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Monoamine Oxidase in the Regulation of Biopsychological Factors: A Literature Review of the Correlates of Time Perspective, Sensation-Seeking, Boredom Proneness, and Affect

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Abstract

This literature review will explore relationships between several psychological factors, such as affect, time perspective, and boredom, with levels of relevant neurotransmitters, namely dopamine and serotonin. For instance, the neurological processes involved in affect could also influence sensation-seeking through changes in cognition and boredom. Additionally, a more negative mood resulting from decreased dopamine levels could result in short-term shifts in one's time perspective. Monoamine oxidase plays a role in the regulation of neurotransmitter levels in the brain. Large amounts of this enzyme result in reduced levels of dopamine and serotonin. Understanding such relationships has the potential to propel further research in biopsychology and influence clinical and counseling methods used for people with harmful sensation-seeking addictions and other related disorders.

Abbreviations: ZTPI – Zimbardo's Time Perspective Inventory; SSS – Sensation-Seeking Scale; Dis – Disinhibition; TAS – Thrill and Adventure Seeking; BPS – Boredoms Proneness Scale; 5-HT – 5 hydroxytryptamine; MAO – Monoamine Oxidase

Monoamine Oxidase in the Regulation of Biopsychological Factors: A Literature Review of the Correlates of Time Perspective, Sensation-Seeking, Boredom Proneness, and Affect

The purpose of this paper is to examine the literature regarding correlates of affect, time perspective, sensation-seeking, and boredom proneness in relation to the activity of specific neurotransmitters, including dopamine and serotonin, and the enzyme monoamine oxidase. For purposes of specificity, this review will discuss these topics in the context of the tendency to take part in impulsive, short-term, risk-taking behaviors (e.g., gambling, drunk driving, drug use, etc.), rather than in the context of a long-term, cognitive process. It will look at the effects of dopamine and serotonin in particular, as these seem to be prominent influences of behavior (Vondavich, 1990). Because there is a well-recognized difference in the level of these neurotransmitters between men and women (Zuckerman, Eysenck, & Eysenck, 1978), this review will briefly consider gender differences in each of the previously-mentioned areas of interest. It will also examine age differences in those same areas. These topics and their correlations will then be related to the common factor of the enzyme monoamine oxidase. The effects of this enzyme in contributing to the correlations of affect, time perspective, sensation-seeking, and boredom will be discussed.

Affect

Because emotion is such an important component of psychology, there is an abundance of literature on affectual observations and measurements, with one of the most commonly used scales being the Positive and Negative Affect Schedule (PANAS). The PANAS asks subjects to use a Likert scale to rank twenty affect-related words based on how often they have experienced them in the last year (Crawford & Henry, 2004; DePaoli & Sweeney, 2000). The words are divided evenly into negative affect (e.g., distressed, afraid) and positive affect (e.g., inspired,

attentive) groups, with ratings scored within each group (DePaoli & Sweeney, 2000). Soubelet and Salthouse (2011) found that age was positively correlated with positive affect on the PANAS and negatively correlated with negative affect. It has also been found that affect and personality types, specifically openness and neuroticism, are strongly correlated in adults, but are only weakly correlated in children and adolescents (Wilson & Gullone, 1999). This suggests that affectual states may be important in the development of how one views the world and interacts with it. Crawford and Henry (2004) found that women tended to have higher negative affect scores on the PANAS, and men tended to have higher positive affect scores. Furthermore, it has been shown that a succession of multiple events perceived as either positive or negative can influence one's overall retrospective experiences (Dubé & Morgan, 1996). These "trend effects" were found to be different between genders, such that women were more likely to experience a negative impact on mood following several subjectively negative events, and men were more likely to experience a positive impact on mood following several subjectively positive events. (Dubé & Morgan, 1996).

Time Perspective

When it comes to the notion of time, there are two main areas of psychological study: time perception – the way in which one perceives time as it passes; and time perspective – the timeframe one brings into focus when thinking about one's life (Zimbardo & Boyd, 1999). This literature review emphasizes the latter, time perspective, which tends to be perceived more consciously rather than subconsciously, and yet seems to play several subconscious roles in altering sensation-seeking, motivation, boredom, and affect by changing the ways in which one thinks about life circumstances (Zakay, 2014; Zimbardo & Boyd, 1999).

The scale most often used to define time perspective is Zimbardo's Time Perspective Inventory (ZTPI; Zimbardo & Boyd, 1999). This scale divides time perspective measures to define the different possible perspectives one can have, including past-negative, past-positive, present-hedonistic, present-fatalistic, and future perspectives (Zimbardo & Boyd, 1999). A past-negative view would be one in which a person mostly concentrates on negative events in the past and does not think about the benefits of those events or how the circumstances they caused may be changed. Someone with a past-positive view, on the other hand, might be characterized as melancholy, always dreaming about "better times" and not entirely cognizant of the good things in the present and future. Present-hedonistic is the view that one should live for the present moment only. Such view-holders try to enjoy the present as much as they can, believing that the past should not be worried about because it is gone and that the future should not be worried about because it cannot be changed. People who have present-fatalistic views have a similar feeling about the future, however they are not enjoying their present. They feel that there is no good coming from their current situation, and they feel defeated by the thought that they cannot change their future. Finally, someone with a future orientation does not often worry about the present or past. They tend to be somewhat focused on what they are doing in the present, but only to the extent of recognizing how it will allow them to reach their future goals, which are their main concern (Zimbardo & Boyd, 1999).

Sensation-Seeking

Sensation-seeking is defined as taking part in impulsive, and sometimes risky, behaviors (Daitzman & Zuckerman, 1980). The most prominent scale for measuring such tendencies is Zuckerman's Sensation-Seeking Scale (SSS; Zuckerman et al., 1964). Zuckerman and colleagues (1964) define this scale, specifically, as an analyzation of one's tendency to seek out risky

situations or scenarios based on one's "sensitivity to internal sensations" (p. 480). This scale has been further researched and broken down into four subscales: Disinhibition, Thrill and Adventure Seeking, Experience Seeking, and Boredom Susceptibility (Zuckerman et al., 1978). Disinhibition (Dis) is defined as the inability to refrain from risky, wild behaviors; Thrill and Adventure Seeking (TAS) is the tendency to engage in thrill-giving activities; Experience Seeking (ES) is the tendency to live a "non-conforming lifestyle" (pg. 140); and Boredom Susceptibility (BS) is a measure of how easily or readily one tires of an activity or task (Zuckerman et al., 1978).

Zuckerman and colleagues (1978) found that males tend to have higher scores on the SSS than females, and also that the scores for both genders decrease with age after puberty. They also noted that men tend to score higher than women on the Dis and TAS subscales in Zuckerman's SSS. Daitzman and Zuckerman (1980) found that levels of both androgen and estrogen hormones correlated with the age and sex differences on both the Dis and TAS subscales. Zuckerman and colleagues (1978) suggested that these scoring differences are caused by the differences in gonadal hormone systems. Additional studies support the hypothesis that hormone differences can be responsible for differences in sensation-seeking (Daitzman & Zuckerman, 1980; Duke, Balzer, & Steinbeck, 2014; Simpkins, Kalra, & Kalra, 1983; Zuckerman et al., 1978). When looking at age differences alone, Steinberg and colleagues (2008) hypothesized that the high sensation-seeking behavior often observed in adolescents is due to the natural development of the gonadal hormone system.

Boredom Proneness

Boredom is thought to be the result of decreased cognitive activity. In other words, the less you engage in thinking about and/or doing something, the more likely it is that you will

become bored (Watt & Blanchard, 1994). A scale commonly used to assess one's tendency to become bored is the Boredom Proneness Scale (BPS; Vodanovich & Kass, 1990). Boredom proneness is also one of the hypothesized causes of impulsive sensation-seeking; in fact, one of the subscales in Zuckerman's SSS is even termed "Boredom Susceptibility" (Zuckerman et al., 1978). For this reason, the Need for Cognition scale (Zakay, 2014), which measures one's enjoyment of and preference for cognitive activities, is also often used to examine susceptibility to boredom. It has been found that Need for Cognition scores and BPS scores are positively correlated (Watt & Blanchard, 1994; Zakay, 2014). This makes logical sense: if a person is often bored with daily activities, he or she is more likely to try to find other ways to pass time and relieve that boredom (Vodanovich & Kass, 1990).

Correlations of Affect, Time Perspective, Sensation-Seeking, and Boredom Proneness

There have been many studies suggesting that time perspective can be an important factor affecting the way one perceives life circumstances and well-being (Strack, Schwarz, & Gschneidinger, 1985; Zimbardo & Boyd, 1999). Especially when combined with affect – positive or negative – it can determine the lens through which someone views their current life situations. For example, in one study by Strack and colleagues (1985), participants were asked to think about either positive or negative events in the distant past. They were then asked to rate their life satisfaction, happiness, and current mood. The results showed that thinking about past negative and positive events had an influence on current mood. When strong emotional affect was elicited by the event, the participant was more likely to report being more or less satisfied with their life, depending on if the affect was positive or negative, respectively (Strack et al., 1985). Thus, if a person had a past-negative orientation and spends a lot of time thinking about negative events from their past, they may be more inclined to have low life satisfaction and think

that their life is not meaningful. As previously mentioned, such correlations between affect and time perspective have also been linked to sensation-seeking and boredom proneness (Zakay, 2014; Zimbardo & Boyd, 1999).

Vodanovich (2003) found a high correlation between the BPS and Zuckerman's SSS, indicating that the more tendency a person has of becoming bored, the higher that person's tendency will be to take part in impulsive behaviors. Related to this notion, it is of interest to note that affect and boredom are inversely correlated with each other (Vodanovich & Kass, 1990) and that affect and cognition are positively correlated (Ashby, Isen, & Turken, 1999). This implies that as affect becomes more positive, cognitive tendencies increase, thus decreasing boredom.

Serotonin and Dopamine

It has often been noted in the literature that boredom is correlated with slowed time perception (e.g., Vodanovich & Kass, 1990; Watt & Blanchard, 1994). The more bored a person is, the slower the person will perceive the passage of time (Brunner & Hen, 1997; Vodanovich & Kass, 1990; Watt & Blanchard, 1994). A possible biological influence on affect, boredom, time perception, and time perspective may be found in the activity of 5-hydroxytryptamine (5-HT) serotonin receptors, specifically. These receptors reside in the amygdala and hippocampal regions of the brain and have been found to have an effect on aggression, affect, and mood (Brunner & Hen, 1997). With more 5-HT serotonin receptors present to take up serotonin – provided enough serotonin is available – affect will increase, but the amount of serotonin will then go down because of its absorption by the receptors. This reduction, in particular, is correlated with slower time perception (Brunner & Hen, 1997). Therefore, it is possible that affect actually does not have a direct effect on cognition and boredom, but that those factors are

simply correlated due to related biological processes. This would mean that, while serotonin levels in 5-HT receptors alter affective states (and thus alter time perspective), the amount of serotonin not used by 5-HT receptors has a different neurological function that results in changes in cognition, boredom, and time perception. Such changes could also potentially alter the way in which one views their life, thus affecting their perceived quality of life and changing their time perspective.

Dopamine levels have been used to explain the correlations between affect, boredom proneness, and need for cognition. Low levels of dopamine have been found to correlate with low cognitive flexibility, which is hypothesized to be a possible cause of cognitive decline in aging, as dopamine levels in the brain decrease at a rate correlated with age increase (Ashby et al., 1999). While affect and cognitive flexibility are correlated, so are dopamine and affect; low affect, such as that seen with mild depressive symptoms, is linked to low dopamine levels as well as low serotonin levels (Ashby et al., 1999). Thus, it is possible that, as dopamine levels become lower, affect is decreased, which reduces cognition, which then results in boredom.

During adolescence, dopamine levels in the brain increase and then begin to decrease towards the end of adolescence – a shift which leads to more sensation-seeking behaviors as an attempt to compensate for the lowered frequency of pleasurable sensations (Steinberg et al., 2008). In addition, Steinberg and colleagues (2008) found that testosterone levels correlate with sensation-seeking behaviors in all age groups. This is significant in relation to the hypothesized reason for the adolescent increase in sensation-seeking: not only is testosterone known to increase during adolescence, which is attributed to changes in behavior and mood (Duke, Balzer, & Steinbeck, 2014), but testosterone has also been identified as a dopamine inhibitor (Simpkins, Kalra, & Kalra, 1983), which makes sense in the context of Steinburg's hypothesis.

Feelings of strong positive and negative affect have been found to correlate, not only with serotonin levels but also with dopamine levels (Ashby et al., 1999). The levels of both neurotransmitters correlate most strongly with positive affect but have also been found in negative affect situations related to anxiety and stress. People who are more sensitive to dopamine typically have higher affect and tend to be more extraverted, meaning they tend to seek out new and exciting experiences (Ashby et al., 1999). They have also have been found to have higher levels of sensation-seeking (Daitzman & Zuckerman, 1980). This raises a question as to why people with high dopamine levels seek to further increase those levels. The explanation is likely that, in having high dopamine levels, they have built up a tolerance to its pleasurable effects (Ashby et al., 1999). When they are involved in activities that others may find very rewarding, they are less affected by the releases of dopamine because they have so much of the neurotransmitter already circulating in their brain. Thus, Ashby and colleagues (1980) found that, to get a rewarding experience, people take part in activities that give them more of a mental rush, which often take the form of increased sexual activity, gambling, drinking, drug usage, and/or aggressive driving. These activities display a downward cycle, normally starting off as being relatively mild and infrequent. However, as the person learns to expect the pleasure and adapt to it, he or she will be more likely to increase frequency and riskiness of the behaviors (Ashby et al., 1980).

Monoamine Oxidase

Monoamine oxidase (MAO) is an enzyme that is used in the process of breaking down dopamine and serotonin, among other neurotransmitters (Shih, Chen, & Ridd, 1999). Because of its high importance in regulating activity of neurotransmitters in the brain, it is a useful factor to consider when looking at the common link between related behaviors. The gene that codes for

the production of MAO is found on the X-chromosome, which means that women naturally produce more of it than men (Robinson et al., 1971; Shih, Chen, & Ridd, 1999). This is thought to be a reason for the increased levels of depression in women; specifically, they would have less serotonin due to the activity of MAO (Daitzman & Zuckerman, 1997; Robinson et al., 1971). It is also used to explain how both MAO inhibitors and selective serotonin reuptake inhibitors can be used as an effective treatment of depression (Robinson et al., 1971). MAO is hypothesized to be one of several causes for personality differences between men and women (Hunter, 2010). For these reasons, MAO is of interest in the context of the correlations between affect, time perspective, sensation-seeking and boredom.

MAO and Affect, Time Perspective, Sensation-Seeking, and Boredom

The effects of MAO on time perspective are relatively straight-forward, though multiple intermediate steps may be involved (Figure 1). Fluctuations in MAO levels would change the levels of dopamine and serotonin present in the brain (Daitzman & Zuckerman, 1980). The levels of these neurotransmitters would alter affect (Brunner & Hen, 1997), which could change the way a person views life situations, thus influencing their time perspective (Strack et al., 1985). For example, increased amounts of MAO would mean less dopamine and serotonin, lower affect, and negative perceived quality of life. Thus, in such a situation, a person would likely have either a past-negative or present-fatalistic time perspective. This flow of logic is supported by observations made in the literature. Zimbardo and Boyd (1999) found that both past-negative and present-fatalistic time perspectives were positively correlated with depression, suggesting low levels of serotonin which may be a result of higher levels of MAO.

According to Zimbardo and Boyd (1999), time perspective is a precursor for specific behaviors, one of which would be sensation-seeking. They found that people who scored low on

Zuckerman's SSS were more likely to have a future-oriented time perspective when tested on the ZTPI. This is logical, as people who are highly concerned with the future would be less focused on the present, meaning that they would spend less time trying to entertain themselves.

This theory makes sense in the context of neurotransmitter levels as well. While, as mentioned above, adolescents have high sensation-seeking due to a lowered amount of dopamine (Steinberg et al., 2008), some people naturally have lower-than-average levels of dopamine throughout their life, which could be caused by high rates of MAO production. If the levels of dopamine are always low, then the reward for doing pleasurable things may not be very strong. A person in such a situation may have less desire to pursue pleasurable sensations because they do not produce enough reward for the action to be worth the effort.

As MAO levels alter levels of serotonin, affectual states are also changed due to the reduced activity of 5-HT serotonin receptors. It is likely that affect influences time perspective, but whether the serotonin levels or 5-HT receptors have a direct influence on cognition, boredom, and time perception is unknown. To explore the previously-mentioned possibilities, it may be that as serotonin increases at 5-HT receptors, affect also increases, which increases cognition and decreases boredom, thus speeding time perception. Or it could be that, while affect and cognition are correlated, they have no direct causal relationship, instead being altered by the activity of the 5-HT receptors. In either case, it is clear that a relationship could exist between each of these factors, being influenced first by levels of MAO and then resulting in either a speeding-up or slowing-down of time perception, which alters one's boredom and sensation-seeking tendencies.

Conclusions

The regulation of neurotransmitter levels through MAO is of great consequence to affect, time perspective, sensation-seeking, and boredom proneness. MAO regulates the actions of the neurotransmitters dopamine and serotonin, which seem to be the key factors that tie together the correlations between all these variables. The way serotonin and dopamine change affect seems to influence time perspective and boredom independently, but the results of boredom on sensation-seeking then seem to relate back to time perspective in a somewhat cyclical manner.

When considering the larger picture, it is clear that boredom proneness and sensation-seeking – and their intermediates of affect, cognition, and time perception – are closely related to each other. It is also evident that sensation-seeking tendencies and time perspectives are related to each other, but less directly, through many intermediate biological and psychological factors, which are beyond the scope of this review.

Limitations and Future Directions

This review makes some important connections regarding the way various neurotransmitters and enzymes in the brain interact with one another. It also speculates on what possible roles they could play in regulating behaviors related to affect, time perspective, sensation-seeking, and boredom. However, there are several areas where such roles and links are not entirely clear and further research is needed to verify and expand on the actions of these molecules and how they relate to human behavior.

Although time perspectives are well-defined and distinct from each other conceptually, in application they are interrelated, and the exact definition of each perspective is variable between individuals. Because time perspectives are so dependent on positive or negative affect, which can fluctuate drastically over time depending on current situations and general mood, it is

unreasonable to assume that people are always set in one time perspective. Often, these perspectives change, and it can be difficult to say for certain whether a person has an overall tendency to experience a specific perspective. There is also clear evidence that a person can experience multiple perspectives at the same time (Zimbardo & Boyd, 1999). Thus, although there is much evidence that time perspective is related to affect, more research is needed to fully understand the bidirectional relationship between the two. It makes sense that negative perspectives correlate with negative affect, but some of the other correlations are not quite as defined. For example, if a person has high positive affect, what should determine whether he or she has past-positive, future, or present hedonistic time perspectives? Those blurry correlations need to be further researched in an effort to understand both the biological and psychological connections between affect and time perspective.

Other possible questions to ask might concern motivational differences between individuals. What is it that causes or allows a person with high positive affect to focus on the future rather than on the past? Also, what differentiates the past-negative perspective from the risk-taking present-hedonistic perspective (Zimbardo & Boyd, 1999)? What psychological processes and heuristics provide the bases for such individualized distinctions? For example, Vodanovich (2003) mentions that BPS scores are positively correlated with higher value of external rewards, which explains the increased immediate and impulsive sensation-seeking tendencies. Yet, the correlations between BPS and internal rewards (e.g., achievement of some long-term goals) are less clear. Biological causes of behaviors that stem from desire for intrinsic rewards may be difficult to uncover due to the longer-term nature of such behaviors. However, it may be possible that the neurotransmitters dopamine and serotonin play a role in the psychological states which promote long-term intrinsic motivation. What may be useful is

looking at emotional affect as a variable with varying degrees of intensity, rather than as simply positive or negative. Correlations may be found between scores on an affect spectrum and time perspective tendencies, in which case a connection may lead to further understanding of how biology may influence long-term motivation.

Again, more research needs to be done on the correlations between affect, cognition, boredom and time perception, especially in the context of biological factors related to the 5-HT serotonin receptors. Answers to the questions raised by such complicated relationships could be of great benefit in the medical and therapeutic fields, helping researchers and medical professionals understand what factors may be driving a person's mood disorders, addictions, or other abnormal or risky behaviors. More research could also be done on both the psychological and biological factors of how cognition and need-for-cognition influence boredom.

As was mentioned above, androgen and estrogen are both positively correlated with the Dis and TAS subscales of the SSS (Daitzman & Zuckerman, 1980). However, androgen is actually a natural inhibitor of MAO production (Ou, Chen, & Shih, 2006), which is contradictory to the previous observation that high production of MAO results in less dopamine and increases sensation-seeking (Steinberg et al., 2008). This suggests, as would be expected, that there are more factors influencing sensation-seeking than just MAO levels and affect. There are likely several biological processes that come together to collectively result in any particular level of sensation-seeking tendencies. For example, not only may it matter whether someone is male or female and at what rate they produce MAO, it also may matter how much of each type of neurotransmitter they have, where those neurotransmitters are concentrated in the brain, what other inhibitors and protagonists are present, and how those things influence specific neurotransmitter and MAO levels.

Expanding on this issue of gender differences, the biological differences affecting behaviors of men and women also need to be further explored. Differing levels of gonadal hormones undoubtedly influence the biopsychological processes of affect, sensation-seeking, and time perspective, but it seems that the comprehensive role of these hormones in such a context are poorly understood.

The conclusions drawn from this review could form a foundation for future empirical research towards finding a collection of biological networks which controls for boredom, sensation-seeking, and overall motivation. Such findings may play a significant role in altering clinical treatment and counseling methods for individuals displaying addictive behaviors.

References

Ashby, F. G., Isen, A. M., & Turken, A. U. (1999). A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review, 106*(3), 529-550. doi: 10.1037/0033-295X.106.3.529.

Brunner, D., & Hen, R. (1997). Insights into the neurobiology of impulsive behavior from serotonin receptor knockout mice. *Annals of the New York Academy of Sciences, 863*, 81-105. doi: 10.1111/j.1749-6632.1997.tb52356.x.

Crawford, J. R., & Henry, J. D. (2004). The positive and negative affect schedule (PANAS): Construct validity, measurement properties and normative data in a large non-clinical sample. *British Journal of Clinical Psychology, 43*, 245-265. doi: 10.1348/0144665031752934.

Daitzman, R., & Zuckerman, M. (1980). Disinhibitory sensation seeking, personality and gonadal hormones. *Personality and Individual Differences, 1*(2), 103-110. doi: 10.1016/0191-8869(80)90027-6.

DePaoli, L. C., & Sweeney, D. C. (2000). Further validation of the positive and negative affect schedule. *Journal of Social Behavior and Personality, 15*(4), 561-568. Retrieved from: <www.academia.edu/10846148/Further_Validation_of_the_Positive_and_Negative_Affect_Schedule>

Dubé, L., & Morgan, M. S. (1996). Trend effects and gender differences in retrospective judgements of consumption emotions. *Journal of Consumer Research, 23*(2), 156-162. doi: http://dx.doi.org/10.1086/209474.

Duke, S. A., Balzer, B. W. R., Steinbeck, K. S. (2014). Testosterone and its effect on human male adolescent mood and behavior: A systematic review. *Journal of Adolescent Health, 55(3),* 315-322. doi: 10.1016/j.jadohealth.2014.05.007.

Hunter, P. (2010). The psycho gene. *EMBO Reports, 11*, 667-669. doi: 10.1038/embor.2010.122.

Mogenson, G. J., Jones, D. L., & Yim, C. Y. (1980). From motivation to action: Functional interface between the limbic system and the motor system. *Progress in Neurobiology, 14*, 69-97. doi: 0301-0082:80.0501-1X)60$05.00:0.

Ou, X.-M., Chen, K., & Shih, J. C. (2006). Glucocorticoid and androgen activation of monoamine oxidase A is regulated differently by R1 and SP1. *Journal of Biological Chemistry, 281*(30), 21512-21525. doi: 10.1074/jbc.M600250200.

Robinson, D. S., Davis, J. M., Nies, A., Ravaris C. L., Sylwester, D. (1971). Relation of sex and aging to monoamine oxidase activity of human brain, plasma, and platelets. *Archives of General Psychiatry, 24*(6), 536-539. doi: 10.1001/archpsyc.1971.01750120052009.

Shih, J. C., Chen, K., Ridd, M. J. (1999). Monoamine oxidase: From genes to behavior. *Annual Review of Neuroscience, 22*, 197-217. doi: 10.1146/annurev.neuro.22.1.197.

Simpkins, J. W., Kalra, S. P., & Kalra, P. S. (1983). Variable effects of testosterone on dopamine activity in several microdissected regions in the preoptic area and medial basal hypothalamus. *Endocrinology, 112*(2), 665-669. doi: 0013-7227/83/1112-0665$02.00.0

Soubelet, A., & Salthouse, T. A. (2011). Influence of social desirability on age differences in self-reports of mood and personality. *Journal of Personality, 79*(4), 741-762. doi: 10.1111/j.1467-6494.2011.00700.x.

Steinberg, L., Albert, D., Cauffman, C., Banich, M., Graham, S., & Woolard, J. (2008). Age differences in sensation seeking and impulsivity as indexed by behavior and self-report:

Evidence for a dual systems model. *Developmental Psychology, 44*(6), 1764-1778. doi: 10.1037/a0012955.

Strack, F., Schwarz, N., & Gschneidinger, E. (1985). Happiness and reminiscing: The role of time perspective, affect, and mode of thinking. *Journal of Personality and Social Psychology, 49*(6), 1460-1469. doi: 10.1037/0022-3514.49.6.1460.

Vodanovich, S. J. (2003). Psychometric measures of boredom: A review of the literature. *The Journal of Psychology, 137*(6), 569-595. doi: 10.1080/00223980309600636.

Vodanovich, S. J., & Kass, S. J. (1990). A factor analytic study of the boredom proneness scale. *Journal of Personality Assessment, 55*(1-2), 115-123. doi: 10.1080/00223891.1990.9674051.

Watt, J. D., & Blanchard, M. J. (1994). Boredom proneness and the need for cognition. *Journal of Research in Personality, 28*(1), 44-51. doi: 10.1006/jrpe.1994.1005.

Wilson, K., & Gullone, E. (1999). The relationship between personality and affect over the lifespan. *Personality and Individual Differences, 27*, 1141-1156. doi: 10.1016/S0191-8869(99)00058-6.

Zakay, D. (2014). Psychological time as information: The case of boredom. *Frontiers in Psychology, 5*, 1-5. doi: 10.3389/fpsyg.2014.00917.

Zimbardo, P. G., & Boyd, J. N. (1999). Putting time in perspective: A valid, reliable, individual-differences metric. *Journal of Personality and Social Psychology, 77*(6), 1271-1288. doi: http://dx.doi.org/10.1037/0022-3514.77.6.1271.

Zuckerman, M., Eysenck, S., & Eysenck, H. J. (1978). Sensation seeking in England and America: Cross-cultural, age, and sex comparisons. *Journal of Consulting and Clinical Psychology, 46*(1), 139-149. doi: 10.1037/0022-006X.46.1.139.

Zuckerman, M., Kolin, E. A., Price, L., & Zoob, I. (1964). Development of a sensation-seeking scale. *Journal of Consulting Psychology, 28*(6), 477-482. doi: 10.1037/h0040995.

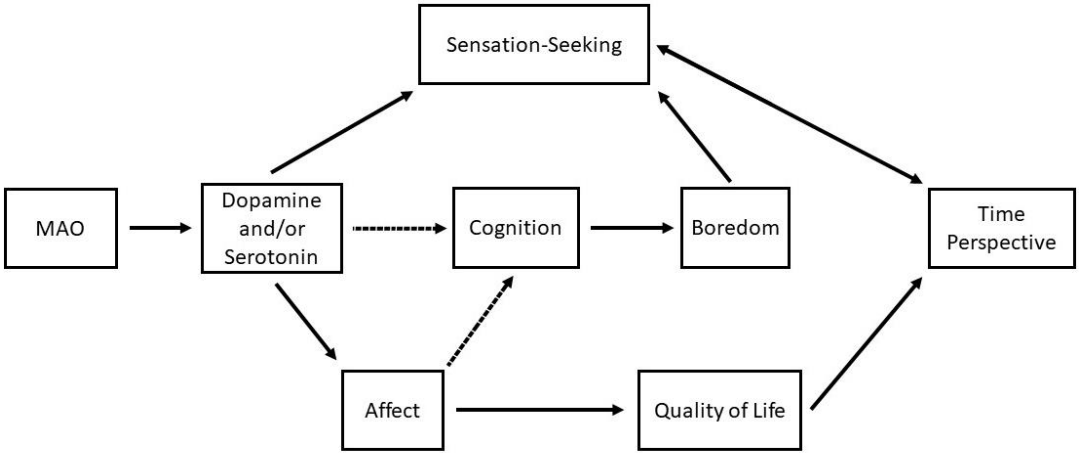

Figure 1. Flow chart of theorized causal effects of MAO on sensation-seeking, affect, cognition, and time perspective. MAO directly affects levels of dopamine and serotonin. Dopamine likely affects sensation-seeking tendencies, which may then affect time perspective, and time perspective may affect sensation-seeking in return. Serotonin has effects on levels of affect, which likely influence perceptions of quality of life, which may then alter time perspectives. Both serotonin and dopamine may affect tendencies towards cognition, and affect may also impact cognition; the broken arrows indicate uncertainty and a possible duality. Cognitive tendencies determine boredom proneness, and boredom may have effects on sensation-seeking. Note that this chart does not display all known correlations.