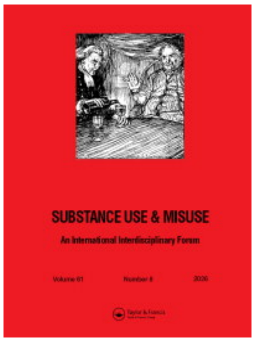


Substance Use & Misuse

ISSN: 1082-6084 (Print) 1532-2491 (Online) Journal homepage: www.tandfonline.com/journals/isum20

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**To cite this article:** Dorsa Tafakori , Mojdeh Jankouk , Vesna Beljo , Stephanie M. Penta & Sarah S. Dermody (11 May 2026): A Controlled Puffing Procedure for Individuals Who Smoke Intermittently: A Pilot Study, Substance Use & Misuse, DOI: 10.1080/10826084.2026.2670604

**To link to this article:** https://doi.org/10.1080/10826084.2026.2670604

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NOTE

# A Controlled Puffing Procedure for Individuals Who Smoke Intermittently: A Pilot Study

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**ABSTRACT**

*Background:* For individuals who smoke cigarette daily, there is published guidance on standardizing smoke exposure in the laboratory; however, we lack such a procedure for individuals who smoke cigarettes intermittently (ITS).

*Objective:* The purpose of this study was to pilot a standardized cigarette self-administration procedure for ITS (i.e., 4 to 27 days per month) and evaluate associated changes in withdrawal, craving, and motivation for smoking cessation.

*Methods:* Twenty-seven adult ITS completed two counterbalanced appointments: one involving typical self-administration (ad lib smoking) and another involving standardized self-administration (prescribed timing and number of puffs).

*Results:* The standardized puffing procedure appeared feasible; however, could not be verified using objective puff topography data. There were no significant differences between conditions on craving or withdrawal reduction, cigarette evaluation, or beliefs or motivations pertaining to smoking cessation.

*Conclusions:* The evaluated controlled self-administration procedure is a tool to standardize smoking exposure among ITS, without substantially altering craving, withdrawal, or smoking cessation-related variables. The procedure could be used in future research to better understand ITS smoking response and associated predictors with a fixed amount of smoke exposure.

**KEYWORDS**
Intermittent smoking; self-administration; experiment; stimulus control

## Introduction

People who smoke intermittently (ITS) smoke cigarettes regularly, but not daily (i.e., on 4–27 days per month; Shiffman et al., 2014). Intermittent smoking increases risks for cardiovascular diseases and lung cancer (Schauer et al., 2014) and warrants tailored cessation interventions. For instance, ITS may benefit from interventions focused on impacts of external stimuli on smoking (Pollak et al., 2021; Shiffman et al., 2014) rather than focusing heavily on withdrawal symptoms, as is done for people who smoke daily (Tindle & Shiffman, 2011).

Novel ITS interventions can be screened using well-controlled laboratory-based self-administration studies (Perkins & Lerman, 2014). Such a self-administration paradigm has been developed, for individuals who smoke daily, to control participant's puffing patterns by having them follow a prescribed puff timing and rhythm (Perkins & Karelitz, 2020). This paradigm standardizes smoke exposure, which is useful for evaluating associated responses and factors (like interventions) impacting those responses in a controlled way.

There is currently no analogous validated procedure for ITS. As ITS topography differs from individuals who smoke daily (Shiffman et al., 2013), it is important to adapt this procedure to emulate their typical smoking exposure. To address this gap, the present study adapted Perkins and Karelitz (2020) cigarette puffing paradigm for ITS. Specifically, we adjusted their procedure to reflect typical puffing patterns (average puff count, duration, and interval) observed in ITS when they smoke freely in the laboratory (Gass et al., 2016). The primary aim of this study was to determine the feasibility of manipulating the puffing patterns of ITS. A secondary aim was to explore the impact of manipulating puffing patterns on smoking response (e.g., craving, withdrawal reduction) and cessation-related outcomes (e.g., motivation and desire to quit). We hypothesized that the manipulation of controlled puffing, which requires deliberate control over smoking, would improve perceptions of cessation readiness, motivation, and self-efficacy, as compared to ad lib smoking that permits habitual, automatic smoking. This hypothesis was based on prior research identifying that enhancing self-control through practice improves smoking cessation outcomes (Muraven, 2010).

## Materials and methods

### Participants

The target sample size was 34 adults who smoke intermittently, based on a power analysis in G*Power (medium within-person effect size $d = 0.50$, two-tailed test, alpha = 0.05, power = 0.80; Faul et al., 2007). Inclusion criteria were

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/10826084.2026.2670604.

aged 19 years or older (legal smoking age in Ontario, Canada), reported smoking manufactured cigarettes 4–27 days per month, reported smoking for at least one year, and reported smoking at their current rate for at least three months. Exclusion criteria included plans to quit smoking in next 30 days, positive QuickStick hCG pregnancy test or planning pregnancy, and breastfeeding. Participants were recruited using social media advertisements, physical flyers, e-posters, and word of mouth.

### Measures

Participants reported demographic characteristics. A timeline followback characterized substance use during past 30 days or since last appointment (i.e., days used, quantity; Sobell & Sobell, 1992). Nicotine dependence was assessed using the 8-item Fagerstrom Test for Nicotine Dependence (FTND; Fagerstrom & Schneider, 1989; Heatherton et al., 1991). Withdrawal was assessed using the 15-item Minnesota Nicotine Withdrawal Scale (MNWS; Hughes & Hatsukami, 1986). Craving was assessed with a single-item visual analogue scale (VAS) item rating current urge to smoke (Mezinskis et al., 2001).

Importance and confidence to quit smoking were each measured on a scale from 1 to 10 with ten being very important or very confident, respectively. The Self-Efficacy Questionnaire (SEQ-12) determined confidence to refrain from smoking in various contexts, with separate subscales for internal and external factors (Etter et al., 2000). The Cigarette Evaluation Scale (CES) assessed twelve sensations possibly experienced after smoking (Westman et al., 1992).

### Procedure

Eligible participants were scheduled for an in-person appointment. Participants were asked to be substance-free, excluding caffeine, for at least 12 h before each appointment, which was verified by self-report only or confirmed with an alcohol breathalyzer reading of 0.000 g/210L. After informed consent was provided, participants completed a baseline survey (first appointment only) and timeline followback. Each participant completed two, one-hour in-person laboratory appointments, spaced about one week apart. The appointment order was counterbalanced, including an experimental (controlled puffing) or control condition (ad lib puffing). In both, participants were instructed to refrain from other activities (e.g., phone use, eating/drinking) and to only smoke one of their usual brand of manufactured cigarette (participant-provided) through a Clinical Research Support System (CReSS) smoking topography device. For ITS, smoking a cigarette through a CReSS has been validated against natural puffing characteristics (Shiffman & Scholl, 2020). Despite following manufacturer instructions, CReSS data were uninterpretable. While participants only smoked one cigarette, devices repeatedly recorded multiple cigarettes smoked (and excessive number of puffs). Therefore, puff topography data were not analyzed.

Prior to the manipulation, participants viewed a sample presentation with sample instructions and then completed the pre-manipulation surveys (MNWS, craving). In the experimental condition, participants were then instructed using automated/timed Powerpoint slides to take 1.2-s cigarette puffs every 28.5 s for a total of 14 puffs (Figure 1). The puff number, puff duration, and puff intervals were based on average ITS puffing characteristics (Gass et al., 2016). The smoking duration was approximately eight minutes. In the control condition, participants viewed a similar presentation with identical duration, but it instructed them to smoke their cigarette freely until prompted to stop. Participants then completed the post-manipulation surveys (importance/confidence to quit smoking, SEQ-12, CES, MNWS, craving).

Participants received a $30 CAD e-gift card per visit. The protocol was approved by the Toronto Metropolitan University Ethics Board (REB 2023-267). The study was pre-registered and analytic files and code, raw topography data, and sample and experimental presentations can be downloaded https://osf.io/4qjbf/.

### Data analysis

Data analyses were completed using (R Core Team 2025). Mixed ANOVA models were conducted with complete cases, with the manipulation (experimental vs. control) as the repeated measures factor. The dependent variables were difference scores (post-pre) for MNWS and VAS or post scores-only for CES, SEQ, and importance/confidence to quit smoking. The covariates were: timepoint (first vs. second appointment) and order (experimental condition occurred first or second). Due to missing data, unregistered sensitivity analyses were performed by estimating the models using linear mixed effects models so all available data (even single appointments) could be used.

## Results

Twenty-seven participants completed both appointments. On average, these participants were 24.96 years old (standard deviation ($SD$ = 9.73), smoked 11.63 days per month ($SD$=7.21), and averaged 2.40 cigarettes per smoking day ($SD$=1.38). Mean FTND score was 2.59 ($SD$=0.84). Sex assigned at birth included 13 male and 14 female participants. Participants identified as Indigenous ($n$=5), East Asian ($n$=5), multiracial ($n$=5), Southeast Asian ($n$=3), White ($n$=3), South Asian ($n$=2), and one each as Black, Latin American/Hispanic/Latinx, West Asian/Middle Eastern, and West Indian. Seven more participants completed one appointment, missed their second appointment, and were subsequently lost to follow-up or discontinued after repeated rescheduling attempts or failure to attend scheduled appointments.

For most ($n$=24, 89%), one cigarette was sufficient for the 14 puffs and 8-min experimental condition. One participant (contrary to instructions) lit a second cigarette, and two participants finished their single cigarette slightly before the 8-min mark.

In the ANOVA models, there were no significant differences between the experimental and control condition on MNWS and craving VAS difference scores, or post-smoking scores for self-efficacy, cigarette evaluation, and importance/confidence to quit smoking (see Table 1). The condition effect sizes were all very small in magnitude ($\check{\eta}^2_G < 0.01$).

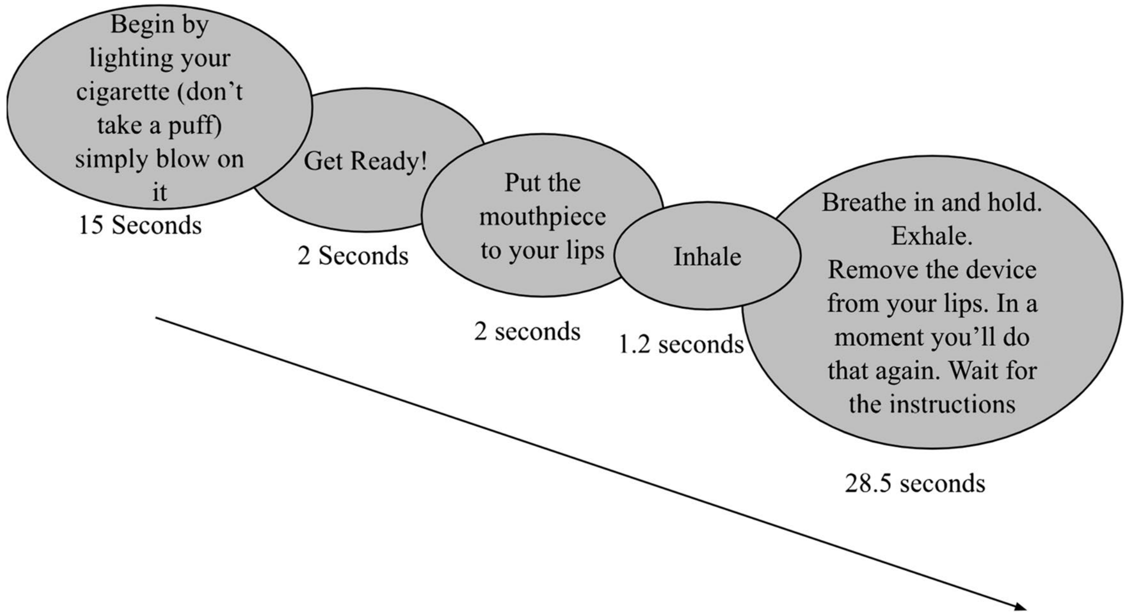


**Figure 1.** Experimental condition instructions.
Experimental condition instructions on the puffing timing where participants were cued to follow the slideshow presentation based on the puffing procedure by Perkins and Karelitz (2020).

**Table 1.** ANOVA model results.

| Model | Effect | Mean (SE) 1 | Mean (SE) 2 | $\breve{\eta}_G^2$ | *F* | *df* | $df_{res}$ | *p* |
|---|---|---|---|---|---|---|---|---|
| MNWS | Order | −4.74 (0.92) | −3.15 (0.92) | .043 | 1.49 | 1 | 25 | .234 |
| | Time | −4.30 (0.75) | −3.59 (0.75) | .009 | 0.88 | 1 | 25 | .356 |
| | Condition | −4.05 (0.75) | −3.84 (0.75) | .001 | 0.06 | 1 | 25 | .809 |
| Craving | Order | −20.4 (6.36) | −24.6 (6.36) | .006 | 0.22 | 1 | 25 | .645 |
| | Time | −21.4 (5.53) | −23.6 (5.53) | .002 | 0.12 | 1 | 25 | .733 |
| | Condition | −20.5 (5.53) | −24.4 (5.53) | .005 | 0.36 | 1 | 25 | .555 |
| Confidence | Order | 6.11 (0.60) | 7.67 (0.60) | .105 | 3.38 | 1 | 25 | .078 |
| | Time | 6.82 (0.46) | 6.95 (0.46) | .001 | 0.16 | 1 | 25 | .694 |
| | Condition | 6.67 (0.46) | 7.11 (0.46) | .009 | 1.80 | 1 | 25 | .192 |
| Importance | Order | 5.51 (0.61) | 6.19 (0.61) | .021 | 0.61 | 1 | 25 | .442 |
| | Time | 5.71 (0.46) | 5.99 (0.46) | .004 | 0.93 | 1 | 25 | .345 |
| | Condition | 6.03 (0.46) | 5.67 (0.46) | .006 | 1.59 | 1 | 25 | .219 |
| SEQ | Order | 1.76 (0.22) | 2.13 (0.22) | .043 | 1.33 | 1 | 25 | .259 |
| External | Time | 1.93 (0.17) | 1.96 (0.17) | .000 | 0.04 | 1 | 25 | .848 |
| | Condition | 1.93 (0.17) | 1.96 (0.17) | .000 | 0.04 | 1 | 25 | .853 |
| SEQ | Order | 1.70 (0.26) | 1.99 (0.26) | .018 | 0.63 | 1 | 25 | .434 |
| Internal | Time | 1.83 (0.22) | 1.86 (0.22) | .000 | 0.01 | 1 | 25 | .923 |
| | Condition | 1.88 (0.22) | 1.81 (0.22) | .001 | 0.11 | 1 | 25 | .744 |
| CES | Order | 3.13 (0.28) | 3.41 (0.28) | .017 | 0.52 | 1 | 25 | .479 |
| | Time | 3.48 (0.21) | 3.05 (0.21) | .039 | 6.45 | 1 | 25 | .018 |
| | Condition | 3.31 (0.21) | 3.22 (0.21) | .001 | 0.18 | 1 | 25 | .676 |

*Note*. The table reports each effect tested, estimated means and standard errors (SEs), generalized eta squared ($\breve{\eta}_G^2$) effect size, the *F* statistic, degrees of freedom for the effect (*df*) and residuals ($df_{res}$), and *p* values. Condition was within-subjects experimental (mean 1) or control (mean 2), time was within-subjects session 1 (mean 1) or session 2 (mean 2), order was between-subjects experimental condition completed first (mean 1) or second (mean 2). Additional abbreviations include MNWS (Minnesota Nicotine Withdrawal Scale), SEQ (Self-Efficacy Questionnaire), and CES (Cigarette Evaluation Scale).

Similarly, no condition effects were detected with sensitivity analyses using linear mixed effects models with all available observations (Supplementary Table A).

## Discussion

We examined a controlled puffing manipulation tailored for ITS. We partly addressed the first aim by demonstrating the paradigm's appropriateness for standardizing smoking in ITS without substantially impacting satisfaction or withdrawal relief from smoking. The experimental smoking duration (14 puffs over 8 min) appeared appropriate for most participants. Three participants finished their cigarettes early. Variability could be attributed to different cigarette types or sizes (e.g., regular, king size) smoked, individual differences around average ITS puff topography characteristics informing the paradigm (Gass et al., 2016), and variability in puff volume or intensity that could not be standardized. For within-subjects designs like ours, this variability is less problematic; however, researchers using between-subjects design could reduce variability by standardizing cigarette type and/or reducing smoking duration to prevent early completion. While we expect participants followed the standardized instructional procedures (we helped ensure they understood the instructions prior to the manipulation using a sample presentation), we could not compare exposure between conditions or verify adherence to the prescribed puffing pattern with topography device data. Contrary to the second hypothesis, the manipulation did not affect smoking cessation readiness, motivation, cigarette evaluations, and self-efficacy. Controlling puffing patterns for a single cigarette may not be sufficient to shift these predictors of cessation.

Results should be considered considering limitations, including the lack of manipulation check or verification of similar exposure between conditions (due to CReSS device malfunctioning) and smaller-than-intended sample size to detect medium-sized effects. However, estimated effect sizes for condition were small in magnitude, suggesting the manipulation did not meaningfully impact the outcomes. Future studies could monitor puffing using effective alternatives like video observation (Mercincavage et al., 2021). Despite these limitations, establishing and piloting this procedure provides an important starting place for future laboratory research wishing to manipulate and/or standardize smoke exposure for ITS. Future research could apply this procedure to improve understanding of factors impacting ITS smoking response, holding smoking exposure constant.

## Author contributions

CRediT: **Dorsa Tafakori**: Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing; **Mojdeh Jankouk**: Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing; **Vesna Beljo**: Data curation, Investigation, Writing – review & editing; **Stephanie M. Penta**: Formal analysis, Writing – original draft, Writing – review & editing; **Sarah S. Dermody**: Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

## Funding

The author(s) reported there is no funding associated with the work featured in this article.

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## Data availability statement

Data and analytic code are available for download at https://osf.io/4qjbf/.

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