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Effects of fun-seeking and external locus of control on smoking behaviour: a cross-sectional analysis on a cohort of working men in Singapore

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ABSTRACT

Objectives We examined the combined effects of behavioural inhibition and behavioural activation, on one hand, and locus of control, on the other hand, on different categories of smoking behaviour (non-smoking, ex-smoking, occasional smoking, daily smoking).

Design This study adopted a cross-sectional design. Participants completed questionnaires regarding demographics, smoking patterns, behavioural inhibition/behavioural activation systems and locus of control.

Setting The study was conducted across four companies from the transportation, cooling plant and education sectors in Singapore.

Participants Three hundred sixty-nine male working adults were included in the final sample.

Results Corroborating previous research, a logistic regression model examining behavioural inhibition/behavioural activation systems revealed that the fun-seeking aspect of behavioural activation was a unique predictor in distinguishing non-smokers from daily smokers (OR=1.24, p=0.012). By contrast, in a separate model examining locus of control, external locus of control was found to be a unique predictor in distinguishing non-smokers from daily smokers (OR=1.13, p<0.001). In addition, a third model combining both behavioural inhibition/behavioural activation systems and locus of control found that only external locus of control remained a significant predictor (OR=1.12, p<0.001). Further analyses revealed a mediating effect of external locus of control on the relationship between fun-seeking and smoking behaviour. That is, the increase in the odds of daily smoking due to fun-seeking was explained by external locus of control (direct pathway OR=1.20, p=0.058; indirect pathway OR=1.04, p<0.050).

Conclusions Overall, fun-seeking through its influence on external locus of control indirectly affects daily smoking behaviour, suggesting a more complex relationship than shown in previous research.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ A strength of this study is that we merged two independent streams of research on smoking behaviour, namely behavioural inhibition system/behavioural activation system and locus of control.
⇒ Another strength is that we examined the potential mediating effects of behavioural inhibition system/behavioural activation system and locus of control on smoking behaviour.
⇒ However, a key limitation is that this study only examined the male population.
⇒ Another key limitation is that smoking behaviour was assessed using self-report.

Cigarette smoking is the leading cause of preventable premature death globally.[1] It is related to various negative health effects, such as respiratory diseases, cardiovascular diseases and cancer.[2] In 2019, it was estimated that there were 1.14 billion smokers worldwide.[3] Males are the predominant driver of this statistic, such that they are approximately five times more likely to smoke than females. Given the high prevalence rate and negative health outcomes of cigarette smoking, it is important to understand the underlying psychological motivations for cigarette smoking and, consequentially, formulate strategies to help those who smoke develop healthy behaviour.

Previous comprehensive research has established two broad motivational systems underlying an individual's behaviour—behavioural inhibition system (BIS) and behavioural activation system (BAS).[4–6] The BIS is thought to serve as a conflict detection and resolution mechanism, inhibiting or avoiding behaviours that have conflicting motivational objectives.[5 6] By contrast, the BAS is viewed as a mechanism that regulates appetitive motivations, whereby the predominant objective is to steer an individual towards desired outcomes.[4 6] The BAS can be further decomposed into three distinctive motivational aspects, namely reward responsiveness, fun-seeking and drive.[4] Reward responsiveness refers to a motivation system driven by positive rewards, whereas fun-seeking refers to a

motivational system driven by novelty and spontaneity. By contrast, drive refers to a motivational system driven by achieving desired goals. Overall, these motivational systems, alongside the fight, flight or freeze mechanism, dynamically interact with each other, mediating one's behaviour,[5] such as smoking.

There is empirical evidence suggesting that these motivational systems may underlie smoking behaviour. Indeed, a previous study has demonstrated that greater levels of fun-seeking were associated with increased odds of being a smoker as compared with a non-smoker in the university student and adult populations.[7–9] Furthermore, another study examining university students also found that increased fun-seeking was associated with a greater frequency of tobacco-related product use.[10] Conversely, previous study also found that current smokers reported lower levels of reward responsiveness as compared with ex-smokers and non-smokers.[11] This finding is also consistent with the study by Voigt *et al* demonstrating that decreased reward responsiveness was associated with a greater frequency of tobacco use.[10] Notably, Morean *et al* also found that decreased BIS was associated with increased odds of being a smoker as compared with a non-smoker.[9] Overall, these findings indicate that motivational systems, particularly appetitive motivations driven by increased fun-seeking and decreased reward responsiveness, to a certain degree may distinguish a smoker from a non-smoker.

While certain behaviours are indeed driven by one's motivational systems, such as the BIS/BAS, it could be argued that a more comprehensive model is required to account for smoking behaviour. For instance, an individual's belief system is also another closely related psychological mechanism to consider in explaining smoking behaviour. In particular, the relationship between locus of control (LOC) and smoking behaviour has been extensively investigated within the literature.[12–19] LOC is the belief that one's actions would directly influence one's future outcomes.[20 21] That is, those with a predominantly internal LOC perceive that outcomes in life are within their personal control, whereas those with a predominantly external LOC perceive that outcomes in life are beyond their control.[20] Notably, LOC has been consistently found to be an important factor in predicting smoking behaviour and smoking cessation. For instance, some studies have found that higher levels of external LOC were associated with greater smoking behaviour in adolescents and college/university students.[12–15] Interestingly, a previous study demonstrated that lower internal LOC measured at age 10 predicted an increased likelihood of smoking behaviour 20 years later during adulthood.[16] Furthermore, previous research also demonstrated that individuals with a greater internal LOC were more successful in smoking cessation, whereas those with a greater external LOC were less successful in smoking cessation.[17–19] Overall, the empirical evidence suggests that LOC may also play a critical role in smoking behaviour.

Given that there is empirical evidence supporting the notion that both BIS/BAS and LOC may underlie smoking behaviour, the first aim of this study was to examine the unique contribution of BIS/BAS and LOC on predicting the different categories of smoking behaviour. Prediction refers to the degree to which one or more predictors may explain the outcome variable. Unique contribution refers to the effect of one predictor on the outcome variable after controlling for the effects of other predictors in the model. In contrast to the motivational systems, LOC is thought to have relatively less proximal influence on our behaviour along the causal pathway according to the theory of planned behaviour.[22–24] Hence, LOC has been suggested to play a part in influencing one's behaviour through its indirect effects on one's motivational systems.[23 24] Indeed, previous meta-analysis has provided some empirical evidence supporting this theory in the context of smoking.[25] Specifically, the meta-analytic structural equation model revealed that smoking is a result of one's motivation to engage in such behaviour, and this motivation is driven by antecedent psychological processes, such as perceived behavioural control. In addition, previous research has shown that internal LOC was positively correlated with BAS.[26 27] By contrast, a recent study found that external LOC was positively associated with BIS.[28] Furthermore, when examining BAS at the dimensional level, this study found that external LOC was also positively associated with fun-seeking. Considering LOC's lesser proximal influence on behaviour and its relationship with BIS/BAS, it appears that the influence of LOC on smoking behaviour may be explained by BIS/BAS. That is, one's perception of control may influence the regulation of one's appetitive motivations, which may then have an indirect impact on one's smoking behaviour. Hence, the second aim of this study was to examine the indirect influence of LOC on the different categories of smoking behaviour through BIS/BAS.

The first hypothesis of the study states that BIS/BAS and LOC are unique predictors of the different categories of smoking behaviour. Based on previous research, it was predicted that BIS/BAS would be associated with the different categories of smoking behaviour.[7–11] Similarly, it was predicted that LOC would be associated with the different categories of smoking behaviour.[12–19] Lastly, it was predicted that both BIS/BAS and LOC would be uniquely associated with the different categories of smoking behaviour.

The second hypothesis states that the relationship between LOC and different categories of smoking behaviour is mediated by BIS/BAS. According to mediation analysis guidelines,[29–31] it was predicted that BIS/BAS would remain a significant predictor of the different categories of smoking behaviour after controlling for the effects of LOC. It was also predicted that BIS/BAS would be associated with LOC. Finally, it was predicted that the direct pathway would be significant, while the indirect pathway would not be significant.

METHOD

Participants

The archival data reported in this study were collected as part of a larger cohort study examining the health effects of underground workspaces.[32] Working adults from various organisations in Singapore were recruited for this study. Due to the low number of females and even lower number of female smokers in the dataset, gender effects could not be robustly estimated. Hence, females were omitted from this study. The final sample consisted of 369 males, with ages ranging from 21 to 66 years (M=39.06, SD=11.05).

Self-report measures

The WHO classification criteria for cigarette smoking status was adopted to assess the current smoking status of each participant.[33 34] Based on the responses to the item "Have you ever smoked cigarettes?", participants who answered 'no' were categorised as non-smoking. Next, participants who answered 'daily', 'occasionally' or 'have stopped smoking completely' on the item "Do you smoke now?" were classified into daily smoking, occasional smoking and ex-smoking categories, respectively.

The BIS/BAS scale is a 24-item self-report inventory designed to assess two distinct motivational systems.[4] Specifically, the BIS subscale assesses one's sensitivity towards aversive outcomes, while the BAS subscales assess the different motivational approaches towards desired appetitive outcomes. The BAS has three underlying dimensions, namely reward responsiveness, fun-seeking and drive. Each item is rated on a 4-point Likert scale (1='very true for me', 2='somewhat true', 3='somewhat false for me, 4='very false for me'). First, negatively keyed items were reverse scored. Thereafter, scores for each scale were derived by the summation of all the respective items. The BIS (range: 7–28) scale and the reward responsiveness (range: 5–20), fun-seeking (range: 4–16) and drive (range: 4–16) subscales have different ranges of possible scores. Higher scores indicate greater sensitivity towards each of the corresponding motivational systems. This inventory has been shown to have moderate to good internal consistency reliability for the inhibition (α=0.74), reward responsiveness (α=0.73), fun-seeking (α=0.66) and drive (α=0.76) scales.

To assess internal and external LOC, we administered the internal and external (chance) scales.[21] Each scale has seven items. One of the items in each scale was written in the context of a car accident for the general population. However, given the low private car ownership rate in Singapore,[35] these context-based items were omitted. Each item is rated on a 5-point Likert scale ('strongly disagree', 'somewhat disagree', 'neither agree nor disagree', 'somewhat agree', 'strongly agree'). The scores for both scales ranged from a minimum of 0 to a maximum of 28. Higher scores on the internal scale indicate a greater perception of one's capacity to control the outcomes in life. By contrast, higher scores on the external scale indicate a greater perception of luck and fate in determining outcomes in life that are beyond one's control. This inventory has been shown to have moderate to good internal consistency reliability for the internal (α=0.67) and external (α=0.79) scales.

Statistical analysis

All statistical analyses were conducted in RStudio.[36] Given the categorical nature of the outcome variable, multinomial logistic regressions (using the mlogit package) were conducted to examine the effects of BIS/BAS and LOC on the different categories of current smoking status. The first model included BIS/BAS as the predictors. The second model included internal and external LOC as the predictors. The third model included BIS/BAS and internal and external LOC as the predictors to examine their unique contributions. Bonferroni correction was applied within each model to account for multiple comparisons across the various categories of the outcome variable when compared with the reference level (α=0.016). Prior to examining the mediation effect of BIS/BAS on the relationship between LOC and current smoking status, two key criteria were examined. First, BIS/BAS had to remain as a significant predictor of current smoking status after controlling for LOC. Second, LOC had to be associated with BIS/BAS. Thereafter, the mediation effect would then be examined through a natural effect model (using the medflex package).

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Table 1 Descriptive statistics of the behavioural inhibition system (BIS), behavioural activation system (BAS) and locus of control

			Range	
	M	SD	Minimum	Maximum
BIS				
Inhibition	19.39	2.71	8	28
BAS				
Reward responsiveness	16.30	2.19	9	20
Fun-seeking	11.41	2.10	6	16
Drive	11.72	2.08	6	16
Locus of control				
Internal	20.30	3.83	6	28
External	12.73	4.75	0	28

N=340–368 due to missing data. Possible ranges of scores (inhibition 7–28; reward responsiveness 5–20; fun-seeking and drive 4–16; internal and external locus of control, 0–28). Current smoking status (daily smoking=22.8%; occasional smoking=6.2%; ex-smoking=11.7%; non-smoking=59.3%). The percentages across all four categories in our sample slightly deviated from national statistics (daily smoking=18.4%; occasional smoking=4.9%; ex-smoking=12.8%; non-smoking=63.9%).[45]

Table 2 Multinomial logistic regression model with the behavioural inhibition system and behavioural activation system as predictors and current smoking status as the outcome variable

						OR, 95% CI	
	OR	β	SE	Z	P value	Lower	Upper
Daily smoking							
Intercept	0.02	−4.16	1.27	−3.28	0.001*	0.00	0.19
Inhibition	1.01	0.01	0.05	0.11	0.914	0.91	1.12
Reward responsiveness	1.05	0.05	0.08	0.64	0.520	0.90	1.24
Fun-seeking	1.24	0.21	0.08	2.51	0.012*	1.05	1.46
Drive	0.98	−0.02	0.09	−0.22	0.829	0.83	1.16
Occasional smoking							
Intercept	0.00	−8.49	2.25	−3.77	<0.001*	0.00	0.02
Inhibition	1.14	0.13	0.10	1.39	0.164	0.95	1.38
Reward responsiveness	0.93	−0.07	0.15	−0.48	0.633	0.69	1.25
Fun-seeking	1.26	0.23	0.15	1.53	0.125	0.94	1.68
Drive	1.19	0.17	0.16	1.06	0.287	0.87	1.62
Ex-smoking							
Intercept	0.04	−3.12	1.59	−1.97	0.049	0.00	0.99
Inhibition	1.04	0.04	0.07	0.63	0.526	0.91	1.19
Reward responsiveness	1.00	0.00	0.10	0.03	0.977	0.82	1.23
Fun-seeking	1.04	0.04	0.10	0.37	0.710	0.85	1.28
Drive	1.02	0.02	0.11	0.14	0.885	0.82	1.26

Non-smoking category was the reference level. N=365 (listwise deletion). Bonferroni-corrected α=0.016.

RESULTS

The descriptive statistics, such as the means, SD and ranges, for all predictors are reported in table 1.

Unique relationship hypothesis

Multinomial logistic regressions were conducted to examine the effects of BIS/BAS and LOC on the different categories of current smoking behaviour. The first model included BIS/BAS as predictors. The assumption of independence among dependent variable choices was tested and satisfied via the Hausman-McFadden test,[37] χ^2=9.07, df=10, p=0.525 (daily smoking category dropped), χ^2=−0.38, df=10, p=1 (occasional smoking category dropped), χ^2=0.02, df=10, p=1 (ex-smoking category dropped). Note that the reference category for these models was non-smoking. In addition, the assumption of no multicollinearity was met. The variance inflation factors (VIF) ranged from 1.16 to 1.88, which is within the guidelines (VIF <10) stipulated by Hair *et al*.[38]. The assumption of linearity was tested and met via the addition of Box-Tidwell transformed predictors in the model.[39] The transformed predictors were not statistically significant (Bonferroni-corrected α=0.016). The BIS/BAS model was statistically significant, χ^2=22.89, p=0.029. As can be seen in table 2, fun-seeking was found to be a significant unique predictor of current smoking behaviour when predicting between daily smokers and non-smokers. That is, individuals who scored 1 point higher on fun-seeking were uniquely predicted to be 1.24 times more likely to fall in the daily smoking category than the non-smoking category, after controlling for inhibition, reward responsiveness and drive.[37–39]

The second model included internal and external LOC as predictors. The assumptions of independence among the dependent variable choices, no multicollinearity and linearity were satisfied. Hausman-McFadden test, χ^2=1.58, df=6, p=0.954 (daily smoking category dropped), χ^2=−0.15, df=6, p=1 (occasional smoking category dropped), χ^2=0.42, df=6, p=0.999 (ex-smoking category dropped). VIF was 1.01. Box-Tidwell transformed predictors were not statistically significant (Bonferroni-corrected α=0.016). The LOC model was found to be significant, χ^2=23.47, p<0.001. As can be seen in table 3, external LOC was found to be a significant unique predictor of current smoking behaviour when predicting between daily smokers and non-smokers. That is, individuals who scored 1 point higher on external LOC were uniquely predicted to be 1.13 times more likely to fall in the daily smoking category than the non-smoking category, after controlling for internal LOC.

The third model included the predictors from the first two models. The assumptions of independence among the dependent variable choices, no multicollinearity and linearity were satisfied. Hausman-McFadden test, χ^2=4.17, df=14, p=0.994 (daily smoking category dropped),

Table 3 Multinomial logistic regression model with the internal and external locus of control as predictors and current smoking status as the outcome variable

	OR	β	SE	Z	P value	OR, 95% CI Lower	Upper
Daily smoking							
Intercept	0.03	−3.38	0.88	−3.86	<0.001*	0.01	0.19
Internal locus of control	1.04	0.04	0.04	1.04	0.296	0.97	1.12
External locus of control	1.13	0.12	0.03	3.98	<0.001*	1.07	1.20
Occasional smoking							
Intercept	0.01	−4.28	1.40	−3.05	0.002*	0.00	0.22
Internal locus of control	1.04	0.04	0.06	0.68	0.495	0.93	1.17
External locus of control	1.10	0.10	0.05	2.02	0.043	1.00	1.22
Ex-smoking							
Intercept	0.43	−0.85	0.97	−0.88	0.378	0.06	2.84
Internal locus of control	0.96	−0.04	0.04	−0.83	0.408	0.88	1.05
External locus of control	1.00	0.00	0.04	0.14	0.892	0.94	1.08

Non-smoking category was the reference level. N=340 (listwise deletion). Bonferroni-corrected α=0.016.

χ^2=−0.90, df=14, p=1 (occasional smoking category dropped), χ^2=−0.26, df=14, p=1 (ex-smoking category dropped). The VIFs ranged from 1.09 to 1.95. Box-Tidwell transformed predictors were not statistically significant (Bonferroni-corrected α=0.016). The full model was found to be significant, χ^2=41.09, p=0.001. As can be seen in table 4, external LOC remained a significant unique predictor of current smoking behaviour when predicting between daily smokers and non-smokers. That is, individuals who scored 1 point higher on external LOC were uniquely predicted to be 1.12 times more likely to fall in the daily smoking category than the non-smoking category, after controlling for inhibition, reward responsiveness, fun-seeking, drive and internal LOC. However, fun-seeking was no longer a significant predictor in this model.

Mediation hypothesis

While we hypothesised that the relationship between LOC and the different categories of smoking behaviour is mediated by BIS/BAS, as can be seen in table 4, fun-seeking was no longer a significant predictor in distinguishing daily smokers from non-smokers after the inclusion of internal and external LOC in the third model. Hence, the first key criterion that the mediator had to be associated with the outcome variable after controlling for the predictor was not met.[29–31] By contrast, external LOC remaining as the only significant predictor in the third model satisfied this criterion, indicating its potential as a mediator. That is, the relationship between fun-seeking motivation and smoking behaviour may be explained by external LOC. Hence, contrary to our initial hypothesis, the mediating effect of external LOC on the relationship between fun-seeking and smoking behaviour was examined. Notably, fun-seeking was found to be a significant predictor of external LOC, β=0.44, SE=0.14, p=0.001, which satisfied the second key criterion of a mediation analysis. Hence, a mediation logistic regression analysis was performed to examine the potential mediating effect of external LOC on the relationship between fun-seeking and current smoking status (daily smoking vs non-smoking) while controlling for other predictors, namely inhibition, reward responsiveness, drive and internal LOC. Given that the outcome variable in our mediation model was binary, using traditional ordinary least square methodology may result in biased estimates.[40] Hence, we adopted the natural effect model for more robust estimates of the direct and indirect pathways.[41 42] The direct pathway was not significant (OR=1.20, β=0.18, SE=0.09, p=0.058, 95% CI=0.99 to 1.44). However, the indirect pathway was found to be significant (OR=1.04, β=0.04, SE=0.02, p<0.050, 95% CI=1.00 to 1.08). Overall, the mediation analysis indicated that, indeed, there was a mediation effect of external LOC on fun-seeking in predicting daily smokers from non-smokers.

DISCUSSION

The present study investigated the relationships between BIS/BAS, LOC and current smoking status. First, we examined the hypothesis that BIS/BAS and LOC are unique predictors of the different categories of smoking behaviour. Fun-seeking, a component of BAS, was found to be associated with current smoking status (daily smoking vs non-smoking) after controlling for BIS and other aspects of BAS (reward responsiveness and drive). This is consistent with similar research previously conducted in other adult populations.[8 9] Similarly, external LOC was also found to be associated with current smoking status

Table 4 Multinomial logistic regression model with the behavioural inhibition system, behavioural activation system and locus of control as predictors, and current smoking status as the outcome variable

						OR, 95% CI	
	OR	β	SE	Z	P value	Lower	Upper
Daily smoking							
Intercept	0.00	−5.57	1.48	−3.78	<0.001*	0.00	0.07
Inhibition	0.99	−0.01	0.06	−0.19	0.847	0.88	1.11
Reward responsiveness	1.14	0.13	0.09	1.44	0.149	0.96	1.35
Fun-seeking	1.19	0.18	0.09	1.94	0.052	1.00	1.43
Drive	0.94	−0.06	0.09	−0.64	0.525	0.78	1.13
Internal locus of control	0.99	−0.01	0.04	−0.15	0.879	0.91	1.08
External locus of control	1.12	0.12	0.03	3.55	<0.001*	1.05	1.20
Occasional smoking							
Intercept	0.00	−8.77	2.41	−3.64	<0.001*	0.00	0.02
Inhibition	1.12	0.11	0.10	1.18	0.239	0.93	1.36
Reward responsiveness	0.98	−0.02	0.15	−0.14	0.891	0.72	1.33
Fun-seeking	1.24	0.22	0.15	1.43	0.154	0.92	1.68
Drive	1.19	0.17	0.16	1.05	0.295	0.86	1.64
Internal locus of control	0.96	−0.04	0.07	−0.60	0.550	0.84	1.10
External locus of control	1.07	0.07	0.05	1.27	0.204	0.96	1.18
Ex-smoking							
Intercept	0.08	−2.52	1.65	−1.52	0.127	0.00	2.05
Inhibition	1.04	0.04	0.07	0.54	0.591	0.91	1.18
Reward responsiveness	1.03	0.03	0.11	0.28	0.777	0.83	1.28
Fun-seeking	1.05	0.05	0.11	0.48	0.632	0.85	1.30
Drive	1.05	0.05	0.11	0.42	0.678	0.84	1.31
Internal locus of control	0.94	−0.06	0.05	−1.29	0.198	0.85	1.03
External locus of control	1.00	0.00	0.04	−0.07	0.943	0.93	1.07

Non-smoking category was the reference level. N=338 (listwise deletion). Bonferroni-corrected α=0.016.

(daily smoking vs non-smoking), controlling for internal LOC. This finding also corroborates previous research conducted in a younger population.[12–15] However, we found that the combined inclusion of BIS/BAS and LOC in the third model demonstrated that only external LOC remained a significant predictor of current smoking status (daily smoking vs non-smoking) when controlling for BIS/BAS and internal LOC. By contrast, fun-seeking was no longer a significant predictor in this model. Next, we examined the mediation hypothesis. Given that the relationship between a mediator and an outcome must remain significant after controlling for the effects of a predictor prior to conducting a mediation analysis, the examination of fun-seeking as a mediator was no longer justified. By contrast, external LOC remaining as a significant predictor was indicative of its potential as a mediator. Indeed, further mediation analysis revealed that the predictive effect of fun-seeking on distinguishing daily smokers from non-smokers was mediated by external LOC.

Overall, these findings suggest that greater levels of fun-seeking motivation were indirectly associated with greater odds of being a daily smoker than a non-smoker through its effects on increased levels of external LOC. This is contrary to the notion that motivational systems are proximally closer to behavioural outcomes as compared with belief systems and that generic belief systems play a part in influencing behaviours through their effects on the motivational systems.[22–24] Hence, it appears that there may be other pathways towards smoking behaviour besides the one proposed by the theory of planned behaviour.[24] Arguably, the reasoned action processes as described in the theory of planned behaviour may not be the only pathway towards smoking behaviour. For instance, other researchers have proposed an alternative pathway towards smoking behaviour that is driven by spontaneity and reactivity towards social situations.[43 44] Given that fun-seeking is a motivational approach primarily driven by novelty and spontaneity,[4] our findings appear to be more in line with this alternative pathway in explaining smoking behaviour.

Hence, these novel findings further our understanding of the potential antecedent processes of smoking behaviour by providing some empirical evidence indicating that external LOC has a mediating effect on how fun-seeking influences smoking behaviour. In other words, a motivation system that is predominantly driven by novelty and spontaneity may lead to an individual believing that one's future outcomes in life are mainly due to chance rather than one's own action, which in turn may then lead to an increased risk of being a daily smoker. Overall, this study provides some indicative evidence to support the notion that external LOC belief may underlie the relationship between fun-seeking motivation and smoking behaviour, which indicates that the relationship is more complex than previous research has suggested.

As previous research has independently demonstrated that BIS/BAS[7–11] and LOC[12–19] were associated with smoking behaviour, the key strength of this study is the merger of these two streams of research by examining the unique contributions of BIS/BAS and LOC on smoking behaviour. In addition, given that previous research has indicated that beliefs (eg, LOC) may influence our behaviour (eg, smoking) through its effects on motivations (eg, BIS/BAS),[22–24] another key strength of this study is that the complex relationship between belief systems, motivational systems and smoking behaviour was investigated through a mediation analysis. However, it is important to note that a key limitation is that this study only examined the male population. The decision to examine only the male population was due to an overrepresentation of men in the sample collected in this project as the organisations, which participants were recruited from, consisted of positions that were primarily male-dominated, such as engineers and technicians.[32] In addition, while the prevalence rate of daily smoking in Singapore is 10.6%, males are approximately 6 times more likely to smoke every day than females.[45] Specifically, the report stated that the prevalence rate of daily smokers for males was 18.4%, whereas the prevalence rate for females was 3.2%. Given the low number of female participants during recruitment and the even lower number of smokers within this subset, gender effects could not be robustly estimated. It should be noted that the gender differences in smoking pertain to a Singapore context and the gender ratio may differ from other populations. For instance, 2020 data from the World Development Indicators of The World Bank suggest that the ratio of female to male tobacco use is fairly equal in some countries, such as Iceland, Denmark and Serbia.[46] Future researchers should take into consideration gender ratio when examining smoking behaviour in a different population or across populations.

LOC and BIS/BAS, however, did not predict the differences among other categories of current smoking status (ie, occasional smoking and ex-smoking relative to non-smoking). This is likely due to the relatively smaller number of observations within each of the two categories of current smoking status (eg, in the full model, occasional smoking, n=22, and ex-smoking, n=43), which is another limitation of the study. Indeed, Jong *et al* have suggested that models with 10 or fewer observations per predictor in the smallest category of the outcome variable, particularly in models with small total sample sizes, are likely to have poor predictive performance.[47] Hence, it appears that our sample size may not be sufficient to provide robust estimates for the occasional smoking and ex-smoking categories in the multinomial logistic regression models. To increase the statistical power of these models, future research should consider increasing the total sample size through greater recruitment effort or adopting stratified sampling across the different categories of current smoking status.

A key methodological limitation pertaining to this study is the use of self-report as an assessment of current smoking status. Notably, previous research comparing self-report and objective assessments of smoking behaviour has shown that a high proportion of patients with asthma and chronic obstructive pulmonary disease that were smokers falsely reported themselves as non-smokers.[48] Another study also found that self-reported assessment underestimated the prevalence of smoking in Georgian adults, particularly women, as compared with objective assessment.[49] A similar pattern of results was also observed in Korean adolescents.[50] By contrast, a study conducted on the Canadian population found that the prevalence of smoking based on subjective assessment approximated those derived from objective assessment.[51] Overall, it appears that the accuracy of self-report as an assessment of smoking behaviour may be dependent on factors, such as gender, situation or culture. Hence, our findings should be interpreted with caution and should only be generalised to Singapore. Future researchers should consider comparing subjective and objective assessments of smoking in the context of the Singapore population. Alternatively, objective measures of smoking, such as urinary cotinine concentration, could be adopted in future studies.

It should be emphasised that there are potential confounding variables, such as gender and cultural differences, that this study did not take into consideration. For instance, multiple studies have found that LOC was influenced by gender and nationality.[52–55] In addition, there is also empirical evidence from functional and structural neuroimaging studies indicating gender differences in BIS/BAS.[56 57] Hence, the complex nature of culture and gender on BIS/BAS, LOC and smoking behaviour should be considered in future research. In addition, given the potential confounding effects between external LOC and fun-seeking on smoking behaviour, our findings should be further tested in future research through a double randomisation design by experimentally manipulating the predictor and mediator in two separate experiments to ascertain the direction of the relationship and, consequentially, provide more concrete evidence of the mediation effects observed in this study.[58]

Our findings may have implications on the strategies involved in the prevention and treatment of smoking

behaviours. Specifically, treatments might benefit by placing more emphasis on changing the belief that one's future health outcomes are mainly dependent on luck and fate, which is beyond one's control. For instance, motivational enhancement therapy has been previously found to be effective in smoking cessation.[59] This therapy is a client-oriented approach directed at enhancing a patient's intrinsic motivation to change their maladaptive behaviours by giving structured feedback, providing clear advice and alternative options, expressing empathy and focusing on the client's self-efficacy, optimism and personal responsibility.[60] The focus on personal responsibility and self-efficacy is closely related to the notion of shifting from a predominantly external LOC to an internal LOC. Indeed, previous research has demonstrated that both LOC and self-efficacy were predictors of smoking cessation.[61] Overall, our findings highlight the importance of giving external LOC beliefs greater consideration over fun-seeking motivations in smoking cessation therapy. Future research should consider experimentally manipulating external LOC beliefs and fun-seeking motivations and examine prospective changes in smoking behaviour.

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