



Then and now: Consumption and dependence in e-cigarette users who formerly smoked cigarettes



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HIGHLIGHTS

- Older and female e-cigarette users prefer high-nicotine, low-power delivery.
- E-juice nicotine concentration tends to be higher for those who vaped for longer.
- Coupling of consumption and dependence is markedly less for vaping than smoking.
- The Fagerström test does not capture motivations for e-cigarette use.

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ABSTRACT

Electronic cigarette use, or vaping, continues to be a focus for regulators and policy makers in public health, particularly since it can compete with or be a substitute for smoking. This study investigated characteristics of nicotine dependence and consumption in a sample of vapers who formerly smoked cigarettes. We recruited 436 (80% male) vapers from several internet discussion forums; 95% of whom previously smoked, but ceased after commencing vaping. These participants completed a retrospective version of the Fagerström Test for Nicotine Dependence (FTND-R), as well as a version modified to suit current vaping (FTND-V), along with measures of consumption. Nicotine dependence appears to reduce markedly when smokers transition to vaping. However, 'decoupling' is observed in the relationship between consumption and dependence in vaping, and the FTND-V showed inadequate psychometric properties. Older and female vapers tend to employ a low-power, higher nicotine-concentration style of vaping. Overall, nicotine concentration tended to increase over time, although this effect was moderated by users' intentions to reduce their intake. Indicators of smoking addiction do not appear to be applicable to vaping, with respect to both internal consistency and relationship to consumption. This suggests that motivations for vaping are less dominated by nicotine delivery (negative reinforcement), and may be driven more by positive reinforcement factors. Nevertheless, e-liquid nicotine concentration was associated, albeit weakly, with dependence among e-cigarette users. Finally, vapers are heterogeneous group with respect to style of consumption, with a high-power/lower nicotine set-up more common among younger men.

1. Introduction

Although originally designed to emulate the experience of smoking, 'vaping' electronic cigarettes (e-cigarettes) is qualitatively different in a number of respects. Most obviously, vaping involves the inhalation of a vapour fog, rather than smoke; with scope for a very broad range of flavouring options (Measham, O'Brien, & Turnbull, 2016). Whilst tobacco smoke is intrinsically an irritant, the 'throat-hit' of e-liquid can be adjusted by varying the proportion of vegetable glycerine and propylene glycol in the e-liquid (Etter, 2016). This customisation can be combined with a choice of nicotine concentration, and device power

settings; yielding a variety of potential user experiences. E-cigarettes yield no ash, and very little residual odour – potentially resulting in a more pleasant subjective experience, especially for novice users or those affected by second-hand vapour (Dawkins & Corcoran, 2013). Additionally, vaping devices can be triggered conveniently at will – accommodating a range of usage patterns.

Vaping is generally very positively perceived by users; as a healthy alternative to the increasing burdens of smoking, and as being more acceptable for consumption in the home or in social situations (Keane, Weier, Fraser, & Gartner, 2016) the public health literature is somewhat polarised on the question of whether vaping is a beneficial or dangerous

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social phenomena. It has been described as having great potential for public health benefit – these writers focus on the diversion of individuals who would otherwise smoke cigarettes, and point to the lack of evidence for any significant health impacts from vaping (Hajek, 2014). Others, including the World Health Organisation, label vaping as a threat to public health, citing similarly the lack of evidence regarding safety of long-term inhalation of various chemical flavourings, and the potential for uptake among non-smokers and the young (Sim & Mackie, 2014). Central to this controversy is the open question of whether or not vaping acts to increase or reduce nicotine addiction (Palazzolo, 2013).

Despite conflicting results in the literature, research suggests that vaping is reasonably effective at delivering nicotine for at least some users (Dawkins & Corcoran, 2013; Etter & Bullen, 2011a,b; Nides, Leischow, Bhattar, & Simmons, 2014; Vansickel & Eissenberg, 2013). Increased nicotine uptake might be accomplished by the use of higher power devices and/or higher concentrations of nicotine in e-liquid (Farsalinos, Romagna, Tsiapras, Kyrzopoulos, & Voudris, 2013); and one study has shown that acute administration of e-cigarettes to smokers increases blood plasma nicotine levels, and decreases self-reported cigarette cravings (Dawkins & Corcoran, 2013; Vansickel & Eissenberg, 2013). However, vaping delivers nicotine less efficiently and more slowly than smoking (Eissenberg, 2010; Vansickel, Weaver, & Eissenberg, 2012). Vaping may act as an effective substitute for smoking for at least some smokers (Barbeau, Burda, & Siegel, 2013; Polosa, Caponnetto, Cibella, & Le-Houezec, 2015; Polosa et al., 2011), with most users reporting successful cigarette cessation (Goniewicz, Lingas, & Hajek, 2013).

The above points lead to ambiguity as to whether vaping has similar or less potential for dependence than smoking – or indeed whether motivations for, and patterns of, consumption are simply qualitatively different than smoking. Hitherto, relatively little research has attempted to measure consumption and dependence among vapers; or to understand changes in dependence after transitioning from smoking, and over extended use. The lack of an established measure of vaping dependence – that is comparable to that associated with cigarettes – presents a significant obstacle to resolving these questions.

1.1. Measuring vaping dependence

Measurement of vaping dependence has generally been done through modifying existing measures for smoking. The Fagerström Test for Nicotine Dependence (Heatherton, Kozlowski, Frecker, & Fagerström, 1991) (FTND) is probably the most widely used measure for smoking addiction. The FTND is subject to psychometric limitations, including suboptimal reliability, and some evidence for lack of unidimensionality (Breteler, Hilberink, Zeeman, & Lammers, 2004; Haddock, Lando, Klesges, Talcott, & Renaud, 1999). Nevertheless, use of the FTND is often recommended on the basis of substantial prior research, its ability to predict relapse, and its brevity (Piper, McCarthy, & Baker, 2006).

Two studies have reported using modifications of the FTND for vaping (Etter, 2015; Etter & Eissenberg, 2015). However, neither the specific item modifications nor the psychometric properties of the modified scale are described. One study (2013) employed modified versions of certain items of the FTND (e.g. ‘time to first vape’), but only conducted single-item comparisons. At the time of data collection for the present study, no validated measure of vaping dependence had been reported., Foulds et al. (2015) recently describe a new 10 item Penn State [Electronic] Cigarette Dependence Index (PS ECDI), including both vaping and smoking variants. The PS ECDI combines probes from the FTND along with items from other sources (Bover, Foulds, Steinberg, Richardson, & Marcella, 2008; Fidler, Shahab, & West, 2011). However, measures of reliability were not reported. Morean and L'Insalata (2017) present a detailed psychometric evaluation of a four-factor vaping questionnaire designed to measure expectancies around vaping. They found that among dual users, vaping was associated with

stronger positive reinforcement, whilst smoking was associated with greater negative reinforcement.

1.2. Vaping and nicotine dependence

There is indirect evidence that nicotine dependence plays a role in the initiation and continuation of e-cigarette use. Dawkins, Turner, Roberts, and Soar (2013) found that only 1% of vapers employ zero-nicotine e-liquid, and 83% describe themselves as ex-smokers. E-liquid containing nicotine, and higher powered device settings, tend to attenuate withdrawal symptoms among smokers to a greater degree (Caponnetto et al., 2013; Etter, 2015; Etter & Bullen, 2011a, 2011b). This is congruent with reports that latest generation, high-powered devices are more effective at increasing plasma nicotine levels (Farsalinos et al., 2014; Vansickel & Eissenberg, 2013). Nevertheless, nicotine dependence may reduce in individuals who transition from cigarettes to vaping. Dawkins et al. (2013) found that time from waking before first use was significantly longer than when smoking. Foulds et al. (2015) found a large overall reduction in all dependence indicators when comparing retrospective smoking to current vaping. Results from other studies also imply lower levels of dependence among ex-smoking vapers, apparently due to less effective nicotine delivery (Farsalinos et al., 2013, 2015; Vansickel et al., 2012). Most vapers rate their dependence as weaker than their prior dependence on cigarettes, but those who vape with nicotine tend to have a higher degree of dependence, and are less likely to intend to stop vaping (Etter & Eissenberg, 2015).

Much less is known about changes in dependence among vapers over time. Dawkins et al. (2013) found that only about one third of vapers were attempting to cut down their e-cigarette use. However, one study on dual-users found a 31% abstinence rate at 6 months (Siegel, Tanwar, & Wood, 2011). A trend towards reduction in e-liquid nicotine strength over time has also been reported (Polosa et al., 2015). In their narrative review, Rahman, Hann, Wilson, and Worrall-Carter (2014) conclude that vaping can either perpetuate or attenuate nicotine addiction, depending on whether the user is motivated to quit.

1.3. Vaping consumption and demographic correlates

Vaping consumption can be measured in several ways, including numbers of puffs or volume of e-juice consumed per day and nicotine strength of e-juice (Dawkins et al., 2013). Differences in patterns of consumption have also been noted in qualitative studies; for instance ‘cloud chasing’ where user employ high powered devices and low or zero nicotine e-juice to produce large clouds of vapour. For younger people, such demonstrative activities, as well as novel flavour combinations, may be a more important motivator than smoking cessation and nicotine consumption (Measham et al., 2016). On the other hand, Goniewicz et al. (2013) concluded that the amount of nicotine delivered was a key factor that determined patterns of e-cigarette use. Further, they found that most used their device within 30 min of waking up, and that consumption followed patterns of prior cigarette smoking. E-cigarette use appears to be more prevalent among younger males (Kenne et al. 2016), and has been correlated with heavy drinking among college students (Littlefield et al. 2015).

1.4. Summary and aims

A consensus appears to be emerging that e-cigarette use is associated with lower levels of dependence than smoking (Etter & Eissenberg, 2015; Farsalinos et al., 2013; Foulds et al., 2015; Goniewicz et al., 2013). However, this evidence is based on either single report items, or vaping dependence measures without psychometric validation – a recognised barrier to progress (Etter, 2015; Etter & Eissenberg, 2015). It is also not clear whether dependence among vapers might increase or decrease over time, and whether or not

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