 33–46. https://doi.org/10.1016/j.neuron.2015.09.020

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