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Individual differences in the processing of smoking-cessation video messages: An imaging genetics study

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ABSTRACT

Studies testing the benefits of enriching smoking-cessation video ads with attention-grabbing sensory features have yielded variable results. Dopamine transporter gene (DAT1) has been implicated in attention deficits. We hypothesized that DAT1 polymorphism is partially responsible for this variability. Using functional magnetic resonance imaging, we examined brain responses to videos high or low in attention-grabbing features, indexed by "message sensation value" (MSV), in 53 smokers genotyped for DAT1. Compared to other smokers, 10/10 homozygotes showed greater neural response to High- vs. Low-MSV smoking-cessation videos in two a priori regions of interest: the right temporoparietal junction and the right ventrolateral prefrontal cortex. These regions are known to underlie stimulus-driven attentional processing. Exploratory analysis showed that the right temporoparietal response positively predicted follow-up smoking behavior indexed by urine cotinine. Our findings suggest that responses to attention-grabbing features in smoking-cessation messages is affected by the DAT1 genotype.

1. Introduction

Public health messages delivered in video format are the mainstay of smoking-cessation campaigns that have contributed to the decline in smoking prevalence in the US (Woloshin, Schwartz, & Welch, 2008). Yet, despite these efforts, smoking remains a leading cause of mortality and morbidity worldwide, and is responsible for more than 480,000 deaths annually in the United States alone (U.S. Department of Health and Human Services, 2014). Therefore, it is imperative to identify the factors that influence audiences' cognitive processing of smoking-cessation videos (Centers for Disease Control and Prevention, 2012).

Sensory features, which attract viewer's attention through engaging visuals, edits, and music, have been hypothesized to be one such factor (D'Silva and Palmgreen, 2007; Helme, Donohew, Baier, & Zittleman, 2007; Morgan, Palmgreen, Stephenson, Hoyle, & Lorch, 2003). Message sensation value (MSV) is a validated measure that has been developed to quantify such sensory features in health promotion videos (Morgan et al., 2003). The prevailing assumption that higher MSV improves cognitive processing and effectiveness of health promotion videos has been challenged by recent neuroimaging studies, which found that videos with lower MSV were better remembered and elicited greater prefrontal and temporal response (Langleben et al., 2009; Seelig et al., 2014). These findings are consistent with predictions of the limited cognitive capacity theories. These theories suggest that although high MSV attracts viewers' attention, it also diverts cognitive resources from processing the health information content in the videos (Petty and Cacioppo, 1986; Wilson and Wolf, 2009).

While these studies question the value of utilizing high MSV as an effective communication tool, they do not address the possibility that individual differences in attention to sensory stimulation may be responsible for the lack of effectiveness of high-MSV videos at a population level (Everett and Palmgreen, 1995; Stephenson and Palmgreen, 2001). Such differences would have been of purely academic interest in the era of network television, but as media becomes more personalized, individual differences in the neurocognitive processing of health promotion videos begin to acquire real life relevance (Chua et al., 2011). Yet, experimental data on the biological basis of individual differences in the cognitive processing of health messages are very limited. Many key traits that may affect individual ability to process health messages, such as selective attention, working memory and reward sensitivity, are influenced by dopaminergic neurotransmission (Gordon, Devaney, Bean, & , Vaidya, 2015). The dopamine transporter gene (DAT1) has a variable number tandem repeat (VNTR) polymorphism that modulates dopaminergic neurotransmission, with the 10-repeat (10R) and 9-repeat (9R) alleles as the most common forms (Mitchell et al., 2000). The

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10R/10R homozygosity has been linked to a higher level of novelty seeking, a trait that indicates greater reactivity to novel external stimulation (Sabol et al., 1999). The 10R allele has also been consistently implicated in increased susceptibility to attention deficit disorder (ADD) (Cook et al., 1995; Gill, Daly, Heron, Hawi, & Fitzgerald, 1997; Gizer, Ficks, & Waldman, 2009; Kebir, Tabbane, Sengupta, & Joober, 2009; Newman et al., 2014). Although it remains unclear whether this association is mediated by the dopamine or dopamine transporter levels (Yang et al., 2007), it suggests that homozygous 10R allele carriers are more likely than others to exhibit poor attentional processing, e.g. difficulty filtering out irrelevant sensory stimuli, which is a key symptom of ADD (American Psychiatric Association, 2000). Therefore, it is possible that when exposed to public health video messages with high MSV, 10R DAT1 homozygotes would be more engaged by the attention-grabbing sensory features compared to carriers of other genotypes.

The present study sought to examine the effect of DAT1 polymorphism on the brain response to high MSV format. The value of such candidate gene approach is limited by the a priori assumptions about the relationship between the gene and the phenotype (Tabor, Risch, & Myers, 2002). However, it remains useful as the practical approach to generate initial data on the effects of individual genetic makeup on the neurocognitive processing of public health communication in a small sample (Simon et al., 2011). Such studies would help to demonstrate the relevance of genetics to the processing of public health video ads and to determine the feasibility of the larger and much more expensive genome-wide association studies. Building on the link between the 10R DAT1 allele and attentional processing deficits described above, we hypothesized that smokers with two copies of the 10R allele (10/10) would differ from smokers without the 10R homozygosity (non-10/10) in the neural response to high-MSV smoking-cessation videos. Specifically, we hypothesized that the 10/10 smokers would show greater neural response to high-MSV vs. low-MSV videos than the non-10/10 smokers in two brain regions: the right temporoparietal junction (rTPJ) and the right ventrolateral prefrontal cortex (rVLPFC). These regions form the strongly right lateralized "ventral attention network" that underlies bottom-up, stimulus-driven attentional processing (Corbetta and Shulman, 2002; Fox, Corbetta, Snyder, Vincent, & Raichle, 2006; Petersen and Posner, 2012; Vossel, Geng, & Fink, 2014), and are thus likely to be modulated by the greater attention-grabbing sensory content in high-MSV videos. The secondary aim of the present study was to explore the contribution of the differences between 10/10 and non-10/10 smokers' ventral attention network response during one-time exposure to smoking-cessation videos to individual variation in future smoking behavior. Smoking was indexed by subjective (self-report) (Gorber, Schofield-Hurwitz, Hardt, Levasseur, & Tremblay, 2009; Perezstable, Marin, Marin, Brody, & Benowitz, 1990) and objective (urine levels of the nicotine metabolite cotinine) measures of smoking (Pokorski, Chen, & Bertholf, 1994; Wall, Johnson, Jacob, & Benowitz, 1988), immediately before and approximately one month after the one-time exposure to 16 smoking-cessation videos.

2. Materials and methods

2.1. Participants

Seventy-four non-treatment-seeking adult daily smokers participated in the study. Eight participants were excluded due to excessive (>1 voxel) head motion during the MRI scan and 15 participants declined to be genotyped, leaving 53 participants (23 female; 3 left-handed) who passed MRI quality control and were genotyped. Participants reported their racial-ethnic characteristics as follows: 28 White, 19 African American, 4 Asian, and 2 Hispanic. Their ages ranged between 18 and 49 years (M ± SE = 31.34 ± 1.33), with 14.16 ± 0.26 years of education. All participants gave written informed consent to participate in the protocol approved by the University of Pennsylvania Institutional Review Board. Exclusion criteria were (1) presence of any DSM-IV-TR Axis 1 psychiatric disorder except tobacco use disorder (American Psychiatric Association, 2000); (2) urine drug screen positive for illicit opioids, benzodiazepines, cannabinoids, cocaine, or methamphetamine; (3) baseline urinary cotinine levels <50 ng/ml (SRNT Subcommittee on Biochemical Verification, 2002); (4) presence of medical or neurological disorder or treatment that may affect the cerebrovascular system; and (5) safety-related contraindications for MRI scanning.

2.2. Task

The video-viewing task is described in the Supplementary materials and in Wang et al. (2013). Each participant viewed eight smoking-cessation videos with Low MSV and eight with High MSV in a random order, separated by a 16 s rest period (gray cross-hair on a homogenous black background). A 16 s rest period was also presented at the beginning of the task. Each video was 30 s long and presented only once.

2.3. Genotyping

Genomic DNA was extracted from anti-coagulated venous blood samples using a standard salting out method (Lahiri and Nurnberger, 1991). Genotyping of the DAT1 40 bp repeat polymorphism (rs28363170) was performed as previously described (Franklin et al., 2009; Vandenbergh et al., 1992) (see Supplementary material). Participants were divided into two cohorts by the DAT1 genotype: 26 homozygous (two copies) for the 10-repeat allele, and 27 with one or no 10R alleles (21 with 10R/9R, 2 with 9R/8R, and 1 each with 10R/8R, 9R/9R, and 3R/3R).

2.4. Procedure

The study included a phone screening, baseline assessment, fMRI session, and a follow-up session 1 month later. Participants were asked to avoid nicotine-replacement products throughout the study and to report any use of such products. At the baseline session, participants were evaluated for eligibility, demographics, and handedness (Oldfield, 1971). One hour before the fMRI session, participants provided urine samples for baseline cotinine levels, reported the average number of cigarettes smoked per day in the past 30 days, and completed the Fagerstrom Test of Nicotine Dependence (FTND) (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991) and other behavioral assessments (see Supplementary material). Approximately 30–45 min before the fMRI session, participants were given an opportunity to smoke one of their own cigarettes outdoors under observation. This minimized individual differences in craving for cigarettes during fMRI session, and avoided this potential confound to the brain response to smoking-cessation videos. All participants took the opportunity to smoke. Before the video task began, participants were instructed to attend to the videos. At the follow-up session approximately 30 days later (M ± SE = 32.08 ± 2.10 d), urine samples for cotinine level were again obtained. Participants were debriefed about the cotinine assay and the study hypotheses only after completion of all assessments.

2.5. MRI data acquisition

MRI imaging was performed using Siemens Tim Trio 3T (Erlangen) system and a 32-channel receive-only head coil. Blood oxygenation level-dependent (BOLD) fMRI was performed, using a whole-brain, single-shot gradient-echo echo-planar sequence with the following parameters: TR/TE = 2000/30 ms, FOV = 220 mm, matrix = 64 × 64, slice thickness/gap = 3.4/0 mm, 32 slices, effective voxel resolution of 3.4 × 3.4 × 3.4 mm. After BOLD fMRI, 5-min MPRAGE T1-weighted images were acquired with the following