The Development of Personality and Motivation through the DRD4 Gene and Social Support

Christina Hollifield

University of California, Davis: PSC 217

The purpose of this paper is to investigate the contributions of the DRD4 gene on personality and motivational development, and how social support may moderate this association.

Personality and Motivation

Several theories frame personality and motivational characteristics as manifesting through active behaviors toward psychological well-being. Ryan and Deci's (2000) Self-determination theory posits that individuals actively maintain a sense of competence, autonomy, and belonging. These appraisals are engendered as intrinsically motivated behaviors to pursue goals that are relevant to personal interests, which in turn have been linked to psychological well-being (Ryan & Deci, 2000). Another group of researchers, Blackwell, Trzesniewski, and Dweck (2007), implemented an intervention in teaching 7th grade students about incremental theory of intelligence, which is the belief that ability and intelligence is not fixed, but is apt to change depending on an individual's efficacy and motivation. Children that received this training workshop showed a positive improvement in motivation compared to the students in the control condition. The authors discussed that these self-perceptions and increases in motivation were related improvements in achievement almost one year later (Blackwell et al., 2007). This study reflects the importance of self-perception and motivation on academic outcomes. Both theories emphasize the salience of personality and motivation in psychological health and future outcomes.

Behavior initiated via personality and motivation is important to empirically examine in order to understand psychological well-being. For example, Werner (1995) reviewed conclusions about such characteristics drawn from her Kauai Study, an investigation of

resilience with a sample of 698 children assessed from 1-year-old to 32 years of age. She found that out of the individuals that grew up in adverse conditions (i.e., in poverty or other negative family circumstances), 1/3 were resilient and became confident caring adults. These resilient individuals reported high levels of perceived competence, self-esteem, autonomy, and emotional stability throughout the childhood, adolescent, and adult questionnaire assessments (Werner, 1995). Individuals with these characteristics appear to be motivated leave stressful environments in pursuit of supportive environments. On the other end of the spectrum, Bridge, Goldstein, and Brent (2006) examined precursors toward adolescent suicide attempts. They discuss that personality disorders and certain personality traits, such as impulsivity and neuroticism, are highly correlated with suicide attempts during adolescence. Given these articles, and many others in the field of developmental psychology and human development, it appears that personality and motivational characteristics play a role in psychological health.

The DRD4 Gene

The human dopamine receptor D4 (DRD4) gene is a popularly explored genetic segment due to its multiple-allele polymorphism. Located on the short arm of chromosome 11, this gene is expressed in the dorsolateral prefrontal and entorhinal cortices, hippocampus, hypothalamus, globus pallidus, substantia nigra, and the dorsal-medial thalamus (Savitz & Ramesar, 2004). Thus, this dopamine receptor is widely distributed in the limbic and prefrontal regions. This gene consists of a 48 base pair variable number of repeats (VNTR) polymorphism in Exon 3, which varies between two and 11 repeats and differs in sequence and the order of the 48 base pair (Savitz & Ramesar, 2004; Lichter et al., 1993). Further, Savitz and Ramesar (2004) indicate that because this polymorphism exists in a region that couples to G proteins and

mediates intracellular signaling, the DRD4 receptor variants may differ in function. As such, understanding how these varying alleles influence functioning and human behaviors remains a critical goal in research.

Lichter et al. (1993) explored how the 48 base pair repeat in the coding region differs between individuals, and through their global analysis of individuals, found that 2, 4, and 7 tandem repeat alleles were the most prevalent in the their sampled populations. Another group of scientists explored the prevalence of the DRD4 repeat alleles. Chang, Kidd, Livak, Pakstis, and Kidd (1996) investigated the allele frequencies of the DRD4 gene VNTR polymorphism in 1,327 individuals from 36 different populations across many countries. Across all the populations, Chang et al. (1996) found the 4-repeat allele as the most prevalent (64.3%), the 7-repeat allele the second most common (20.6%), the 2-repeat allele the third most predominant (8.2%), and the remaining alleles uncommon (<1%). The allele frequencies across different continents suggest that the 4-repeat allele is widely distributed, the 7-repeat allele is most common in the Americas, and the 2-repeat allele is most prevalent in Asian samples. Given the results of these two studies, these authors suggest that these variant alleles contain different pharmacological properties, which makes the identification and frequencies of these alleles important for health applications (Chang et al., 1996; Lichter et al., 1993).

What understanding can researchers acquire by differentiating these various allele repeats? Shoots and Val Tol (2003) performed electrophoretic mobility shift assays and used a D4 repeat-luciferase reporter vector in order to investigate the role of the human DRD4 repeat sequence. They found that the repeated sequence acts as a substrate for a nuclear binding factor, indicating that each of these variant alleles differentially suppresses promoter activity.

The results revealed that the 7-repeat allele significantly suppressed the expression of the luciferase reporter in comparison to the 2 and 4 repeat alleles (Shoots & Van Tol, 2003). These authors suggest that these differences are likely due to RNA stability or translational efficiency mechanisms. In addition, these DRD4 allelic differences have implications for gene expression of dopamine receptors, dopaminergic functioning, and consequently behavioral disorders.

Utilizing another technique, Simpson, Vetuz, Wilson, Brookes, and Kent (2010) explored the functional role of the DRD4 gene polymorphism using post-mortem brain tissue samples in 28 humans. These authors quantified DRD4 mRNA expression levels in relation to the varying allele repeats. Although the results didn't yield any significant associations between genotype repeats and the mRNA expression, a weak trend was found between the 7-repeat allele and reduced DRD4 mRNA expression (Simpson et al., 2010). This study suggests that the 7-repeat allele may exist as a risk factor for individuals; given the weak trend of the analysis, this may emphasize the significance of environmental interactions with this specific DRD4 genotype.

So what is the significance of studying this specific polymorphism? The DRD4 gene is associated with the expression of the D4 receptor in the dopaminergic system of the prefrontal cortex, which contributes to reinforcing actions that usually lead to rewards (Frank & Fossella, 2011). Through these motor and cognitive actions, such as behavioral adjustments and decision conflicts, dopaminergic agents potentiate effortful motivated behavior (Frank & Fossella, 2011). And as the previously literature reflected, the 7-repeat allele appears to reduce the expression of the D4 receptor, consequently altering its regulation in the dopaminergic system and resulting motivated behaviors. The differential effects of the DRD4 polymorphism in the

dopaminergic system lead researchers to explore its association with personality and motivation.

DRD4 Associations with Personality and Motivation

A meta-analysis of 309 papers inspected the association of the DRD4 gene VNTR polymorphism and extroversion as measured by various personality questionnaires (Munafo, Yalcin, Willis-Owen, & Flint, 2008). They limited their analysis to samples of adults from non-psychiatric populations. The results yielded heterogeneous findings between samples, rendering the association between the VNTR polymorphism and approach-related traits insignificant (Munafo et al, 2008). In fact, this heterogeneity between studies was significant when assessing the association between the DRD4 polymorphism and novelty seeking or impulsivity. Further, twin studies suggest that major dimensions of personality are 50% heritable, yet the variance of environmental and genetic contributions toward personality are still unknown; this likely explains why behavioral genetics research in this area is so inconsistent (Savitz & Ramersar, 2004). Because such a disparity exists in the literature between the DRD4 gene VNTR polymorphism and personality traits, it is critical to further investigate these associations in diverse community samples across different countries.

The dopaminergic system has been suggested to correlate with personality variables (Savitz & Ramersar, 2004). One such example is a study researching the association between the DRD4 polymorphism and persistence, as well as other personality scales. Szekely et al. (2004) recruited a sample of 157 Caucasian Hungarian students using non-invasive DNA sampling. They reported similar DRD4 allele frequencies as Chang et al.'s (1996) global study of allele frequencies, increasing the confidence of their sample and genotypic analysis. Szekely et

al. (2004) found that males with a 7-repeat polymorphism scored lower on persistence scales; however, there was no association with novelty seeking and the DRD4 polymorphism for males or females. The authors concluded that the DRD4 7-repeat allele may be a risk factor for males toward attention deficit and hyperactivity disorder. The results possibly indicate that there is an association between the 7-repeat allele and less motivated behavior, as these lower persistence scores for males may have implications for the lack of motivation toward goals.

Frank and Fossella (2011) discuss the link of the DRD4 gene with motivation circuits in the brain. Reviewing studies that investigated the association between dopamine polymorphisms and learning, performance, and motivation, Frank and Fossella (2011) suggest that a genetic component exists in these varying alleles that explain individual differences in motivation. Specifically, increased probabilities of gaining rewards or dopamine release (due to the expression of dopamine receptors from the DRD4 polymorphism) are associated with motivated behavior (Frank & Fossella, 2011). Although review articles such as this argue persuasive links between dopamine receptor genes and motivation, there is little research that has investigated this association. Therefore, it is critical to empirically explore the association between the DRD4 polymorphism and motivation in humans.

The Role of Social Support

Many researchers discuss outcome behaviors in terms of environment and genetic interactions. For instance, Belsky and Pluess (2009) frame their theory of differential susceptibility as some individuals as being more sensitive to their social environment than others. This includes both vulnerability in adverse environments and flourishing in supportive environments. In a review of articles that empirically tested differential susceptibility through

the DRD4 polymorphism and social support, Belsky et al. (2009) discussed how parenting quality during infancy interacts with the 7-repeat allele in predicting sensation seeking during toddlerhood. This group also cites that externalizing behavior in toddlers was predicted by an interaction between parental sensitivity and the 7-repeat allele. These results indicate that during low parental sensitivity or quality the 7-repeat variant acts as a risk allele; however, during high parental sensitivity or quality the 7-repeat allele actually enhances an individual's outcomes compared to individuals without this polymorphism (Belsky et al., 2009). Further, these authors noted that parental interventions improved children's behavior, but only for those with the 7-repeat allele, exemplifying genotypically susceptible children. It appears that the 7-repeat allele interacts with social support in the environment to predict personality and behavioral outcomes.

Sheese, Voelker, Rothbart, and Posner (2007) investigated the interaction between parenting quality, the DRD4 polymorphism, and temperament. Children between 18 and 21 months were recruited along with their mother for the study. In addition to genotyping for the DRD4 polymorphism, a 10 minute interaction between the child and parent was video-recorded in order to code parental quality. The results indicated that the presence of the 7-repeat allele influenced the child's sensitivity to parenting quality while children without this variant were not influenced by parental quality in relation to temperament scores (Sheese et al., 2007). The 7-repeat allele and low parental quality predicted higher levels of sensation-seeking, activity, high-intensity pleasure, and impulsivity compared to high parental quality. This gene by environment interaction reflects how the DRD4 polymorphism interacts with social support in predicting characteristics that are in line with personality and motivation.

Self-determination theory suggests that the variance in intrinsic motivation is dependent on an individual's perception and reactions to their social environment (Ryan & Deci, 2000). Situating the differential susceptibility of the DRD4 polymorphism as it interacts with social support in this framework appears appropriate. Perhaps it is within an individual's appraisal of their social support that the expression and functionality of the D4 receptors in several regions of the brains are ignited to influence personality and motivation.

Research Gaps and Solutions

There is a growing trend in research to examine gene by environment interactions in terms of maternal sensitivity and DRD4 polymorphisms in predicting personality. However, little few researchers have investigated other forms of social support, such as siblings. Indeed, siblings may serve as a critical emotional resource throughout the lifespan as they scaffold many social and learning experiences (Kramer & Conger, 2009). In addition, behaviors such as intrinsically motivated actions should be evaluated, or perceptions of autonomy, competence, and belonging, in order to fill the research gap in understanding motivation.

Using the Family Transitions Project, a longitudinal on-going dataset of over 500 Iowan families, these research gaps can be addressed. This study includes scales of parental support and personality, as well as DNA samples including the DRD4 gene VNTR polymorphism. Not only could previous studies be replicated due to inconsistent conclusions from previous literature, but a plethora of sibling relationship quality and motivational measures exist in both questionnaire and behavioral interaction form. It is proposed to utilize this rich data to facilitate these research questions.

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