Cigarette smoking duration mediates the association between future thinking and norepinephrine level

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HIGHLIGHTS

- Future thinking is associated with smoking cigarettes for longer durations.
- Smoking cigarettes for longer durations is associated with higher norepinephrine.
- Smoking duration significantly mediated the future thinking- norepinephrine link.

ARTICLE INFO

ABSTRACT

Fixating on the present moment rather than considering future consequences of behavior is considered to be a hallmark of drug addiction. As an example, cigarette smokers devalue delayed consequences to a greater extent than nonsmokers, and former smokers devalue delayed consequences more than nonsmokers, but less than current smokers. Further, cigarette smokers have higher norepinephrine levels than nonsmokers, which is indicative of poor future health outcomes. It is unclear how duration of cigarette smoking may impact these associations. The current secondary analysis of publicly available data investigated whether extent of future thinking is associated with smoking duration, as well as norepinephrine level, in a large national US sample ($N = 985$) of current, former, and never smokers. Individuals scoring lower on future thinking tended to smoke for longer durations and had higher norepinephrine levels relative to individuals scoring higher on future thinking. In addition, duration of cigarette abstinence interacted significantly with future thinking and smoking duration for former smokers. Specifically, the mediation relationship between future thinking, smoking duration, and norepinephrine level for former smokers was strongest at shorter durations of cigarette abstinence and decreased as a function of increasing duration of cigarette abstinence. Overall, results from this study suggest the potential importance of implementing smoking cessation treatments as early as possible for smokers and support future thinking as a potential therapeutic target for smoking cessation treatment.

1. Introduction

Duration of cigarette smoking plays a role in several health outcomes, in which longer durations are associated with worsening health (e.g., chronic obstructive pulmonary disease, lung cancer; U.S. Department of Health and Human Services, 2014). One potential underlying mechanism for smokers' increased risk for poor health is associated with elevated central and peripheral NE levels relative to nonsmokers (see reviews by Maas, 1984; Bruijnzeel, 2012). High urinary NE levels are indicative of amplified sympathetic nervous system activity (Reuben, Talvi, Rowe, & Seeman, 2000; Supiano, Hogikyan, Sidani, Galecki, & Krueger, 1999), and are related to the development of cardiovascular disease, obesity, inflammatory disorders, and other conditions often seen in cigarette smokers (see Bayles, Dawood, Lambert, Schlaich, & Lambert, 2008 and Puzserova & Bernatova, 2016 for reviews). High urinary NE levels also predict a greater incidence of premature mortality (Reuben et al., 2000). However, to our knowledge, no work exists that examines whether urinary NE levels increase gradually with increasing smoking duration or if levels increase following smoking initiation and then reach a plateau, with no further increases occurring during smoking maintenance.

In addition to effects of smoking duration on NE levels, only a few studies to date have examined the relation between smoking cessation and NE (West, Russell, Jarvis, Pizzey, & Kadam, 1984; Ward, Garvey, & Bliss, 1991; Zuspan & Davis, 1979). In one study (Zuspan & Davis, 1979), urinary NE levels were not only reduced significantly from pre-

to post-smoking cessation, but post-cessation NE levels were comparable to those for nonsmokers. Given that inclusion criteria for most studies specify a minimum number of years smoking to be classified as a current cigarette smoker (e.g., at least one year; West et al., 1984; Zuspan & Davis, 1979), smoking duration may vary widely between participants in a given sample. It therefore remains unclear whether NE levels will recover for individuals that smoke for 10 years in a similar manner to those that smoke for 20 years.

In addition to characterizing effects of smoking duration and cessation on NE dysregulation, recent attention has been directed towards understanding psychological factors that may be associated with behaviors such as smoking and physiological biomarkers of health such as NE (Powell, Pickering, Dawkins, West, & Powell, 2004; Schwartz & Portnoy, 2017), with the long-term goal of developing better treatments for cessation. One such factor is future thinking, because those who are fixated on the present moment and seek immediate rewards may engage in a variety of unhealthy behaviors, including smoking (e.g., Adams, 2012; Beenstock, Lindson-Hawley, Aveyard, & Adams, 2014; Bickel, Odum, & Madden, 1999). Indeed, relative to never cigarette smokers, current smokers tend to score lower across a variety of measures that arguably assess future thinking: Considerations of Future Consequences Scale (Adams, 2012; Beenstock et al., 2014), delay-discounting assessments (Bickel et al., 1999; Mitchell & Wilson, 2012; Reynolds, Richards, Horn, & Karraker, 2004), and the Barratt Impulsiveness Scale (Chang, Lim, Lau, & Alicata, 2017). Current smokers have also shown to devalue delayed rewards more heavily than former smokers (Bickel et al., 1999; Odum, Maddgen, & Bickel, 2002; Skinner, Aubin, & Berlin, 2004), suggesting that higher future thinking promotes successful cessation (Sheffer et al., 2014) and/or that future thinking increases following smoking cessation (Bickel et al., 1999; Odum et al., 2002; Skinner et al., 2004).

1.1. Current study

The current secondary data analysis tested whether future thinking predicted urinary NE levels in a large national U.S. sample of adults, aged 28–84. Based on prior research, we predicted that lower future thinking would be associated with longer smoking durations and in turn, higher levels of NE. We also hypothesized that the strength of the mediation for former smokers would decline with a longer duration of smoking abstinence.

2. Material and methods

2.1. Sample

The national survey of Midlife Development in the United States (MIDUS) is a publicly available, longitudinal survey aimed at understanding developmental differences in physical and mental health based on psychological, social, and behavioral factors. The first wave of MIDUS data collection (1995–1996; MIDUS 1) included 7108 non-institutionalized participants, aged 28 to 84 years, selected via random-digit telephone dialing. The second MIDUS wave (2004–2006; MIDUS 2) involved re-contacting 4963 participants from MIDUS 1 to participate in additional survey measures. Detailed information regarding attrition between waves is available elsewhere (Radler & Ryff, 2010). The current study drew from participants that completed the MIDUS 2 assessment ($n = 4963$), which included a 30-min telephone questionnaire followed by an ~2-h questionnaire that participants received via mail and sent back upon completion.

All MIDUS 2 respondents were eligible for further participation in biomarker assessments, given their willingness to stay overnight at a study-affiliated center: University of California Los Angeles, University of Wisconsin, or Georgetown University. Biomarker data were collected from 2004 and 2009 from $n = 1097$, with an average of 2.80 years ($SD = 1.33$) between MIDUS 2 completion and biomarker assessment.

Samples taken included blood, urine, and saliva for analysis of biomarkers reflecting functioning of the autonomic nervous system, immune system, and others (see Love, Seeman, Weinstein, & Ryff, 2010 for full description).

To be included in the current analysis, participants had to have completed the following measures at MIDUS 2: phone and self-administered questionnaires; demographic information; future thinking assessments (i.e., Live for Today (LFT) scale); and questions related to current and/or past cigarette smoking and other drug use. Respondents were also required to have provided medication use information and a 12-h urine sample for analysis of NE level during the biomarker subproject. Respondents missing any of these items, including the urine sample ($n = 38$), were removed from analyses. Comparing respondents with complete versus incomplete data at MIDUS 2, participants with complete data were significantly older ($t(4960) = 9.57$, $p < .001$), more likely to be white/Caucasian ($X^2 = 47.23$, $p < .001$), and male ($X^2 = 37.54, p < .001$). Attrition analyses also revealed that those who did not complete the biomarker subproject scored lower on future thinking (assessed via the LFT scale; $t(3968) = -6.64$, $p < .001$; CI = -0.21 to -0.12) and to have smoked longer ($t(4916) = -4.61$, $p < .001$; CI = -3.59 to -1.45) than those that completed the biomarker assessment. Of the 1097 participants who completed the biomarker subproject and the MIDUS 2 questionnaires, 985 were included in the final sample.

2.2. Measures

2.2.1. Covariates

All models were adjusted for potential confounds of age, sex, race, education, and medication use. Participants' were aged 28 to 84 years ($M = 55.43$, $SD = 12.45$), and were primarily female (53.5%) and Caucasian (90.2%). Educational attainment was scored on a scale from 1 (no school/some grade school) to 12 (graduate or professional degree) with mean level of education being some college/college graduate ($M = 7.20$, $SD = 2.52$). Dichotomous variables were created for sex, race (white/Caucasian coded 0, all other races coded 1, including black/African American, Native American/Alaskan, Native Aleutian Islander/Eskimo, Native Hawaiian/Pacific Islander), and medication use that can be linked to NE levels (blood pressure, cholesterol, depression, corticosteroids; Annane, Sebille, Charpentier, et al., 2002; Chistiakov, Ashwell, Orekhov, & Bobryshev, 2015; Chrousos, 2009; Vaughan, Murphy, & Buckley, 1996). All models were also adjusted for time lag between completion of the self-administered questionnaire at MIDUS 2 and completion of the biomarker assessment ($M = 25.32$ months, $SD = 14.22$, range 0 to 62).

2.2.2. Future thinking

Future thinking was evaluated using a scale contained in the MIDUS 2 self-administered questionnaire, "Live for Today" (LFT; Prenda & Lachman, 2001). LFT is a subscale of the Planning and Making Sense of the Past questionnaire in MIDUS 2. LFT items assess the extent to which participants think about the future, and the scale includes four items (i.e., "I live one day at a time"; "I have too many things to think about today to think about tomorrow"; "I believe there is no sense planning too far ahead because so many things can change"; "There is no use in thinking about the past because there is nothing you can do about it"). Each item was presented on a 4-point Likert scale ranging from 1 (strongly agree) to 4 (strongly disagree). The LFT scale was created by reverse-coding and computing the average of the four items. Higher scores reflect lower future thinking (Cronbach's alpha = 0.65, $M = 2.28$, $SD = 0.68$). Validation of the LFT scale is indicated by significant correlations with alternative measures of future thinking (e.g., Consideration of Future Consequences Scale; r range = 0.31 to 0.33, p's < 0.01; Basile & Toplak, 2015; Strathman, Gleicher, Boninger, & Edwards, 1994).