Exploring pedestrian nudging: Current advancements and future challenges

Claudio Feliciani*[1] and Alessandro Corbetta[2]

[1]Graduate School of Engineering, The University of Tokyo, Tokyo, Japan
[2]Department of Applied Physics and Science Education, Eindhoven University of Technology, Eindhoven, The Netherlands

Abstract Pedestrian nudging represents a simple and yet valid solution to change people's behavior in walking environments. However, research by the authors reveal that effectiveness can vary depending on environment and experimental context, making it difficult to draw general conclusions and, eventually, automated protocols. To prove this, we present a summary from our experiments while extending the call to participants of the PED2025 conference to increase the overall sample size (of studies) and help to find patterns providing valid evidence to support future implementations of nudging solutions in pedestrian spaces.

Keywords Crowd control, Nudging, Environmental stimuli, Lighting, Crowd sensing

Introduction and background

Crowd control is a multi-layer process in which members of a crowd receive increasingly disrupting instructions to change their behavior [3]. When risk and urgency is low, crowd control is performed using simple and neutral information, usually through signage allowing people to find their way. On the other hand, when risk is judged high, and countermeasures need to be taken depending on the situation, barriers or deviations are prepared and physical layout is changed to steer people and reduce density in critical locations.

"Pedestrian nudging" also represents a layer of crowd control and follows the principles proposed under the nudge theory: a concept in behavioral economics that suggests that positive reinforcement and indirect suggestions can influence people's decisions and behavior without restricting their freedom of choice. From a practical perspective, pedestrian nudging can be performed by modifying the environment where people walk, for example changing lighting conditions, using music or sounds, or automatizing signage to prioritize underutilized routes. In the frame of crowd control, nudging takes a special role for several reasons: 1) It allows to change people's behavior without restricting their freedom of choice, 2) It has the potential of being automated measuring crowd conditions, and 3) It is relatively cheap to operate, thus minimizing or delaying the need of human intervention.

However, little research has been performed on pedestrian nudging and results are not always coherent and encouraging. One of the difficulties is that such research is not possible (or very difficult) in a laboratory setting and experiments are often performed in ecological scenarios where a number of (hidden) variable also influence crowd motion. For instance, the dynamics of people is different when there are social groups or people have a strong social identity (football supporters of the same team, for example). Such factors often go undetected when pedestrian data are collected to measure the efficacy of nudging solutions, therefore potentially contributing to information gap and, ultimately, conflicting results.

Representative results

To provide evidence in support of the arguments raised above, we will present several studies, some sharing very similar conditions, yet resulting in different outcomes.

Light was tested in four different experiments: at the Glow 2027 festival in Eindhoven (The Netherlands), in the jellyfish area of a large aquarium (Kaiyukan) in Osaka (Japan), at the 2024 Iwaki firework display (Japan), and through a long-term experiment in a university in Tokyo (Japan) [4]. Among the four

*Email of the corresponding author: feliciani@g.ecc.u-tokyo.ac.jp

experiments only the latter two managed to change people's behavior using light above a 10% threshold, possibly because of the relative importance played by lighting in those contexts.

Further, three experiments employing a visual indication (such as an arrow) are also considered: the already mentioned Glow 2027 festival [1] and long-term experiment in Tokyo, and, in addition, another experiment in the Kaiyukan aquarium. In this case, all three experiments managed to change people's motion to some extent, although the degree of "intrusion" can be considered somewhat large and, still, the efficacy in changing people's motion was in the order of 5-10% (20% at the most).

Finally, sound was also tested in the long-term experiment in Tokyo without satisfactory results in term of steering efficiency while worked oppositely respect to expectations in experiments performed in Eindhoven [2].

Results for the above experiments are summarized in Table 1. From a quick glance, it should be already clear that results are diverse depending on the setup, although some patterns start to emerge. For example, experiments using visual indications appears to be more effective compared to other solutions.

Table 1: Summary of the results from the experiments presented above. Efficacy is always evaluated in regard to the measured variable (speed, density, waiting time, etc.).

Name (location & year)	Stimulus used	Efficacy	Notes
Glow festival (Eindhoven, 2017)	Light	$\leq 5\%$	Density dependance
Kaiyukan jellyfish area (Osaka, 2024)	Light	None	Dark environment
Firework display (Iwaki, 2024)	Light	10-15%	Outdoor event
University entrance (Tokyo, 2023)	Light	$\approx 5\%$	Change over 2 months
Glow festival (Eindhoven, 2017)	Stimulus array	5%	Large bright arrow
University entrance (Tokyo, 2023)	LED display arrow	$\approx 5\%$	Change over 2 months
Kaiyukan Pacific Ocean tank (Osaka, 2024)	Wall projection	15-20%	Text and animation
University entrance (Tokyo, 2023)	Sound	None	Sound on transit
TU/Eindhoven (Eindhoven, 2022)	Sound	5%	16 loudspeakers used

Discussion

When people move in an ecological context a number of variables affect their behavior. This would require a large sample size to perform valid statistical tests and underline patterns in the data. However, sample size for nudging experiments is very limited, making such approach not possible, for the moment. A potential reason is that nudging studies often do not get published for several reasons, making a (meta) review difficult. In some cases the study was too simple to become a standalone publication, in others there were negative (yet valid) results, and/or, sometimes, study are simply hard to find in the literature.

The purpose of this work is to bring the problematic to the audience of PED2025 and potentially find a sufficient number of studies to expand the database presented in Table 1. The authors are aware of several unpublished studies which could help obtaining a better overall picture on nudging. However, there are likely more and PED2025 represents an ideal opportunity to spread the message and raise awareness that, in a proper context, a negative or non-conclusive study can still represent a significant piece of information for research in pedestrian nudging.

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