The Association between ADHD and Creativity

XIN ZHAO

University of California, Berkeley

**Abstract**

Are children and adults with ADHD more creative? This review will discuss the relationship between creativity and Attention Deficit Hyperactivity Disorder (ADHD) and will investigate related biological models and behavioral experiments. By examining research that studied ADHD children, ADHD adults, high-creativity individuals and control subjects, this review will present discrepant research regarding the relationship between ADHD and creativity. Spontaneous Eye Blink Rate (EBR) has been found to be a valid measure for creativity and dopamine. Children with ADHD not on medication display lower dopamine levels and EBR when performing goal-directed tasks. Interestingly, other researchers have observed children and adults, with ADHD symptoms and diagnosis, are more likely to score higher in divergent thinking tasks and less in convergent thinking tasks than controls. A possible explanation is that the dopamine levels mediate ADHD symptoms, and also, lead to different performances in convergent thinking tasks and divergent thinking tasks. Hopefully further research can help attain accurate diagnoses for children with high creativity and improve treatments for people with ADHD.

**Key Word**: ADHD, Spontaneous Eye Blink Rate (EBR), Creativity, Convergent Thinking, Divergent Thinking

**Introduction**

Are individuals with ADHD symptoms more or less creative than normal controls? A clearer relation between creativity and ADHD cannot only increase the validity of ADHD diagnosis and treatment, but also provide policy implications for education programs. Independently, Attention Deficit Hyperactivity Disorder (ADHD) and creativity have been heavily studied, both empirically and theoretically in the past few decades. However, the relation between creativity and ADHD has been less investigated and presents clinical psychology with increasingly controversial and limited literatures. The purpose of this study is to explore the theoretical models on the potential relationships between ADHD and creativity at different levels (i.e. cognitive function, genetic prevalence, neurochemical). The major hypothesis: individuals with ADHD perform better in divergent thinking tasks but worse in convergent thinking tasks than normal controls. Although there are no current studies with random assignment directly investigating the relationship between ADHD and creativity, the related theoretical models and laboratory findings can provide important implications for future research.

**Definitions**

**I. ADHD**

According to the newest Diagnostic and Statistical Manual of Mental Disorders (DSM-V; American Psychiatric Association, 2013), characteristics of ADHD include impulsivity, hyperactivity or inattentiveness. Up to 12% of children in the United States receive a diagnosis of ADHD (Hinojosa et al., 2012). Children with ADHD usually experience peer rejection, academic underachievement, markedly worse parent-child interactions, decreased self-esteem and lowered independence. ADHD is also persistent throughout adolescence and adulthood; the negative psychosocial factors from childhood continue to affect them in adolescence and adulthood. These factors include decision making, occupational, interpersonal, and behavioral problems (Hinojosa et al., 2012; Miller et al., 2013). According to Faraone and Biederman (2005), 2.9% of adults in the United States received diagnoses for Narrow ADHD and 16.4% received diagnoses for Broad ADHD.

**II. Creativity**

Creativity is usually marked by novelty and appropriateness (Abraham et al., 2011; Sternberg, 2005; Runco, 2004). More specifically, novelty is measured by how a response is different from the average. Appropriateness indicates how well the response can be accepted and suitable to social norms or requirements. At an individual level, creativity is associated with novel ideas, innovative approaches, and academic and career achievement. At a societal level, creativity is essential for technology, arts and literature. However, creativity is relatively subjective and abstract, so it is hard to find a universal method of operationalizing it, especially in clinical contexts.

Due to the social recognition and benefits of creativity, “creative achievement” has been recognized as one of the most popular and valid measures (Johnson et al., 2012). Nonetheless, it is still very difficult for researchers to study children participants, as it is hard to define and/or predict creative achievements in longitudinal studies. Individuals usually need persistency, experiences, knowledge and opportunities to attain creative achievement, which requires a large time frame not usually accessible in childhood (Johnson et al. 2012). Thus, most empirical investigations are focused on creative “potential” instead of creative “achievement” for child and adolescent research (White & Shah, 2007). Researchers have different ways of measuring creativity, of which common measures in the past decades include creative thinking, performance, ability, cognition, behavior, and imagination. Despite overlap, these creative constructs are not synonyms. In this paper, we measure creativity through divergent thinking tasks and convergent tasks in laboratory settings.

**III. Divergent thinking and convergent thinking**

Creative divergent thinking is a bottom-up process in which solutions are not restricted by one correct answer. Researchers measure the frequency, flexibility, and originality in divergent thinking responses. The most commonly used task is the alternative use task (AUT; Guilford, 1967), in which participants are required to list as many possible uses as they can for a common object, such as a brick. In contrast, convergent thinking is a top-down process requiring constant attention to finding one single right answer. Researchers measure creative pathways in this goal-directed task. The most commonly used convergent thinking task is the Remote Association Task (RAT; Mednick, 1962), in which participants are required to present a single word to associate all three of the presented words (e.g. cottage, blue, mouse).

**Experimental Evidence**

Only a few current empirical literatures explore the relation between ADHD and creativity, and a clear relationship cannot be found if we do not distinguish between divergent thinking and convergent thinking. In a study by Healey and Rucklige (2006), researchers investigated the relationship between ADHD and creativity. They measured ADHD symptomatology of children with parent and teacher reports of Conners’ Rating Scales Revised long version (CPRS-R; Conners, 1997). Formal diagnosis of ADHD was not required to be included in the ADHD group in the study. The ADHD group included children who received *T*-scores of 65 or above, per parent report of CPRS-R. Healey and Rucklige (2006) measured creativity using the Torrance Tests of Creative Thinking (TTCT; Torrance, 1998), which is usually regarded as a measure of divergent thinking. Children receiving scores above the 90th percentile were included in the creative groups. The authors found that 40% of recruited creative children displayed ADHD symptoms. Although this 40% of the sample can possibly suggest a connection between ADHD and creativity, it is unclear whether children with ADHD were more creative or that creative children were more likely to be diagnosed with ADHD. The underlying mechanisms have been investigated in divergent research lines within the past few decades**.**

White and Shah (2006) seem to find a solution for this puzzle, suggesting that there appears to be a positive correlation between ADHD and creativity in divergent tasks, but a negative correlation in convergent tasks. With a sample of 90 undergraduate students, they find that adults with past ADHD diagnoses outperform in AUT but underperform in RAT tasks compared to non-diagnosed. However, we should always be aware of the objectivity of methods in the behavioral experiments of creativity research. Due to the blurring definition and constructs of creativity, AUT and RAT may not be the greatest measurements of creativity despite their popularity. The following sections will investigate the potential mechanisms underlying this correlation.

**Neuroscientific Model**

Several researchers have provided genetic explanations of the relationship between ADHD and creativity (Dietrich, A., 2004; Dietrich & Kanso, 2010; DiMaio, Grizenko, & Joober, 2003; Ding et al., 2002; Stelzel et al., 2009). Certain genes are defined as possible etiological factors for the development of ADHD symptoms. The Dopamine D4 Receptor (DRD4) is important for synaptic dopamine signaling (Mayseless et a., 2014), which is present in the general population. DRD4-7R allele can be a potential mediator to explain the mentioned relationship between ADHD and creativity. DRD4-7R allele is found to be associated with deficits in sustained attention, impulsivity/hyperactivity, and novelty seeking.

In a study conducted by Auerbach and his collaborators (2001), infants with DRD4-7R had lower sustained attention(De Dreu et al., 2011). Individuals with DRD4-7R displayed attention problems rather than inhibitory control (Albrecht et al., 2014). As earlier mentioned, this lack of sustained attention in infancy may be persistent into adolescence and adulthood. This finding about inconsistent attention is in coherence with our theoretical analysis in the working memory cerebellum model. As earlier mentioned, sustained attention is crucial for convergent thinking tasks. Therefore, it is possible that children with inattentive problems perform worse in convergent thinking tasks. Meanwhile, their lack of attention may also lead to “thinking outside the box”, which is essential for divergent thinking tasks. Considering the relationship between DRD4 and creativity, we would expect individuals with ADHD to be more creative in divergent tasks. However, Albrecht’s team (2001) also found that infants with DRD4-7R scored lower on novelty-seeking (a facet of creativity). Although deficits in sustained attention are different from ADHD diagnosis, Albrecht’s finding can provide potential empirical evidence for the relationship between ADHD and creativity.

Additional empirical evidence may provide explanation on the inconsistent findings of this research line regarding the association between ADHD and creativity in divergent tasks. In a sample of 184 healthy participants, with a statistical control for both age and education, individuals with DRD4-7R scored lower in the fluency domain and had lower cognitive flexibility in AUT, compared to people without DRD4-7R (Mayseless et al., 2013). Mayselseless’ team (2013) explained their finding by pointing out that DRD4-7R allele is associated with impulsivity and hyperactivity; therefore, they reasoned, participants with the 7R allele were less capable of suppressing those common, less creative ideas. Based on their findings regarding the relationship between impulsivity and creativity, they also suggest that ADHD is likely to be associated with lower creativity.

However, it is questionable whether their deduction about ADHD can be generalized into real-world situations. Most children with ADHD are medicated for relieving symptoms. Therefore, it is uncertain whether children with ADHD are more or less creative when their hyperactive/impulsive symptoms are relieved by medication. Also, the children carrying the DRD4-7R allele may need higher doses of methylphenidate to relieve their symptoms (Hamarman et al., 2004) and this may be a moderator of their cognitive flexibility, which can explain their underperformance of flexibility dimension in AUT. Although higher doses are different from the substance dependence of methamphetamine, findings on substance dependence of methamphetamine (excessive amount of methamphetamine) can possibly link the the dosing of stimulants and creativity. Researchers report poorer performance of cognitive flexibility tasks within substance dependent patients using methamphetamine (Verdejo-García, Bechara, A., Recknor, & Pérez-García, 2006). At the same time, we have to be aware of the fact that the stated genotypes can only provide possible explanations on group tendencies, indicating vulnerability of the ADHD subgroups. Correlation is very different from causation. The genes cannot be identified as a causal factor for diagnosis on individual levels.

One alternative explanation is that there are three different forms of ADHD. According to the Fifth Edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM–5; American Psychiatric Association, 2013), ADHD is categorized into three subtypes: ADHD Predominantly Inattentive Type, ADHD Predominantly Hyperactive-Impulsive Type, and ADHD Combined Type. These three forms of ADHD are very different in terms of etiology, symptomatology, and impairment between the three forms of ADHD. It is possible that inattentive symptoms and hyperactive/impulsive symptoms play different roles in children’s performance of divergent and convergent tasks.

From a microscopic angle, theories on dopamine levels seem to integrate well with working memory to provide an underlying mechanism for our major hypothesis. Many researchers have found that genetic factors play an important role in connecting dopamine activities to the topic of creativity and ADHD. DAT1, DRD2, DRD4, and COMT, are involved in dopaminergic activities (DA) such as binding on dopamine receptors, inhibiting dopamine receptor uptake and increasing dopamine synthesis (Auerbach et al., 2011; DiMaio, Grizenko, & Joober, 2003; Kutanvich et al., 2004). These mentioned dopamine activities have been found within individuals who scored higher on divergent thinking tasks and have ADHD symptoms. Therefore, they have also been identified as possible gene candidates to explain the heritability of ADHD and creativity (Auerbach et al., 2011; Kutanovich et al., 2004).

Besides genetic investigations, this theoretical hypothesis has also been supported in laboratory settings. Eye Blink Rate (EBR) measures how many times a person blinks their eyes spontaneously per minute. EBR has been identified as an indirect, but valid, clinical mark for irregular dopamine levels in the brain with good reliability (Shukla, 1985). More specifically, increased dopaminergic activities in the brain can make an individual spontaneously blink their eyes more. In a study with 18 young healthy adults, Colzato, Wouwe and Hommel (2007) discovered a positive correlation (r=0.14) between EBR and how relevant the responses are. In other words, the finding is correspondent to support that EBR is associated with the efficiency of the forward dynamics process in the working memory cerebellum model. EBR is thus indirectly measuring dopamine levels.

The dopamine levels are found to be associated with individuals’ performance in divergent thinking tasks and convergent thinking tasks. Chermahini and Hommel (2010) found a negative correlation (r=-0.2) between EBR and creative performance in convergent thinking tasks with a sample of thirty-five college students. This not only provides laboratory data on the association between creativity and dopamine levels, but also more importantly, stimulates valid inquiry about the major hypothesis that people with ADHD symptoms may outperform in creativity tasks in convergent thinking scenarios (RAT). Because dopamine deletion is one of the potential causal factors of deficits in working memory (Ellis et al., 2005) and people with ADHD usually have lower dopamine levels than normal average people, it would be reasonable to assume that people with ADHD have lower EBR (Konrad et al., 2003) and then higher creative performance in convergent thinking tasks based on the negative correlation shown (Konrad et al., 2003). On the other hand, the empirical evidence, at the neurotransmitter level, for creative performance of healthy college students in divergent thinking tasks presents more disagreement on the topic. Chermahini and Hommel (2010) find a quadratic relationship (U-shape) between EBR and creative performance in divergent thinking tasks within a sample of 117 college students without clinical screening. Creative performance in the divergent thinking tasks peak at average dopamine. Two years later, the same study was reproduced and the same U-shape graph was obtained with 81 students without clinical screening in the same university (Chermanhini and Hommel, 2012). The U-shape graph is included at the end of this paper (See Graph 1). More explicitly, creative performance in AUT tasks increase as EBR increases, but, when EBR is greater than 25 times per minute, creative performance is negatively related to EBR. The first half of the result (before 25 times per minute) contradicts within the initial hypothesis. According to the initial hypothesis, the creative performance in AUT should have kept increasing as EBR increases in the divergent thinking tasks. It is questionable whether their finding can be generalized to child samples, in either medicated or unmedicated scenarios.

Additionally, the empirical finding that creative performance in the divergent thinking tasks peak at average dopamine levels is an inconsistent with the previously mentioned major hypothesis, which states that Children with ADHD performed better in divergent thinking tasks of creativity. Chermanhini and Hommel (2010) did not find strong support for the correlation of creativity and EBR; this presents us with conflicts of current research, meaning there is a need for future research with more sophisticated design and larger sample size.

Although children with ADHD have been found to have an inefficient dopaminergic system due to deficits in functioning dopamine receptors (Auerbach et al., 2011), there is no universal agreement on how to quantify dopamine neurotransmitter levels within children with ADHD diagnosis or symptoms. Non-medicated children with ADHD were reported to have lower levels of dopamine. Despite the side effects and trepidation of using stimulants, medication has proved to be the most efficient and prevalent treatment for ADHD so far. Children with ADHD on medication (stimulants) have a boosted dopamine level, which is higher than normal controls. Considering that dopamine levels are related to ADHD symptoms, medication use, and creativity, it is possible that medicated children with ADHD may perform differently than non-medicated children with ADHD. Children with ADHD not on medication have significantly lower EBR than normal control during cognitive functioning tasks (Caplan, Guthrie & Komo, 1996). This corresponds to the negative correlation between EBR and convergent thinking (Chermahini & Hommel, 2010) in adult controls. Despite the mentioned effects of stimulants, the children still have working memory deficits and lack of sustained attention compared to their normal control group due to earlier dopamine depletion before being medicated. Therefore, children with ADHD are not able to perform appropriately in goal-directed tasks and are more likely to score lower in convergent thinking tasks.

**Discussions**

Based on our literature review, our major hypothesis is that creative thinking of individuals with ADHD may depend on task type. More specifically, children with ADHD may perform better in divergent thinking tasks but worse in convergent thinking tasks. This can be partially validated by most of the theoretical models regarding working memory, genetic prevalence, and dopamine levels. However, a small part of the current research findings contradict our major hypothesis, such as, the U-shape relationship presented by Chermahini and Hommel (2010). Although their findings display that ADHD symptoms are associated with lower creative performance in convergent thinking tasks, it is questionable whether EBR, normally measured non-ADHD adults, is applicable in children with ADHD. In order to test the main hypothesis in a more direct and valid way, we need to do random assignment with a control group and an experimental group to examine the relationship between EBR and creative performance in convergent thinking tasks and divergent thinking tasks. Besides the disagreement in the field, there are few empirical and review articles on ADHD and EBR. It is questionable whether people with ADHD show the same EBR pattern presented in the college-student sample in Iran (Chermahini and Hommel, 2010; 2012) and whether the same structures follow through from childhood to adulthood. Also, ADHD is categorized into three subtypes: Impulsive, Inattentive, and Combined, and It is not clear whether the three subtypes share the same pattern in terms of creativity. This is an important focus in this line of research, since the large variance of ADHD symptoms and characteristics across different subgroups might lead to differences in creativity in divergent and convergent thinking tasks.

Exploring underlying mechanisms of interaction between ADHD and creativity is particularly important for the following two reasons. First, more consistent and valid research evidence on the correlation between ADHD and creativity can help reduce the stigma against ADHD. Second, the underlying mechanisms of the existing association can provide valuable educational systems on managing ADHD students. The gene-environment interaction model presents that children with an ADHD predisposition can have social and academic impairments in both home and school environments. In other words, externalizing behaviors of ADHD children might be associated with increasingly negative parent-child interactions, thus exacerbating the child’s symptoms (Hinojosa et al., 2012; McCabe et al., 2003; Miller, Nigg & Miller, 2009). Reducing stigma can help break this cycle. A clearer and more accurate understanding of the genes in a multiracial/multiethnic environment will also reduce stigma and prejudice in increasingly diverse classroom settings.

Second, a more convergent research line on the relationship between ADHD and creativity can help improve diagnostic efficiency and treatment outcomes. Misdiagnosing creative behaviors as ADHD symptoms can have persistent influences on children across their lifespan (Cramond, 1994; Golsh, 2000). Stimulants combined with behavioral therapy have been the most efficient and popular treatment for children diagnosed with ADHD (Faraone et al., Short, 2002). Misdiagnosing and prescribing stimulants to those who do not have ADHD might have persistent negative impacts on a child’s life overall. On the other hand, children’s ADHD symptomatology might be hidden by their creativity and therefore they do not receive diagnosis and treatment (Fugate et al, 2013; Leroux and levitt Perman, 2000). This situation of false negatives might lead to severe impairments in both home and school environments for individuals with a misdiagnosis (Fugate et al., 2013).

Most researchers investigating the correlation between EBR and creative performance in convergent thinking tasks and divergent tasks, conducted the experiment in university laboratories with college students rather than clinical setting with children with attention problems. It would be incorrect to assume that there is the same linear relationship among all aging groups, considering no scientific research has shown a similar pattern within children and adolescent samples. Due to this uncertainty about EBR and dopamine activities in children with ADHD, it is possible that EBR prediction of creation show different patterns compared to normative college students. The conflicting research findings presented in current studies question the underlying mechanisms of the relationship between ADHD and creativity. Further investigations with more sophisticated research designs and large sample sizes are needed. Exploration in this line of research will provide valuable implementations on classroom management and education policy for children with ADHD and creative children.

**Acknowledgements**

This review would not have been possible without the guidance and support of Dr. Charlan Nemeth and Dr. Stephen Hinshaw. I would also like to thank my diligent and supportive editors, Anna Nguyen, Jack Serna, and Olivia Cavagnaro. I would also like to thank everyone in the seminar of Psychology of Creativity at UC Berkeley, for making great suggestions and comments.

References

Auerbach, J. G., Benjamin, J., Faroy, M., Geller, V., & Ebstein, R. (2001). DRD4 related to infant attention and information processing: A developmental link to ADHD? *Psychiatric Genetics, 11*(1), 31-35. doi: 10.1097/00041444-200103000-00006

Abraham, A., Windmann, S., Siefen, R., Daum, I., & Güntürkün, O. (2006). Creative thinking in adolescents with attention deficit hyperactivity disorder (ADHD). *Child Neuropsychology, 12*(2), 111-123. doi: [10.1080/09297040500320691](http://dx.doi.org/10.1080/09297040500320691)

Albrecht, B., Brandeis, D., von Sandersleben, H. U., Valko, L., Heinrich, H., Xu, X., . . . Banaschewski, T. (2014). Genetics of preparation and response control in ADHD: The role of DRD4 and DAT1. *Journal of Child Psychology and Psychiatry, 55*(8), 914-923. doi: 10.1111/jcpp.12212

Chermahini, S. A., & Hommel, B. (2012). More creative through positive mood? not everyone! *Frontiers in Human Neuroscience, 6* Retrieved from<http://search.proquest.com/docview/1272268335?accountid=14496>

Colzato, L. S., van Wouwe, N. C., & Hommel, B. (2007). Spontaneous eyeblink rate predicts the strength of visuomotor binding. *Neuropsychologia, 45*(10), 2387-2392. doi: 10.1016/j.neuropsychologia.2007.03.004

Caplan, R., Guthrie, D., & Komo, S. (1996). Blink rate in children with attention-deficit–hyperactivity disorder. *Biological Psychiatry, 39*(12), 1032-1038. Retrieved from<http://search.proquest.com/docview/618856236?accountid=14496>

Chermahini, S. A., & Hommel, B. (2010). The (b)link between creativity and dopamine: Spontaneous eye blink rates predict and dissociate divergent and convergent thinking. *Cognition, 115*(3), 458-465. doi: 10.1016/j.cognition.2010.03.007

De Dreu, Carsten K. W., Nijstad, B. A., Baas, M., Wolsink, I., & Roskes, M. (2012). Working memory benefits creative insight, musical improvisation, and original ideation through maintained task-focused attention. *Personality and Social Psychology Bulletin, 38*(5), 656-669. doi: 10.1177/0146167211435795

Dietrich, A. (2004). The cognitive neuroscience of creativity. *Psychonomic Bulletin and Review. 11*, 1011–1026. doi: 10.3758/BF03196731

Dietrich, A., and Kanso, R. (2010). A review of EEG, ERP, and neuroimaging studies of creativity and insight. *Psychonomic* *Bulletin and Review. 136,* 822–848. doi: 10.1037/a0019749

DiMaio, S., Grizenko, N., and Joober, R. (2003). Dopamine genes and attention-deficit hyperactivity disorder: a review. *Journal of Psychiatry and Neuroscience.* 28, 27–38.

Ding, Y. C., Chi, H. C., Grady, D. L., Morishima, A., Kidd, J. R., Kidd, K. K., . . . [Moyzis](http://www.pnas.org/search?author1=Robert+K.+Moyzis&sortspec=date&submit=Submit), R. K. (2002). Evidence of positive selection acting at the human dopamine receptor D4 gene locus. *Proceedings of the National Academy of Sciences of the United States of America,* 99, 309–314. doi: 10.1073/pnas.012464099

Ellis, K. A., Mehta, M. A., Wesnes, K. A., Armstrong, S., & Nathan, P. J. (2005). Combined D1/D2 receptor stimulation under conditions of dopamine depletion impairs spatial working memory performance in humans. *Psychopharmacology, 181*(4), 771-780. doi: 10.10071/s00213-005-0019-2

Faraone, S. V., Short, E. J., Biederman, J., Findling R. L., Roe, C., & Manos, M. J. (2002)  Efficacy of Adderall and methylphenidate in attention deficit hyperactivity disorder: a drug–placebo and drug–drug response curve analysis of a naturalistic study. *International Journal of Neuropsychopharmacology, 5,* 121–129.

Faraone, S. V., & Biederman, J. (2005). What is the prevalence of adult ADHD? results of a population screen of 966 adults. *Journal of Attention Disorders, 9*(2), 384-391. doi: 10.1177/1087054705281478

Hinojosa, M. S., Hinojosa, R., Fernandez-Baca, D., Knapp, C., Thompson, L. A., & Christou, A. (2012). Racial and ethnic variation in ADHD, comorbid illnesses, and parental strain. *Journal of Health Care for the Poor and Underserved, 23*(1), 273-289.

Healey, D., & Rucklidge, J. J. (2006). An investigation into the relationship among ADHD symptomatology, creativity, and neuropsychological functioning in children. *Child Neuropsychology, 12*(6), 421-438. doi: 10.1080/09297040600806086

Healey, D. M., & Rucklidge, J. J. (2008) *The Relationship Between ADHD and Creativity.* The ADHD Report 16(3): 1-4. doi: [10.1521/adhd.2008.16.3.1](http://dx.doi.org/10.1521/adhd.2008.16.3.1).

Hamarman, S., Fossella, J., Ulger, C., Brimacombe, M., & Dermody, J. (2004). Dopamine receptor 4 (DRD4) 7-repeat allele predicts methylphenidate dose response in children with attention deficit hyperactivity disorder: A pharmacogenetic study. *Journal of Child and Adolescent Psychopharmacology, 14*(4), 564-574. doi: 10.1089/cap.2004.14.564

Konrad, K., Gauggel, S., & Schurek, J. (2003). Catecholamine functioning in children with traumatic brain injuries and children with attention-deficit/hyperactivity disorder. *Cognitive Brain* Research*, 16*: 425–433.

Miller, T. W., Nigg J. T., & Miller, R. L. (2009) Attention deficit hyperactivity disorder in African American children: what can be concluded from the past ten years? *Clinical Psychology Review, 29*(1): 77–86.

McCabe, K. M., Yeh, M., Lau, A., Garland, A., & Hough, R. (2003). Racial/Ethnic differences in caregiver strain and perceived social support among parents of youth with emotional and behavioral problems. *Mental Health Services Research, 5*(3), 137-147. doi:http://dx.doi.org/10.1023/A:1024439317884

Mayseless, N., Uzefovsky, F., Shalev, I., Ebstein, R. P., & Shamay-Tsoory, S. (2013). The association between creativity and 7R polymorphism in the dopamine receptor D4 gene (DRD4). *Frontiers in Human Neuroscience, 7* doi: 10.3389/fnhum.2013.00502

Nemeth, C. J., & Wachtler, J. (1983). Creative problem solving as a result of majority vs minority influence. *European Journal of Social Psychology, 13*(1), 45-55. doi: [10.1002/ejsp.2420130103](http://dx.doi.org/10.1002/ejsp.2420130103)

Shukla, D. (1985). Blink rate as clinical indicator. *Neurology*, 35, 286.

Shaw, G. A. (1992).Hyperactivity and creativity: The tacit dimension. *Bulletin of the Psychonomic Society, 30*(2), 157-160. Retrieved from http://search.proquest.com/docview/618132428?accountid=14496

Swartwood, M. O., Swartwood, J. N., & Farrell, J. (2003). Stimulant Treatment of ADHD: Effects on Creativity and Flexibility in Problem Solving. *Creativity Research Journal*, *15*(4), 417-419.

Sternberg, R.J. (2005). *Handbook of Creativity*. New York: Cambridge University Press

Stelzel, C., Basten, U., Montag, C., Reuter, M., & Fiebach, C. J. (2009). Effects of dopamine-related gene–gene interactions on working memory component processes. *European Journal of Neuroscience, 29*(5), 1056-1063. doi: 10.1111/j.1460-9568.2009.06647.x

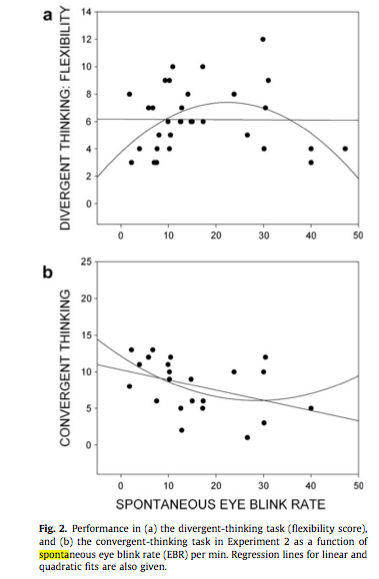
Takeuchi, H., Taki, Y., Hashizume, H., Sassa, Y., Nagase, T., Nouchi, R., & Kawashima, R. (2011). Failing to deactivate: The association between brain activity during a working memory task and creativity. *NeuroImage, 55*(2), 681-687. doi: [10.1016/j.neuroimage.2010.11.052](http://dx.doi.org/10.1016/j.neuroimage.2010.11.052)

White, H.A., and Shah, P. (2011). [Creative style and achievement in adults with attention-deficit/hyperactivity disorder](http://www.sciencedirect.com/science/article/pii/S019188691000601X). [*Personality*](http://www.psychologytoday.com/basics/personality) *and Individual Differences 5*(50): 673-677.

White, H.A., and Shaw, P. (2006). [Uninhibited imaginations: Creativity in adults with attention-deficit/hyperactivity disorder](http://www.sciencedirect.com/science/article/pii/S0191886905003764). *Personality and Individual Differences 40*(6): 1121-1131.

Verdejo-García, A., Bechara, A., Recknor, E. C., & Pérez-García, M. (2006). Executive dysfunction in substance dependent individuals during drug use and abstinence: An examination of the behavioral, cognitive and emotional correlates of addiction. *Journal of the International Neuropsychological Society, 12*(3), 405-415. doi: 10.1017/S1355617706060486

Appendix



This graph displays the U-shaping relationship between creativity and spontaneous eye blink rate (Chermanhini and Hommel, 2012).