



Can “Nudging” Play a Role to Promote Pro-Environmental Behaviour?

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ABSTRACT

Rising environmental issues are now a global concern, in part due to human behaviour which is generally not environmentally friendly in doing daily living activities such as littering, excessive vehicle use, wasteful resources consumption, combustion of fossil fuel, consume non-recyclable product and consume non-organic product. An emerged behavioural change approach known as “nudging” offers an insight to promote pro-environmental behaviour amongst people by influencing people’s decisions with choice architecture. This paper aims to review the status quo of pro-environmental context in nudging for behaviour change and the nudging techniques that are available for selection to promote pro-environmental behaviour. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework was adopted in this review. A total of 37 eligible articles were identified from acknowledged databases, Web of Science (WOS) and SCOPUS for inclusion of review. This review found that the majority of nudging studies show positive effects in nudging the targeted behaviour of people and demonstrate that the nudging technique has great potential to influence pro-environmental behaviour. Furthermore, this review presented seven types of nudging techniques (prompting, sizing, proximity, presentation, priming, labelling, functional design) which can be adopted for pro-environmental purposes. This paper provides an insight for pro-environmentalists and stakeholders into the usefulness of the nudging approach and how it can be applied in pro-environmental context. The concepts of implementation and recommendations for each nudging technique are described in this paper.

1. Introduction

Environmental issues and degradation such as climate change, air pollution, energy shortage and improper waste management are topics that have caused concern and debate around the globe (Osbaldiston and Schott, 2012; Kharat et al., 2017). It has gained the attention of numerous governments, as well as non-government organisations, to urge for environmental protection and conservation (Schanes et al., 2018; Martínez-Españeira et al., 2014; Revell, 2013; Lokhorst et al., 2013). The occurrence of environmental issues is in part due to human behaviour which is not environmentally friendly in daily routines such as littering, excessive vehicle use, wasteful energy consumption, wasteful water consumption, combustion of fossil fuel, consume non-recyclable product and consume non-organic product (Lehman and Geller, 2004; Stern et al., 2016; Ari and Yilmaz, 2017). Many people may not be aware that human behaviour is a contributing factor for the rising environmental issues because the impacts resulted from behaviour are usually non-immediate and only apparent over time, for instance ozone hole, accumulation of greenhouse gases in the atmosphere and loss of species (Kollmuss and Agyeman, 2002).

Human behaviours, in fact, have considerable impacts on the environment. However, the level of the impacts, either high or low, is de-

pendant on people’s choices of decision in relation to the activities. Such activity choices are as simple as: printing - print on double-sided pages or single-sided pages (Egebark and Ekström, 2016); eating - eat more vegetables or more meats (Kurz, 2018); purchasing - purchase organic products or non-organic products (Becchetti et al., 2020) / purchase energy-saving product or non-energy saving product (Zhao et al., 2019); travelling - car sharing or driving alone (Amatuni et al., 2020); trash disposing - dispose separated waste or non-separated waste (Xu et al., 2021; Zhang and Wang, 2020); shopping - shop with reusable bags or single-use plastic bags (Bharadwaj et al., 2021; Van Rensburg et al., 2020); and so on. People’s decisions on how to execute such activities determine the impacts and consequences for the environment. For instance, the decision to print double-sided pages can help to reduce paper consumption and subsequently help to save more trees from paper production; purchasing energy-saving products can help to reduce energy consumption and conserve more energy resources than non-energy-saving products; practising waste separation before disposal can help to reduce landfills and protect the natural environment from pollution and degradation.

Considering that environmental issues are mainly rooted in human behaviour, facilitating behaviour change amongst people towards pro-environmental behaviour is necessary for the protection of the environment (Staats, 2004; Reddy et al., 2017). Pro-environmental behaviour is

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a behaviour that yields little or no harm to the environment and which also benefits the environment (Steg and Vlek, 2009). It is a behaviour that aims to protect and develop a healthy environment (Kharat et al., 2017). Moreover, pro-environmental behaviour is also a sustainable behaviour that working on one of the three pillars for sustainable development which is environmental sustainability, to conserve natural resources and protect ecosystems to ensure long-term viability of current and future generation on this planet (Ones et al., 2015). Environmental degradation could, therefore, be reduced when people engage with increased pro-environmental behaviours (Balundé et al., 2019). Nevertheless, in daily life, people tend to make choices, and might forget their goals when making decisions (Weßel et al., 2019). People mainly rely on either “System 1” thinking or “System 2” thinking when making decision (Kahneman, 2003). “System 1” provides quick and automatic response, whereas “System 2” provides slow and effortful response. “System 1” requires less efforts to think about the problem in-depth and it is usually emotionally charged compared to “System 2” which is effortful and deliberately controlled. Most people tend to decide and respond promptly in daily living activities such as eating, purchasing, consuming, disposing and so on, where “System 1” thinking used to take place and quickly suggest a decision to people for action. With “System 1” thinking mode, people might forget what they should do and simply make decisions for their behaviour based on their emotion and preference at that moment in time. In such circumstance, a behavioural change approach can help to influence people to make the desired decisions and facilitate behaviour change, which is “nudging” (Weßel et al., 2019).

Nudging was introduced in 2008 by Richard Thaler and Cass Sustein, and defined as “any aspect of the choice architecture that alters people’s behaviour in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and cheap to avoid. Nudges are not mandates. Putting fruit at eye level counts as a nudge. Banning junk food does not.” (Thaler and Sustein, 2008). Meanwhile, the “choice architecture”, mentioned in the definition, refers to the “environment in which individuals make choices” (Thaler and Sustein, 2008). In 2017, the founder of nudge, Richard Thaler, won the Nobel Prize in Economics for his contribution in developing nudge to change public behaviour.

Nudging is an approach that changes people’s behaviour by altering the decision-making environment in order to influence people’s decisions when choosing on what to act. Its implementation has to be easy, cheap and not mandatory (Thaler and Sustein, 2008). Nudging influences people’s choice of actions without limiting their options or enforcing rules and regulations. Instead, it guides people in a desired direction when making decisions by erecting cues in the environment (Weßel et al., 2019). Without depriving any existing options, people’s decisions can be improved by making changes on how the desired options are presented to them within the context (Schmidt and Engelen, 2020). Apart from that, nudging should not significantly change the financial situation of people before and after the nudging. These incentives or advantages could be in terms of time, trouble, social sanctions and monetary (Hausman and Welch, 2010).

Nudging has been recognised as effective policy tool to align intention and action in facilitating behavioural change amongst public (Momsen and Stoerk, 2014). Several governments and organisations around the world such as The Behavioural Insights Team in UK and Dominican Republic’s tax authority have adopted nudging approach to improve their public policies in relation to environment, health, education, tax, etc. (Behavioural Insights Team, 2021; Holz et al., 2020). Moreover, nudging has gained the support and recommendation of several researchers in promoting pro-environmental behaviour change (Karlsen and Andersen, 2019; Lehner et al., 2016; Sunstein, 2014). To apply nudging in promoting pro-environmental behaviour change amongst people, it is necessary to understand nudging techniques and its implementation to ensure optimal effects. However, it was found that there is lack of literature that specifically review nudging techniques and propose for pro-environmental context. Most of the reviews on nudging

topic for promoting behavioural change were found in health-related contexts such as healthy dietary behaviour (Cesareo et al., 2021; Laiou et al., 2021; Marcano-Olivier et al., 2020; Harbers et al., 2020; Broers et al., 2017; DeCosta et al., 2017; Nørnberg et al., 2016; Bucher et al., 2016; Arno and Thomas, 2016), healthy lifestyle behaviour (Laiou et al., 2021; Landais et al., 2020; Ledderer et al., 2020) and healthcare behaviour (Nwafor et al., 2021; Wang and Groene, 2020; Yoong et al., 2020; Möllenkamp et al., 2019). Whereas, for nudging pro-environmental behaviour, only one review was found, which was the review by Byerly et al. (2018). Byerly et al. (2018) focused to investigate the evidence that encourages the utilisation of nudging approach in promoting pro-environmental behaviour, rather than investigate what are the available nudging techniques and how could the nudging techniques be utilised. Such study is useful to provide insight into the overall performance of nudging in promoting pro-environmental behaviour; nevertheless, how to apply nudging is remained unclear. Moreover, another review by Ferrari et al. (2019) in relation to nudging for improving environmental impact offers similar insight where the review was aimed to investigate the effectiveness of the nudging and focused on sustainable food consumption behaviour only. Thus, the following research questions were raised for nudging pro-environmental behaviour.

- RQ1: What is the status quo of pro-environmental context in nudging for behaviour change?
- RQ2: How can nudging be used to promote pro-environmental behaviour?
- RQ3: What is the overall effectiveness of nudging and what are the factors affecting its effectiveness?

To address above research questions, this paper aims to review the status quo of pro-environmental context in nudging for behaviour change and the nudging techniques that are available for selection to promote pro-environmental behaviour. This paper is expected to contribute to the existing literature by filling the literature gap of limited review on different nudging techniques and their application for promoting pro-environmental behaviour. Furthermore, a new insight would also be provided to the policymakers and practitioners on the applicability of nudging approach and how to use nudging techniques to promote pro-environmental behaviour change amongst the community. The remainder of this paper is structured as follows: Section 2 explains the research methodology adopted in this review; Section 3 presents the results of review process; Section 4 discusses on the findings of the review in accordance to the research questions; and lastly, Section 5 summarizes the conclusions and recommendations drawn from this review.

2. Research Methodology

To achieve the research objectives in this paper, a systematic review was conducted. This review focused on the articles that explicitly described nudging as their research subjects. This study adopted the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guideline (Moher et al., 2009) as the fundamental framework for collecting data and reporting the review process. PRISMA is a reporting guideline that guide the authors to report the results of systematic review and address the issue of suboptimal reporting in a review. PRISMA and other guidelines such as CONSORT (Consolidated Standards of Reporting Trials) (Schulz et al., 2010) and STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) (Von Elm et al., 2014), are widely adopted in medical research for observational data reporting. However, PRISMA is not limited to medical research, it is also applicable to other research areas to improve the reporting of systematic reviews and meta-analyses (Moher et al., 2009). It has been adopted by several researchers as a guideline to report the review of nudging approach to promote behaviour change (Landais et al., 2020; Wang and Groene, 2020; Yoong et al., 2020; Broers et al., 2017; Arno and Thomas, 2016; Wilson et al., 2016). There were several phases involved in the review process, namely identification of article, duplicate

screening on article, eligibility assessment on article, inclusion and exclusion of article. The review process will be explained in the following section.

2.1. Data Collection

This study was initiated with a literature search, conducted in October 2020, to collect the relevant articles. The literature search for this paper was carried out with the two most acknowledged electronic databases, namely Web of Science and SCOPUS (Silva et al., 2020; Vecchio and Cavallo, 2019). The search string of **Nudge* AND *Behaviour Change* OR *Nudging* AND *Behaviour Change** were applied to the electronic databases, with the time limit on the latest 5 years of publications, from year 2016 to year 2020. The 5 years limit was determined in accordance to the study by Ferrari et al. (2019) where their finding highlighted that nudging for sustainable purpose is a relatively new field and most of the studies were published after 2016. Furthermore, the systematic review on nudging done by Vecchio and Cavallo (2019) applied the 3 years limit in identifying the eligible studies. Hence, the 5 years limit applied in this review was acceptable. Also, manual searches were done on the reference lists of the databases identified articles to trace additional articles that met the review criteria.

Prior to the literature search process, inclusion and exclusion criteria were outlined to guide the researchers in identifying the relevant articles from the large databases for inclusion in this review. The inclusion and exclusion criteria were adapted from Johnson et al. (2017) where the researchers conducted systematic review on concept of gamification and serious games in energy conservation behaviour context and included the criteria of full peer-reviewed papers that explicitly stated gamification or game elements, described outcomes relating to energy conservation, involved empirical research, and explained research methodology, in determining the eligible papers for the review.

Thus, the papers that fulfilled the following inclusion criteria (ICs) were included in this review:

- IC1. Full papers (including full conference papers) published in latest 5 years (2016–2020)
- IC2. Written in the English language
- IC3. Explicitly stated and described nudging as the research subject and design strategy
- IC4. Clearly stated and described nudging intervention
- IC5. Empirical research that conducted field experiments to examine the impact or effectiveness or nudging

The papers that fulfilled at least one of the following exclusion criteria (ECs) were excluded:

- EC1. Papers published before 2016
- EC2. Written in a language other than English
- EC3. Short papers (1–4 pages, e.g., extended abstract or research in progress)
- EC4. Mentioned nudging but not as part of the research being conducted
- EC5. Presented based on a prototype or framework or proposal or concept
- EC6. No empirical data

The duplicated articles from the two electronic databases, Web of Science and SCOPUS, were removed from the data group.

2.2. Data Analysis

All the articles searched from the electronic databases with the targeted search string were subjected to a few layers of eligibility assessments based on the PRISMA framework to determine the eligible articles for inclusion in this review. It is worth noting that, in this paper, all the eligible articles reported on empirical studies where field experiments had been conducted.

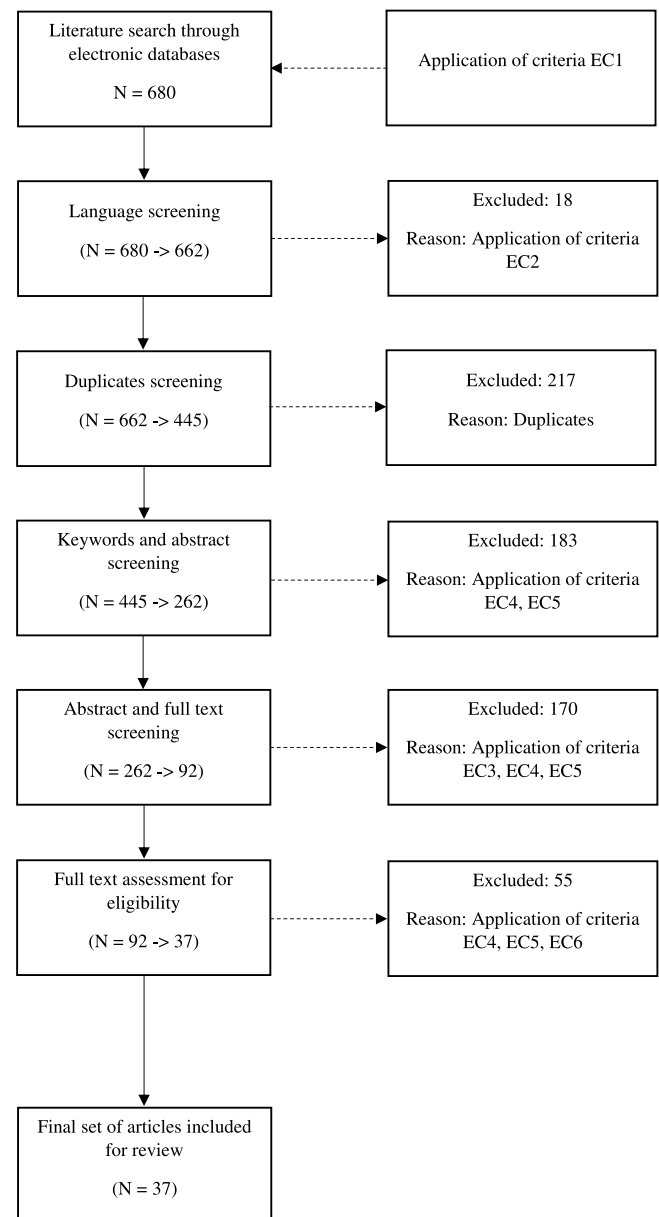


Fig. 1. Review process based on PRISMA framework.

This review adopted content analysis method to analyse the eligible articles in this paper. Content analysis is a widely used qualitative analysis method and is useful to analyse text data (Hsieh and Shannon, 2005). It helps to transform a large amount of text data into organised and concise key findings in accordance to the research objectives (Erlingsson and Brysiewicz, 2017). In this review, the content analysis was performed independently by two authors who have experience in analysing text data with content analysis method. Any discrepancies in the results analysed by the two authors were resolved through discussions.

3. Results

The reviewing process based on the PRISMA framework is presented in Fig. 1. There was a total of 680 articles found from the Web of Science and SCOPUS databases with the application of search string and time limit on the latest five years, 2016–2020. The inclusion and exclusion criteria were applied when assessing the eligibility of the articles. The review process was started with language screening. 668 articles

traced from the electronic databases were subjected to language screening, where 18 articles published in a language other than English were removed. 217 articles were removed from the record during duplicates screening, leaving 445 non-duplicated articles for further eligibility assessments. The 445 non-duplicated articles were screened for their keywords and abstracts for the first layer of assessment to remove unfit articles by applying the inclusion and exclusion criteria as determined in the earlier section. A total of 183 articles were removed in keywords and abstract screening. The remaining 262 articles went through another round of assessment – abstract and full text screening – to determine their relevance to the purpose of this paper. The application of criteria EC3, EC4 and EC5 removed 170 articles from the record. A total of 92 articles were subjected to in-depth full text assessment to determine their eligibility for inclusion in this review. During this full text assessment stage, every article was assessed repeatedly to understand and confirm their contents. In the end, there were a total of 37 eligible articles included for review in this paper.

Table 1 presents the review table for the eligible articles. All eligible articles were reviewed and analysed based on the inclusion criteria and research questions of this paper. The review outcomes were tabulated in Table 1 with the findings on the author(s), area of interest, objective of the study, the adopted nudging technique(s), data collection method(s) and result(s) from all eligible articles. In this review, the studies would be deemed to report effective result (+) if the authors reported significant positive effects; mixed effective result (~) if the authors reported both significant positive and no effects under different settings; or ineffective result (-) if the authors reported no significant positive effects.

4. Discussion

The findings of this paper are organised into three sub-sections based on the research questions formulated in this paper for discussion. The following sub-sections present the discussions involved.

4.1. What is the status quo of pro-environmental context in nudging for behaviour change?

The review of the included nudging articles in this paper revealed that 37.84% of the nudging studies were focused on the pro-environmental context. The adoption of nudging approaches in a pro-environmental context covered the purposes of waste reduction, waste recycling, energy conservation, sustainable consumption, water conservation, and sustainable travel. Conversely, 62.16% of nudging studies were in a non-pro-environmental context, such as healthy consumption (Kanchanachitra et al., 2020; Schindler-Ruwisch and Gordon, 2020; Venema et al., 2020; etc.), hand hygiene (Grover et al., 2018; Naluonde et al., 2019; Dreibelbis et al., 2016; etc.), healthy activity (Van der Meiden et al., 2019; Venema et al., 2018), healthcare (Huf et al., 2020), product sales (Broers et al., 2019) and safety transport (Namazu et al., 2018). Fig. 2 shows the adoption of nudging in pro-environmental and non-pro-environmental contexts.

Amongst the nudging studies applied in a pro-environmental context, waste reduction and waste recycling are the two purposes that gained the most interest of the nudging researchers, which was approximately 18.92%. Waste management is a challenging task for many authorities across all cities (Abdel-Shafy and Mansour, 2018). Increasing waste generation by humans has resulted in several negative environmental impacts, including, but not limited to, the common issues of pollution, increased demand of landfills and a scarcity of resources. In the U.S., 20 million tons of wood are needed to support the usage of 5 million metric tons of paper usage amongst office workers annually, and it was estimated that by reducing this consumption by 5%, 6.5 million trees could be saved, 6500 acres of forest could be freed up for other purposes, and a large amount of greenhouse gas emissions could be prevented annually (Egebark and Ekström, 2016). Thus, to reduce paper waste, Chakravarty and Mishra (2019) adopted the nudging

approach to promote paper waste reduction amongst individuals in the workplace. Furthermore, nudging has also been adopted for dealing with food waste issues, whereby nudging interventions have been implemented in restaurants in efforts to reduce food waste amongst consumers (Vermote et al., 2018; Jagau and Vyrastekova, 2017). To manage waste on the floor in China's workplaces, a gold coin illustration image has been used to nudge the workers to keep the floor clean (Wu and Paluck, 2018). Undoubtedly, the promotion of the reduction in waste generation is important to protect the environment, but what individuals should do with the generated waste is also another concern of researchers. Several studies have adopted the nudging approach to promote waste recycling amongst individuals (Linder et al., 2018; McCoy et al., 2018; Shearer et al., 2017).

The adoption of the nudging approach is not limited to the context of waste management, but also to the energy conservation context (Cappa et al., 2020; Agarwal et al., 2017). An informational nudge, in the form of feedback information, was used by Cappa et al. (2020) in an energy-demand management project. Meanwhile, in a "Project Zero Carbon" programme for primary and secondary schools by the National Environment Agency, Singapore, school children were treated as the medium to nudge their households to reduce electricity usage by 10% or more at home (Argawal et al., 2017).

Looking further, food production has a non-negligible effect on the environment, especially in terms of the impact of greenhouse gas emissions throughout the production process (Dai et al., 2020). Sustainable consumption has started to gain the attention of pro-environmental practitioners and was defined as, "the use of goods and services that respond to basic needs and bring a better quality of life, while minimising the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardise the needs of future generations", during the Oslo Symposium 1994 (Baker, 1996). For the sake of the environment, consumers had started to be nudged towards sustainable consumption, where they were nudged to select organic products (Becchetti et al., 2020), more sustainable meat (Coucke et al., 2019), and vegetarian foods (Kurz, 2018) for their daily consumption. Different food types do in fact contribute to different levels of greenhouse gas emissions during production and, therefore, have different levels of impact on the environment. Choosing the food types which are more environmentally friendly can thus help to mitigate the greenhouse effects.

Other than that, the adoption of the nudging approach in a pro-environmental context has also been extended to the purposes of water conservation and sustainable travel. Bhanot (2018) reported on the implementation of the nudging approach by a California-based firm during a campaign to encourage water conservation behaviour amongst the 45,866 households in both cities and towns. Such campaigns have provided solid evidence on the usefulness of the nudging approach in encouraging water conservation. Meanwhile, sustainable travel is another behaviour that should not be neglected in the effort to protect and conserve the natural environment from damage. Different travel methods yield different environmental impacts. For instance, walking and cycling are more environmentally friendly than car driving. Nevertheless, for long-distance travel, where walking and cycling are not practical, people can in fact opt for carpooling or public transport rather than driving alone. The fewer the number of running vehicles, the fewer the greenhouse gas emissions. Riggs (2017) reported that the nudging approach was adopted on campus to influence the decisions of various campus constituencies for their campus transportation choices.

Combining the above, it could be seen that the nudging approach has started to gain recognition amongst pro-environmentalists as a means to foster and encourage pro-environmental behaviour amongst individuals. Its adoption in a pro-environmental context may not be as popular as in a non-pro-environmental context, and especially so in a health-related context. However, the growing interest amongst pro-environmentalists towards its adoption in pro-environmental contexts is noticeable and has been extended to various environmental-related fields for tackling environmental issues. More importantly, this aligns with the evidence

Table 1
Review table for eligible articles.

Author	Area	Objective	Nudging Technique	Data Collection	Result
Kanchanachitra et al., 2020	Healthy consumption	To examine the effect of micro-environment factor with nudges on fish sauce consumption	Change the convenience of the objects (design); Provide information; Provide information with emotional stimulus	Field experiment + observation	<i>Mixed effective</i> All three nudges show reduction of fish sauce consumption, but only change the convenience of the object shows significant effect
Cappa et al., 2020	Energy-conservation	To examine the effectiveness of informational nudges in energy-demand management	Feedback information	Field experiment + observation + survey	<i>Effective</i> Feedback is effective to enhance citizen motivation and awareness of environmentally-related issues
Becchetti et al., 2020	Green purchase	To access the effect of poster on purchase choice	Information poster	Field experiment + observation	<i>Effective</i> A simple informational poster can have significant changes on purchase choice
Schindler-Ruwisch and Gordon, 2020	Healthy consumption	To study and apply nudges to promote healthy dining amongst university students	Placement changes; Signage	Field experiment + observation	<i>Mixed effective</i> Two out of three nudge settings showed significant effect in promoting healthy dining
Venema et al., 2020	Healthy consumption	To investigate if a portion size nudge can reduce sugar consumption	Reduce portion size	Field experiment + observation + survey	<i>Effective</i> Reducing the spoon's portion size was effective to reduce sugar consumption
Huf et al., 2020	Healthcare	To assess the impact of SMS reminders to improve cervical screening rates	Reminder	Field experiment + observation	<i>Effective</i> The cervical screening participation rates are improved with the SMS reminder
2019 Healthy consumption	Healthy consumption	To investigate the effect of repositioning the menu items on consumers' selection	Repositioning	Field experiment + observation	<i>Ineffective</i> Repositioning does not increase the selection of fruit and vegetable items
Sogari et al., 2019	Healthy consumption	To test if health message labelling on food can influence consumer choice on healthy food consumption	Labelling	Field experiment + observation	<i>Mixed effective</i> Only one out of two nudge settings showed significant effect
Chakravarty and Mishra, 2019	Waste reduction	To examine if social norm poster can nudge the employees to reduce paper usage	Social norm	Field experiment + observation	<i>Effective</i> The paper usage was found reduced with the social norm poster presented to employees
Chapman et al., 2019	Healthy consumption	To evaluate three nudges and promote healthier foods sales	Cognitive fatigue prevention design – floor arrow design Scarcity messages Product placement	Field experiment + observation + survey	<i>Mixed effective</i> One nudge alone is not significant to influence purchasing behaviour; multiple concurrent nudges may be needed
Knowles et al., 2019	Healthy consumption	To evaluate proximity effect of different foods	Placement	Field experiment + observation + survey	<i>Effective</i> Fruit consumption was significantly increased when chocolate was positioned further away from them
Broers et al., 2019	Product sales	To test the effectiveness of the nudges in increasing the customers' choice on particular soup without increasing the overall soup choice	Default-name; Tasting	Field experiment + observation	<i>Effective</i> Both nudges are able to increase the customers' choice on particular food without increasing the overall choice
Schmidtke et al., 2019	Healthy consumption	To investigate if changing the order of soft drinks can influence consumers' selection on drinks	Changing the order	Field experiment + observation	<i>Effective</i> The changing order of the soft drinks has increased the sales of no sugar soft drinks and decreased the sugary soft drinks
Van der Meiden et al., 2019	Healthy activity	To investigate if the nudge interventions are effective to stimulate stair use amongst employees	Reminder poster; Footprint painting	Field experiment + observation + survey	<i>Mixed effective</i> Footprint nudging significantly increased stair use amongst employees, whereas the impact of poster was not significant
Coucke et al., 2019	Sustainable consumption	To investigate the effect of visual cues nudge in influencing consumers' purchase behaviour of sustainable meat choices	Change display size; Change display quantity	Field experiment + observation	<i>Mixed effective</i> The sales of poultry (more sustainable meat) were increased during the intervention but the less sustainable meat sales did not decrease
Kosite et al., 2019	Healthy consumption	To examine the impact of using larger and smaller size plates on self-served food consumption	Change in size	Field experiment + observation	<i>Ineffective</i> There was no significant difference on food consumption between larger and smaller size plates
Naluonde et al., 2019	Hand hygiene	To investigate the effect of disruptive cues in increasing hand-washing with soap amongst students	Disruptive cue	Field experiment + observation	<i>Effective</i> The nudge intervention (disruptive cues) significantly improved the hand-washing with soap practice amongst students
Wu and Paluck, 2018	Waste reduction	To prevent the workers from throwing waste on the floor	Image illustration	Field experiment + observation	<i>Effective</i> Waste on the floor was significantly reduced
Bhanot, 2018	Water conservation	To study the effect of social norm message in changing user behaviour	Social norm message	Field experiment + observation	<i>Effective</i> The social norm message is useful in tackling water conservation behaviour change
Walmsley et al., 2018	Healthy consumption	To examine the effect of re-arrangement in affecting purchasing behaviour	Re-arrangement	Field experiment + observation	<i>Mixed effective</i> One of the re-arrangement settings showed significant increment in percentage of sales for fruits and vegetables, whereas another setting did not show significant increment

(continued on next page)

Table 1 (continued)

Author	Area	Objective	Nudging Technique	Data Collection	Result
Grover et al., 2018	Hand hygiene	To determine the impact of hand-washing nudge as compared to hygiene education intervention	Paved path painting; Handprint painting; Shoeprint painting; Arrow painting	Field experiment + observation	<i>Effective</i> The hand-washing nudge and hygiene education intervention are equally effective
Kurz, 2018	Sustainable consumption	To test the effect of nudging in increasing vegetarian food consumption to mitigate greenhouse effect	Changing the order; Enhance the visibility	Field experiment + observation	<i>Effective</i> The nudges were found to increase the sales of vegetarian meals
Vasiljevic et al., 2018	Healthy consumption	To examine the effect of calorie labelling on energy purchased in worksite cafeterias	Labelling	Field experiment + observation	<i>Mixed effective</i> Only one out of six sites show significant reduction in energy purchased
Hollands et al., 2018	Healthy consumption	To examine the effect of reducing portion sizes in worksite cafeterias	Reducing size	Field experiment + observation	<i>Mixed effective</i> amongst six sites, only two sites showed reductions in energy intake by reducing portion sizes
Vermote et al., 2018	Waste reduction	To examine the effect of reducing French fries portion on French fries consumption and plate waste	Reduce portion size	Field experiment + observation + interview	<i>Effective</i> The French fries intake and plate waste were found reduced with the reduced French fries portion size
McCoy et al., 2018	Recycling	To test the effectiveness of nudge in enhancing recycling behaviour	Relocation	Field experiment + observation	<i>Effective</i> The waste diversion rates were improved and the result indicated that the nudge intervention could enhance the recycling behaviour
Linder et al., 2018	Recycling	To test the effectiveness of information intervention in promoting food waste recycling	Social norm information leaflet	Field experiment + observation	<i>Effective</i> The information leaflet increased the food waste recycling
Namazul et al., 2018	Safety transport	To examine the effect of reminder cards to increase vehicle inspection behaviour	Reminder	Field experiment + observation + interview	<i>Effective</i> The reminder card was found to be effective to significantly increase the vehicle inspection behaviour amongst the users
Agarwal et al., 2017	Energy conservation	To test the effect of school children nudges on household electricity conservation	School children nudge	Field experiment + observation	<i>Effective</i> School children nudge was found to be effective in bringing the electricity conservation message home and influencing families' electricity conservation behaviour
Riggs, 2017	Sustainable travel	To evaluate the effect of financial and social norms to influence travelling modes	Social norm	Field experiment + observation + survey	<i>Effective</i> Social norm nudge is more effective to influence the travelling modes in comparison to financial incentive
Jagau and Vyrastekova, 2017	Waste reduction	To explore the impact of information campaign in increasing consumers' awareness on food waste	Poster	Field experiment + observation + survey	<i>Mixed effective</i> The demand for smaller portion of meal is increased after the implementation of the campaign but no significant difference for food waste
Friis et al., 2017	Healthy consumption	To test and compare the effect of three different nudges in promoting vegetable consumption	Priming; Default option; Perceived variety presentation	Field experiment + observation	<i>Effective</i> The three nudges were found to be effective in promoting healthier meal composition; they either help to increase vegetable intake or decrease meat intake
Venema et al., 2018	Healthy activity	To assess the effect of the default nudge on reducing sedentary behaviour at workplace	Default	Field experiment + observation	<i>Effective</i> The default nudge has increased the stand-up working rates in the offices
Shearer et al., 2017	Recycling	To investigate the effectiveness of sticker prompt in encouraging household food waste recycling	Reminder sticker prompt	Field experiment + observation	<i>Effective</i> The sticker prompt has significantly increased and sustained the food waste recycling rate
Kongsbak et al., 2016	Healthy consumption	To assess the reduction of energy intake in meal with choice architectural intervention	Reorganise the physical environment	Field experiment + observation	<i>Effective</i> Reorganising the placement in a buffet can increase the quantity of fruit and vegetable intake and decrease the other meal components
Dreibelbis et al., 2016	Hand hygiene	To test the effectiveness of the nudges in encouraging hand-washing with soap	Pathway painting; Footprint painting	Field experiment + observation	<i>Effective</i> Higher rate of hand-washing with soap was observed after the implementation of painting nudge
King et al., 2016	Hand hygiene	To investigate the effect of prime nudge in influencing hand hygiene compliance amongst visitors	Olfactory prime; Visual prime	Field experiment + observation	<i>Mixed effective</i> Prime nudge can influence hand hygiene compliance amongst visitors of intensive care unit, however there was one visual prime setting which did not show significant improvement

reported by Byerly et al. (2018) on the adoption of the nudging approach in a pro-environmental context. Overall, the finding of this review suggests that nudging ought to be adopted further and expanded into various environmental fields as an approach to foster pro-environmental behaviour.

4.2. What is the overall effectiveness of nudging and what are the factors that affecting its effectiveness?

The effectiveness of an emerging approach is always the concern of researchers. It was, therefore, the reported nudging effects amongst the

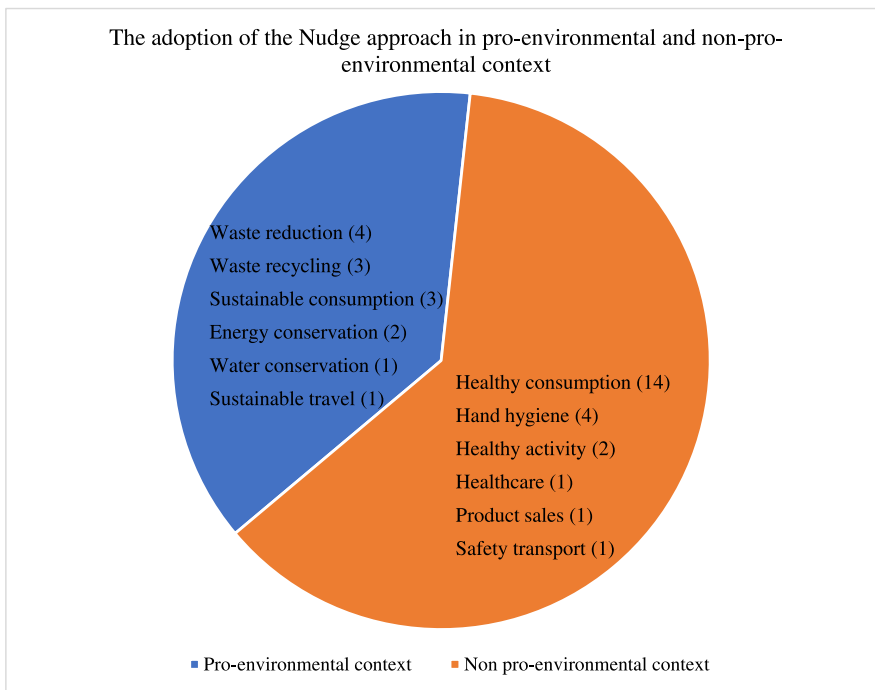


Fig. 2. The adoption of nudging approach in pro-environmental and non-pro-environmental context.

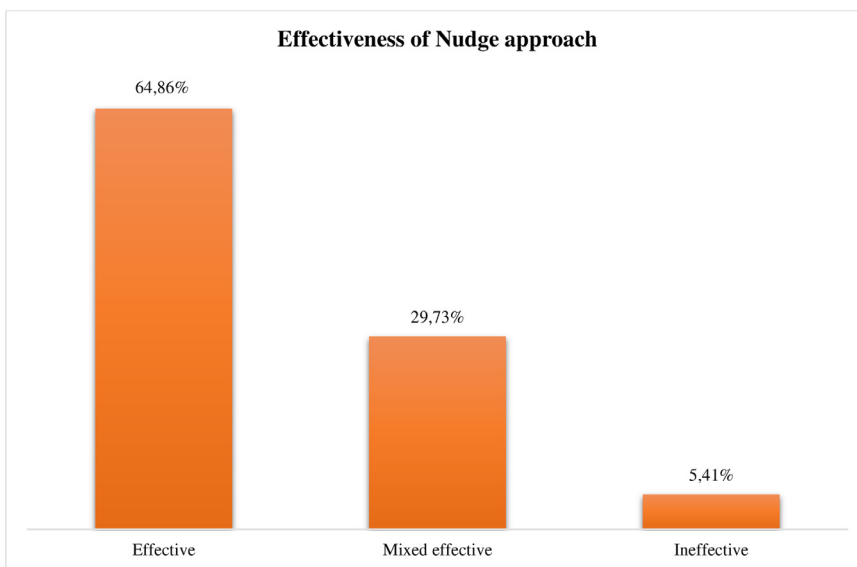


Fig. 3. The effectiveness of nudging approach from 37 eligible studies included in this review.

included studies in this paper were reviewed. The included studies in this review would be deemed to be effective (+) if the authors reported significant positive effects, mixed effective (~) if the authors reported both significant positive and no effects under different settings, or ineffective (-) if the authors reported no significant positive effects.

Figure 3 shows the effectiveness of the nudging approach amongst the included studies for review. The findings show that 64.86% of the studies show effective outcome and 29.73% of the studies show mixed effective. Meanwhile, only 5.41% of the studies show ineffective outcome (Wyse et al., 2019; Kosite et al., 2019). This indicates that the effectiveness of nudging varies across the studies, with a majority showing positive outcome. This varying outcome is unsurprising for behavioural intervention, since it is a solution for dealing with human behaviour which is, in itself, a unique entity.

Different people indeed have different self-equipped characteristics which are not manipulable. Such characteristics may influence the effect

of a nudging. Sogari et al. (2019) suggested that nudging information would be more effective if addressed specifically to the needs of the targeted group. In a study by Vasiljevic et al. (2018), it was found that a targeted group with demographic characteristics that varied across six experimental sites showed different effectiveness patterns across the six sites. Moreover, the personal long-term goal might also limit the effectiveness of nudging to a certain population group only (Kanchanachitra et al., 2020). To enhance the effectiveness of the nudging, the characteristics of the targeted group are necessary to be studied and considered in order to determine the suitable nudging for the targeted group.

Besides, environmental setting is another factor that may affect the effectiveness of nudging, where, in real-life settings, there are often many distractions that could make people overlook the nudging intervention or the information brought by the intervention (Kanchanachitra et al., 2020). Schindler-Ruwisch and Gordon (2020) pointed out that the level of exposure of individuals to nudging interventions would affect

the changes brought by the nudge too. If an individual did not notice the nudging intervention, it is less likely that he or she would be nudged for the desired behaviour.

Another factor that may affect the outcome of the nudging is that one nudging alone may not be sufficient to encourage changes amongst individuals. Instead, multiple concurrent nudging interventions may be needed (Wyse et al., 2019; Chapman et al., 2019). It has been suggested that to implement more than one nudging within a setting may enhance the overall effectiveness of the behavioural change initiative. This suggestion is in consideration of the environmental setting factor, whereby one nudging might be easily overlooked by the individuals due to the uncontrollable on-site distractions. Meanwhile, multiple concurrent nudging interventions can complement each other's shortcomings within the setting. Moreover, multiple nudging interventions can help to maximise the outcome when diversified demographics are involved within the targeted group, as the impact of one nudging may be limited to certain people.

There is no guarantee that the nudging approach will work in all cases (Van der Meiden et al., 2019). However, it should be noted that there is less likely to be one solution for all – an approach with guaranteed outcomes across all cases when dealing with humans, even with an advanced technological approach. The effectiveness of the nudging varies across the studies. Nevertheless, its power to nudge one's actions is promising and should not be overlooked, since the majority of the studies reviewed in this paper have reported positive outcomes. To ensure and optimise the outcome, careful consideration should be placed on the affecting factors, such as the visibility of the nudging intervention, multiple nudging interventions, and environmental/on-site setting.

4.3. How can nudging be used to promote pro-environmental behaviour?

When nudging was found to have promising effects in nudging people's actions and behaviour, how it could be applied to nudge pro-environmental behaviour would be the next question raised. Therefore, this section will present the nudging techniques that might be considered by pro-environmentalist to adopt for nudging pro-environmental behaviour.

Different researchers may use different terms for similar meanings/functions of nudging intervention, and where overlapping may occur. Thus, content analysis was carried out to transform and summarise the large amount of text contents from various studies into key results (Erlingsson and Brysiewicz, 2017). The meanings and functions of the nudging interventions found in the included studies were reviewed and those that were similar to each other were categorised into the same intervention type for better reference for future researchers. The analysis was completed via several steps to achieve a key set of nudging intervention types. The ultimate findings of the nudging techniques were categorized according to nudging intervention types, as suggested by Hollands et al. (2013).

Figure 4 shows the process of content analysis in achieving the key findings. The initial analysis (the condensation process) of the contents of the 37 included studies found 52 data for nudging techniques. Overlapping issues were found amongst these 52 data and, therefore, the data were further analysed and grouped according to similar data into relevant nudging codes. Based on the definitions and characteristics reported on the 52 data, those that demonstrated similar implementation concepts were grouped under the same code, for instance, "placement changes, repositioning, product placement, changing the order, re-arrangement, relocation and reorganize the physical environment" are coded as change placement. A total of 11 codes were created for the nudging techniques: (i) change design, (ii) provide information, (iii) change placement, (iv) change size, (v) provide cue, (vi) change quantity, (vii) change presentation, (viii) labelling, (ix) default setting, (x) social norm, and (xi) priming. These 11 nudging technique codes were further categorised and summarised into different nudging technique types. Generally, the nudging techniques were summarised into seven

technique types of key findings, namely: prompting, sizing, proximity, presentation, labelling, priming, and functional design.

Prompting refers to using non-personalised information/messages to promote or raise awareness of a targeted behaviour amongst people (Hollands et al., 2013). The practitioners of nudging cannot only provide knowledge information (Cappa et al., 2020; Becchetti et al., 2020; Schindler-Ruwisch and Gordon, 2020; Chapman et al., 2019) to people in order to raise their awareness, but can also provide people with social norm information (Bhanot, 2018; Linder et al., 2018; Chakravarty and Mishra, 2019) to influence their decision by exposing them to what others are doing. Furthermore, reminder messages are another content that can be delivered to the people (Huf et al., 2020; Van der Meiden et al., 2019; Namazu et al., 2018; Shearer et al., 2017) to promote targeted behaviour, while simultaneously serving to remind and prompt people's action in case they have forgotten. Both information and messages can be delivered and presented in the form of leaflets, posters, signage, cards, sticker prompts, and so on, whichever is most suitable to the case. To promote pro-environmental behaviour, pro-environmentalists can expose the community more to environmental-related information in order to raise community awareness on the importance of practising pro-environmental behaviour, and thus to save natural resources for future generations (Cappa et al., 2020; Dixon et al., 2015). Moreover, the social norm information concerning what has been done by others within the community could also be exposed to people, in the hope that they would be influenced for action having seen others doing it (Bhanot, 2018). The information would be greatly delivered and communicated to the people if the initiative could gain the support of mass media so that they can promote the information with their expertise. People are often forgetful, and most of the time they unintentionally practise non-pro-environmental behaviour. Placing a reminder or sticker prompt such as, "Please switch off the lighting when you leave", at the exit door would help to prompt and remind people to check on the lighting before they leave. Other than that, a sticker prompt with the message of, "No food waste please. Remember to use your food caddy", could be placed on refuse bins to remind and encourage food waste separation from general refuse (Shearer et al., 2017).

Sizing refers to changing the size or the quantity of the object to influence people's behaviour (Hollands et al., 2013). Reducing or increasing the size or quantity of the equipment can help to nudge the volume of consumption by people (Venema et al., 2020; Kosite et al., 2019; Hollands et al., 2018; Vermote et al., 2018). To promote sustainable food choices for reducing environmental impacts brought about by food production, Coucke et al. (2019) increased the display area size and quantity of sustainable meat products within a local supermarket to nudge shoppers towards selecting a sustainable meat product. Meanwhile, to encourage recycling behaviour within a community, the size of a recycling bin could be enlarged to promote recycling activities within the community. This has already been implemented in Edinburgh where residents were given a larger recycling bin (240 litres) and a smaller size of trash bin (140 litres) in order to nudge them to separate more recyclable items when the trash bin capacity was reduced (Stephen, 2014). This intervention was found to successfully increase the recycling rate by 85 per cent.

Proximity refers to making behavioural options either easier or harder to engage with, to either motivate (easier to engage) people engagement in a desired behaviour, or demotivate (harder to engage) the people from engaging in an undesired behaviour (Hollands et al., 2013). This can be done with two techniques: default setting (Broers et al., 2019; Friis et al., 2017; Venema et al., 2018) and change placement (Schindler-Ruwisch and Gordon, 2020; Knowles et al., 2019; Schmidtke et al., 2019; Walmsley et al., 2018; Kurz, 2018; McCoy et al., 2018; Kongsbak et al., 2016). Default setting refers to a pre-set setting of equipment or environment, as opposed to the desired one where people can engage in the targeted behaviour directly, unless additional effort is made to change the option. This default setting technique can help people to engage in a desired behaviour with less effort and, subse-

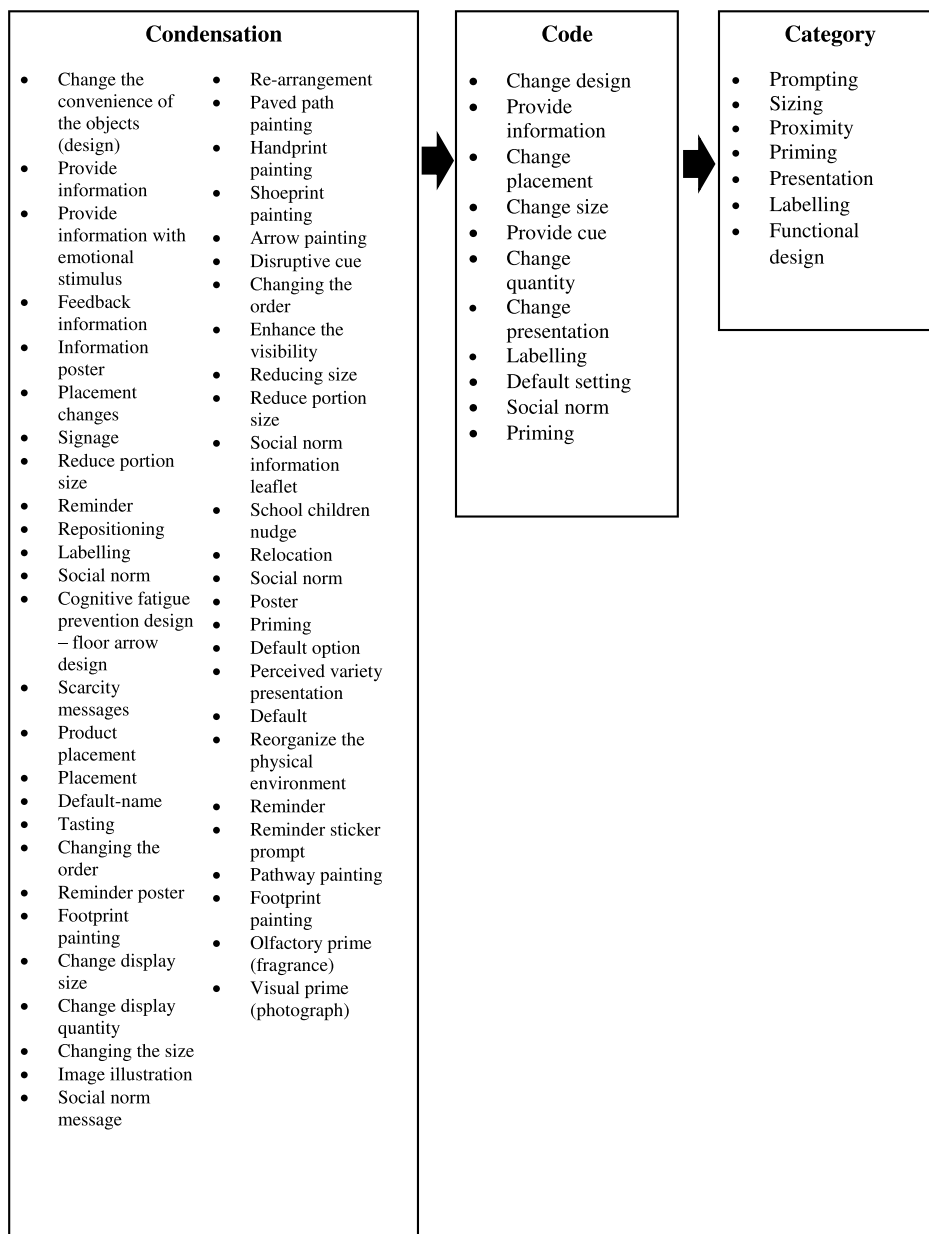


Fig. 4. The process of content analysis in achieving the key nudging techniques.

quently, helps to enhance the engagement of the community in the targeted behaviour. In the workplace, default setting can be implemented to promote pro-environmental behaviour amongst the workforce where the default setting of the printing machine, for instance, can be set to double-sided printing (Weßel et al., 2019; Egebark and Ekström, 2016). With such a default printing setting, the office workers would easily and directly contribute to reducing paper usage for the environmental good and without any additional effort required. Other than that, a default setting for a pro-environmental context can also be achieved with the implementation of not providing single-use plastic bag to shoppers, not providing plastic straws for beverages to customers, and so on. Change placement refers to changing the existing placement of the object in order to alter its visibility and convenience to people, in order to influence their decisions to act. This technique can be used to promote sustainable consumption by rearranging vegetarian meal options to the top position when presented to consumers, whereas meat options are moved to the later position, to influence people's selection decisions (Kurz, 2018). Besides, this technique can also be used for encouraging green purchasing amongst shoppers, whereby green products can be placed at the eye

level to the shoppers within the store setting. Shoppers would be easier to nudge for green purchasing behaviour when the green products are always presented at their eye level. Furthermore, to promote recycling behaviour, it is suggested that recycling bins be relocated to places where people often pass by (McCoy et al., 2018). It is believed that people would be willing to recycle their items if the location of the recycle bin is convenient.

Priming refers to placing cues within the environment to influence people's subconscious behavioural responses (Hollands et al., 2013). Providing people with cues aims to trigger and unlock the subconscious of the people and consequently lead to their subconscious action, whereas cues can be provided via visual cues (Chapman et al., 2019; Van der Meiden et al., 2019; Wu and Paluck, 2018; Grover et al., 2018; Friis et al., 2017; King et al., 2016; Dreibelbis et al., 2016) and olfactory cues (Friis et al., 2017; King et al., 2016). In a pro-environmental context, environmental cues can be provided via visual cues by painting footprints or arrows on the floor to lead people to the organic product section in order to trigger green purchase behaviour, to lead people to the location of the trash bin to reduce littering issues, or even to lead

people to the stairs to encourage the use of stairs instead of escalators. When people see the footprints or arrows, their subconscious could be unlocked and perceive that the footprint or arrow is asking them to go in the pointed direction, thus leading them to their subconscious response – follow the path and trigger their action when reaching the targeted destination. Other than that, using red colour paper to issue warning letters or serious notices to households on environmental issues within neighbourhoods (e.g., open burning, improper waste disposal, etc.) may help to trigger their subconscious feelings of fear or panic and later help to discourage their non-pro-environmental behaviour. In short, priming is a technique that focuses on using cues to unlock people's subconscious action that lead to targeted behaviour.

Presentation refers to altering the sensory qualities or visual presentation of a product to influence people's behaviour (Hollands et al., 2013). As implemented by Friis et al. (2017) to promote vegetable consumption in a buffet setting, the researchers changed the presentation style of the salads from mixed vegetables in a bowl to different vegetables in different bowls, to create a sense of perceived variety amongst the consumers and to nudge their consumption. Meanwhile, in a pro-environmental context for recycling purposes, it is suggested that the presentation or the design of the recycle bin be changed from the traditional image to an attractive image in order to attract the attention of the people and catch their interest for disposing recyclable items. For instance, in a shopping mall in Malaysia, AEON Malaysia, they designed recycle bins into the shapes and images of the recyclable items, such as bottle-shape and can-shape recycle bins, to encourage people to throw recyclable items into the correct recycle bins.

Labelling refers to putting up the endorsed information or specific details of a product or option (Hollands et al., 2013). This nudging has been carried out by Sogari et al. (2019) and Vasiljevic et al. (2018), where calorie labelling was put on the foods for sale in cafeterias to provide calorie consumption information to workers in the hopes of nudging them to reduce their energy intake. This labelling approach has in fact been incorporated into our daily lives to encourage pro-environmental behaviour. Many of us may not be aware that it is a nudging. If we have noticed, we might see that some electrical appliances have been labelled with energy star ratings to indicate their energy efficiency and energy saving features. Such energy star labelling is indeed a nudging technique to educate shoppers about the energy saving features of electrical appliances with the aim to influence the decision of shoppers in selecting energy-saving products and to practise green purchasing behaviour. It is suggested that energy efficiency labelling be applied to guide people in making energy efficiency decisions, since insufficient information can lead to people's underestimation of energy efficiency (Newell and Siikamäki, 2014).

Functional design refers to altering the design or function of an object or environment in order to influence its usage or consumption (Hollands et al., 2013). In a study conducted by Kanchanachitra et al. (2020), and in order to nudge students to reduce fish sauce consumption in canteens for health concerns, the fish sauce serving bottle setting was changed to a bowl and spoon setting, where more effort was required to extract the fish sauce by using a spoon than by extracting directly from a bottle, thus reducing the quantity of sauce extracted. In Japan, an architect named Shigeru Ban used a square tube to create square toilet paper to reduce consumption and to prevent wastage (Chang, 2012). The rationale for creating the toilet paper with a square tube, rather than a typical round tube, was that extra dispensing motion was needed for pulling the toilet paper on a square tube than for a round tube. As such, users would not be able to easily over-pull the toilet paper for usage, preventing wastage.

Overall, the review shows that nudging can be implemented via several methods and is not limited to just one specific technique. The selection of suitable nudging techniques for implementation is based on the judgement of the researchers or practitioners and consideration of the targeted aim, targeted group, and the existing environmental setting. As mentioned in an earlier section, the effectiveness of the nudging may be influenced by the targeted group and the environmental setting. Con-

sidering those factors when selecting and designing the nudging is necessary to enhance the success of the nudging intervention in fostering pro-environmental behaviour.

5. Conclusion

This paper has contributed to nudging knowledge by reviewing existing nudging literature databases and presenting an overview of the status quo of the nudging approach. This paper is advancing the understanding of nudging for pro-environmental behaviour change as limited literature was found in the existing databases to review different nudging techniques and how different nudging techniques could be applied for promoting pro-environmental behaviour change. This finding could inspire future research to conduct experimental study to further examine the effectiveness of different techniques in nudging pro-environmental behaviour change. Moreover, this paper provides a new insight to pro-environmentalists, as well as the policymakers and stakeholders on utilising nudging as an approach to nudge the public to engage on pro-environmental behaviour.

Through the review, nudging has demonstrated promising outcomes in promoting the desired practice and behaviour amongst individuals where the majority of the literatures reported positive effects in nudging targeted actions and behaviour amongst people. Overall, the nudging approach has great potential to expand into a pro-environmental context since the approach is yet to be widely adopted for promoting pro-environmental behaviour.

Furthermore, this review has also concluded several types of nudging techniques from nudging studies that can be referred to by pro-environmentalists in promoting pro-environmental behaviour, namely prompting, sizing, proximity, priming, presentation, labelling and functional design.

The concepts of implementation and recommendations for each technique are:

- **Prompting** – Using non-personalised information to promote or raise awareness on a targeted behaviour. The information that is suggested for prompting pro-environmental behaviour are knowledge information (e.g., environmental conservation knowledge, updated environmental information, existing environmental issues) and social norm information (e.g., what has been done by others for the environmental good)
- **Sizing** – Changing the size or the quantity of the object. Some of the suggestions for pro-environmental purposes are enlarge recycle bin size to encourage recycling behaviour, reduce general trash bin size to encourage waste separation, reduce plate size to reduce food wastage, etc.
- **Proximity** – Making the behavioural options either easier or harder to engage with. This is suggested to be implemented by making pro-environmental settings as default settings (e.g., double-sided printing, no straw is provided, cutlery is only provided upon request) and changing the placement of pro-environmental products or objects to make them near to people (e.g., place the sustainable foods or energy-saving products at consumers' eye level, place the recycle bins next to the exit door).
- **Priming** – Placing cues within the environment to influence subconscious decisions. Cues are suggested to be placed within on-site environments to unlock the subconscious of people and to trigger their subconscious responses that lead to pro-environmental behaviour (e.g., footprint painting that could stimulate people to walk in a desired direction and to lead people to use the staircase or to the organic product section).
- **Presentation** – Altering the visual design or the presentation of the object. It is suggested that the presentation of pro-environmental objects or tools can be changed or re-designed to attract the attention of people to adopt or consume it (e.g., change the appearance of the recycle bin, change the packaging of the sustainable foods).

- **Labelling** – Putting up endorsed information or specific details of an object or option. The endorsed pro-environmental information or details can be labelled on the pro-environmental product to provide information to the consumers (e.g., labelling energy-saving features information on electrical appliances, labelling the amount of greenhouse gas emissions during the production of a food).
- **Functional design** – Altering the functional design of the object or environment. The functional design of the object can be altered to influence people's usage, either for encouraging or reducing resources consumption (e.g., changing the shape of toilet paper into squares to prevent over consumption).

This finding could serve as a reference for pro-environmentalists on available nudging techniques for adoption. It is recommended to extend this finding in future pro-environmental studies for implementing the nudging approach in real field settings. Careful consideration must be placed on the characteristics of the targeted group, as well as the existing environmental setting prior to the implementation during the nudging selection stage (Kanchanachitra et al., 2020; Vasiljevic et al., 2018). It is necessary to consider the characteristics of the targeted group and the existing environmental setting because some nudging interventions may have limited effects on a selected group only, whereas some environmental settings may not be suitable for selected nudging and would rule out its effects. Understanding the profile of the targeted group can help to determine and design a nudging that matches the conditions of the targeted group (Karlsen and Andersen, 2019). Moreover, it is also recommended to adopt more than one nudging within a setting to enhance its effectiveness (Wyse et al., 2019; Chapman et al., 2019). Multiple nudging interventions should be considered to be applied concurrently within a setting to enhance the overall nudging effects in achieving optimal outcomes.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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