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MARIJUANA USE AND SUBSEQUENT ILLICIT DRUG USE: REVISIT THE GATEWAY THEORY

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Adolescent marijuana use is a major public health concern. Early use of marijuana is linked to many adverse health outcomes in early adulthood such as poor social and behavioral adjustment and mental health issues (Bagot, Milin, Kaminer 2015; Scholes Balog et al 2016; Castellanos-Ryan et al 2017) and may increase the risk of substance abuse in later life. According to the gateway theory proposed by Denise Kandel and Richard Faust (1975), early onset of lighter licit substances such as alcohol and cigarettes is typically followed by lighter illicit substance, such as marijuana, and in turn increases the likelihood of using harder illicit substances (e.g., meth, heroin, and crack/cocaine). However, evidence on whether marijuana use leads to further substance use is mixed and few US-based studies have investigated the long-term effects of adolescent marijuana use on further progression to more destructive illicit substances. Moreover, moderating factors of this sequence have not been adequately examined. For example, exposure to marijuana at younger age may pose a greater risk of using harder illicit substances due to early initiation (Woodcock et al 2015). Other demographic factors such as gender and race-ethnicity may also moderate this sequence given the varied prevalence rates of and norms toward substance use across different demographic groups. More research is clearly needed to test these hypotheses.

Kandel and Faust's (1975) seminal study, which originally proposed the gateway theory, used two longitudinal surveys of a random sample of high school students in New York. They found that 55% of weekly and heavy marijuana users progressed to harder substances compared to 27% of those who were just monthly marijuana users. Based on these findings, Kandel and Faust contend that progression to illicit substances rarely occurs without prior experience with marijuana, suggesting that the use of marijuana is a likely "gateway" to more destructive illicit substances, that is, a sequence exists progressing from frequent/heavy marijuana use to harder substances (Kandel 2002). Biological and social mechanisms underlying this sequence have also been suggested and tested. Animal studies on addiction have produced strong evidence of the gateway progression (Cadoni et al 2001; Pistis et al 2004; Panlilio et al 2013). For example, Pistis et al (2004) found that early exposure to marijuana in adolescent rats increases brain sensitivity to drugs of abuse such as morphine, cocaine, and amphetamine. Socio-environmental mechanisms also exist. As Lynskey and Hall (2005) suggested, adolescent marijuana users are likely to follow the gateway sequence and are at a higher risk of taking on harder illicit drugs because they have gained more access to and opportunities to try harder illicit substances through peers who are hard substance users. Marijuana use may also increase the acceptance level of doing substances, which means the young marijuana user might perceive substance use as less risky or less deviant such that they become less concerned and more curious about taking on harder drugs (Wagner & Anthony

2002; Reddon et al. 2018). These socio-behavioral mechanisms likely play a more salient role in contributing to the gateway sequence today given that marijuana has been legalized for medical use in more than 30 states and for recreational use for 11 states and the District of Columbia (Wu, Wen & Wilson In press).

Since Kandel & Faust's publication, a rich literature has been produced testing the gateway theory reporting inconsistent findings. On the one hand, many studies have provided supportive evidence (Yamaguchi, Kandel 1984; Kandel, Yamaguchi 1993; Golub, Johnson 1994; Morral et al. 2002; Agrawal, Neale, Prescott, Kendler 2004; Gundy & Rebellon, 2010; Secades-Villa et al. 2015; Woodcock et al. 2015; Keyes, Hamilton, Kandel 2016). A variety of study designs have been employed in these studies. Woodcock et al (2015) used retrospective data on a sample of US adults and found that among current heroin users 79.7% of individuals who progressed to heroin, were consistent with the gateway pattern of progression. Taylor et al (2017) used prospective data from a UK birth cohort of adolescents and showed that compared to nonusers, adolescents who were late onset or early onset occasional marijuana users and regular users had greater odds of using other illicit substances in early adulthood. Meanwhile, Lynskey et al (2003) examined this sequence using MZ (identical) and DZ (fraternal) twin pairs and found that regardless of zygosity, the twin who used marijuana by the age of 17 was significantly more likely to progress to harder substances compared to their co-twin, who was a nonuser.

On the other hand, inconsistent findings have also been documented (Golub, Johnson 1994, Mackesy-Amiti, Fendrich, Goldstein 1997, Tarter et al 2006; Choo 2008; Attaiaa et al. 2016; Reddon et al. 2018). Many people who use marijuana may not follow the gateway sequence. An ethnographic study of adults in New York found that serious drug users showed gateway-inconsistent patterns of progression; that is, about 40% of males and 35% females used marijuana prior to alcohol, while 40% of males and females used illicit drugs before using marijuana (Mackesy-Amiti, Fendrich, Goldstein, 1997). These findings show that the use of licit substances or other hard illicit substance did not depend on prior use of marijuana. U.S.-based longitudinal studies have provided partial support for the gateway theory. For example, Cleveland and Wiebe (2008) used data from the National Longitudinal Study of Adolescent to Adult Health (Add Health) and examined adolescent MZ and DZ twin pairs and found that differences in early marijuana use in twin pairs predicted differences in later hard substance use among DZ twin pairs, but not for MZ twin pairs. These results imply that those with a genetic predisposition are more likely to try marijuana than others. The authors suggested these differential findings can be better explained by a genetically influenced behavioral trajectory rather than a gateway pattern of progression. Attaiaa et al (2016) used retrospective data from a French population-based sample of individuals ages 15-64 and found that individuals who used more substances previously, had higher odds of further progression. However, individuals who followed the gateway sequence or who were polysubstance users did not significantly differ in their risk of using harder illicit substances. These results suggest that the order of initiation may not be related to further progression of harder substances and that the number of substances previously used may be a better predictor than the pattern of substance-use progression assumed by the gateway theory.

The empirical discrepancies on the gateway sequence might have resulted from differences in study design and analytical approach but may also reflect the fact that the sequence is only applicable to some socio-demographic groups but not others. Few studies have investigated the specificity of this sequence for different groups. Evidence shows that those who initiate marijuana at an earlier age relative to later age are more likely to use other illicit substances than those who are older first-time marijuana users (Fergusson, Boden , Horwood

2006; Gallegos, Zaring-Hinkle, Wang, and Bray 2020). Inconsistent findings have been reported as to whether gender is a moderator (Fiellin et al. 2013; Buu et al. 2014). The strength of the sequence may also vary by race/ethnicity (McCabe, 2007; Pacek, Malcolm, & Martins 2013). More research is warranted to explore the moderating effects of socio-demographic factors in the gateway sequence.

Using five waves of the ADD Health longitudinal data that spanned for more than 20 years of follow-up, the purposes of the current study are two-fold. First, we revisit the gateway theory by examining the long-term prospective study of adolescent marijuana use and subsequent harder illicit drug use in adulthood. Second, we investigate whether this association varies by age at first use, gender, and race/ethnicity. We hypothesized that there would be significant and positive associations between adolescent marijuana use and other illicit substance use in middle adulthood, but these associations would be weaker among individuals who initiated marijuana use at older ages. We also expected that these associations would be weaker among women than men and among blacks than whites because of higher prevalence of substance use among men and whites compared to their counterparts (McCabe et al 2007).

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