

One Nudge Can Be Enough: Reducing Cigarette Butt Littering in Public Areas

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Received: 23. 2. 2024

Revised: 25. 6. 2024

Accepted: 23. 7. 2024

Published: 27. 11. 2024

ABSTRACT

The purpose of this paper is to investigate how public administration can reduce cigarette butt littering in public areas. Cigarette butt littering is a problem for every local government unit; however, policy solutions are either very difficult to implement or expensive. This paper demonstrates the potential of behavioural science, namely nudges employing gamification, salience, and priming.

Design/Methodology/Approach: In collaboration with local public administration, two field quasi-experiments were conducted to explore the effectiveness of low-complexity behavioural measures to tackle cigarette butt littering in heterogeneous public spaces. The study tested both the effectiveness of a single behavioural measure and the follow-up effect of a combination of low-complexity measures. In the first quasi-experiment,

a standalone intervention (priming stickers) and the follow-up combination of measures (priming stickers with gamified ballot bins) were tested. In the second quasi-experiment, a standalone salience nudge (crime scene) was first implemented, followed by a combination of the initial (crime scene) and follow-up salience (toxicity) nudges to nudge smokers from cigarette butt littering in public space. Both quasi-experiments used a before-and-after design.

Findings: The results suggest that a single behavioural intervention may be sufficient to achieve the desired behavioural change, and reinforcing its effects within a relatively short time period with a follow-up intervention may not deliver any additional statistically significant effects.

Originality/Value: This research contributes to public administration research, specifically by applying behavioural insights and experimental approaches to studying public policies. Although this approach is gaining popularity, there remains a lack of evidence from field (quasi-)experimental studies on the effects of behavioural interventions in reducing pollution in public spaces.

Keywords: littering, cigarette butts, nudge, gamification, priming, salience

JEL: Q50, R11, D91

1 Introduction

Littering is an important public policy issue, especially when it contributes significantly to environmental problems. Approximately 1.2 million tons of cigarette butts are released into the environment every year (Kadir and Sarani, 2015), and this waste pollutes air, water, and soil (Ghasemi et al., 2022). Cigarettes contain 150 highly toxic compounds that could initiate carcinogenesis or trigger other harmful changes in human genes (Araújo and Costa, 2019). These negative impacts of cigarette butt littering make a strong case for interventions aimed at changing the behavior of smokers. Strengthening sustainable behavior among smokers requires not only a profound understanding of smoking and cigarette butt littering habits, but also the implementation of interventions aimed at decreasing cigarette butt littering.

Insights from psychology and behavioral science can complement more traditional approaches to regulating human behavior (e.g., restrictions and sanctions). According to Barak-Corren and Kariv-Teitelbaum (2021), understanding how individuals make decisions and what influences their behavior is key to effective change. Thus, behavioral science can be applied in public administration to understand and change existing littering patterns. Smoking is a highly habitual behavior (Rath et al., 2012) and a social activity (Huang et al., 2019). Smokers often light cigarettes unintentionally (Jager, 2003), as is the decision to dispose of cigarette butts (Dehdari, 2020). In this context, restrictions and penalties may not always be effective measures, and behavioral interventions could be considered to complement traditional measures. The literature identifies several drivers for littering cigarette butts, such as

a lack of social pressure and a lack of knowledge about the negative social consequences of smoking (Wallace-Williams et al., 2023) and its negative ecological impacts (Webler and Jakubowski, 2022), a low availability of trash bins (Schultz et al., 2013) or highly littered areas, which reduce the motivation to dispose of cigarette butts in the trash bin (Kaur and Singh, 2022). In this article, we report two field quasi-experiments that aim at potential drivers for littering using gamification, salience, and priming. Thus, this article tests the practical feasibility of behavioral interventions as a complement to standard policy solutions. We contribute to the Public Administration literature and to the literature on pro-social and pro-environmental behavior by utilizing insights from behavioral science to reduce cigarette littering in public areas.

Despite the extensive theoretical framework of pro-environmental nudges, their field testing on heterogeneous samples and in public spaces (e.g., parks) is limited. This is mostly because various challenges arise when measuring the samples in real-world settings. The research on littering prevention with an application of behavioral interventions is usually conducted on homogeneous samples of individuals (e.g., students on campuses). Moreover, the effectiveness of nudges is usually measured separately, without considering the measurement of potential follow-up effects related to additional nudges and thus testing the effectiveness of the combination of two behavioral interventions. Our aim is to explore the impact of a single low-complexity behavioral measure and the effect of a follow-up intervention as a combination of low-complexity measures on littering behavior in a public space with a heterogeneous group of visitors. This study aims to examine the effects of behavioral interventions that can complement standard public policies (e.g., smoking restrictions, maintenance) at two different sites in a public lake area maintained by the city district of Bratislava, Slovakia. Although many public organizations develop and implement nudges to strengthen pro-environmental and pro-social behavior, robust experimental settings and measurements of their effects and impact are often missing or unreliable. Therefore, we utilize a quasi-experimental design.

Prior to designing the interventions, we conducted a behavioral audit aimed at identifying the group of individuals who contribute most to the littering of cigarette butts in the Strkovec Lake area and determining the factors influencing their littering behavior. The audit consisted of semi-structured observations covering both weekdays and weekends, as well as mornings, afternoons, and evenings. We then conducted 13 semi-structured interviews to gain further insight. We identified the areas with a high concentration of cigarette butts and the main littering patterns, such as ignorance and indifference to the negative environmental impact, lack of motivation to dispose of cigarette butts in the litter bin, and an insufficient number of litter bins in some parts of the site. We addressed these main reasons for cigarette butt littering using the behavioral insights of salience, priming, and gamification.

At the first field site, the smokers were primed with stickers that exhibited the number of steps to the nearest bin for cigarette butt disposal. The follow-

up intervention involved a gamified ballot bin. At the second site, smokers were exposed to a crime scene installation, which served as a salience nudge that highlighted the accumulation effect of cigarette butts. This was followed by another salience nudge in the form of information about the toxicity of cigarette butts.

The results demonstrate that the first interventions significantly reduced the number of cigarette butts discarded on the ground. However, the follow-up interventions did not lead to significant changes compared to the state after the first interventions. These findings suggest that initial interventions may have mitigated the potential impact of subsequent nudges in reducing cigarette butt littering. The findings also imply that using a standalone nudge may be sufficient to achieve the desired behavioral change, and combining multiple nudges may not provide additional benefits in the short term.

The article begins by discussing behavioral insights related to cigarette butt littering and its prevention, followed by the methodology, the design of interventions, and a description of each intervention. Next, we present the results, interpretation, and discussion. Finally, the article concludes with practical recommendations for policymakers and suggestions for further research.

2 Littering Problem – From Standard Policies to Behavioral Interventions

Many smokers light cigarettes out of habit (Jager, 2003), and their decisions about how to dispose of cigarette butts are often made without conscious thought (Dehdari, 2020). Therefore, littering of cigarette butts may often be the result of unconscious actions. Patel et al. (2013) state that butt littering behavior is often the norm among smokers. In addition, several other factors can negatively influence littering. The presence of existing litter increases the littering problem, while the availability of trash bins can reduce littering (Schultz et al., 2013). Al-Mosa (2017) and Schultz et al. (2013) highlight the impact of the amount of existing litter and the distance to trash bins on individual littering behavior. Johannes et al. (2021) demonstrated that poorly designed prohibitive signs and inaccessible trash bins are part of the reason for littering. People prefer signs in bright colors and labels that communicate where to dispose of specific items. Trash cans with signage are effective in reducing littering. Although more neutrally worded antilittering signs are advised, there is little evidence that the “do” type of message is more effective than imploring people “not” to litter (Newcomb and Newcomb, 2020). Kaur and Singh (2022) suggest that interventions aiming at reducing cigarette butt littering should focus on cleaning littered areas and regularly maintaining trash bins.

In addition to infrastructure and environmental factors, a lack of awareness of the toxicity of cigarette butts may contribute to the littering problem. Cigarette filters are made of non-biodegradable materials and contain hazardous chemicals such as arsenic, benzene, and hydrogen cyanide (Torkashvand et

al., 2020). Torkashvand et al. (2020) state that raising awareness about the toxicity of cigarette waste is important for mitigating the littering problem, as individual behavior plays a crucial role in waste production. Webler and Jakubowski (2022) suggest that littering is more likely among individuals who believe that cigarette butts are biodegradable and harmless to the environment, and among those who are not bothered by seeing cigarette butts on the ground. Research suggests that smokers' age and gender may also influence cigarette butt littering. Kolodko and Read (2018) and Schultz et al. (2013) found that age was negatively correlated with littering, while Rath et al. (2012) and Huang et al. (2019) found that males were significantly more likely to litter cigarette butts.

The traditional approach used by public administrations is the regulation of smoking behavior. Regulations are often targeted at reducing smoking in the area (through smoking restrictions or bans) and deterring littering (Alpizar et al., 2020). This mechanism is based on traditional expected utility models (deterrence), which portray individuals as rational decision-makers who carefully weigh the expected costs and benefits (Navarro-Martinez et al., 2018). Patel et al. (2013) mention stronger enforcement of littering laws as one solution, although they are aware of the limits of this approach. However, regulations based on deterring undesirable behavior through orders (and sanctions in the event of non-compliance) necessarily assume administrative capacity to enforce the rules.

The relevance of behavioral science lies in its contribution to understanding the causes of individuals' behavior and finding ways to nudge people to make better decisions. Cognitive limits, social preferences, social norms, and socio-economic factors influence people's behavior. Therefore, nudging is one of the available environmental policy instruments (Carlsson et al., 2021). Chetty (2015) argues that behavioral economics has implications for public policy and public administration. It provides new tools to influence the actions of individuals. These tools are not based on do's and don'ts but on the use of defaults or framing. In addition, behavioral economics can provide better predictions about the effects of existing policies and insights for identifying more effective public policies and measures. The key is to use the methodological apparatus of behavioral science (e.g., experiments) to better estimate the effects of interventions (public policies), not only in terms of effectiveness but also in terms of their impact on the well-being of individuals. We applied this approach with local public administration to tackle cigarette butt littering. Behavioral interventions that aim to decrease cigarette littering include nudging, which refers to a non-coercive method based on a choice architecture that predictably affects the behavior of individuals. Nudge can take many forms and employ various psychological mechanisms. Nudges can thus provide people with better and more comprehensible information, or they can be based on non-informational influences on the decision-making process (Noggle, 2018). In this paper, we explore three specific behavioral insights with low interaction complexity: gamification, salience, and priming.

3 Priming, Salience, Gamification, and Complexity of Interaction

Priming is one of the behavioral insights used to nudge smokers toward socially responsible behavior. Wilson et al. (2016) define priming as subconscious cues that can be physical, verbal, or sensational, and nudge toward a particular choice. Priming can take the form of environmental cues or visual reminders of the proximity of designated smoking areas or trash bins, which can prime individuals to consider the environment and dispose of their cigarette butts responsibly. According to Schultz et al. (2013), the availability and distance between the user and the trash bin need to be considered as relevant factors. Therefore, one possible approach is to make it easier to find trash bins by using priming in the form of footprints leading to litter bins on the sidewalks. This approach has already been tested in several contexts, and the results have shown varying degrees of effectiveness. A 42% reduction in gum litter, which can be similar to cigarette butt litter, was achieved through priming with posters and floor stickers in an experiment conducted in Bristol and Cardiff (Hall and Campbell, 2020). However, the effectiveness varied between sites due to pedestrian traffic, unplanned cleaning, heavy rainfall, and construction works (ibid.). Turner (2018) examined the effectiveness of low-cost interventions, such as reminders about the location of trash bins, at a community golf course. Although the reminders reduced cigarette butt littering, Turner (2018) suggests that the introduction of the trash bins alone was the most effective intervention.

Another strategy used in nudging is to gain people's attention by providing information that increases the salience of gains, losses, or risks. Salience thus refers to the attention-grabbing nature of an individual, making certain choices more prominent, and it can be used to alter behavior (Noggle, 2018). Houser et al. (2021) stress that these stimuli need to be novel, accessible, and easy to understand. Wilson et al. (2016) argue that reactions are elicited primarily through emotional associations in response to the nudge. In this context, novel information related to the toxicity of cigarette butts and their negative impact on the environment can be provided by salience nudge, as drawing attention to this novel information can change the behavior of smokers. Salience can also be used to emphasize cigarette butt littering as a form of anti-social behavior, and its use could increase the likelihood that people will refrain from littering. A strategic placement of visual reminders, such as posters depicting environmental damage caused by cigarette butts near smoking areas, increases the likelihood of proper disposal (Reiter and Samuel, 1980). The trial conducted by Hall and Campbell (2020) indicates that simple reminders at the point of gum littering can have a significant impact on the incidence of littering. In addition, Wallace-Williams et al. (2023) found that social pressures and cognitive factors play a significant role in smokers' behavior, and therefore, priming strategies, such as highlighting the negative social consequences of smoking and promoting a sense of social responsibility, can be effective in nudging smokers towards socially responsible behavior.

Gamification is an intervention that incorporates elements of game design in non-gaming contexts (Bassanelli et al., 2022; AlMarshedi et al., 2017). It is based on research on heuristics, design patterns, and the dynamics of games. Gamification is used to improve user engagement and experience (Bassanelli et al., 2022). In addition, public administrations are increasingly applying gamification as an emerging game-based approach in policymaking and implementation. The attractiveness of this approach stems from its relatively low resource requirements (Hassan and Hamari, 2020). However, it requires the capacity to design systems, services, and processes that provide positive, engaging experiences similar to those of games, as well as the capacity for active analysis, implementation, monitoring of decisions, and maintenance of an applied game (Hassan and Thibault, 2020; Klamert and Münster, 2017). Gamification has been introduced to several areas such as education, habit formation, healthcare, and environmental issues (Koivisto and Hamari, 2019), but also in the context of cigarette butt littering, where gamification is applied to encourage responsible disposal of cigarette butts. Ballot bins that require simple interaction (voting with a cigarette butt) have been tested primarily in a homogeneous environment (colleges) and among homogeneous intervention groups (students) (Kolodko and Read, 2018). An example is the student dormitory in the city of Sibiu in Romania, where on-site littering was reduced by 60% (Selagea et al., 2016). However, according to Pavlovský et al. (2022), the effectiveness of ballot bins is more of a challenge in public spaces with high heterogeneity of visitors.

4 Methodology

To support pro-environmental and pro-social behavior in the public area of Strkovec Lake in Bratislava, Slovakia, a combination of three behavioral mechanisms has been tested – priming, gamification, and salience. Cigarette butt littering is a relevant problem in this public space. The area around Strkovec Lake attracts various groups of visitors, such as parents with children, joggers, hobby fishermen, buffet visitors, and individuals relaxing on benches. Smokers are present in each category, particularly among passersby, buffet visitors, and those relaxing on benches.

Priming, salience, and gamification can be used in behavioral interventions – nudges. The application of these findings may differ in terms of expected social pressure and interaction complexity (Huang et al., 2019). Smokers' behavior can be noticed and judged by other people (pressure), which can incentivize smokers to behave in the desired way. The complexity of the interaction can be low (without immediate feedback) or high (with immediate feedback). We examine the effectiveness of nudges with low interaction complexity – no immediate feedback on behavioral interventions provided to target users.

The effectiveness of low-complexity behavioral measures can be tested using experimental methods (John, 2017). The standard is a randomized control trial, which is not applicable in all cases due to the limited possibility of con-

trolling all relevant variables (John, 2017; Haynes et al., 2012). Therefore, a quasi-experimental method (before-and-after evaluation) is applied.

Four low-level complexity nudges have been designed within two quasi-experiments. There was no direct interaction between researchers and park visitors. These interventions were implemented at two sites in the public space:

- priming smokers to the nearest trash bin with follow-up gamification using ballot bins in the southwestern part of Strkovec Lake, and
- providing salient information about the littering problem with providing follow-up salient information about the toxicity of cigarette butts in the western part of the Strkovec Lake area, around the buffet.

The main research question in both quasi-experiments is the following:

RQ: To what extent do the low-complexity nudges, standalone and in combination, mitigate cigarette butt littering in public spaces?

The quasi-experiments had a pre- and post-test design and were conducted over a period of 11 weeks from 19 July 2021 to 4 October 2021 (see Table 1). Measurements were divided into three main phases: baseline measurements, the first intervention measurements, and follow-up intervention measurements. In total, 22 measurements were made.

Table 1: Overview of Quasi-Experiments and Timeframe

	Baseline	Intervention 1	Intervention 1 and Intervention 2	Intervention Sites
Quasi-experiment 1	-	Priming	Priming and Gamification	the southwestern part of the Strkovec Lake area
Quasi-experiment 2	-	Salience	Salience and Salience	the western part of the Strkovec Lake area, around the buffet
Timeframe	from 19 July to 8 August 2021	from 9 August to 5 September 2021	from 6 September to 4 October 2021	-

Source: authors

4.1 Quasi-experiment 1

The first quasi-experiment was conducted in the southwestern part of Strkovec Lake (see Appendix 1, Figure 2). The area had three benches and a trash bin placed slightly away from the bench area, so smokers had to walk a few steps to dispose of their cigarette butts. We tested the effectiveness of priming and a combination of priming and gamification interventions in reducing cigarette butt litter.

The research sub-questions are as follows:

SQ1: To what extent does priming to the nearest trash bin affect the number of cigarette butts outside the bin?

SQ2: To what extent does gamification, in combination with priming, influence the number of cigarette butts outside the bin?

Hypotheses: We expected that both priming to the nearest bin (H1) and the combination of priming and gamification (H2) would decrease the amount of cigarette butt littering.

The first behavioral intervention – priming – was implemented on 9 August and included the installation of stickers with a number of steps to the nearest trash bin and an arrow showing the direction (see Appendix 2, Figure 3a). The intervention was intended to nudge individuals toward the target behavior by using subconscious cues, which is a typical mechanism of priming (Wilson et al., 2016).

The second intervention, in the form of a ballot bin, represented gamification with elements of game design (Bassanelli et al., 2022). The ballot bin was installed on 6 September near the benches, conveniently located for passersby. The question on the ballot bin asked: ‘Which superpower would you choose?’ Possible answers were ‘invisibility’ and ‘flying’ (see Appendix 2, Figure 3b). We intentionally did not remove the first intervention before installing the follow-up intervention, allowing us to measure the accumulated effect of both during the last phase of the quasi-experiment (see Table 1).

4.2 Quasi-experiment 2

The second quasi-experiment was conducted in the eastern part of Strkovec Lake, covering the area around the buffet. This area had several benches and a high number of trash bins to dispose of waste. Despite that, the area was still polluted by cigarette butts.

The research sub-questions are as follows:

SQ3: To what extent does increasing the salience of cigarette butt littering affect the number of cigarette butts outside the trash bin?

SQ4: To what extent does salient information on the toxicity of cigarette butts, in combination with the salience of cigarette butt littering, influence the number of cigarette butts outside the trash bin?

Hypotheses: We expected that both salient information on cigarette butt accumulation (H3) and the combination of cigarette butt accumulation and toxicity (H4) would decrease the number of cigarette butts outside trash bins.

The first intervention was a salience nudge in the form of a so-called crime scene. The area was taped with barricade tape, and stickers illustrating cigarette butts were placed inside the secured area (see Appendix 2, Figure 4a).

We also installed a plate with the information that this area was cleaned from cigarette butts. We intended to increase the salience of cigarette butt littering and show its accumulation effect.

The second intervention was also a salience nudge. We installed stickers with information on the toxicity of cigarette butt littering (see Appendix 2, Figure 4b). The stickers were placed in front of the benches. Each sticker contained one of two messages: (1) 'Cigarette butts are not natural material, they are toxic waste - it is right to throw them in the trash' and (2) 'Cigarette butts contain up to 140 toxic substances'. Both interventions provided vivid examples and explanations to draw attention to the desired behavior, which is a typical mechanism of salience nudges (Wilson et al., 2016). As in quasi-experiment 1, we deliberately did not remove the first intervention before installing the second one. Therefore, we could measure the combined effect of the crime scene and the salient information on the toxicity of cigarette butts.

4.3 Limitations

Based on a behavioral audit, we selected two locations as the most polluted zones. The first zone includes three benches in the southwestern part of Strkovec Lake. The second zone covers the area around the buffet (see Figure 2 in Appendix 1). We acknowledge that the limited number of data collection locations and the lack of control over visitors and their socio-demographic characteristics are limitations of this research. These factors could introduce bias and impact the validity of our conclusions, but a more controlled experimental design was not feasible. In addition, we argue that both locations – the benches and the area around the buffet – are typically locations where cigarette butt littering occurs. Therefore, the selection of locations should not significantly impact the validity of our findings.

Although we were unable to control the number of visitors or their demographic characteristics, we did control other variables that could affect attendance at the Strkovec Lake area and indirectly the behavior of visitors, such as weather conditions, summer vacations, working days and weekends, social events on the premises, and more (see Table 5 in Appendix 3). Another limitation is that, due to the uncontrolled field design, some participants may have been exposed to both quasi-experiments.

Because of the difficulties in finding a similar location that could serve as a control location, a before-after design was used. This implies that we assumed the baseline period (before intervention) reflects what would have occurred in the absence of Intervention 1. Therefore, our results comparing Intervention 1 to the baseline period should be interpreted with caution, as they rest on the premise that the baseline period accurately represents what would have happened without the intervention.

An additional limitation of this research relates to the implementation of subsequent interventions. When the follow-up interventions were introduced, the initial interventions were not removed. This led to interactions between

interventions and difficulties in isolating the effects of each individual intervention. Furthermore, another limitation is the small number of observations. All measurements were collected over an 11-week period, biweekly, for a total of 22 data collections at both sites. We prioritized the quality of data collection over quantity. Therefore, we closely cooperated with a third-party organization that followed the data collection protocol and collected all data.

5 Results

This part of the article reports the results of the interventions implemented at two sites of Strkovec Lake. At the first site (quasi-experiment 1), we used priming and gamification. At the second site (quasi-experiment 2), we used two variations of salience (highlighting the extent of cigarette butt pollution and its harmfulness to health). First, we report the results for the first site (quasi-experiment 1), and later the results for the second site (quasi-experiment 2).

Two behavioral interventions were implemented at the first site (quasi-experiment 1) after a three-week baseline measurement. The interventions were implemented four weeks apart. The first intervention drew attention to the proximity of trash bins using stickers with the number of steps to the nearest bin and an arrow pointing to it. The second intervention involved installing a ballot bin to nudge the target group toward social behavior using game design elements. The data showed a significant reduction (45%) in the mean number of cigarette butts after the introduction of the first intervention (bin priming). The follow-up intervention (gamification – ballot bin) strengthened the effects of the previous intervention, reducing the volume of cigarette butts outside the trash bin by 53% (see Table 2). It should be noted that extreme values in the number of cigarette butts were observed during the monitoring of the quasi-experiment, which were reflected in the standard deviation values, especially in the baseline and intervention 1 (stickers). These extreme values may have been caused by social events that took place on the days preceding waste collection. At the same time, we controlled for the potential effect of social events in the OLS regression model (see Table 4). The combined effect of both interventions on the amount of cigarette butt pollution on the ground was 74% (see Figure 1).

Table 2: The effects of the Quasi-experiment 1 (stickers and Ballot bin)

	N – number of measurements (data collection)	Mean value (SD) – cigarette butts as unit of measurement
0 – baseline	6	82.5 (66.31)
1 – priming to the nearest bin via stickers	8	45.3 (35.25)
2 – priming with gamification (Ballot bin) (combination)	8	21.4 (5.53)

Source: authors

A one-factor analysis of variance (one-way ANOVA) indicates statistically significant differences in the number of cigarette butts in the southwestern part of Strkovec Lake [$F(2, 19) = 3.95, p = 0.037$]. The Tukey post-hoc test shows that intervention 2 – ballot bin – is statistically significant ($p = 0.029$) only when compared to the baseline (reductions in the mean number of cigarette butts on the ground from 82.5 to 21.4 measurement units), but it is not statistically significant compared to intervention 1. The effect size of the first intervention (stickers) compared to the baseline is meaningful, although not statistically significant. Statistical insignificance may be attributed to a relatively large standard deviation, suggesting that some smokers did not change their behavior. One reason may be that the distance to the nearest bin was perceived by smokers as too long, inconvenient, and requiring too much effort. Consequently, the reminder of the proximity of the bin via the sticker may simply not have been motivating enough.

Table 3: The effects of the Quasi-experiment 2 (Salience – crime scene and toxic waste)

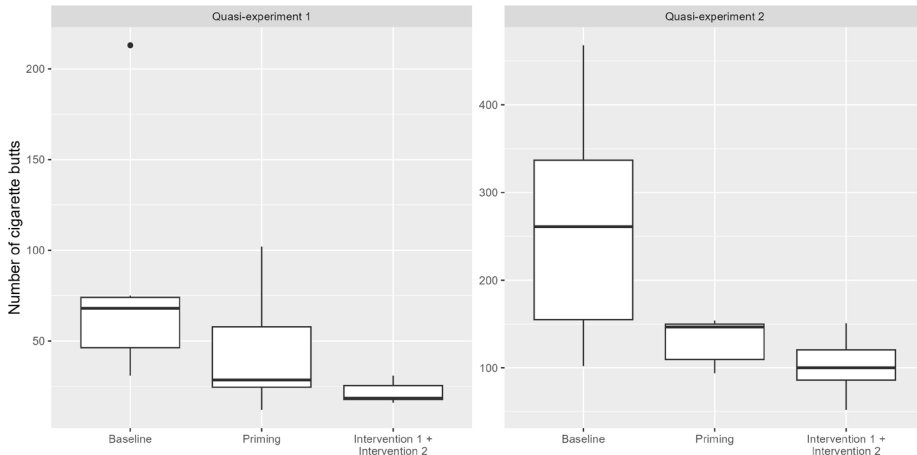
	N – number of measurements (data collection)	Mean value (SD) – cigarette butts as unit of measurement
0 – baseline	6	262.3 (138.7)
1 – Crime scene	8	132.6 (24.34)
2 – Crime scene with Toxic waste (combination)	8	102.4 (34.73)

Source: authors

The other two behavioral interventions were implemented at the second site (quasi-experiment 2) after a three-week baseline measurement period. The first intervention (1) had the form of a crime scene installation designed to draw the attention of smokers to the number of cigarette butts outside the trash bin. The motivation for this intervention was based on the assumption that some smokers do not perceive cigarette butts as litter because of their small size. The second intervention also aimed to draw attention to the toxicity of cigarette butts. The assumption in this case was that some smokers and non-smokers lack knowledge about the toxicity of cigarette butts.

As with the measurements of interventions at the other site (quasi-experiment 1), the data show a large variation in the number of cigarette butts, as indicated by the high standard deviation (SD). This variation was primarily observed in the baseline phase measurements. Since the third-party organization that collected data used identical protocols, the variation due to worker turnover should be negligible.

Figure 1: Reduction of cigarette butts by quasi-experiment 1 and 2



Source: authors

The effectiveness of both interventions was tested against a baseline using a one-way ANOVA test. This test showed that the differences in the mean number of cigarette butts on the ground were statistically significant [$F(2, 19) = 8.31, p = 0.003$]. The Tukey post-hoc test shows that in both cases, the changes are statistically significant from baseline (intervention crime scene vs. baseline ($p = 0.013$); intervention toxic waste vs. baseline ($p = 0.003$)). After the introduction of the first intervention (crime scene), the mean number of cigarette butts was reduced by 130 units (50%). The follow-up intervention (toxic waste) increased the effects of the previous intervention by 26% in reducing the volume of cigarette butts on the ground by 30 cigarette butts (see Table 3). However, this difference is not statistically significant according to the Tukey post-hoc test. In sum, after the implementation of the second intervention, the number of cigarette butts on the ground decreased by 160 units of measurement compared to the baseline (61%), and this difference is statistically significant.

A separate model (see Table 4) was calculated for each zone (quasi-experiment). Linear regression indicates that in both quasi-experiments, none of the control variables (temperature, rainfall, wind, level of COVID-19 restrictions, school holidays, cultural events, and weekends) significantly influenced littering – the number of cigarette butts ($p > 0.05$). In the first quasi-experiment, the first intervention (priming to trash bins) reduced the number of cigarette butts by 70 in comparison to the baseline, and the effect is statistically significant ($p < 0.05$). The follow-up intervention (ballot bin) also indicates a statistically significant effect size, with a reduction of almost 130 cigarette butts compared to the baseline. The first intervention (salience – crime scene) in quasi-experiment 2 reduced the number of cigarette butts by 195 compared to the baseline, and the effect is statistically significant ($p < 0.01$). When comparing the effect of the follow-up intervention (salience – toxicity) to the base-

line, the effect size in the reduction of cigarette butts was meaningful (-162), but smaller compared to the first intervention, and was not statistically significant. In other words, we do not see any boosting effect but quite the contrary, there is a possible backfiring effect. The explanatory power of both models ranges from 0.13 to 0.36, which means that the models explain 13% and 36% of the variance in the dependent variable (mean number of cigarette butts). However, it is important to note that the number of observations for both studies is limited to 22 (11 weeks of measurement). In summary, these results show that the first interventions (priming and salience) reduced littering and the effects are statistically significant, while we do not have solid evidence that follow-up interventions significantly improved the behavior of smokers.

From both models, we also created nested models without any control variables, so they contained only the number of cigarette butts as the dependent variable and the interventions as the independent variables. The nested models fit as well as the original models in the case of quasi-experiment 1 [$F(7,12)=0.72, p=0.66$] and quasi-experiment 2 [$F(7,12)=0.78, p=0.61$].

Table 4: Linear regression

Outcome: number of cigarette butts	Zone 1 (Quasi-experiment 1)			Zone 2 (Quasi-experiment 2)		
	Estimate	Standard error	CI (2.5% - 97.5%)	Estimate	Standard error	CI (2.5% - 97.5%)
(Intercept)	221.960	146.967	-98.253 – 542.173	706.105*	272.046	113.367 – 1298.842
Intervention 1 (priming) – Baseline	-70.178*	29.0895	-133.559 – -6.797			
Intervention 2 (Ballot bin and priming) – Baseline	-129.705*	55.664	-250.986 – -8.424			
Intervention 1 (salience – crime scene) – Baseline				-195.070**	53.847	-312.392 – -77.748
Intervention 2 (toxicity and crime scene) – Baseline				-161.578	103.038	-386.078 – 62.923
Temperature	-4.963	4.483	-14.730 – 4.804	-8.277	8.298	-26.356 – 9.803
Rainfall	-0.214	1.014	-2.422 – 1.995	0.877	1.876	-3.211 – 4.965
Wind	-1.567	2.787	-7.640 – 4.505	-9.707	5.159	-20.947 – 1.534
COVID-19 Restrictions	-25.007	35.472	-102.294 – 52.280	-42.938	65.661	-186.002 – 100.126
School holiday – no school holiday	48.666	60.244	-82.594 – 179.927	-77.237	111.516	-320.209 – 165.736
Cultural events – no cultural events	26.192	25.834	-30.095 – 82.478	24.138	47.820	-80.052 – 128.328
Weekend – workday	3.192	23.083	-47.100 – 53.485	-28.048	42.728	-121.143 – 65.048
N	22			22		
R / adj. R ²	0.502 / 0.128			0.634 / 0.36		
AIC	236.183			263.277		

Source: authors

Note: Reference groups for each categorical (nominal scale and ordinal scale) variables: *School holiday* – no school (summer) holiday; *Cultural events* – no cultural events in or nearby the area; *Weekend* – workdays (from Monday to Thursday; *Intervention 1 (priming or salience – crime scene)* – Baseline; *Intervention 2 (Ballot bin or salience – toxicity)* – Baseline; *COVID-19 measures/restrictions* – the scales/colors on the COVID-19 automat (from green to red) that indicate the severity of the measures (ordinal scale). Variables Temperature, Rainfall, Wind are numeric (*continuous*). Significance codes: < 0.001 '***', < 0.01 '**', < 0.05 '*'.

6 Discussion

Low-complexity interventions can effectively nudge against cigarette butt littering, but most importantly, combining them does not necessarily lead to a significant increase in positive effects. Although the overall effects after two interventions in both quasi-experiments delivered positive results in terms of reducing cigarette butts compared to the baseline, the follow-up interventions did not statistically significantly reduce cigarette butt litter when compared to the first interventions in both quasi-experiments. In other words, both follow-up interventions demonstrated positive effect sizes in reducing cigarette butt litter, but the effects were not statistically significant in comparison to the first interventions. The findings show that nudges can effectively complement traditional public policies in smoking and littering regulation. In addition, the study suggests that local public administrations do not need to implement multiple behavioral interventions, but one can be enough.

The non-significant boosting effects of the follow-up interventions that accompanied the first interventions are nonetheless not surprising, since the effectiveness of both first-installed low-complexity nudges might have crowded out the potential effectiveness of the follow-up interventions. The positive change in the site's cleanliness after the first interventions may have stimulated a contextual impression of cleanliness that can, according to Tehan et al. (2017), reinforce non-littering behavior.

In the first quasi-experiment, the sticker informing and navigating (priming) to the nearest trash bin reduced cigarette butt littering by 45%. This result may be due to making butt disposal cognitively cheaper, hence more accessible, and thus more likely to be acted upon by cognitive misers (Stanovich, 2009) and those relying on what Kahneman (2013) labeled as System 1 automatic thinking. By including the information '10 steps to the nearest bin', the intervention aimed to influence the perceived effort needed to dispose of the cigarette butt in the bin. Although the effect of the sticker intervention is meaningful, we have mixed evidence on its significance. The regression model shows that the effect is statistically significant, while the ANOVA test does not. In other words, the results suggest that the deviation within the groups (interventions) is relatively high, complicating the decision on whether the groups differ significantly from each other. Hence, we are not able to rule out the possibility that priming (Hertwig and Grüne-Yanoff, 2017), the message about the proximity of the nearest bin, has limited effectiveness in changing smokers' behavior. Information about the proximity to the nearest trash bin may not be sufficient to change littering behavior because some smokers may be aware (Bazerman and Moore, 2012) of other facts about the consequences of littering that may influence their decision. The effect of the priming intervention can be limited because, for some smokers, the information about the distance to the nearest trash bin may have made littering less effortful, which is something future research in this area could focus more on.

The purpose of the follow-up nudge (ballot bin) that complemented the first nudge (priming) in the first quasi-experiment was to test whether friction

against the desired cigarette butt disposal might be caused not only by mental but also by physical effort. To make this physical effort less important, and therefore decrease the perceived costs of the desired cigarette butt disposal behavior (Huang et al., 2019; Schultz et al., 2013), we added new infrastructure to the area – the ballot bin. Although the reduction in the number of cigarette butts is of meaningful size, the improvement by the ballot bin is not statistically significant compared to the navigation stickers. However, the combined effect of both interventions reduced cigarette butt litter from cigarette butts by 74% compared to the baseline, and this change was statistically significant. We used a neutral question on the ballot bin ('Which superpower would you choose?'), and we did not change this question during testing. Using the question about superpowers was an attempt to avoid loaded language in order not to confound measurements by adding an extra intervention.

In the second quasi-experiment, both salience low-complexity nudges demonstrated meaningful effect sizes, but only the first installed crime scene intervention was consistently significant across our analyses. Increasing the salience of cigarette butt littering by crime scene reduced the number of cigarette butts outside the trash bins by 50%. The effectiveness of the crime scene intervention can be attributed to its attractive design. Altering the choice architecture by adding infographics might have effectively signaled (Krijnen et al., 2018) that someone cares about the site and might be watching, thus creating a form of psychological costs in the form of distress from being observed and possibly socially or otherwise punished. Furthermore, smokers might not have realized (due to the bounded awareness (Bazerman and Moore, 2012)) that they are in fact causing such a serious problem until somebody made the problem salient. The crime scene nudge thus influenced their decision-making (Hertwig and Grüne-Yanoff, 2017) by directing their attention to overlooked information about the existence of a problem. Moreover, the crime scene nudge not only made the existence of the problem salient but also personalized the problem for that particular location by making it clear that this is the place where the problem occurs.

The follow-up toxicity nudge that complemented the first nudge (crime scene) aimed to help smokers realize an important and often overlooked aspect of their habitual (Rath et al., 2012) and automatic (Jager, 2003) behaviors. By making the harmfulness of the butts salient, the intervention highlighted that cigarette butts are toxic waste. Although the follow-up combined (toxicity and crime scene) intervention had a generally positive effect size, it did not statistically significantly reduce cigarette butt littering. Intervening in an area with a relatively low volume of cigarette litter may have weakened the potential effectiveness of the follow-up intervention.

The first installed interventions reduced the litter by almost half in both quasi-experiments. Therefore, the significant effects of the first interventions may have created an impression of the cleanliness at the site, which according to the assertion of Tehan et al. (2017), correlates with the likelihood of additional litter. The findings suggest that the first nudge limited the potential of the

follow-up nudge. In contrast to meta-observations from other environmental policy domains, namely pro-energy conservation nudging studies (Byerly et al., 2018; Delmas et al., 2013), observations from our quasi-experiments suggest that using a single behavioral intervention may be sufficient to achieve the desired behavioral change, while reinforcing it with a follow-up intervention after a short period of time may not yield any additional statistically significant effects.

7 Conclusions and Recommendations

This research contributes to the literature on low-complexity nudges and the effectiveness of nudging in waste reduction. It also contributes to the public administration literature from the perspective of applying nudging in public policy problems. The findings suggest that using a single behavioral intervention may be sufficient to achieve the desired behavioral change and that efforts to further strengthen the results by additional follow-up intervention may not produce statistically significant improvement compared to the first intervention. Research indicates that if a follow-up intervention is implemented within a short period after the first intervention (4 weeks), the first intervention may crowd out the potential of follow-up behavioral intervention.

This article provides three practical recommendations for public administration organizations and public policies. First, the insights gained from this research can inform broader public service management strategies. Specifically, the low-complexity nudges tested could be adapted to address forms of unhealthy and unecological behaviors, such as general or cigarette butt littering. Public administrations could implement nudges that incorporate insights on priming, salience, and gamification to promote healthier and more environmentally friendly behaviors among smokers as well as the general public. The local public administration may focus on implementing and maintaining one behavioral intervention, possibly replacing it with another only after a few months when the positive effects of the original intervention begin to fade.

Second, the implementation of any intervention requires careful planning of data collection to evaluate its effectiveness. Collecting reliable data is a challenge in field (quasi-)experiments in waste management, especially when multiple stakeholders from within and outside the public administration (or non-profit organizations) are involved. Given the length of time needed to measure and evaluate the impact of the intervention, there may be short periods when members of the municipality's community service department are on vacation in large numbers, which can jeopardize the continuity of the measurements. Therefore, it is important to develop data collection protocols and have a backup plan, such as working with volunteers or third-party organizations.

Third, the condition of installed interventions needs to be monitored, as they can be damaged by weather conditions or human activities. The intervention must be repaired as soon as damage occurs. In addition, public administration

representatives may be interested in presenting and publicizing the cooperation in local media and on social networks. However, media coverage of the intervention and its intent can significantly affect the results, and therefore, it is important that the collaborating organization maintains confidentiality throughout the implementation of the quasi-experiment. Any type of media coverage can endanger the validity of measurements and bias the results.

There are not many field (quasi-)experiments with rigorous measurement of low-complexity interventions in this area. One of the reasons for the low number of similar studies is the difficulty in implementing and measuring nudges in public spaces with a high degree of heterogeneity among visitors. In these quasi-experiments, we had two data collection locations and no control over the visitors and their socio-demographic characteristics. Both selected locations (benches and the area around the buffet) are typically locations where cigarette butt littering occurs. However, future research should consider a larger and more diverse set of locations to validate these findings further.

Acknowledgment – *This work was supported by the Slovak Research and Development Agency under the grant (APVV-18-0435) Behavioral Interventions in Local Government: Increasing the Efficiency of Local Public Policies.*

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Appendix 1

The two most polluted zones were identified at Strkovec Lake (see Figure 2). The first site contains three benches in the southwestern part of Strkovec Lake. The second site covers the area around the buffet. Strkovec Lake, including both targeted zones, is an open and easily accessible area without any specific entry points or fences to restrict access.

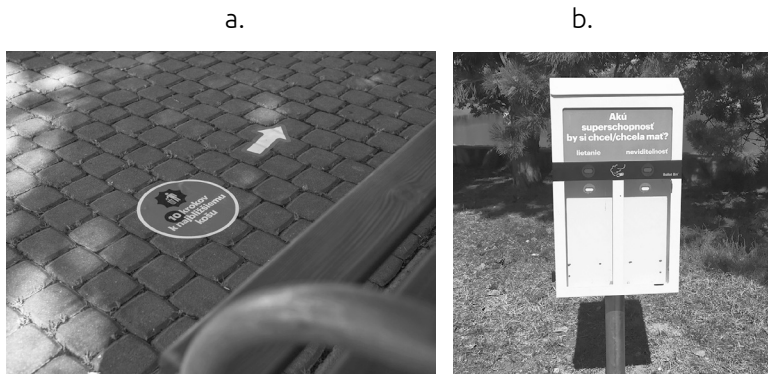
Figure 2: Sites of interventions in quasi-experiments on Strkovec Lake



Source: authors, based on OpenStreetMap and Leaflet package in R (Cheng et al., 2024)

Appendix 2

Figure 3: Quasi-experiment 1 – (a) arrows to the nearest bin and (b) ballot bin



Source: authors

Figure 4: Quasi-experiment 2 – crime scene (a) and information on toxicity (b)



Source: authors

Appendix 3

Table 5: List of Variables Used in both Quasi-Experiments

Variable	Description
Number of cigarette butts	Dependent variable Numerical
Priming	Independent variable Dummy 1 – Intervention, 0 – Baseline
Priming + Gamification	Independent variable Dummy 1 – Intervention, 0 – Baseline
Salience (crime scene)	Independent variable Dummy 1 – Intervention, 0 – Baseline
Salience (crime scene) + Salience (toxicity)	Independent variable Dummy 1 – Intervention, 0 – Baseline
Temperature	Control variable Interval
Rainfall	Control variable Numerical
Wind	Control variable Numerical
COVID-19 restrictions	Control variable Ordinal 0 – monitoring 1 – Watch I Slovakia's "COVID Automat" Traffic Light System that indicates severity of restrictions. It included 7 levels in ascending order (monitoring, watch I, watch II, warning I, warning II, warning III, warning IV). However, during the data measurements in Bratislava, only two of these levels were implemented.
School holidays	Control variable Dummy 1 – Yes, 0 – No
Cultural events	Control variable Dummy 1 – Yes, 0 – No
Days of the week	Control variable Dummy 1 – Fri, Sat, Sun 0 – Mon, Tue, Wed, Thu

Source: authors

Note: The variables "Priming" and "Priming and Gamification" apply only to quasi-experiment 1, while the variables "Salience" and "Salience and Salience" apply only to quasi-experiment 2.