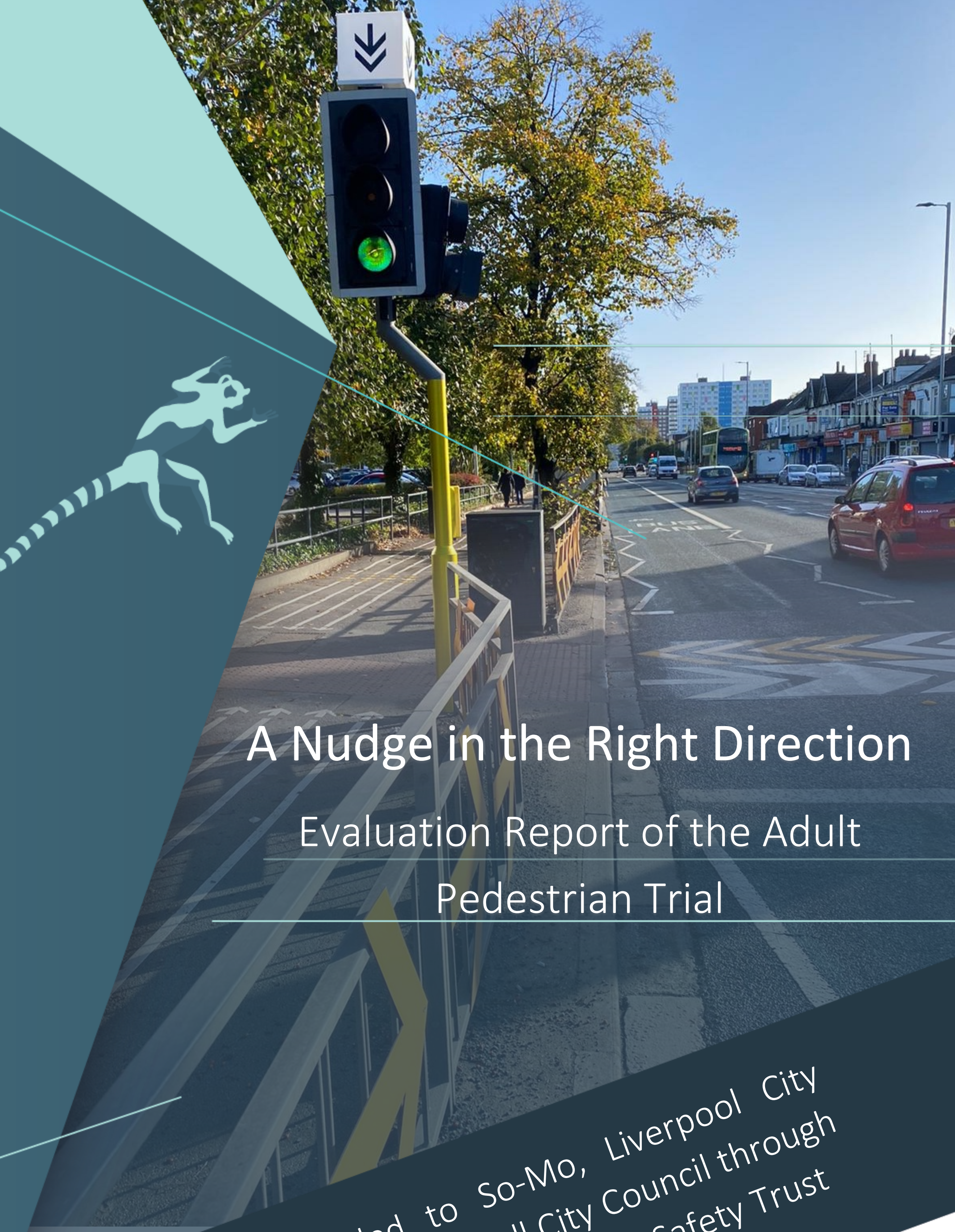

A Nudge in the Right Direction

Evaluation Report of the Adult Pedestrian Trial

Provided to So-Mo, Liverpool City Council and Hull City Council through funding from The Road Safety Trust

agilysis

Hull City Council

Liverpool City Council

The Road Safety Trust
Making Roads Safer

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ACKNOWLEDGEMENTS

This report has been prepared by Agilysis for So-Mo, Liverpool City Council, and Hull City Council as an independent evaluation of the innovative crossing designs trialled in those cities. The team would like to thank The Road Safety Trust for funding the research.

Any errors or omissions are the authors' sole responsibility.

FOREWORD, IAN WIGGINS, LIVERPOOL CITY COUNCIL

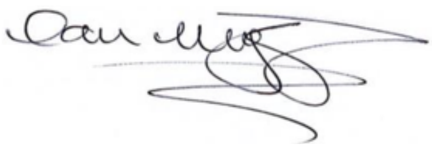
In 2018, I sat down with colleagues from Liverpool City Council (LCC) Highways and Transportation team to discuss a serious problem. An appraisal of Liverpool's casualty data revealed Liverpool held the unenviable position of having the highest rate of APC (adult pedestrian casualties) outside of London. This did not come as a complete surprise: Liverpool's figures had been consistently high for 10 years. We knew that this problem was unlikely to go away by itself. We'd made numerous attempts to bring down the number and severity of APCs in the city through a variety of data-led road safety engineering schemes and education initiatives targeted at this specific road-user group. For example, Liverpool was one of the first local authorities to roll out the 20mph scheme, that saw 70% of Liverpool's roads brought down to speeds designed to benefit pedestrians and cyclists. This work, also delivered with So-Mo, was recognised for its pioneering approach, which achieved a 3.5mph average speed reduction and a return on investment of £18.8M. Yet despite these efforts, we had still not achieved the low casualty figures our citizens deserved and needed.

This 2018 discussion was the start of a 5-year journey which culminated in on-street trials of strikingly different pedestrian crossings in Liverpool and Hull. One which saw LCC commission work and collaborate with So-Mo, a Behavioural Science Company who developed the intervention and trial methodology, Agilysis who supported the trial design and analysed the results, and Smiling Wolf, a Liverpool based design agency, who turned So-Mo's ideas into reality. Hull City Council and Safer Roads Humber generously provided their time, expertise, and financial support that meant we trialled the new crossings in two cities. This partnership would expand to include over 12 different organisations, suppliers, and stakeholders, all working together to deliver the first, UK-based, trial of a behavioural science intervention to increase use of pedestrian crossings in high-risk locations.

Installing and delivering an on-site crossing intervention is not an inconsiderable task, made harder by the onset of the COVID19 pandemic. I would like to take this opportunity to thank every member of the team for their hard work and dedication to this first-of-a-kind project. I would also like to thank our funders for enabling this work, especially The Road Safety Trust for having continued faith in us and our partners.

We are proud of the work we have done - the main finding that behaviourally designed interventions can increase safe pedestrian crossings is new information that should be shared with the wider road safety and transport planning community. I urge you to read this report to understand what it takes to deliver such a trial and consider how the lessons we learned can be applied to your own practice. If, like me, you are not a behavioural scientist I suggest you read the introductory essay written by Nicola Wass of So-Mo, which provides a fascinating insight into the use of Behavioural Science and its value to Safe System approaches.

Ian Wiggins, Team Leader, Road Safety and Traffic Management, Liverpool City Council



INTRODUCTION - A BEHAVIOURAL SCIENCE PERSPECTIVE, NICOLA WASS SO-MO

Just as an architect will design the layout and features of a building to influence how people move and interact within it, a behavioural scientist will attempt to 'nudge' human behaviour by subtly altering the way in which choices are organised, framed, and presented. This is known as 'choice architecture'. The report you are about to read evaluates an intervention that altered the choice architecture of two pedestrian crossings in order to prompt a safer choice. Before we discuss this in detail, let's first explore the field of behavioural science and its value in relation to policy and intervention design.

BEHAVIOURAL SCIENCE – THE SCIENCE OF HUMAN CHOICE AND DECISION-MAKING

Our choices and behaviours are influenced by millions of years of genetic evolution, cultural changes, lived experiences, values, and beliefs. Behavioural science assimilates all of this into a set of principles, insights, and methodologies that can be used to derive profound insight into human behaviour. Rooted in traditional psychology, behavioural science emerged as a distinct discipline, in the 70s and 80s, largely due to the pioneering work of renowned psychologists Daniel Kahneman and Amos Tversky.

Kahneman and Tversky conducted experiments that underscored the influence of heuristics, (mental shortcuts), and cognitive biases on human decision-making[1]. Their work on 'Prospect Theory' demonstrated that losses carry a far more pronounced emotional weight than equivalent gains, for example, an individual might refuse to sell an asset even when it's economically beneficial to do so because the pain of a potential loss feels greater than the pleasure of an equivalent or greater gain. This challenges classical economic models, including "rational choice theory" which presuppose that individuals rationally analyse choices, and always pursue outcomes that align with their best interests.

Kahneman also popularised the idea of 'dual-process theory,' two distinct systems of thinking: System 1, characterised by its fast, automatic, and intuitive nature; and System 2, which is deliberate, analytical, and more effortful. In his 2011 book "Thinking, Fast and Slow[2]" Kahneman illustrates how humans rely heavily on System 1, resulting in decisions that diverge from objectively "rational" choices.

Another pioneer of the behavioural sciences was Richard Thaler. In 2008, Thaler described the concept of libertarian paternalism; where policymakers could use behavioural science to effectively 'nudge 'individuals toward more beneficial choices by altering the way in which choices were presented. This shift in thinking expediated a shift towards 'applied behavioural science', paving the way for behavioural units such as the Behavioural Insights Team (BIT) founded within the UK government in 2010 under the leadership of Professor David Halpern. Halpern has always been keen to emphasise that behavioural science is experimental in nature and most behavioural interventions, even when they are theoretically sound do not work[3]; however, when they do, the impact can be profound.

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[1] Kahneman, Daniel & Tversky, Amos, 1979. "Prospect Theory: An Analysis of Decision under Risk," Econometrica, Econometric Society, vol. 47(2), pages 263-291, March

[2] Kahneman, D. (2011). Thinking, fast and slow. Farrar, Straus, and Giroux.

[3] Behavioural Insights Team. (2019, October 30). Finding the unicorns: Behavioural science in government grows up. GOV.UK Blog. https://quarterly.blog.gov.uk/2019/10/30/finding-the-unicorns-behavioural-science-in-government-grows-up/

A great example of a small change that had a profound impact is the BIT's early work on tax returns. The government at the time were concerned that a substantial number of people did not pay taxes on time, despite prompts in the form of reminder letters. Halpern knew that deliberate changes to the way in which communications are framed can alter a person's decisions and judgments; changing the outcome, even when the underlying facts do not change. He hypothesised that minor changes to the wording of the reminder letter could influence behaviour and improve compliance.

To test this, the BIT created five versions of the reminder letter, each deploying a different framing device. Taxpayers who were due to receive a letter about unpaid taxes, were randomly assigned one of five different versions of the letter. One of these used a 'minority norm' frame:

"Nine out of ten people in the UK have paid their tax on time. You belong to the minority who have not paid yet."

This message triggers a psychological mechanism known as the 'in group' 'out group,' effect a powerful motivator of behaviour. It was the equivalent to being told "no one in the village likes you…." The urge to belong and be accepted by one's community is deeply ingrained in human nature, tracing back to our evolutionary roots, when being ostracised from the group could leave an individual vulnerable to harm. This desire to avoid social isolation can drive individuals to modify their behaviours to conform with group norms, even if it means going against their inclinations or values.

Analysis of results revealed that the version of the letter which included the minority norm, triggered a 5.1% increase in tax returns when compared to the control - the original letter sent out by the Department for Work and Pensions.

In the world of behavioural science, context, and scale matter. A small percentage change within a large population will result in a high absolute number of people changing their behaviour. Insertion of a single sentence brought in an unearned revenue of £2.5 million in just 28 days. A later iteration went on to leverage around £200 million within two years.

The low-cost, high-return nature of this intervention triggered a wave of interest from governments across the world, eager to apply similar behavioural nudges to their own fiscal policies.

CONTEXT MATTERS

The Irish government, inspired by the results of the trial, attempted to replicate the UK's successes. A series of Randomised Control Trials (RCTs) were used to test different framing devices, including the successful minority norm. Expecting a similar result, they were surprised to find that the version of the letter which applied the minority norm, performed worst out of all the framing devices.

The minority norm framed letter resulted in a -1.6% reduction in tax returns when compared to the control letter[4]. The evaluation of the trial did not elaborate on why the minority norm had failed; however, we could hypothesise that different social norms and beliefs about taxation and government acted as a powerful moderator – negating the power of the minority norm.

[4] Kennedy, S., O'Carroll, R., Shirran, M., & Walsh, K. (2017). Applying Behavioural Science in Tax Administration – A Summary of Lessons Learned. Irish Government Economic and Evaluation Service. https://www.revenue.ie/en/corporate/documents/research/applying-behavioural-science.pdf

This latter example demonstrates a limitation of the 'Test, Learn, Adapt'[5] approach used by the BIT. An RTC will provide evidence of what works within a specific context but lacks foundational understanding of the root causes and specific barriers at play. Lack of meaningful insight into why an intervention worked in one context makes replication of results unreliable.

Why have I included this story? I've included it because the lesson it contains is as relevant now as it was then. Just because a behavioural intervention is successful in one context, there is no guarantee that it will yield the same or similar result in another. If this evaluation provides one clear lesson to the sector, it is that context matters and careful consideration should always be given to understanding the role contextual factors present in the environment, play in both driving and reinforcing our behaviour!

LIVERPOOL INTERVENTION

In 2019, So-Mo, a behavioural science consultancy specialising in Highways and Transportation, together with Agilysis, a company who excel in data analysis and evaluation, were asked by Liverpool City Council to help them understand why the city was experiencing the second highest rate of adult pedestrian casualties in the UK. Analysis of adult pedestrian casualty data, coupled with in-context observations, identified two distinct 'typologies' associated with increased adult pedestrian casualty risk.

The first cluster could be described as 'outlier high streets.' Collisions here occurred mostly in the daytime. The second cluster featured sites associated with the night-time economy. In these locations, incidents were concentrated at night during the weekend. Observational studies of sites in these clusters confirmed widespread underuse of available pedestrian crossings. This observation was supported by adult pedestrian casualty data from 2017 which showed that, 267 out of 1,212 (22%) of pedestrian collisions occurred within 50 metres of a pedestrian crossing.

Pedestrian crossings are designed for safe passage and are commonly found in locations where unaided crossing is difficult and risky. From the perspective of rational choice theory, the decision to cross a dangerous road unaided rather than walk a short distance to a safer, designated crossing would be considered irrational. These models assume individuals act logically when they have both the opportunity and the capability to do so – as was the case for individuals here. This suggested to us that it may be possible to nudge decision-making towards safer behaviours by altering the choice architecture in these locations.

Real-world trials are a significant undertaking. From the outset, we knew we wouldn't have the luxury of testing five different interventions to see which had the greatest effect; it would only be possible to develop one or two testable prototypes at most.

So-Mo's behavioural framework uses a diagnostic approach to derive a nuanced understanding of the drivers and determinants of behaviour using the insights gained to select the most promising behavioural levers.

Drivers of behaviour are the immediate factors that motivate a person to take a specific action. These can be internal (like emotions, desires, or psychological states), or external (such as environmental cues or social influences). Determinants of behaviour are broader and more foundational elements that influence behaviour over the long term. They encompass the underlying conditions,

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[5] Haynes, L., Service, O., Goldacre, B., & Torgerson, D. (2012). Test, Learn, Adapt: Developing Public Policy with Randomised Controlled Trials. Cabinet Office Behavioural Insights Team. Retrieved from https://assets.publishing.service.gov.uk/media/5a7488c8e5274a7f9c586c23/TLA-1906126.pdf.

characteristics, or contexts that prompt various behaviours to occur. Determinants can include cultural norms, socioeconomic status, education, physical environment, and inherent personality traits.

When a behavioural scientist has limited opportunity to test multiple interventions, there is a pragmatic rationale to using a diagnostic approach to intervention design. This method stands in contrast to the 'Test, Adapt, and Learn' approach, which depends on the experimental testing of various behavioural levers to ascertain which, if any, are effective.

INSIGHTS INTO THE TWO TYPOLOGIES AND DESCRIPTION OF CORRESPONDING INTERVENTIONS

Outlier High Streets Liverpool

The high streets constituting the first cluster emerged as bustling suburban shopping hubs, typically intersected by four lanes of fast-moving traffic. These high streets were located outside of the city centre and were well used by the local community, particularly during daylight hours. Consequently, the majority of incidents documented in these areas occurred in the daytime and involved residents who resided close to the high street.

An observational study revealed that it took the same or similar amount of time to walk 30 metres to a crossing, press the button and wait, as it did to precariously cross four lanes of fast-moving traffic. Despite this, many pedestrians still opted to cross by line of sight, away from the designated crossing area. When asked to detail the final stages of their journey and their decision-making process, a common theme emerged: pedestrians did not recall noticing the crossing. This phenomenon, known as 'inattentive blindness' or ‘selective attention,’ suggests a filtering out of non-essential stimuli.

Selective attention can occur when individuals are immersed in goal-oriented tasks within familiar settings. Their cognitive engagement is sharply tuned to specific objectives and, while their senses continue to absorb the full gamut of environmental stimuli, only information deemed immediately relevant to their goals is prioritised. Under routine conditions, this selective attention streamlines focus[6].

People employing selective attention are not disengaged or unaware; rather, this is an example of system one thinking in action[7]. Their brains are engaged in a highly efficient form of information processing. When an unexpected event occurs or a potential threat is perceived, the brain's attentional system is capable of rapidly shifting to a more analytical and conscious mode. This shift enables an individual to assess emerging risk and respond accordingly.

The data told us that crossing these roads unaided was dangerous. So, why were people not alert to the risk posed and attending to the fact that there was a crossing located nearby?

The phenomenon contributing to this complacency is known as the 'Path well-travelled bias', where individuals subconsciously perceive familiar environments as safe[8]. Each time a behaviour is performed without incident, it reinforces the belief that the chosen path has negligible risk, thus strengthening the neural pathways that favour this habitual choice.

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[6] McLeod, S. A. (2018). Selective attention. Retrieved from https://www.simplypsychology.org/attention-models.html

[7] Kahneman, D. (2011). Thinking, fast and slow. Farrar, Straus, and Giroux.

[8] Martens M.H. The failure to respond to changes in the road environment: Does route familiarity play a role? *Transp. Res. F Traffic Psychol. Behav.* 2018; **57**:23–35. doi: 10.1016/j.trf.2017.08.003.

Another consideration was that these high streets were situated in areas of deprivation with elevated levels of poor health[9]. At the population level, more people would be managing challenges to their finance and health, suggesting the scarcity phenomenon could further impede decision making. The scarcity phenomenon is well documented in research; if the mind is focused on immediate and pressing needs, other abilities and skills such as attention, self-control, and planning slow down and are harder to access[10].

We hypothesised that people in these locations were focused on getting to where they were going as quickly and efficiently as possible. They did not view the act of crossing by sight line as dangerous because they had crossed this way before without incident. A lack of risk awareness was further compounded by these individuals having a higher cognitive load due to circumstance, leaving them with less available cognitive bandwidth needed to make effortful, analytic decisions.

In response, the intervention was intentionally straightforward, aiming to reduce cognitive burden and align with the residents' goal-oriented behaviour. Visual enhancements were made to the road infrastructure: the addition of striking graphics on the roads and pavements created visual cues suggestive of speed and direction, while bold colours and markings on guard rails, bollards, and light poles were used to make the crossing points conspicuous within their settings.

Additionally, a subtle reduction in pedestrian wait times at crossings was implemented—not enough to alter their essential functioning, but sufficient to subtly shift perceptions, encouraging and reinforcing the belief that using the crossing was a quick and efficient way to achieve their intended goal.

Roads central to the night-time economy

Our study focused on roads intersecting the direct paths (desire lines) of pedestrians traveling between popular clubs and bars. Observations confirmed the expected: a sizeable number of individuals displayed signs of intoxication, a common occurrence in city centres during weekend nights. It is important to clarify that we cast no aspersions on these behaviours; rather, we noted it as a prevalent factor that may be contributing to risk.

The influence of alcohol and drugs on behaviour is well-documented. They impair reaction times, shorten attention spans, and often result in riskier behaviours[11] all of which can lead to incorrect use of pedestrian crossings. Our analysis of fatality data in Liverpool corroborated this, highlighting substance use as a significant factor in night-time collisions.

A particular behaviour pattern, known as 'herd behaviour', was also observed. It describes how individuals in a group may collectively make decisions as a group. This is problematic when people in the group are under the influence and crossing the road[12]. We observed groups of people stepping into the path of oncoming traffic, even though the original actor did not first check it was safe to do so.

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[9] Marmot, M., Allen, J. Boyce, T. Goldblatt, P. Morrison, J. (2020) Health equity in England: The Marmot Review 10 years on. London: Institute of Health Equity

[10] Mullainathan, S, Shafir, E. (2014). Scarcity: The New Science of Having Less and How It Defines Our Lives. Picador USA.

[11] Van Skike, C.E, Goodlett, C. Matthews, D.B. (2019). Acute alcohol and cognition: Remembering what it causes us to forget, Alcohol, **79**, p105-125.

[12] Pelé, M, Deneubourg, J, and Sueur, C. 2019. "Decision-Making Processes Underlying Pedestrian Behaviors at Signalized Crossings: Part 2. Do Pedestrians Show Cultural Herding Behavior?" *Safety* 5, no. 4: 82. https://doi.org/10.3390/safety5040082

To counter these challenges, the intervention employed strategies to make crossings more visually and emotionally salient, integrating them into the fabric of the night's entertainment. The designs on the footways were crafted to capture attention with humour and vibrant colours, using compliments that aligned to the pedestrians' desire to feel good about themselves and have fun. The design drew upon the iconic work of Peter Blake, whose art is deeply ingrained in Liverpool's cultural landscape. Additionally, a light topper on the crossing pole featured eyes which directed the gaze to the crossing footway, while painted footsteps applied to the pavement aimed to lead pedestrians safely towards the crossing points. This approach sought to blend safety with the existing goal of enjoyment, ensuring that the safe choice to use crossings aligned with their night-time experience. For a comprehensive overview of the intervention and its components, please refer to page 26.

DECISION TO ATTEMPT REPLICATION

Our diagnostic approach presented another significant advantage. By delineating the drivers and determinants of behaviour within specific contexts, we aimed to diminish the necessity for conducting new trials in the future. With a comprehensive 'blueprint' derived from initial findings further enhanced by the trial, we anticipated the ability to proactively identify other appropriate locations in the future, contingent on a successful proof of principle.

In an ambitious move, we expanded our research to include replication trials in Hull. Our goal was to test the wider relevance and applicability of our interventions, by testing their validity across different comparable settings.

Even under normal conditions, this would have been a significant undertaking. Then, within days of the project initiating, the rapid spread of COVID-19 brought about the UK's first lockdown. This not only changed the behavioural, physical, and operational landscape beyond recognition, it made the identification of suitable sites for comparison extremely difficult. Observational inspections of proposed sites were rendered unfeasible. As a result, Agilysis who were responsible for identifying comparators had to rely on interpretation of hard data, and the local knowledge and insight of partners in Hull. This was not without its pitfalls; when restrictions were lifted and we were able to visit sites in Hull, it became clear that the sites chosen did not match the conditions at the Liverpool trial sites, rendering them ineffective comparators.

WHY SITES CHOSEN FOR REPLICATION WERE UNSUITABLE

The Hull site ultimately selected to trial the outlier high-street intervention, failed for several reasons: footfall was far lower than the site in Liverpool and although the site had a smattering of shops and businesses along the road, many were boarded up. The area was not a functioning high street. Rather than serving local shoppers, the crossing was used by people from outside the area who were attending a large nearby hospital. Collisions at the site were experienced by people from a range of socio-economic backgrounds from a wide geographical radius, meaning that the drivers and determinants of behaviour were not the same.

The site selected to trial the night-time economy intervention was also markedly different, not just in pedestrian footfall, which was again significantly lower, but more critically, the Hull crossing was poorly lit and located away from the desire line used by night-time revellers, making it an unsuitable candidate for effective behavioural nudging. If an individual is unaware of the opportunity to use a crossing due to poor visibility of the alternative choice, it is exceedingly difficult to nudge them. Given that the crossing at the trial site was hardly visible to people using the bars in this location, (which were by contrast brightly lit), a decision was taken to exclude this site from the evaluation.

By the time these discoveries were made, we were past the point of selecting alternatives. The interventions had been installed. Upon reflection, when the COVID-19 pandemic-imposed constraints on our ability to apply the carefully developed site selection criteria, it would have been prudent to either temporarily suspend the research until such time as observations and immersive evaluations could be resumed, or to narrow our focus exclusively to the Liverpool sites, where our understanding was more comprehensive and conditions more controllable.

RESULTS AND INSIGHTS

In the field of behavioural science, certainty is never a given. Modifying the choice architecture to subtly 'nudge' behaviours in an automatic and intuitive manner does not come with guaranteed success. Our interventions were experimental by nature, conceptualised to assess the proof of principle.

Our mission was to conduct empirical trials of two distinct interventions, crafted for areas where pedestrian safety was a concern. We aimed to rigorously observe and measure their impact, with the objective of determining whether these interventions were capable of changing behaviour within their real-world settings.

The following section provides discussion on results of the trial. For a comprehensive understanding of the research methodologies used and analysis of results please refer to pages 35 to 52 of this report.

Liverpool's Outlier High Street and Hull Comparator Site

The intervention trialled at the outlier high street in Liverpool, demonstrated an impressive 14% increase in the use of designated crossings. Analysis of over 4,000 individual crossings produced a result that was not only statistically significant, but conclusively demonstrated that it is possible to improve pedestrian safety without restricting individual freedom of choice. This was a significant finding.

Success was influenced by the fact that this intervention was highly tailored to a busy high-street. It had been designed to overcome specific cognitive biases assessed to be increasing risk-taking in this type of location. By enhancing the salience of the crossings and reducing wait times, we created a 'path of least resistance' that naturally guided individuals towards a safer behaviour. This is choice architecture in action - the optimal behaviour becomes more likely through careful contextual design.

The intended replication site in Hull did not share contextual features with Liverpool. This was not a bustling high street with people making regular habitual journeys. So, it was no surprise when analysis of crossings at the Hull site did not achieve a statistically significant result. This highlights the critical role that context plays in the effectiveness of behavioural interventions and the need for a deep individual and contextual understanding when considering wider application of successful interventions.

Liverpool's Night-Time Economy Intervention

The Liverpool city centre intervention did not demonstrate an improvement in correct crossings. This result underscores the challenge of designing interventions in complex environments. These subtle behavioural nudges were unable to override sensory overload and the state of intoxication. Whilst disappointing, this reinforces the value of empirical testing of novel interventions and provides crucial insights concerning the power of contextual factors. It also aligns with David Halpern's observation that even the best understood problems with theoretically robust interventions may yield limited effect in real-world scenarios.

LEARNING

Whilst the impressive results from the Liverpool outlier high-street intervention suggest that nudge-based interventions can effectively alter pedestrian behaviour in certain contexts, they also underscore the importance of employing a diagnostic approach from the outset.

The trial findings also reinforce the importance of context and of augmenting hard data with direct observations when selecting sites for replication. For effective comparison, such sites must closely mirror the original setting in terms of demographics, behaviours, and environmental characteristics. Real-world observations are needed to validate and support data-driven decisions. Such diligence is crucial to ensure the replicability and effectiveness of behavioural interventions across varied urban landscapes.

The final insight is that on-street trials are required to accurately measure the efficacy of real-world, behavioural interventions which aim to improve road safety. While simulations and controlled environments have some merit, they lack the unpredictability and complexity of the real world.

On-street trials are indispensable for testing the effectiveness of interventions against ingrained biases. The Hawthorne effect, also known as the observer effect, refers to the phenomenon in which individuals modify or improve their behaviour in response to their awareness of being observed. This awareness can interfere with the spontaneous, automatic processes that nudges intend to tap into. For example, the 'path well-travelled bias' can only be experienced in locations of high familiarity. Taking participants out of a familiar environment into an unfamiliar one, would have meant we were unable to test the intervention's effect on this bias. Similarly, it is challenging to recreate the experience of a night out in Liverpool with friends within a virtual simulation to fully test the moderating effect of intoxication and herd behaviour! This reinforces the fundamental tenet of behavioural science: empirical real-world testing is essential. The conditions and biases intrinsic to the original environment cannot be replicated in a laboratory or simulated setting.

In conclusion, this study contributes valuable insights into the application of behavioural science in urban planning and public safety. While it demonstrates the potential for nudge-based interventions to improve pedestrian behaviour, it also highlights the complexities of implementing such measures across diverse urban settings.

We recommend further research to understand the long-term effects of the outlier high street interventions. We also recommend efforts to dissect which components of the design have the most impact, and then refining them to meet all acceptability criteria prior to scaling.

WIDER IMPLICATIONS

The value of this work extends beyond the immediate results. It offers a methodological contribution to the field – a combination of empirical testing and contextual sensitivity that can inform future interventions.

Looking ahead, we hope, that by sharing these findings, we will foster greater understanding and adoption of applied behavioural science within the Highways and Transportation sectors, aiding transport planners and road safety officers in their efforts to create safe, sustainable neighbourhoods through implementation of Safe System approaches.

GUIDANCE FOR FUTURE BEHAVIOURAL SCIENCE APPLICATIONS IN ROAD SAFETY

For practitioners and policymakers eager to harness the power of behavioural science in road safety, the following advice distils key lessons from our experiences in Liverpool and Hull:

Utilise Diagnostic Approaches: Start with a thorough analysis of the area and its users. This diagnostic process should inform the intervention design, ensuring that it addresses the specific behavioural drivers and environmental factors at play.

Account for Behavioural Biases: Design interventions with an awareness of common behavioural biases, and test for their influence during trials. This ensures that interventions are not only theoretically sound but also effective.

Commit to On-Street Trials: There is no substitute for real-world testing. Simulated environments cannot capture the complexities of human behaviour in a live urban context. Conducting on-street trials provides invaluable insights into how an intervention interacts with the array of variables that influence behaviour and decision-making.

Prioritise Empirical Evidence: Use data from on-street trials to guide decisions on scalability and replication. Empirical evidence will indicate whether the intervention can achieve similar success in different settings or if adjustments are necessary.

Embrace Contextual Sensitivity: Understand that the success of behavioural interventions is deeply rooted in context. Invest time in on-site observations rather than relying solely on hard data to inform design decisions.

Prepare for Variability: Accept that not all interventions will work as planned. Be ready to learn from both successes and failures and use these learnings to refine future applications.

Ensure Ethical Considerations: Maintain ethical standards in all aspects of the project. This includes respecting the autonomy of individuals and ensuring interventions are non-coercive and transparent.

Plan for Scalability with Caution: Recognise that a successful intervention in one location may not translate directly to another. Scalability should be approached with caution and should be based on detailed knowledge of the factors that informed the original behavioural intervention and where needed, be open to further testing designed to provide additional validation.

Build Collaborative Teams: Collaborative efforts that bring together diverse expertise – from behavioural scientists and urban planners to local authorities and community stakeholders – can yield more nuanced and robust interventions.

Communicate Clearly: Throughout the project, maintain clear and open communication with all stakeholders involved. Transparency about goals, methods, and findings builds trust and enhances the legitimacy of the interventions.

Finally, it is important to note that this project set out to test 'proof of principle'. The study was designed with this goal in mind. An important next step will be to expand the study, both in terms of duration, a longitudinal study would be a sensible next step, and to build in further iterative testing with a range of road user groups, to ensure that any final intervention is not only effective in terms of changing pedestrian crossing behaviour but also meets tightly defined, collectively authored acceptability and feasibility criteria.

By adhering to these guidelines, future projects can not only replicate the successes but also avoid some of the pitfalls encountered in our work. It is through such disciplined, evidence-based approaches that behavioural science can contribute most effectively to the creation of safer, more sustainable urban environments.

Nicola Wass
Chief Executive
So-Mo

So-Mo is a leading consultancy in applied behavioural science, founded by Nicola Wass in 2012. So-Mo uniquely blends diverse disciplines to pioneer solutions in highways, transportation, and road safety and the wider public sector. They have used applied behavioural science to improve adherence to 20mph speed limits, increase COVID-19 self-testing rates, and increase seatbelt wearing among young South Asian teenagers. More recently they have incorporated behavioural data science into their approach using behavioural insights to improve predictive modelling capabilities. During the pandemic they created a predictive algorithm that forecasted hospital admissions 10 days ahead. This crucial insight gave Integrated Care Boards the ability to strategize resource allocation effectively, safeguarding patients at a time of crisis.

Dr. Holly Hope, So-Mo's Head of Behavioural Science and Research fellow in Behavioural Science and Tanya Fosdick Research Director at Agilysis were integral to this research.

MAIN REPORT - EXECUTIVE SUMMARY

Liverpool has one of the highest adult pedestrian casualty rates outside of London. After extensive analysis, observations, and the collection of primary data at key locations, specific behaviours were identified as contributing to pedestrian collision risk. These included the underuse of traffic light-controlled crossings.

To try to encourage crossing use and reduce pedestrian risk, two nudge-based interventions have been designed, tailored to pedestrians in the two different problem areas: 1. outlier high streets (Faster Boarding) and 2. city centre/night-time economy (Compli-Crossing). The designs are shown in situ below.

Figure 1 – High Street (Faster Boarding) (left) and Night time (Compli-Crossing) (right) designs

To establish proof of principle, and on the recommendation of the Department for Transport (DfT), So-Mo, a behavioural science consultancy, working with Liverpool City Council, introduced these embedded nudges to existing crossings in Liverpool and also tested the replicability of the nudge-based interventions in a second city (Hull). Hull, being a Northern university city of a similar size with similar sociodemographic and road networks, was considered a suitable candidate city to test replicability. A partnership has been established between Merseyside Road Safety Partnership, Liverpool City Council, Safer Roads Humber, and Hull City Council to achieve these aims. Agilysis has provided two main functions in delivery of this work. The selection of sites in Liverpool and Hull intended to test, using an observational study, whether the interventions developed in Liverpool could achieve similar results when applied to sites sharing the characteristics of the locations in Liverpool. Second, Agilysis have the role of independent evaluator and authored the evaluation portion of this document. Funding was secured from The Road Safety Trust to conduct the study, with the project supplemented with contributions from Safer Roads Humber, Merseyside Road Safety Partnership, and both local authorities.

To test effectiveness, the study counted the proportion of correct crossings at three sites (two in Liverpool and one in Hull) during a baseline period (when no intervention was in place) and an intervention period (when the behavioural intervention was in situ). Whilst a fourth site (night-time economy site in Hull) had the intervention designs applied, it was decided when coding started that the location was not appropriate to nudge people into changing their behaviour and therefore the main analysis does not apply to this site. The exclusion was because of two reasons: firstly, pedestrians in the night-time economy were using a desire line to cross the road from destination to destination and the pelican crossing was located several metres away from this desire line. Observing behaviour when the intervention was in place showed that people were unlikely to detour down the road to use the crossing. Secondly, the crossing was poorly lit and was not clearly discernible against the well-lit bars and nightclubs, making it unlikely that impaired pedestrians would attend to the crossing and be drawn to use it.

Equally, it was determined that the site in Hull selected to test replicability of the Faster Boarding intervention also differed from the site in Liverpool, in terms of the demographics of the people using the crossings and its purpose to cross for the purpose of shopping on the high street. As a result, it provided an imperfect site for means of replicability testing and the findings should take this into consideration.

Secondary outcomes were monitored in the trial to ensure that there are no negative unintended impacts from the interventions. These included collecting data on vehicle speeds and flow, injury collisions, and anti-social behaviour.

Site selection was based on identifying locations in both cities where there had been a history of adult pedestrians being injured. The sites had to all be in 30mph speed limits and the crossing type was a pelican (in Hull) or puffin (in Liverpool)[13]. For the Compli-Crossing design, the crossing had to be situated in an area used by the night-time economy and have pedestrian collisions at those times. The Faster Boarding crossing had to have four lanes of traffic and be in a 'high street' location, where shops were present. Short listed sites were reviewed for appropriateness by stakeholders in each city, and some were excluded because there were existing schemes due to go in. It was difficult to perform site visits and observe pedestrian behaviour at the time of selection because of Covid-19 restrictions (and this contributed to not understanding how people behaved at the excluded site in Hull).

CCTV footage was obtained for the baseline and intervention periods for the selected sites. Slices of footage were then selected for coding by the So-Mo team, based on the time of day when risk is at its highest at the site type. Coders were trained to count the numbers of crossings in the slices of footage, determining whether the crossings were correct or incorrect (either because they crossed without a signal for traffic to stop or because they did not use the crossing itself).

The coded data was anonymised and provided to Agilysis for analysis, blinded to the site type, location, and time period for initial statistical testing.

STUDY DESIGN AND LIMITATIONS

The CCTV footage used was obtained as part of a revised study design by temporarily installing cameras at the sites which were solely for the trial, ensuring the footage would be dedicated to the crossings and not diverted to view elsewhere in the area. In the process of identifying dedicated cameras to install at the sites, an Artificial Intelligence (AI) solution was identified. These AI cameras would record pedestrian crossing behaviour 24 hours a day and use machine learning to identify whether the crossing was undertaken between defined areas of the crossing (either on the crossing or outside of the crossing). The use of AI strengthened the study design by automatically counting all pedestrian movements, greatly increasing the sample size, and removing the need to manually decide whether a crossing was correct or not. AI cameras were installed for the study period in September and October 2021, covering a two-week baseline period and two-week intervention period, with an installation period in between.

[13] "Pelican crossings are controlled by the pedestrian pressing the button on the wait box. Sometimes there is a bleeper to help blind or partially sighted people know when it is safe to cross. Puffin crossings look very similar to pelicans. Puffin crossings are an updated version of a pelican crossing. One of the main differences is that the red and green figure signals are just above the wait box and not on the other side of the road. Puffin crossings have special sensors built in which can detect a pedestrian waiting and make sure that traffic remains stopped until all the pedestrians have crossed the road. Puffins do not have a flashing green figure for pedestrians or a flashing amber for drivers." (Hull City Council, 2023)

Several weeks after the end of the intervention period, the company commissioned to obtain the count data on behalf of the partnership reported that a permanent data loss had occurred, resulting in both footage and count data becoming inaccessible. Most of the design elements of the intervention had been removed by the time of this data loss discovery, meaning it was not possible to recapture footage for analysis.

After extensive consultation with project partners and The Road Safety Trust, it was agreed that the footage recorded by the existing local authority CCTV cameras situated at the four sites could be used, and a similar outcome obtained using manual counting. This was possible as the site selection process required existing CCTV cameras to be in the vicinity of all candidate sites. The footage from the intervention period had been retained and was useable, meaning the interventions did not need to be reinstalled.

Unfortunately, by the time the data loss had been identified, the baseline footage from the local authority CCTV cameras had been overwritten and was not available. A decision was made to conduct a new baseline 12 months after the intervention, to try to match the conditions in the original baseline.

There are a number of limitations with this revised study design:

- **The use of local authority CCTV cameras**: The local authority CCTV cameras positioned at the trial locations are there for crime and security purposes. They can rotate to allow the authority to respond to events in the vicinity of the signal-controlled crossing. This meant that the cameras were not focused on the crossings 24 hours a day during the trial period.

  The So-Mo team only coded slices of footage when the cameras were trained on the agreed count lines and there were no outages. This limitation only became an issue at Anlaby Road as there was not enough daytime footage for coding, meaning it was necessary to include some evening footage to increase the sample size.

- **Sample size:** The AI cameras would have greatly increased the sample size of counted crossings, as all pedestrian movements would have been included. Furthermore, whilst the focus of the analysis would have been on the times of day and days of the week the interventions were designed for, the larger sample size would have provided an opportunity to analyse the influence of these interventions at other times of the day.

- **Manual coding accuracy:** The accuracy of artificial intelligence is dependent on the machine learning used to train the AI to detect objects. As no AI footage of the intervention sites was available, it is not possible to determine how accurate the AI counts would have been. However, given the volume of AI coding which would have been generated, and the way in which reliability checks were programmed into the data processing stage, it is envisaged that a high number of accurate counts would have been created.

  However, the methodology for manually coding was robust and involved in-depth training of coders, with reliability testing throughout to ensure that consistent coding was achieved.

- **Baseline period before the intervention:** Retrospective baselining presents challenges and there is a risk that meaningful results might not be produced. The risk with baselining 12 months after the interventions has been installed is that a permanent change in pedestrian behaviour had occurred.

However, it is not unheard of for baselines to occur post-intervention. 'Cross over design' is a method used in some randomised controlled trials. Furthermore, the designs were not intended to alter pedestrian beliefs or knowledge and were intended to work on an automatic and intuitive level. It was therefore felt that the effects should be experienced when an individual was interacting with the nudges. As such, a 12 month 'washout' period is likely to have been more than sufficient for pedestrians to be behaving as they did before the interventions were installed.

FINDINGS

Despite the challenges encountered throughout the trial, footage from three sites was successfully coded and shared with Agilysis for analysis. There were almost 4,000 crossings coded for both high street sites and nearly 6,500 crossings counted at the Liverpool night time site.

The analysis found the following:

- **There was a 14% improvement in correct crossings at the high street (Faster Boarding) site in Liverpool and this was unlikely to have occurred by chance.**
- There was no improvement in the proportion of correct crossings at the high street site in Hull. However, given the differences in population demographic and context this is not surprising.
- There was no improvement in the proportion of correct crossings at the night time economy site in Liverpool.
- There were no reported injury collisions at any of the four sites during the baseline or intervention periods.
- There were no changes in speed and traffic flows at any of the four sites between the baseline and intervention periods.
- Aside from an instance of minor graffiti at one site in Hull, there was no reported anti-social behaviour when the intervention was in place.

Qualitative data were also collected. Engagement with Sensory and Physically Impaired Road Users took place throughout the trial, from the planning stage to during the intervention period of the study. Valuable feedback was received during the design period and changes were subsequently made. Road safety audits were also conducted. There was limited participation in engagement days at the Liverpool sites when the interventions were in place and therefore it is difficult to draw conclusions on the impact on people with neurological diseases (such as dementia and Parkinson's disease) or neurodevelopmental disorders (including autism and autism spectrum disorder). Engagement activity with local groups in Hull was positive, with an access group for the partially sighted and blind providing good feedback and indicating they were pleased that the partners were trying to do something different. More research into the impact on Sensory and Physically Impaired Road Users is needed to fully understand impact.

Interviews were conducted with partners in Hull in November 2021. A range of topics was covered to explore the installation, implementation, durability, and effectiveness of the interventions. The interviews also explored the trial itself, including the reception from the media, anti-social behaviour, and collisions. A wrap up meeting was held in July 2023 to present the findings to the partners and to explore lessons learnt. Whilst there was disappointment initially that the interventions did not have a positive impact at all locations, partners did recognise the value of the study and that there are benefits to learning from negative results. By identifying differences in locations, despite best attempts to match sites based on set criteria, the study has shown that there is a range of environmental factors which influence pedestrian crossing behaviour. It would not be appropriate to install these types of intervention at every signal-controlled crossing and achieving different results has shown that the context of the crossing must be carefully considered before proceeding with such an intervention. Participation in this trial was seen as a rewarding and beneficial opportunity for the participating local highways authorities.

An internal ‘lessons learnt’ session was also conducted amongst the project team. A range of recommendations was proposed, which may have helped overcome the challenges encountered throughout the project. These covered the site selection limitations, with a key recommendation that final site selection for a study of this type should come after observations of behaviour are carried out. Other recommendations related to practical project-related considerations. Contingency planning is a must as there were many challenges encountered prior to the trial dates which either did or could have delayed installation (or ended the project). These included the Covid-19 pandemic, a fatality at one site and a sink hole at another, plus the loss of the evaluation data. None of these eventualities could have been planned for and were well-managed by So-Mo in their project management role. However, building in a contingency budget to manage unexpected events would have reduced the burden on the company. There were other lessons learnt which related to partnership working including: the identification of good subcontractors; bringing in specialist advice when required; providing behavioural science training to partners early on to bring all up to speed; and identifying dedicated officers and resources for the duration of the project. Finally, a study of this type can attract high levels of media attention, and social media interactions can prove difficult. Having more professional support from local authority press offices would have helped to manage these interactions.

The study aims were:

1. To determine if a behavioural science informed nudge-based intervention can be used to modify pedestrian crossing designs in order to:

    - increase the number of crossings made by pedestrians inside a 30-metre distance at the crossing site.
    - increase the number of pedestrians who make a ‘correct crossing’.

The analysis has shown that a behavioural science informed nudge-based intervention can be used to modify pedestrian crossing designs to increase the numbers of correct crossings by an amount unlikely to have occurred by chance.

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2. To determine if the effect of the embedded nudges varies across locations, time of day and type of nudge-based intervention.

The analysis did find that the effect of these interventions does vary across location and type of intervention, with the high street site in Liverpool achieving a 14% increase in correct crossing. The equivalent site in Hull did not achieve any improvement, nor did the night time site in Liverpool. These are important findings, as despite strict criteria to match conditions between the two cities, local context, differences in both the environment and the way in which specific *crossings are used (and by whom) led to different outcomes. This influences how effective these types of interventions can be.*

3. To determine if there are any unintended consequences of installing novel and innovative crossing designs, for pedestrians or other road users (feasibility and acceptability) and if they vary by location.

The study found no unintended consequences from these interventions, with no increases in reported injury collisions, or observed collisions or anti-social behaviour. There were no changes in traffic flow or vehicle speeds which might have indicated a change to driver behaviour through distraction or avoiding the area of the crossing.

4. To determine whether this type of nudge-based intervention can be rolled out in line with local authority priorities and demands.

Through interviews in Hull, it was deemed that this type of intervention could be rolled out in line with local authority priorities and demands and that they might be receptive to their installation. Site selection remains key.

The analysis presented here has shown that a behavioural science informed nudge-based intervention can be used to modify pedestrian crossing designs to increase the numbers of correct crossings by an amount unlikely to have been down to chance. It should be remembered that an effect was only conclusively observed at one site. The trial was over a short period of time (two weeks) so it would be interesting to determine if the measures would sustain a prolonged effect on behaviour over a longer period, which would suggest the interventions had a sustained effect on unconscious decision making, rather than being a conscious novelty. This would require a study conducted over many months to determine how long effects last and if they are permanent. Furthermore, it would be interesting to understand which of the nudge measures incorporated into the design had the most impact or whether it was due to the combination of elements. This may require a study which only measures the impact of particular design components or different combinations.

A larger and/or longer study may address some of the uncertainty around the effect of the interventions. With the night time site, there was an initially a decrease in correct crossings which appeared not to be due to chance, however, this was reduced in the regression model when weather was accounted for. Likewise, the reduction in correct crossings at the Hull high street site was close to a level of significance which is worthy of further exploration. At this site, the limitation was the number of available slices of footage for coding.

Based on this analysis, the two high street sites produced quite different results, with a 14% increase in correct crossings in Liverpool, which was unlikely to be due to chance. The Hull high street, on the hand, experienced a 15% reduction in correct crossings, however, it is not possible to determine whether this was due to chance. Whilst the two sites had similar total counts of crossings for the baseline and intervention periods, the regression model also accounted for the number of slices of data used for counting. For the Hull high street, because the CCTV cameras were moved more frequently, more samples of footage were required with fewer crossings in each (200 samples for Hull compared to 70 for Liverpool). The smaller numbers of crossings per sample for the Hull high street meant that it was more difficult to determine whether the 15% reduction in correct crossings was due to chance.

With the night time site, design, a challenging outcome was trying to be achieved: nudging impaired people into altering their behaviour. The hope here was that the behavioural intervention would cut through the competing sensory inputs in the night-time environment and encourage safe crossing. However, given the difficulties of achieving such nudges, to take a Safe System approach to reducing risk for impaired pedestrians, highways authorities should consider temporary closures of streets in night-time economy areas or reducing speeds significantly to reduce the impact of collisions.

The study found no unintended consequences from these interventions, with no increases in reported injury collisions, or observed collisions or anti-social behaviour. A longer-term study would be needed to see any significant changes in collision levels or anti-social behaviour. There were no changes in traffic flow or vehicle speeds which might have indicated a change to driver behaviour through distraction or avoiding the area of the crossing and the volume of traffic analysed was deemed high enough to have detected any such changes.

Through interviews in Hull, it was deemed that this type of intervention could be rolled out in line with local authority priorities and demands and that they might be receptive to their installation.

Whilst the interventions did not achieve significant improvements across all sites, the study partners recognised the benefits of participating in such a project and that there are benefits to learning from negative results.

This study was conducted over a three-year period, which was challenging for a few reasons, including effective site selection for purposes of replicability and trying to monitor public behaviour when movement was restricted due to the Covid-19 pandemic, resulting in a delay. The study had to be adapted at several points over the period, without compromising the output and still meeting the study aims.

The study has demonstrated the value of conducting an on-road trial of behavioural interventions to understand the factors influencing how nudges might be effective.

A NUDGE IN THE RIGHT DIRECTION?

Liverpool City Council experiences one of the highest adult pedestrian casualty rates outside of London. After extensive analysis, observations, and the collection of primary data at key locations, specific behaviours were identified as contributing to pedestrian collision risk. These included the underuse of traffic light-controlled crossings.

An observational study was designed to test if behavioural interventions, when added to existing signal-controlled crossings, are: 1) feasible and acceptable to key stakeholders; 2) improve pedestrian crossing behaviour; and 3) are replicable in other UK cities.

This report sets out the independent evaluation of this observational study. Funding was secured from The Road Safety Trust to undertake the research. The study has involved many partners with Liverpool City Council, Hull City Council, Merseyside Road Safety Partnership and Safer Roads Humber providing funding and resources, including engineering expertise, on-road implementation, communications support, and CCTV access. So-Mo, a UK based behavioural science consultancy with a strong track record in highways, transportation, and modality, was commissioned to design this trial, including designing solutions based on the behavioural insights identified from analysis and observations. The intervention designs were created by Smiling Wolf who worked with So-Mo to embed behavioural levers in physical 'nudges' installed at the crossing sites. Agilysis was commissioned to undertake selection of sites in Hull, where they worked with officers from Safer Roads Humber and Hull City Council and to undertake this independent evaluation.

BACKGROUND AND RATIONALE

Liverpool City Council experienced the highest adult pedestrian casualty rates outside of London in 2017, according to STATS19 analysis, and this was the rationale for embarking on this project. Analysis of this dataset revealed that, 267 out of 1,212 (22%) of pedestrian collisions occurring between 2012-2016 were either on or within 50 metres of the pedestrian crossing at the time of the collision occurring. This suggests that incorrect or insufficient use of available crossings is a significant contributor to the high number of adult pedestrian casualties experienced in Liverpool. Through analysis of contributory factors, it was found that 71% of adult pedestrians were thought to have contributed to their collision occurring, compared to 49% of the drivers who hit them. Driver behaviour, including traffic contraventions (such as disobeying traffic signals and pedestrian crossing facilities), speeding, and unsafe behaviours (including aggressive or careless driving) were not identified as contributory factors at these locations. The proportions of drivers in collisions in Liverpool receiving these contributory factors were lower than in authorities with comparable road networks and/or socio-demographic populations (Road Safety Analysis, 2018). Further, detailed analysis of anonymised Merseyside Police fatal collision reports, based on extensive investigation and submitted as evidence to the coroner, identified that drugs, alcohol, and night-time all featured heavily in the deaths of adult pedestrians in the city centre (Road Safety Analysis, 2018).

Outside of the city centre, driver behaviour was still not a factor. Pedestrians and the related drivers were identified as local to the area of collision and tended to be from lower socioeconomic strata, with a high proportion of collisions occurring in the day. Importantly, locations of collisions were where multi-lane arterial routes also served as high streets, located in high density residential areas, where one might expect better use of crossings (So-Mo, 2018).

Previously, local authorities have utilised the three Es of road safety: education, engineering, and enforcement to effect change; however, pedestrian casualties continue to rise (Downey, Saleh, Muley, & Kharbeche, 2019). In the identified scenarios, it was proposed that the three Es would have limited effect; adults understand how to use pedestrian crossings and do not require education. Puffin and pelican crossings provided in the city centre facilitate safe quick crossings, but adults are simply not using them. Jaywalking is not illegal in the UK, so as such enforcement is not an actionable response without changes to legislation. Engineering measures, such as barriers which are intended to prevent crossing near to but not on designated crossings, have been found, under certain conditions, to increase pedestrian risk, trapping pedestrians who cross by line of sight in the road (Transport for London, 2017). This was further reinforced by So-Mo observations of pedestrians forced into the carriageway by these barriers. Engineering measures to calm and slow down traffic to 20mph when applied as both 'zones' and 'area wide schemes' have been shown to generate a small reduction in speed. Reductions in vehicle speed will, in turn, reduce the severity of impact (Atkins, 2018) (Elvik, 2019). However, interventions of this type can be costly and take time to implement and embed.

Therefore, Liverpool City Council, funded by Merseyside Road Safety Partnership, commissioned So-Mo to develop a response to the problem. This resulted in an innovative nudge-based intervention that can be embedded within existing engineered crossings, to reduce adult pedestrian collisions occurring within 30 metres of the pedestrian crossing. The design was informed by behavioural science and an in-depth insight study into pedestrian behaviours in urban environments, conducted over a 12-month period.

The nudge-based behavioural intervention embeds transparent nudges into an existing signal-controlled crossing using visual cues intended to make crossings more salient and compelling to pedestrians in a busy and distracting urban setting (Hansen & Jespersen, 2013). Two nudge-based interventions have been designed, tailored to pedestrians in the two different problem areas: 1. outlier high streets and 2. city centre/night-time economy. They are low-cost compared to comparable measures and have been developed in consultation with the Department for Transport, TOPAS, engineers, behavioural scientists, Liverpool John Moores University Public Health Observatory, data scientists, road safety officers, vulnerable road users, and the police. It was not anticipated that there would be any increased risk to pedestrians because the location, operation, and access to the existing signal-controlled crossing remained unchanged by the embedded nudge-based intervention. However, the study collected data on secondary outcomes (including vehicle speeds, injury collisions, and anti-social behaviour) to ensure there were no negative unintended impacts.

To establish proof of principle, and on the recommendation of the Department for Transport (DfT), So-Mo, working with Liverpool City Council, introduced these embedded nudges to existing crossings in Liverpool and also tested the nudge-based intervention's replicability in a second city (Hull). Hull being a Northern university city of a similar size with similar sociodemographic and road networks, was considered a suitable candidate city to test replicability. Prior to designing these interventions, extensive analysis and research had been undertaken to understand the adult pedestrian safety issues in Liverpool. This included identifying 'comparator authorities': several similar local authorities which share common characteristics and therefore might encounter similar levels of risk. There were two approaches taken to identify appropriate comparative authorities: looking at those with similar network demands and those with similar populations. Road Safety Analysis has devised a classification system which groups similar authorities together, based on road network characteristics[14]. The classification system is based on 'Network density' which is calculated by dividing the total length of roads (km) in a highway authority by the area (km^2) of the highway authority. This 'network density' value gives an indication of how urban an authority is and authorities with similar network density values tend to have similar collision rates. When plotting the collision rate index values against the

[14] http://mast.roadsafetyanalysis.org/wiki/index.php?title=HANCS

network density values, a correlation was evident with road risk generally increasing as the network density increased.

The percentage of urban roads in an authority, as defined by the Department of Transport, is also used in the Road Safety Analysis classification system. Grouping highway authorities using the 'network density' and 'percentage urban roads' figures led to the creation of 5 super-groups and 11 sub-groups. RSA named the classification system 'Highway Authority Network Classification System' (HANCS). Liverpool City belongs the HANCS sub-group B2: 'very densely networked super urban authorities not in London'. Hull City is one of 18 local authorities also in this HANCS group.

Mosaic Public Sector[15]is a socio-demographic classification system covering the whole of the United Kingdom. It is intended to provide an accurate and comprehensive view of citizens and their needs by describing them in terms of demographics, lifestyle, culture, and behaviour. It is based on data from a wide range of public and private sources. It is used to enable policy decisions, communications activities, and resources strategies across the public sector. Mosaic classifies the community represented by each UK postcode into one of 15 Groups and 66 Types. MAST links STATS19 drivers and casualties to Mosaic by using postcodes. This makes it possible to expose the socio-demographic profiles of the communities of those involved in collisions.

Experian, the creators of Mosaic Public Sector, has calculated the degree of socio-economic similarity of every local authority in Britain to every other such area, on the basis of proportions of proximate Mosaic Types within the resident populations. This analysis was undertaken specifically for MAST Online. It should be noted that there is no necessary relationship between size or location on one hand, and socio-demographic similarity on the other. Hull City is in the list of most similar authorities for Liverpool City.

There were two other cities which were in both lists as network and sociodemographic comparators: Manchester and Nottingham. There was a previous working relationship between Hull City Council and members of the project team and so Hull was selected as an appropriate comparator.

A partnership was established between Merseyside Road Safety Partnership, Liverpool City Council, Safer Roads Humber, and Hull City Council to achieve the aim of testing replicability.

STUDY AIMS

1. To determine if a behavioural science informed nudge-based intervention can be used to modify pedestrian crossing designs to:
    - increase the number of crossings made by pedestrians inside a 30-metre distance at the crossing site.
    - increase the number of pedestrians who make a 'correct crossing'.

2. To determine if the effect of the embedded nudges varies across locations, time of day and type of nudge-based intervention.

3. To determine if there are any unintended consequences of installing novel and innovative crossing designs, for pedestrians or other road users (feasibility and acceptability) and if they vary by location.

4. To determine whether this type of nudge-based intervention can be rolled out in line with local authority priorities and demands.

[15] http://www.experian.co.uk/assets/marketing-services/brochures/mosaic-ps-brochure.pdf

SITES

NUDGE-BASED INTERVENTIONS

PUFFIN crossings (Pedestrian User-Friendly INtelligent) are a type of signal-controlled facility designed to reduce delays to vehicle wait times and improve pedestrian safety. Puffin crossings also provide the facility to reduce pedestrian wait times within parameters set out in Traffic Signs Regulations and General Directions (TSRGD).

Often, they are placed in areas of high traffic flow, where unaided crossing would be difficult. Puffin crossings can be programmed to stop traffic within a maximum time from when a pedestrian presses the button or when traffic flow reduces to a certain rate. A standing red figure, visible only to the pedestrian indicates that the pedestrian must wait; a green walking figure provides a signal to cross. A beeping sound is usually heard when the green figure is lit.

Puffin crossings can be placed to facilitate road crossing of one, two or multiple lanes of traffic.

Pelican crossings (Pedestrian Light Controlled) are older versions of Puffin crossings, where the red and green figure signals are on the opposite side of the road. The selected sites in Liverpool were Puffin crossings and the ones in Hull were Pelican crossings.

This project is a proof of principle evaluation of a behavioural intervention that embeds nudges to existing signal-controlled crossings and its association with pedestrian crossing behaviour. The comparator is the existing signal-controlled crossing period in two weeks of baseline when there were no nudges embedded into crossing at sites in Liverpool and Hull. Nothing about the location or underlying function or operation of the signal-controlled crossing was changed.

The nudges aim to make the existing signal-controlled crossing more salient to pedestrians, and thereby better used by pedestrians.

Nudge-based intervention 1: Faster Boarding (High streets)

The first behavioural intervention is aimed at daytime pedestrian road users who are crossing the road to access shops and services in a suburban area divided by multiple lanes of traffic, typically with high traffic flow in and out of the city. Despite these being highly risky roads to cross, signal-controlled crossings were observed to be poorly used. Locals in these areas may not perceive the risk they face due to a number of cognitive limitations and biases.

Behavioural analysis

Goal directed behaviour is a voluntary behaviour with an underlying intention. Maintaining a goal-directed behaviour requires the brain to selectively attend to sensory stimuli considered most important to achieving that goal; this is at the expense of the rest of the sensory stimuli (Anderson, 2016). At the same time, a surveillance mechanism is in operation so that potential threats are attended to. This is highly relevant to someone who is in transit, when the brain is processing a large amount of sensory stimuli at speed. Goal directed behaviour simplifies the cognitive task of navigating a busy city centre for road users. In particular, it is believed that goal directed behaviour also occurs when pedestrians cross by line of sight. Goal oriented behaviour encourages pedestrians to see sub-optimal crossing behaviours (e.g., crossing four lanes of traffic in a diagonal, away from the crossing), as the best way to achieve their goal if doing so appears to attain their goal more directly.

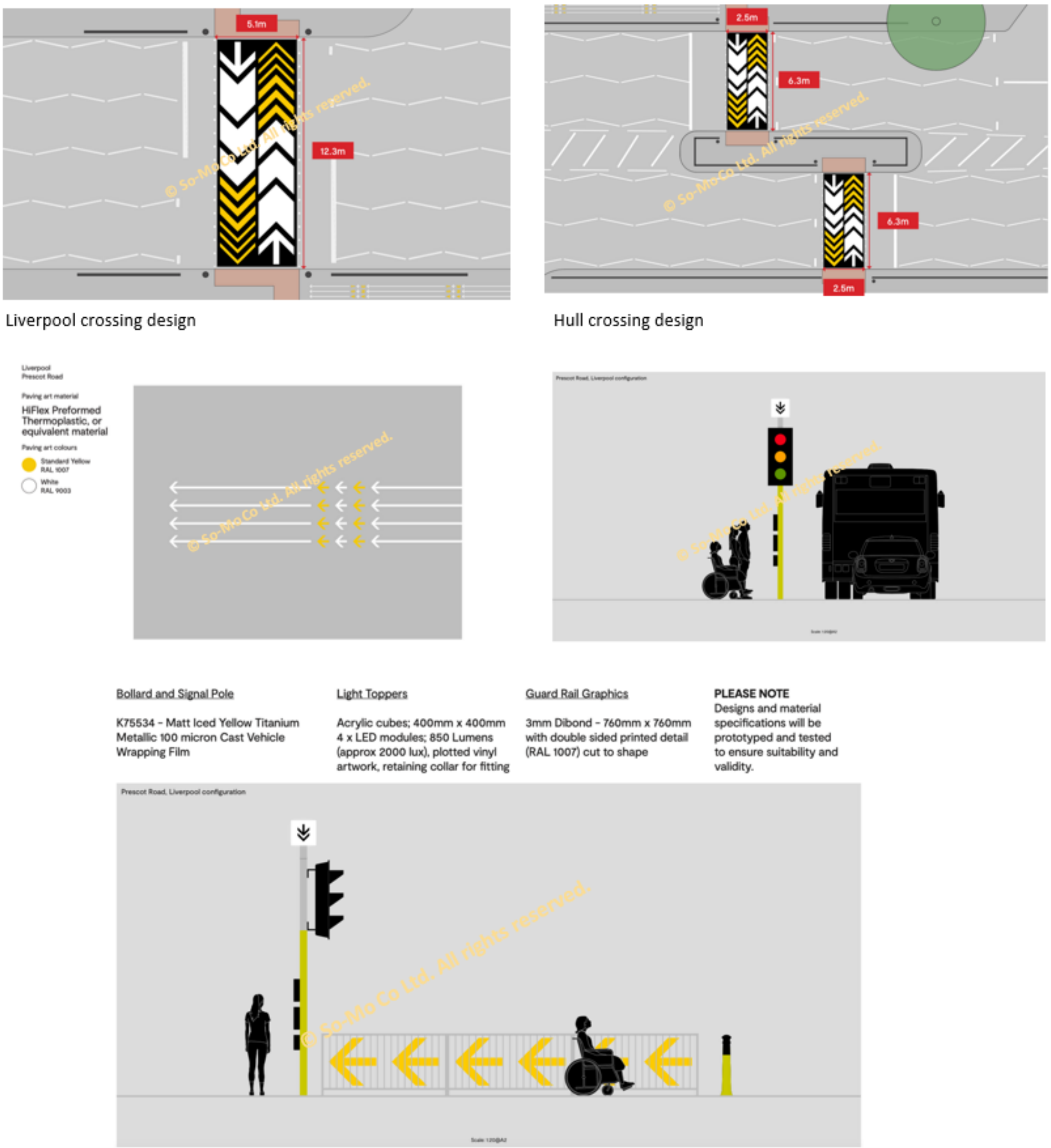
Secondly, the path well-travelled bias suggests pedestrians do not view familiar routes to the shops/bank/café as risky because they frequently walk the route and have not been in a collision, hence their attention to them is limited compared to novel unfamiliar environments where the 'task' is harder (Zakay & Block, 2004).

Thirdly, the crossings in both cities are in areas where there is poverty, unemployment, and poor physical and mental health and where pedestrian casualties are higher (Downey, Saleh, Muley, & Kharbeche, 2019). These stressors lower attentional bandwidth, further reducing the ability to make good road crossing decisions (Dean, Schilbach, & Schofield, 2018).

The nudge-based intervention at these signal-controlled crossings exploits the goal-oriented behaviour of pedestrians in these areas, namely, to cross the road as quickly as possible to reach the shop/service they require. Whilst there were no changes to the underlying function and operation of the crossing, the wait time was lowered to favour pedestrians, within acceptable legal and site-specific parameters.

Repainting of roads, pavements, and additional signage to crossing masts highlighted that the signal-controlled crossing is the fastest (and best) way to cross the road. Pedestrians are guided to the crossing with easily recognisable graphics and messaging. When using the crossing, faster movement is perceived due to the increased frequency of chevrons when approaching the opposite side of the road. Bold colours and graphics are applied to adjacent guard rails, bollards, and light poles to make the crossing stand out from its environment. Colours are authoritative and recognisable in terms of traffic signs, providing a directive impetus. The design is deliberately kept simple to avoid cognitive overload in a context where pedestrians are believed to be experiencing higher cognitive demands linked to indicators of multiple deprivation. A light topper fitted to the top of the crossing pole features the same design elements as the footway. This aids crossing visibility from a distance, while reinforcing the language of speed and movement. Lines on the pavement are visually similar to those on the roadway, creating a visual and physical connection to the crossing point. The use of similar shapes and colours is deliberate. Illustrative designs of the Faster Boarding intervention are shown overleaf.

Figure 2 – High Street (Faster Boarding design)



Nudge-based intervention 2: Compli Crossing (Night time)

The second behavioural intervention is aimed at pedestrians, who are in the city at night for social and leisure purposes, these include: groups of students, residents on a night out, and visitors to the city e.g., hen and stag parties. Often these groups are crossing whilst under the influence of drugs and/or alcohol, increasing risk taking and poor judgement.

Behavioural analysis

So-Mo's behavioural analysis of pedestrian crossing behaviour explains that both alcohol and drugs impair cognitive functioning across a number of domains. So-Mo conducted three observations at night-time weekend evenings in Liverpool, where pedestrians were noted to be displaying signs of inebriation. These included shouting, catcalling, and pushing; swearing or nuisance type behaviour (including climbing onto public furniture); moving very slowly in an unfocused way, indicating slowed reactions; and stumbling or swaying, indicating a loss of coordination. Pedestrians displaying some or all of these indicators were observed to be acting in ways that would increase their risk of being involved in a traffic collision. This included walking in the road, rather than the pavement; stepping into the road towards stationary taxis without looking; diagonal crossing by sightline, which sometimes resulted in them being trapped in the carriageway on the wrong side of barriers; and stepping into the road in groups (herd behaviour) without appearing to look. There were frequent occasions when these behaviours put pedestrians into the path of oncoming traffic, causing the traffic to stop or slow to avoid a collision. An example observation can be viewed on YouTube.[16] The observed behaviours are supported by existing research into the impact of alcohol on the brain (Thomas, Riemann, & Jones, 2019) (Thomas, Tillman, & Riemann, 2023).

Relevant to safe crossing behaviours, substance use reduces a pedestrian's attentional bandwidth, limiting a person's ability to judge traffic speed and to spot hazards (Montgomery, Fisk, Murphy, Ryland, & Hilton, 2012). In addition, there are numerous sensory stimuli diverting attention which will reduce attentional bandwidth further (Regan, Lee, & Young, 2008).

When inebriated, prefrontal cortex activity is also reduced. This is problematic because the prefrontal cortex is responsible for inhibitory control, which helps individuals avoid or resist risky behaviours. Alcohol and drugs slow response time, limit attention and increase risky behaviour; these cognitive processes mean that attending to and using a signal-controlled crossing correctly will be affected when drunk or on drugs (Welch, Carson, & Lawrie, 2013).

Goal directed behaviour is a voluntary behaviour with an underlying intention. Maintaining a goal-directed behaviour requires the brain to selectively attend to sensory stimuli considered most important to achieving that goal; this is at the expense of the rest of the sensory stimuli. Attentional control, switching from attending to the social activity to road crossing is challenging under the conditions of being drunk and in a group. Self-regulation is limited in people who are drunk, and they are more reliant on herd behaviour when in groups; safe crossing is less likely to happen when crossing as a group.

Finally, herd behaviour was detected in these locations, where, for example, pedestrians walking in a group were observed to do what others in the group were doing, instead of using their own information or making independent decisions. This becomes problematic when a drunken member of the group steps into the road and others follow, despite the fact that the originator did not first check it was safe to do so.

The night-time design, designed for use at crossings on a desire line in the night-time economy, aims to encourage safer behaviour by rewarding and acknowledging the intrinsic goal of people who are in the city for the purpose of a night out to have fun and feel good about themselves. The images and language on the footway compliment the person crossing (male and/or female) in a fun and light-hearted way. The design is intended to be highly salient (bold, bright colours); something that is needed to cut through the visual and auditory noise of a city at night. This design is also reminiscent of the work of artist Peter Blake, who not only designed the artwork for The Beatles' Sgt. Pepper's Lonely Hearts Club Band album but also Liverpool's 'Dazzle Ferry', commissioned by Liverpool Biennial and partners, as part of the First World War commemorations. Peter Blake was also the lead artist in a flagship Capital of Culture exhibition used to launch Hull's Capital of Culture year.

[16] https://www.youtube.com/watch?v=C631c8nxUIA

A light topper fitted to the top of the crossing pole features 'eyes' whose gaze is directed down to the crossing area, thus enhancing crossing visibility from a distance whilst playfully directing the pedestrian's own gaze down towards the crossing area. Footsteps on the pavement and cues on the bollards are similar in shape and colour to the main elements and colours on the crossing footway, drawing the eye towards the crossing area and encouraging pedestrians from a distance of 30 metres away to first attend to and then continue to the crossing. The use of similar shapes and colours is deliberate as the designers wanted to harness the brain's ability to attend to and relate objects that are similar. Illustrative designs of the Compli-Crossing intervention are shown below.

Figure 3 – Night time (Compli-Crossing design)

Liverpool crossing design

Hull crossing design

All designs were developed in discussion with a range of stakeholders including the Department for Transport who, whilst recognising the temporary and experimental nature of the research, were keen that the designs did not inadvertently break regulations and guidelines set out in The Traffic Signs Regulations and General Direction (TSRGD) 2016. The TSRGD sets out the law regarding the design and conditions of use of official traffic signs that can be lawfully placed on or near roads in England, Scotland and Wales.

SITE SELECTION

A site selection process was followed to identify four sites in each city: two each of Compli-crossing and Faster Boarding. The plan was to have a primary and secondary site for each intervention type for each city, providing a back-up if the site was deemed unsuitable or become unavailable.

Police analysts in both cities filtered collision data from 2014 to 2018 to identify potential locations. The filters which were applied returned collisions which involved a pedestrian casualty aged 16 years or over; who was near a 'pelican, puffin, toucan or similar crossing'; and were not on the pedestrian crossing facility at the time. All severities of injury were included.

Table 1 - Site selection criteria

Site Selection Criteria	Compli-Crossing	Faster Boarding
History of pedestrian collisions	✓	✓
Casualties aged 16 or above	✓	✓
Pedestrian casualty location 'not on crossing facility'	✓	✓
30mph speed limit	✓	✓
Signal-controlled crossing facility	✓	✓
Night-time economy location	✓	✗
Night-time pedestrian collisions	✓	✗
Four lanes of traffic	✗	✓
'High street' location (presence of shops etc)	✗	✓

Once a long list of potential sites was identified, all of those where a signal-controlled crossing was in place were taken forward for further analysis. The analyses looked at time of day and day of week of the pedestrian collision, flagging those incidents which occurred in night-time economy periods (defined as occurring between 10pm and 6am on Friday, Saturday, or Sunday nights). It looked at casualty age, pedestrian contributory factors, driver contributory factors, and pedestrian carriageway location, and casualty home postcode. This additional analysis produced shortlists of sites, with the aim of identifying two of each site type in each city.

The project team used Google Streetview to assess each shortlisted location to determine suitability. For example, in Liverpool, some of the sites with four lanes of traffic had a large grassed central reservation and were therefore unlikely to encourage the goal-oriented diagonal crossing behaviour as the grassed area split the crossing action into two manoeuvres. Others were situated in residential or commercial areas and did not have a 'high street' feel. For Compli-crossing, some of the sites were not situated in heavily populated night-time economy areas.

A proforma was completed by the local authorities and project team for each site, providing a brief description for each, and then summarising site details, which covered:

- Pedestrian casualty numbers (within 50m of crossing for 2014-2018)
- Comments on the casualty analysis, including age of pedestrians, and timing of collisions.
- Subjective analysis of footfall (where available)
- Demographic profile of area and pedestrians using the crossing
- Ambient lighting levels (to ensure footage would be clear)

- Crossing information (make and model, time between vehicle red light and green figure, crossing area dimensions, number of poles, cable survey)
- CCTV information (permanent installation, distance to nearest CCTV camera).

The initial review of sites was followed by discussions with local stakeholders to gain their insight into the sites and the behaviour of road users in their vicinity. Some of the shortlisted sites were excluded from the list because they were due to have works under the Emergency Active Travel Funding, where the installation of new cycle lanes would reduce the number of lanes from four to two, and roadworks were potentially due to be in place at the time of the trial. The shortlisted sites were as follows:

Table 2 - Shortlisted sites

Road Name	City	Night time (Compli-Crossing)	High street (Faster Boarding)	Site Description
Hanover Street	Liverpool	1		This site includes a wide puffin crossing, linking bars, restaurants, nightclubs and hotels, close to a train station. The area has a high footfall at night and impaired pedestrians were identified in the collision analysis, the majority of whom were aged between 18 and 30 years old. The area is also used by taxis late at night, increasing the potential for pedestrian conflict.
Central Station	Liverpool	2		This site is close to a busy train station but had fewer night-time pedestrian collisions, although some were early evening at weekends. Some of the casualties were older, although the profile was mixed.
Prescot Road/ Orleans Road	Liverpool		1	This site has shops on both sides of four lanes of traffic, with residential streets situated behind the main road. The collisions occurred on weekdays and most during the day. Casualties lived within 1.5 miles away in communities classified as deprived.
Prescot Road/ Baden Road	Liverpool		2	This site has shops, a library and pubs on both sites of four lanes of traffic. The site is complicated as the crossing is situated on a large pedestrian island, which is surrounded by barriers. There is also an island parking area, which requires pedestrian access.
Lowgate	Hull	1		This site is situated in the 'old town' of Hull where bars, restaurants and nightclubs are located in a network of narrow streets. Lowgate itself dissects some of these streets and is the central location for taxi ranks. This site has a history of pedestrian collisions and has previously been subject to night-time economy road closures.
Anlaby Road	Hull		1	This site has four lanes of traffic on one of the main arterial routes in the city. There are shops on one site of the road and hospital parking on the other. The crossing has a central island, forcing pedestrians to perform two crossing actions.
Spring Bank	Hull		2	This site has four lanes of traffic, with a selection of takeaways, shops and international supermarkets on one side, with residential properties on the other.

Unfortunately, site selection started in April 2020 and therefore site visits were not possible due to Covid restrictions. This did mean that it was not possible for the project team to observe natural pedestrian crossing behaviour at the sites.

Four sites were taken forward for inclusion in the trial. Images of the interventions in situ and plans of each site area are shown in Appendix 1: Selected Sites (maps and Interventions in situ) on page 65.

Hanover Street, Liverpool had already been observed prior to undertaking this study and was the inspiration for the night time design. The profile of the pedestrian casualties, the signal-controlled crossing location, and the surrounding locality all met the criteria for this intervention. Finding an equivalent site in Hull was more difficult. There were sites which had similar pedestrian casualty profiles and were in busy night-time economy locations. However, the crossing facilities were zebra, not signal-controlled, crossings. At the time of site selection, the design elements being considered required the use of a signal-controlled crossing. Furthermore, consistency of crossing type across the cities would allow comparisons, which would be more difficult if different designs were monitored. The Lowgate site was not ideal for two reasons: the footfall was not as high as for Hanover Street; and the location of the pelican crossing was better suited for day-time pedestrian desire lines (linking shops and banks) than for night-time movement (between bars and clubs). However, in the absence of another appropriate site, and given the high night-time economy pedestrian issues, it was selected for Hull's night time site.

The Prescot Road/Orleans Road site in Liverpool met the criteria for the high street intervention. There are busy shops on both sides of the four lanes of traffic, with an optician's, banks, a pharmacy, and bakery all located at the crossing. There is no central reservation for pedestrians, encouraging direct crossing actions across four lanes. The adult pedestrians injured at this site all lived within 1.5 miles of the crossing and were all from the most deprived 10% communities. All these criteria aligned with the goal-oriented behaviour hypothesised by So-Mo and the path well-travelled bias which leads people who live locally to the site to incorrectly categorise the site as lower risk. The Spring Bank site in Hull was a reasonable match for this site. Whilst it didn't have shops on both sides at the crossing location, it is situated in an area of deprivation and like Prescot Road, it is surrounded by densely packed houses. However, this site was subject to lane closures to provide additional cycling space under the Emergency Active Travel Fund, meaning that there would no longer be four lanes of traffic, and roadworks would be in place at the time of the trial. The second site selected for Faster Boarding in Hull was Anlaby Road, near to the junction with Coltman Street. On one site of the road is a hospital building whilst on the other side are shops, including a takeaway, accountants, and estate agents. The crossing itself is staggered, with a pedestrian island in the middle. The area is also deprived and there is housing densely packed behind the side of the road with shops. However, with the hospital on the other side, the location does feel more industrial than Prescot Road.

In retrospect, the Anlaby Road site in Hull was an adequate comparison site on paper but less so in reality. Analysis of the postcodes of pedestrian casualties at Prescot Road found that all three individuals lived within 1.2 miles of the signal-controlled crossing. This compared to 4 miles for the three casualties injured at Anlaby Road. Those injured at Prescot Road all lived in the 10% most deprived communities, whereas the home locations of those at Anlaby Road were more mixed in terms of deprivation. The design of the intervention used in these locations was focused on working with people with limited cognitive bandwidth and who are goal oriented in an area in which they are familiar. The Anlaby Road site was not a high street situated in a dense residential area like Prescot Road, and instead, the crossing was used to access the hospital. This meant there were differences in motivation and behaviour between the two high street sites.

It is interesting to observe how difficult it is to match locations across two cities. The rationale for using Hull as the comparator city for testing whether the interventions were replicable was that it has a similar sociodemographic profile and similar road network to Liverpool. At a granular level, however, there are many differences, with more frequent use of zebra crossings in the night-time economy and fewer ‘high streets’ located on arterial routes in Hull.

METHODOLOGY

STUDY DESIGN

The study was designed to determine if the behavioural interventions influenced the way in which pedestrians used the signal-controlled crossings. To measure any change, the proportion of pedestrians who cross the road correctly during the intervention period would be compared to the baseline period. This is the main outcome measure.

Main Outcome

- The proportion of pedestrians who cross the road correctly during the intervention period, compared to the baseline period.

A number of secondary outcomes were identified. To identify any unintended consequences of the behavioural interventions, amongst pedestrians or drivers, other data were collected.

Secondary Outcomes

- Reported injury collisions compared by baseline and intervention period.
- Traffic flow and vehicle speed, compared by baseline and intervention period.
- Anti-social behaviour, compared by baseline and intervention period.

The original study protocol involved obtaining CCTV footage from each local authority and coding correct crossings by training researchers to manually code. Whilst exploring whether better quality CCTV cameras could be utilised, and which would not be diverted to a different view by the local authority, an artificial intelligence solution was identified. This would enable all crossings to be coded by the machine learning, increasing the sample size and power of the analysis. These AI cameras were used to gather data during September and October 2021 for baseline and intervention periods.

The methods of data collection for the various measures are shown in Table 3.

Table 3 - Methods used to capture main and secondary outcomes

Outcomes	**Method**			
	CCTV categorised data	**Interviews**	**STATS19**	**Tube/ radar box**
Main				
Pedestrian crossing	Yes	No	No	No
Secondary				
Collisions	No	Yes	Yes	No
Antisocial behaviour	No	Yes	No	No
Traffic flow and vehicle speed	No	No	No	Yes

DATA ISSUES

Covid-19

The study was originally intended to conclude in December 2021, with the interventions studied in March and April 2021. However, restrictions on movement during the Covid-19 pandemic meant that Liverpool City Council, their partners, and suppliers were unable to install the crossings in early 2021 as originally planned. This required new timeframes to be agreed by the parties involved.

Working during an ever-changing situation, the data collection period was delayed to autumn 2021 when restrictions were no longer in place.

Data Loss

Further delays in study completion were experienced due to problems caused by an external technology supplier. It was agreed that the project completion date would be extended, whilst Liverpool City Council, and stakeholders sought to resolve the issue.

Unfortunately, two weeks after the trial period, the project team were informed that a permanent data loss had occurred, resulting in all the footage data becoming inaccessible. There was no AI count data retrievable for either the baseline or trial periods, impacting the whole project. At this point, most of the elements of the interventions had been removed from the sites, meaning it was not possible to recapture footage for analysis.

So-Mo immediately initiated a crisis investigation, engaging partners in Liverpool and Hull City Councils to determine what footage, if any, from nearby local authority CCTV cameras were available. Fortunately, footage from all sites from when the intervention was in situ was available and shared with So-Mo, in line with associated data governance procedures. No data from the baseline period was accessible from the local authority CCTV footage due to camera overwrite. Whilst there were local authority cameras in the vicinity of all four sites (this had been a prerequisite of site selection as the original methodology involved manual counting of this footage), there were limitations with these cameras. The local authorities must be able to move the focus of these cameras to deal with live events and therefore not all hours of footage were recording behaviour on the pedestrian crossings. Furthermore, unlike the AI cameras, the project team did not have control over the angles of the cameras, which limited what was in view.

REVISED STUDY DESIGN

So-Mo inspected the footage received from local authority cameras to determine whether there was sufficient data to produce a meaningful research outcome. The footage was sped up and was observed to see how much of the total time at site had the crossing in view. The number of crossings per minute were counted and observed at different portions of time, to estimate a crossing rate (person per minute). If there was a crossing rate of >=6/minute, 300 minutes of footage during the trial and baseline phases could be viewed. If the crossing rate was lower, then more hours of footage would be required to be certain that enough crossings were observed to achieve power at a given site.

The Liverpool night time site is unusual as there is very high footfall, and the static camera was able to record an uninterrupted view of the crossing for 30 days with the installation in situ. This means there were 100,000 crossings recorded for the periods in question.

For the other sites, it was a more time-consuming task to calculate crossing rates as the cameras were not stationary and/or the crossings had lower footfall, and/or the trial intervention was partially or completely removed during the period the footage was available for. This required considerably more footage observed to ascertain that, given the number of usable hours of footage and footfall level, there would be sufficient crossings during the trial phase to achieve power. From these observations, it was determined that whilst more footage would be required to be observed at the Liverpool high street, Hull night time, and Hull high street, there was sufficient CCTV captured during the trial phase for a meaningful comparison to be made. From 30 days of footage viewed for Prescot Road, timestamped periods where data were usable and viewed, there were ~15,000 crossings. For Lowgate, there were eight days of footage, with 50 hours that were usable, with ~2,000 crossings; and for Anlaby Road, there were 12 days of footage with 100 usable hours, resulting in ~5,000 crossings.

A solution was required to remedy the situation, and which would secure the approval of all parties, including Liverpool City Council (as its immediate client) and The Road Safety Trust as the Project commissioner and grant provider. To get the project back into the position it was in prior to the data loss incident, a period of re-capturing baseline footage required matched conditions one-year on from the original baseline period. Approval to proceed with re-collection of baseline data was granted by The Road Safety Trust on 18th July 2022. Re-collection of baseline data was conducted in October 2022.

The original protocol, which included manual coding of slices of footage, had already been approved by The Road Safety Trust. Extensive due diligence had taken place to revert from this original protocol, but it was robust enough to go back to. It should be noted that ethical approval was not required, given the nature of the camera monitoring, anonymity, and data storage processes.

Due to the loss of the AI functionality, which would automatically count pedestrian behaviour within the pedestrian crossing, all local authority footage and newly collected baseline footage had to be manually counted/coded before being provided to Agilysis to analyse and interpret.

Despite these extreme challenges, sufficient crossings were observed and counted to continue with this evaluation.

STUDY PERIOD

The original trial dates were in March and April 2021, however, due to Covid-19 restrictions, the trial was delayed until autumn 2021. The original baseline data period (used in this report for evaluating the impact on traffic flow and vehicle speeds, and road traffic collisions) was **27th September to 10th October 2021**). The behavioural interventions were installed in the following week, with all elements in place for the trial period of **18th to 31st October 2021.**

The interventions were removed at different times with the Hull high street returned to its original condition on 30th November 2021; Hull night time on 9th November 2021; and both Liverpool sites on 18th January 2022.

The re-baseline period was **22nd October to 4th November 2022**. This provided a time period similar to the conditions when the behavioural interventions were in place but was 12 months later. This provided sufficient time for pedestrian behaviour to revert back to 'normal'.

Whilst there was a 12-month gap between the intervention and baseline periods, there were no significant changes to any of the site locations in terms of key businesses closing, change of use in the area, or long-term effects of Covid on numbers of pedestrians. All four sites remained well-used and well-served.

TRIAL LIMITATIONS

There are several limitations from using the revised design to collect pedestrian crossing data.

Local Authority CCTV Cameras

Local authority CCTV cameras are positioned in locations so that the organisation can monitor activities to prevent and detect crime. They can be used to reassure the public about community safety and can provide evidence to relevant enforcement agencies. This means that these cameras can be rotated to focus on different locations within the camera's field of view. Therefore, the cameras were not focused on the signal-controlled crossing 24 hours a day and there were periods when pedestrian behaviour footage was unavailable for coding.

Slices of footage were only coded when the cameras were trained on the agreed count lines and there were no outages. The only site where this became an issue was at the Hull high street where there was not enough daytime footage obtained from the CCTV cameras, meaning it was necessary to include some slices from the evening to increase the sample size.

Sample Size

The AI cameras would have greatly increased the sample size of counted crossings, as all pedestrian movements identified at the sites would have been included. Furthermore, whilst the analysis of this data would have focused on measuring the effect at the times of day and days of the week for which the interventions were designed for, this larger sample of all times of the day would have provided an opportunity to analyse the influence of these interventions at other times.

Manual Coding Accuracy

The accuracy of artificial intelligence is dependent on the machine learning used to train the AI to detect objects. As no AI footage of the intervention sites was available, it is not possible to determine how accurate the AI counts would have been. However, given the volume of AI coding which would have been generated, and the way in which reliability checks were programmed into the data processing stage, it is envisaged that a high number of accurate counts would have been created.

However, the methodology for manually coding involved in-depth training of coders and reliability testing to ensure that consistent counting was achieved. The section Appendix 2: Coding Methodology on page 73 details how reliability was ensured.

Requirement for a new baseline period

Retrospective baselining presents challenges and there is a risk that meaningful results might not be produced. The risk with baselining 12 months after the interventions has been installed is that a permanent change in pedestrian behaviour might have occurred.

However, it is not unheard of for baselines to occur post-intervention. 'Cross over design' is a method used in some randomised controlled trials. From a behavioural science perspective, it is important to note that both interventions were designed to change behaviour without the need to tell people how to use them or explain the reason for being there in the first place. The intention was for them to be an instinctive 'nudge' and pedestrian beliefs and knowledge would not be altered by the crossings. This is because the interventions changed the context in which poor crossing behaviour occurs. The aim was to alter the choice architecture to prompt a different available choice, without educating, persuading, or informing people in these locations on the risks of non-use or the benefits of crossings. The interventions were designed to work on an automatic and intuitive level and the effects should only be experienced when an individual was interacting with the nudges. As such, a 12 month 'washout' period is likely to have been more than sufficient for pedestrians to be behaving as they did before the interventions were installed.

A statistical test, known as the VanderWeele estimate (VanderWeele & Ding, 2017), was applied to the Prescot Road analysis to account for any unmeasured confounding in this observational study caused by baselining 12 months later.

Lowgate

It was decided not to code the footage from the night time site at Lowgate, Hull. A night-time observation undertaken when the behavioural intervention was in place revealed that two key elements were missing. Firstly, pedestrians were using a very clear desire line, to head between destinations in the night-time economy, moving directly from one bar across the road to the next. The pelican crossing was located several metres away from this desire line, further down the road. The second issue was that the crossing itself was poorly lit and was barely discernible against the well-lit colourful, noisy, and bright bars and nightclubs. It was doubtful that a drunk pedestrian in that location would even be aware that an alternative, safer choice was in the proximity and therefore it did not make sense to code the crossing data at that location. Hull City Council is currently investigating other solutions to reduce pedestrian risk at this site.

Whilst not a study limitation related to the data loss, the exclusion of the night time site in Hull means that it would not be possible to determine if the results found for the night time site in Liverpool would be replicable elsewhere.

DATA COLLECTION

Coding crossing counts

A methodology was designed which was used to guide selection and coding of footage from the local authority CCTV cameras at all sites. On completion of coding, an anonymised dataset was then provided to Agilysis to analyse.

Footage from each site in the intervention phase was viewed in its entirety to identify periods when the intervention was entirely in place. Footage was selected at times of day when the risk of a KSI was highest at these sites. Nearest equivalent footage (day of week, time of day) at baseline was selected to compare.

The crossing at Hanover Street, Liverpool was a night-time intervention, hence night-time footage was selected. For the other two sites, these were interventions to prevent KSIs during the day, so daytime footage was prioritised.

At the Hull high street site, the intervention was fully installed until 4th November; after this, only the pavement and road markings were retained. Useable footage was limited to the 1st and 2nd November, so the period of observation was extended from 07:00 – 19:00, accounting for 73% of the footage used in the analysis.

The dates and times when footage was used are shown in Table 4 and the full coding protocol is shown in Appendix 2: Coding Methodology.

Table 4 - Dates of footage reviewed by site and phase

Site	Intervention	Phase	Dates	Times
Hanover Street Liverpool	Compli-Crossing	Baseline	23.10.22 (Friday) 29.10.22 (Saturday) 30.10.22 (Sunday)	22:00 to 02:00
Hanover Street Liverpool	Compli-Crossing	Intervention	29.10.21 (Friday) 30.10.21 (Saturday) 31.10.21 (Sunday)	22:00 to 02:00
Prescot Road Liverpool	Faster Boarding	Baseline	22.10.22 (Saturday) 25.10.22 (Tuesday) 01.11.22 (Tuesday) 02.11.22 (Wednesday) 04.11.22 (Friday)	07:00 to 18:00
Prescot Road Liverpool	Faster Boarding	Intervention	23.10.21 (Saturday) 26.10.21 (Tuesday) 02.11.21 (Tuesday) 03.11.21 (Wednesday) 19.11.21 (Friday)	07:00 to 18:00
Anlaby Road Hull	Faster Boarding	Baseline	29.10.22 (Saturday) 31.10.22 (Monday) 01.11.22 (Tuesday)	07:00 to 19:00
Anlaby Road Hull	Faster Boarding	Intervention	01.11.21 (Monday) 02.11.21 (Tuesday) 06.11.21 (Saturday)	07:00 to 19:00

Blinding

Analysts from Agilysis were given an anonymised dataset regarding location, type of nudge-based intervention, and which observations were in the baseline or intervention periods. This was to reduce the potential for error or bias. The analytical team had no access to the CCTV footage or the uncoded material before analysis was completed. At that point, the team were unblinded and were able to match the results to the site, time period, and intervention type.

Statistical analysis

Statistical analysis was carried out by Agilysis to determine the magnitude and significance of any effects on crossing behaviour from the intervention, separating out any effects arising from differences in other factors, such as weather and light conditions. A series of sample crossing counts for each site, from both the pre-intervention and post-intervention time periods, were used for statistical modelling. These samples were taken from manual counts over fixed time periods of video footage. Each sample included a count of correct crossings, a total count of crossings, an anonymised site number, and flag determining whether the sample was taken pre- or post-intervention. These records were supplemented with additional flags determining whether the sample was taken at night, and whether adverse weather conditions were present.

For each site, a Poisson regression model was fitted, which assumes that the number of correct crossings X is Poisson distributed with mean λ which depends linearly on Boolean flags for night-time δ_n, adverse weather δ_w and whether the time period was post-intervention δ_i, offset by the total number of crossings in the sample Y. That is to say:

$$X \sim \mathrm{Po}(\lambda), \quad \lambda = Y \cdot \exp(\beta_0 + \beta_n \delta_n + \beta_w \delta_w + \beta_i \delta_i)$$

for some β_0, β_n, β_w and β_i. From the values of $\exp(\beta_n)$, $\exp(\beta_w)$ and $\exp(\beta_i)$, one can determine the relative effect of night-time (β_n), adverse weather (β_w), and the intervention (β_i) respectively on the expected number of correct crossings (where β_0 is the intercept). From their p-values one can indicate how likely (the probability) these effects are real and have not occurred by chance.

Weather

Weather is a potential confounding factor, with adverse weather (such as heavy rain) likely to influence the crossing behaviour of pedestrians, who may cross at different locations or with less awareness of their environment. In such cases, the presence (or not) of the nudge-based crossing is unlikely to encourage people to walk to the crossing and wait and will therefore influence the results. Weather data was obtained for each city, measuring rainfall, wind speed, and temperature with any periods of particularly inclement weather identified and marked in the blinded data.

The project team would like to thank Dr Roger Brugge of the University of Reading for sharing 3 hourly data from the appropriate weather stations for all days in the intervention and new baseline periods. Using this data, an 'adverse weather' flag was created for the analysis, based on weather station codes which covered drizzle, rain, fog, hail, and snow, as well as wind above 22 knots (classified as 'strong breeze' on the Beaufort Scale, where umbrellas would be difficult to be kept under control).

SECONDARY OUTCOMES

Whilst the interventions were designed to influence pedestrian crossing behaviour, additional data were collected to ensure there were no unintended consequences. These included recording any antisocial behaviour undertaken by pedestrians using the crossings and any changes in behaviour by drivers. None of these secondary outcomes are related to the pedestrian crossing behaviour and it was agreed to use the data collected during the original baseline and intervention periods to assess these secondary outcomes. The data loss had no impact on these behaviours or their data collection methods.

Interview data

It was not possible to capture near misses or traffic conflicts with this coding methodology. However, interviews with key stakeholders provided important contextual information on whether the interventions impacted on the level of antisocial behaviour, traffic flow, collisions, and any unexpected events associated with the crossings.

The interviews also provided an opportunity to conduct a process evaluation and understand the implementation process and stakeholders' impressions of the barriers and facilitators of conducting this type of trial and installing these types of crossings.

STATS19

Any pedestrian-vehicle injury collisions reported to the police, and which occurred within 30 metres of the selected crossings were captured for the original baseline period and intervention period. Whilst these sites have been selected because there are high numbers of pedestrians who have been injured in their vicinity, it should be remembered that injury collisions are relatively rare events. As the number of collisions which might have occurred in the baseline or intervention period were likely to be low, in-depth statistical analysis would also be limited. As such, the descriptions recorded by attending police officers were to be reviewed to understand the circumstances of collisions within the two time periods, alongside basic analysis on time of day, day of week, weather conditions, and vehicle type. The contributory factors assigned to all pedestrians and vehicle drivers and sociodemographic characteristics of all participants would be described in any reported collisions.

Speed and traffic flow

The interventions are targeting pedestrian behaviour, rather than driver behaviour. For drivers, the signal-controlled crossing still operated in the same way as any other puffin crossing, with the same sequence of lights and rules applying.

However, there could be changes in driver behaviour due to the installation of the intervention (with drivers avoiding the road or increasing or decreasing their speed in response), or external factors could affect the routes that drivers take (such as roadworks, that increase or decrease the traffic volumes). Therefore, data was collected on traffic flows and vehicle speeds to understand changes in pedestrian crossing behaviour in the context of the prevailing traffic.

Automatic Traffic Counters (ATCs) utilising pneumatic tubes and secure data collection devices were deployed for the original baseline (in 2021) and intervention periods to monitor the number of vehicles approaching the crossing and the speed at which they were travelling at.

RESULTS

MAIN OUTCOMES – INTERVENTION 1: HIGH STREET (FASTER BOARDING)

Figure 4 and Table 5 show the numbers of crossings at the high street site, by the coded behaviour. It shows there was little change in the number or proportion of correct crossings, with a slight decrease in the number who crossed incorrectly (but which represented the same proportion overall).

Figure 4 - Numbers of crossings, by coded type for Baseline and Intervention periods at Hull high street site

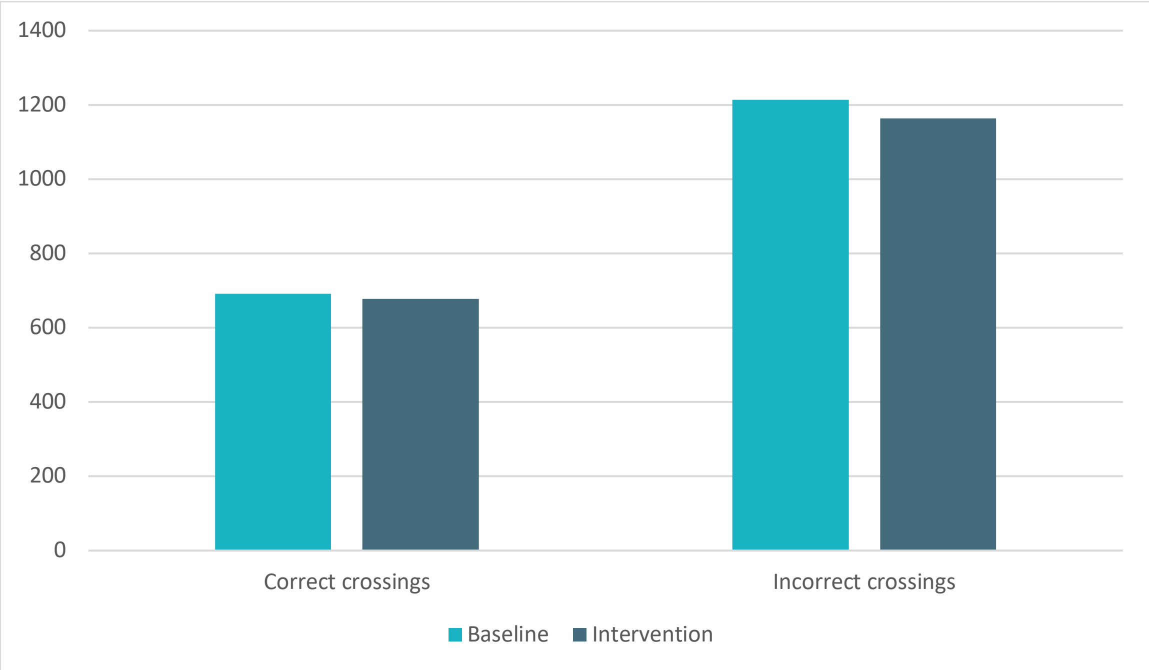


Table 5 - Numbers of crossings by coded type for Baseline and Intervention periods at Hull high street site

Hull high street	Baseline		Intervention		
	Number	Percentage	Number	Percentage	p-value
Correct crossings	692	36%	678	37%	0.785181
Incorrect crossings	1,213	64%	1,164	63%	
Total crossings	1,905		1,842		

Figure 5 and Table 6 show the number and proportion of crossings at the Liverpool high street site by coded crossing type. It shows a clear increase in the number and proportion of correct crossings.

Figure 5 - Numbers of crossings, by coded type for Baseline and Intervention periods at Liverpool high street

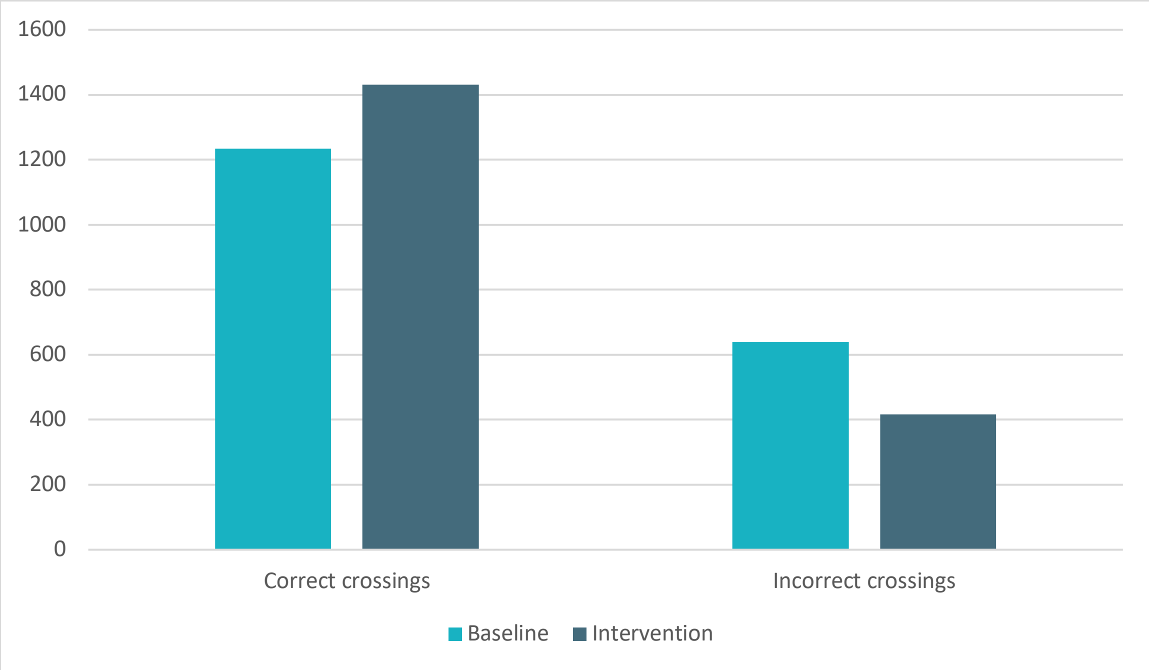


Table 6 - Numbers of crossings by coded type for Baseline and Intervention periods at Liverpool high street

Liverpool high street	Baseline		Intervention		
	Number	Percentage	Number	Percentage	p-value
Correct crossings	1,235	66%	1,431	77%	6.37E-15*
Incorrect crossings	639	34%	416	23%	
Total crossings	1,874		1,847		

*p-value significant at 0.05

Poisson regression analysis was undertaken on the crossing data, with the results shown in Appendix 3: Statistical Analysis. The Poisson regression analysis found that the two high street sites produced quite different results, with a 14% increase in correct crossings in Liverpool, which was unlikely to be due to chance. The Hull high street, on the hand, experienced a 15% reduction in correct crossings, however. Whilst the two sites had similar total counts of crossings for the baseline and intervention periods, the regression model also accounted for the number of slices of data used for counting. For the Hull high street, because the CCTV cameras were moved more frequently, more samples of footage were required but with fewer crossings in each (200 samples for Hull compared to 70 for Liverpool). The smaller numbers of crossings per sample for the Hull site meant that it was more difficult to determine whether the 15% reduction in correct crossings was due to chance.

MAIN OUTCOMES – INTERVENTION 2: NIGHT TIME (COMPLI-CROSSING)

Figure 6 and Table 7 show the numbers of crossings at the Liverpool night time site on Hanover Street, by the coded behaviour. It shows there was a small reduction in the number of correct crossings and an increase in the number of incorrect crossings. This reduction in correct crossings was unlikely to have occurred by chance, according to the statistical test.

Figure 6 - Numbers of crossings, by coded type for Baseline and Intervention periods at Liverpool night time

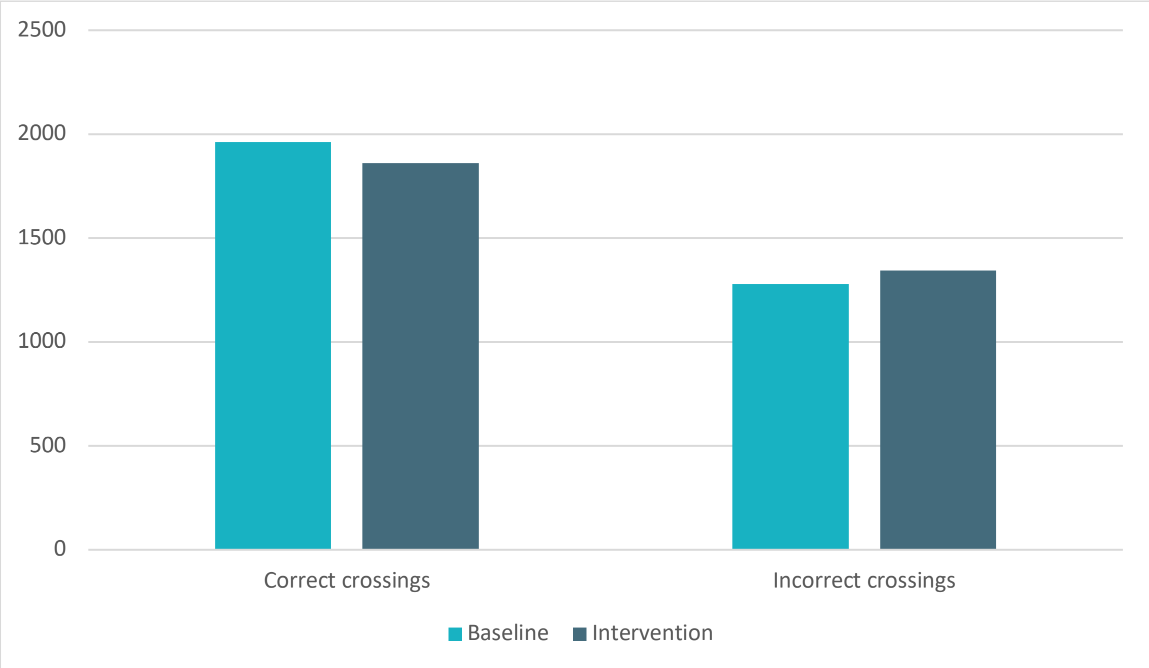


Table 7 - Numbers of crossings by coded type for Baseline and Intervention periods at Liverpool night time

Liverpool night time	Baseline		Intervention		
	Number	Percentage	Number	Percentage	p-value
Correct crossings	1,963	61%	1,861	58%	0.045044
Incorrect crossings	1,279	39%	1,344	42%	
Total crossings	3,242		3,205		

The Poisson Regression analysis for this site can be found in Appendix 3: Statistical Analysis. Unlike the initial testing on the proportions of correct crossings, the regression model suggests that, although the expected proportion of correct crossings is 5% lower during the intervention period, this change is likely to be due to chance.

Sample Sizes

Overall, across all sites, the proportion of correct crossings increased from 55% (3,890/7,021) to 58% (3,970/6,894).

To distinguish a change of this size from random fluctuation ($p<0.05$), a study at 80% power would need a sample of around 8,109 crossings in each period (or of 10,856 at 90% power). Here, power indicates the confidence with which a study can assert that it would not wrongly reject a true effect.

At a stricter level of statistical significance, a study (at 80% power) would need around 12,066 crossings in each period (or of 15,372 at 90% power).

This study had a total of 7,021 crossings in the baseline period, and of 6,894 in the intervention period. More confidence in the results across all sites could have been achieved with a slightly larger sample.

SECONDARY OUTCOMES

Reported injury collisions

All sites were selected because of the high number of injury collisions which involved adult pedestrians. The night time sites in Liverpool and Hull were selected because some of these pedestrian collisions occurred during times associated with the night-time economy (late nights at weekends). The high street sites are both urban dual carriageways (30mph). Collisions were included for analysis if they occurred within 30 metres of the crossing.

Monitoring of collisions took place during the original trial dates, because the issues with CCTV capture would not influence road user behaviour and the likelihood of a collision occurring.

Table 8 shows the number of casualties and collisions at the two high street sites in the original site selection periods and also in the more recent period before the interventions were installed.

Table 8 – Intervention 1: High Streets (Faster Boarding) Site Selection – Pedestrian Casualties and Injury Collisions

	2014-2018 Pedestrian Casualties	2014-2018 All Injury Collisions	2019-2021* Pedestrian Casualties	2019-2021* All Injury Collisions
Anlaby Road, Hull	3	23	0	14
Prescot Road, Liverpool	3	5	0	0

*Prior to the start of the trial period of 26/09/2021

During the trial month, in both the baseline and intervention periods, there were no injury collisions reported at either high street site, as shown in Table 9.

There was a pedestrian slightly injured in the vicinity of the Liverpool high street site after the trial period, but before all the intervention elements had been removed (in December 2021). This incident occurred in the dark and involved a teenage pedestrian who was using the crossing. The crossing was not on the green figure phase at the time and the pedestrian crossed from behind stationary vehicles, assuming that all lanes were stopped. The main intervention elements of road markings had been removed the day before the incident.

Table 9 – Intervention 1: High Streets (Faster Boarding) Trial Period - Pedestrian Casualties and Injury Collisions (27/09/2021-31/10/2021)

	Baseline Pedestrian Casualties	Baseline Injury Collisions	Intervention Pedestrian Casualties	Intervention Injury Collisions
Anlaby Road, Hull	0	0	0	0
Prescot Road, Liverpool	0	0	0	0

Table 10 shows the numbers of injured pedestrian casualties and the total number of injury collisions during the site selection period of 2014 to 2018 at the two night time sites. As can be seen, the Liverpool night time site had a particularly high number of pedestrians injured in this period, and all these collisions involved a single pedestrian casualty. The table also shows the numbers which occurred during the project initiation period, prior to trial implementation. Sadly, at the night time site in Hull on Lowgate, north of the crossing where there were a cluster of collisions in the site selection period, there was a fatal collision involving a pedestrian in August 2021, a few weeks before trial implementation. The project team worked closely with the deceased's family on the decision to continue with the trial.

Table 10 – Intervention 2: Night Time (Compli-Crossing) Site Selection – Pedestrian Casualties and Injury Collisions

	2014-2018 Pedestrian Casualties	2014-2018 All Injury Collisions	2019-2021* Pedestrian Casualties	2019-2021* All Injury Collisions
Hanover Street, Liverpool	17	17	0	0
Lowgate, Hull	6	8	3	3

*Prior to the start of the trial period of 26/09/2021

Table 11 shows the trial month data, for both the baseline and intervention periods at the two night time sites. There were no reported injury collisions at either site.

Table 11 - Intervention 2: Night Time (Compli-Crossing) - Pedestrian Casualties and Injury Collisions (27/09/2021-31/10/2021)

	Baseline Pedestrian Casualties	Baseline Injury Collisions	Intervention Pedestrian Casualties	Intervention Injury Collisions
Hanover Street, Liverpool	0	0	0	0
Lowgate, Hull	0	0	0	0

Whilst these sites were selected because there were high numbers of pedestrians who have been injured in their vicinity, it should be remembered that injury collisions are relatively rare events. The project team predicted that the number of collisions which might occur during the trial was likely to be low, limiting in-depth statistical analysis. This analysis was a secondary outcome measure, included to identify any immediate, observable increase in risky behaviour (by drivers or pedestrians) which resulted in reported injury collisions.

These figures suggest that risk did not dramatically increase during the intervention period, but it is not possible to state any direct impact on safety from the crossing designs. This is determined through the main outcome measures related to observed pedestrian behaviour.

Traffic flow and vehicle speed data

Speed and traffic flow data were collected during the original baseline and intervention periods, for the same reasons as the collision data were analysed for the original periods. Driver behaviour would not be influenced by the effectiveness or not of the CCTV cameras.

As can be seen from the tables below, there were no large differences in mean or 85th percentile speeds, traffic flows, or the proportions of vehicles travelling over the posted speed limit between the baseline and intervention periods. The ATC tubes in Liverpool were regularly damaged by street cleaning machines, and therefore some dates were excluded from the analysis, and only data from the eastbound channel was collected for the Liverpool night time site.

Intervention 1: High Street (Faster Boarding)

Table 12 - Anlaby Road, Hull Speed and Traffic Flow data

	Total Vehicles	% over the posted speed limit	Mean speed	85th percentile speed
Week 1 Baseline	129,420	19.6%	25.2mph	30.6mph
Week 2 Baseline	124,659	16.4%	24.2mph	29.8mph
Week 1 Intervention	126,566	19.2%	25.1mph	30.5mph
Week 2 Intervention	123,602	20.5%	25.5mph	30.8mph

Table 13 – Prescot Road, Liverpool Speed and Traffic Flow data

	Total Vehicles	% over the posted speed limit	Mean speed	85th percentile speed
Week 1 Baseline	12,880	14%	22.1mph	30.4mph
Week 2 Baseline	13,648	8%	21.1mph	27.3mph
Week 1 Intervention	15,307	6%	19.4mph	26.7mph
Week 2 Intervention	9,748	8%	20.1mph	27.6mph

Intervention 2: Night time (Compli-Crossing)

Table 14 - Lowgate, Hull Speed and Traffic Flow data

	Total Vehicles	% over the posted speed limit	Mean speed	85th percentile speed
Week 1 Baseline	51,754	1.9%	18.6mph	23.7mph
Week 2 Baseline	49,794	1.7%	18.4mph	23.5mph
Week 1 Intervention	51,172	1.5%	17.8mph	22.9mph
Week 2 Intervention	48,154	1.7%	17.9mph	23.2mph

Table 15 – Hanover Street, Liverpool Speed and Traffic Flow data – Eastbound only

	Total Vehicles	% over the posted speed limit	Mean speed	85th percentile speed
Week 1 Baseline	3,312	0.2%	12.9mph	17.1mph
Week 2 Baseline	3,863	0.1%	12.2mph	15.8mph
Week 1 Intervention	3,843	0.2%	11.2mph	14.4mph
Week 2 Intervention	3,204	0.0%	15.5mph	15.9mph

Anti-social behaviour

An interview took place with the Control Room Manager at Hull City Council. As their role involved monitoring the cameras at the two locations in Hull, they were able to identify any issues at the sites. They reported that there were no known instances of anti-social behaviour linked to the crossings and there were no observed collisions.

There was some vandalism at the sites in Hull. The first incident was at the night time site, where the design looks like graffiti, and therefore it was felt that it was not surprising that someone added to it. This vandalism was shared on social media and then similar graffiti was added to the high street site.

Vulnerable road users

Throughout the trial, So-Mo conducted activities to engage with Sensory and Physically Impaired Road Users, ensuring their feedback was included throughout each phase.

Prototype 1 – engagement and feedback

In January 2020, Sensory and Physically Impaired Road Users from Liverpool City Council, Greenbank Project, Spinal Injuries Association, The Wheel of Life Liverpool, Inclusion 4 Disability, RNIB, Road Peace Liverpool and Liverpool City Region Combined Authority, and the Pocklington Trust reviewed a full-scale prototype of the behavioural intervention in a warehouse setting in Liverpool. They provided feedback on the use of sound, lights, and materials, which were implemented in the final designs. For example, the use of sound to nudge correct crossing was difficult to discern at the sound levels that would also allow environmental noise to be heard, and so sound was removed from the designs. Lighting was considered highly effective, and moving lights were the most salient but concerns about causing dizziness for some road users were noted and removed from the final designs. Finally, all parties endorsed the use of coloured poles, pole toppers, and footsteps on paving to crossing, with recommendations the colours be brighter. Similarly, with the road crossing itself, the red chosen was too dull and there needed to be more contrast between the colour of raised paving and the crossing road surface. These recommendations were all incorporated into the refined designs. However, instead of a flat one-colour road surface, chevrons were used at one site to increase the perception of speed. Due to the removal of dynamic elements of sound and moving lights, the red reflective surfacing on the design for the night-time economy sites were changed to incorporate a more dynamic and engaging design.

Feedback on refined designs

Sensory and Physically Impaired Road Users from Liverpool City Council, Greenbank Project, Spinal Injuries Association, The Wheel of Life Liverpool, Inclusion 4 Disability, RNIB, Road Peace Liverpool City Region Combined Authority reviewed re-designs of the crossing in November 2020. Their feedback, which focused on including light as an important element but that the light needed to be carefully directed so that it did not obscure people's vision or be too distracting once at the crossing, was included in a final consultation in December 2020, which included all stakeholders (e.g., Police, local authorities, other road users, the Department for Transport, and the City Access Forum). Possible risks and mitigation strategies were identified for both designs (high street and night time) which were both signed off.

Feedback on refined 3D prototypes

It was planned to conduct a second review of full-scale prototypes in a warehouse setting in January 2021. However, due to ongoing Covid restrictions that were in place at the time and the likely risk to health, this step was cancelled. However, the prototypes designs and specifications were subject to Road Safety Audits.

Road safety audits

In April to May 2021, Road Safety Audits with respect to the needs of vulnerable road users were conducted at all sites to ensure 1) while interventions were installed access or use of crossings was not impeded and 2) the risk of installed interventions causing unintentional harm was minimised, for example, either by unintentional effects on traffic, or the materials used (e.g., slippery walking surfaces). Fourteen recommendations were made to protect vulnerable road users; all of which were implemented into the final installed sites.

On site prototypes

Prior to installation, a final on-street prototyping event took place in Liverpool City Centre on 4th February 2021.

At this time, the UK was under restricted movement, and a recent Covid outbreak had been reported in Liverpool. As such, on-road prototype testing was conducted by a skeleton crew, under supervision of So-Mo and Liverpool City Council Highways Officers and engineers.

Several tests were conducted including ensuring that the visual cues and nudges attached to railings could not be detached, and that a person in a wheelchair or a child could be clearly viewed by a vehicle in transit.

Trial engagement

In October 2021, Sensory and Physically Impaired Road Users engagement events took place shortly after installation in Liverpool and Hull.

Real-world design can have unintended consequences for people outside the defined cohort. Neuro-diverse, sensory, and physically impaired individuals are important in this context.

The project team remain highly committed to robust testing and given the findings for the Liverpool high street site, it is recommended that the partnership seek to conduct further engagement to seek where refinements can be made.

Liverpool

Sensory and Physically Impaired Road Users and local charities who represent them (Bradbury Fields, RNIB and Merseyside Sight Loss Council) were invited to an on-site review of the installed crossings; refreshments and travel expenses were made available.

Promotion attempts were via engagement with local groups, invitations issued via Twitter to individuals who self-identified as having physical, sensory and/or neurological conditions and also requests to share an invitation to attend were sent to the Liverpool City Council Corporate Access Forum.

One individual (RNIB) who had visual impairment was positive about both designs, but particularly the crossing design at the high street site where the use of high contrast markings and arrows helped him identify and use the crossing. Another (Liverpool City Council councillor and PIRU) who attended the engagement day reported his friend (Inclusion 4 Disability) used the high street crossing on a previous Sunday morning with her guide dog and while the dog successfully navigated the high street crossing, it crossed diagonally, which may pose a risk. The guide dog owner believed that the guide dog behaved this way as the dogs are trained to recognise black and white contrasting stripes on a zebra crossing, and this may be why this dog veered towards the chevrons of the same colour.

During the engagement day, a visually impaired road user was observed using the night time site with his guide dog. When asked for comment, he explained that he was totally blind and relied on a guide dog to help him navigate the city. He had not noticed any difference in the manner his dog had guided him. Nor did his sighted companion.

Regarding the Liverpool night time crossing design, a concern was raised by a person who did not attend a consultation event that patterned floor designs might cause people with dementia to perceive dark spaces as holes. This was considered important feedback, and the project team were disappointed that there was not the opportunity to understand this further, as they were unable to speak with a person or carer with this lived experience on the day.

It was agreed that in Liverpool, the limited participation in the engagement day made it difficult to draw conclusions and that further engagement that included people with lived experience of neurological diseases and impairments, was required.

The project team remained highly committed to gathering feedback from sensory, physically, and neurologically impaired road users and suggested making further attempts to broker engagement with the Liverpool City Council Corporate Access Forum Chair and wider groups. This was rejected by the Corporate Access Forum, who requested that the trial sites were removed as soon as the trial period ended.

Hull

Hull City Council conducted independent engagement activity with local groups. Hull Access Improvement Group (HAIG) represents, amongst other groups, blind and partially sighted residents. HAIG also champions improvements for those with physical limitations and learning difficulties. A meeting with HAIG was positive. The chevrons caused concern for one person who had impaired vision after a stroke. This individual found the night time design easier to deal with. The group provided good feedback and were pleased that the partners were trying to do something different. This was in contrast with criticisms from groups in the Liverpool area who felt that guide dogs would be disoriented by the crossing. Requests for empirical testing to substantiate this and, if required, suggestions for how this might be addressed in future designs were denied.

LESSONS LEARNED

INSIGHTS FROM PARTNER INTERVIEWS

Interviews were conducted with stakeholders from Hull in November 2021, immediately after the trial period and before the CCTV data issue. Interviews with stakeholders from Liverpool had not been arranged when the project was paused to investigate the data issue and when the decision to restart the trial was made, it was agreed that too much time had passed to gather good insights from stakeholders. Therefore, the following is based on the experiences from one city only.

All interviews were conducted via Microsoft Teams by Agilysis and followed the interview guide included in Appendix 4: Stakeholder Interview Guide on page 77.

The interviews covered a range of topics, including the installation, implementation, durability, and effectiveness of the interventions. The interviews also explored the trial itself, including responses from the media, anti-social behaviour, and collisions.

There were seven interviews in total, covering the following roles and organisations:

- Traffic Management Officer, Humberside Police
- Traffic Engineer, Hull City Council
- Marketing Officer, Safer Roads Humber
- Design and Commissioning Team Leader, Hull City Council
- Intelligence Systems Manager, Hull City Council
- Control Room Manager, Hull City Council
- Highways Development and Design Engineer, Hull City Council

Installation

Overall, it was felt that installation was quick and straightforward, and it was due to good planning. The methods used to install the crossings on the road surface were efficient and quick and no problems were reported. It was felt that the number of meetings prior to installation supported this; there was a high level of communications, with clear action points and so it was clear who owned which tasks.

The only issue which occurred was prior to installation, where permits for installation needed to be amended at the last minute because out of hours traffic flow, with a contraflow required at the Anlaby Road site. This issue occurred because it was not clear what works were required until a couple of weeks before installation. Engaging with the contractor earlier would have helped to resolve this, although it didn't affect the actual installation.

Implementation

There was some confusion over the design of the high street intervention. Stakeholders felt that people didn't really understand the way that the design was supposed to work, with comments in the local paper and social media about the white lines on the footpath. One interviewee watched people walking down the middle of the chevrons and avoiding the crossing design itself.

Communication with the public and explaining the purpose of the crossings was mentioned by several stakeholders. Explaining the purpose of the trial to the public could have influenced the results but the crossings did attract a lot of negative public and media interest, which in turn led to misinformation. It was acknowledged by stakeholders that a huge press campaign could have stopped the comments but that could have skewed the findings and it had been previously discussed within the project team. The aim was to empirically test behaviours without influencing perception or attitudes towards the sites or educating on risk profiles and by explaining the purpose of the crossings, it would have negatively impacted the ability of the trial to determine whether the intervention (designed to 'nudge' behaviours in a nonconscious way without need for information or persuasion) would change behaviour.

It was felt that the crossings were negatively received in the press and on social media for a few reasons. Several stakeholders though that it was because people attack anything that is different and like to complain without knowing what is going on. Similarly, Hull City Council was in a period where public opinion of the authority was low. There were a lot of road works going on because of delays caused during the Covid pandemic and there were complaints that the crossings were a waste of money. The final issue with the press and social media was that it is important to have sufficient resource available to respond to queries. In addition, the pace of the press asking questions was faster than the Council and partners could issue responses, and this made communications challenging.

Colleagues of interviewees didn't always understand the crossing designs either. For example, those within the project team had had Nudge Theory and the principles of applied behavioural science explained to them but their colleagues were sceptical about being able to encourage people, especially in the night-time economy, to walk further to get to the crossing. Some of those not on the project team also thought that the night time design was a bit flamboyant for the Old Town area of Hull, due to it being a conservation area.

There were some social media comments that the night time design was obviously designed by men and that the words involved were sexist. It was noted that this person was contradicted on social media for reading too much into the design.

One interviewee reported that they were aware of one person who had impaired vision after a stroke and couldn't perceive the road properly when the high street chevrons were in place. She reported crossing the road looking upwards.

One practical issue which was reported was that installation started a couple of days earlier than expected, whilst the press officer was on leave, meaning there was little preparation to respond to the media. There was also a fatality near the night time site in the weeks before the trial, but this was managed well by the partnership media manager. The Family Liaison Officer worked closely with the family to explain the trial and that it was not connected to the incident. In the end, the family were supportive of the trial and felt that it could benefit others who had experienced a tragedy like themselves.

There was some vandalism at the sites. The first incident was at the night time site, which looks like graffiti, and therefore it was felt that it was not surprising that someone added to it. This vandalism was shared on social media and then graffiti was added to the Faster Boarding site.

There were many positives in relation to implementation, though. Other than the small amount of graffiti, no other anti-social behaviour was reported or observed, and this was seen as a strong positive as there were pre-trial concerns that people would be encouraged to spend time on the crossings, especially at the night-time economy site. There were also no collisions (including damage only collisions) reported or observed during the trial.

Whilst there was some negative press, overall, it was felt that there was positive feedback to the interventions. With the night time intervention, some felt that people liked it and wanted to see and take photos of it. It was stated that the crossings were meant to be noticed so that the large amount of social media attention was a good thing. Even with the large amount of social media attention, it was felt that this was because people were interested in what it was about, rather than stating that the design wouldn't work or should be in a different place. One respondent thought there was fewer negative criticisms than they had expected.

The press day was really positive and involved multiple stakeholders, with coverage on various television and radio stations.

Durability

Overall, even though the materials were designed to last for the trial period and not a longer time, most of the elements were considered to be durable. It was felt that the road markings would be long-lasting, depending on traffic flows at the sites in question, and could last several years.

The pole toppers might need to be re-designed, depending on the site, as they would need to be removed to access the pole cap terminations underneath. These could be hinged in a permanent design.

Effectiveness

Opinion was divided on the potential effectiveness of the designs.

With the night time crossing design, one interviewee though that it should be effective as it is so bright and should attract pedestrians.

Another thought it wouldn't work in another night-time economy location and that it would likely have a negative effect because people would lie in the road and take pictures. It was felt that it would be preferable to steer pedestrians to the physical location through barriers, although this can be difficult to implement and not create issues for other road users, such as cyclists. These thoughts were echoed by another interviewee who through that a road closure or physical barriers would be better at that location. It was argued that there is so much occurring in that location, with many distractions for drivers and that the design wasn't the right solution for Lowgate. However, they did say that it might work somewhere else.

The high street design received more positive feedback. The site received a lot of comments and the media referred to it as having a 'Mario Kart' design. This made people curious about it and they were attracted to it to go and take a look. It was felt by another interviewee that the design was visually clear, with the arrows on the pavement and the bright arrows across the road. There was a little confusion about the arrows appearing to go the wrong way across the road, but this was due to the location of the tactile pavement and the consultation with accessibility experts who requested that the placement was aligned with how guide dogs are trained to lead a visually impaired pedestrian to the button box. A final interviewee though that the signage should steer people towards the crossing and that it would educate people to not follow desire lines.

There were two interviewees who didn't think the high street design would be effective. One said that people took offence at being told that they didn't know how to cross the road properly and that it was a form of social control. The other thought that it would not have an effect on the local drug users in the area, and that they would continue to cross where they liked.

One respondent didn't think that either design would be effective, and that people would get used to the design and cross where they used to cross. However, they did state that they hadn't observed any crossings so wouldn't be able to say. This was echoed by a further interviewee who stated that they couldn't say whether they thought they were effective because they hadn't seen any data. They were interested in the results but thought that they probably did encourage people to cross properly.

Most Effective Design

Opinion was also divided as to which was the most effective design.

Several interviewees thought that the night time design would be the most effective. One thought the wackier design would have more of an impact. Another thought that the night time one would be more effective because of the demographics of pedestrians in the night-time economy area. They also wondered if it would be because of people's perceptions of what they are designed to do. They said that "the night-time economy one is more attractive to people who are that way inclined – more happy and in that more playful mood."

Others thought that high street design would be more effective, although one interviewee who stated this acknowledged that they were not the target audience for night time design. The arrows in the high street design appealed to them more and felt it made it clear what it wants people to do. Another interviewee spoke about the criticisms of the directions of the arrows in the high street design and that they were suggesting where people should walk. This person said that this was not the intention; it was to encourage people to cross at that location. However, they wondered if the arrows were reversed to be on the left, it might stop people from thinking they need to walk on the right.

One person was unsure but thought that location was key. With the high street crossing, they felt that the planning of the whole area needed looking at because the crossing location is not at the most suitable place for pedestrians, but it couldn't be moved closer to the traffic lights without causing traffic flow issues.

Making the designs more effective

Interviewees were asked if the designs could be made more effective. Several of them thought that the designs were good – colourful and attractive – and that it would be difficult to know how they could be enhanced to achieve what they set out to do.

One interviewee was concerned about the lifespan of the road markings as they need to be colourful and fresh to be impactful and they may need regular replacement to maintain impact. It could end up being expensive to refresh them every three to four years (which is how long normal anti-skid lasts for, although this could be longer as the material was thermoplastic).

Vandalism was a concern for one person, especially in the night-time economy areas. They were worried that people would climb the crossings and try to rip off or bend the toppers.

One person asked why the posts of all signal-controlled crossings couldn't be a different colour. They felt that the trial made them question why the posts are currently dark colours and that painting them a bright colour made them stand out and highlight them to both drivers and pedestrians. They countered the argument that they could be distracting to drivers by saying that perhaps that says something about what the driver ought to be doing in these locations in terms of concentration.

One person wondered if it would be possible to combine elements from the two designs and that the arrows from the high street design could be used to make the night time crossing clearer as to what people ought to be doing.

Lastly, there was a concern that some of the phrases in the night time design were a bit glib and insensitive, but this was because the site was so close to the recent fatality.

Limitations

One concern voiced by several interviewees was that people would get used to them and that they wouldn't work in the long term. Once the novelty has worn off, people would return to using their old desire lines.

A few people mentioned that driver distraction could either be an issue or would be cited as causing issues. They were concerned that drivers might put in claims against the council if they were involved in a collision, saying that they took their eyes of the road to look at the designs. Other drivers might try to use it as a defence for failing to stop for a red light (although they thought that the stop lines were still visible and separate from the design).

Another interviewee was initially concerned about pedestrian distraction and that the graphics could encourage people to stay in the carriageway and take selfie photos.

As above, the long-term effectiveness was questioned and how people took to them and if they were educated as to why they were there.

This is related to another comment about framing and ensuring that people understand why the crossing is installed at that site. It would counter some of the negative comments that were received about implying that people were not intelligent and don't know how to cross the road.

It was important to have the correct sites and one person said that the night time design would never be permanently installed at a location like Lowgate, and that perhaps is should never have been a site. They did think it was fine as a trial site, though.

A couple of people stated that these should not be installed at every signal-controlled crossing, and that there would be a need to be selective as to where they are placed (with sites selected because of identified issues). If they were everywhere, it was felt that they would become "background chatter" or "a bit of so what – a bit of colourful crossing and some gold wrap on the pole – it becomes the norm and not have the same impact."

Site selection was further discussed by another interviewee. If there were to be criteria for installation, it needs to be robust enough to justify choosing one crossing over another and cost-benefit analysis needs to justify investment. They reported that there had been a struggle to find sites which were similar to the ones in Liverpool and therefore developing flexible but appropriate criteria is important.

Likelihood of adoption

Whilst one interviewee thought that Hull City could adopt the designs at certain locations, there were practical considerations raised by others.

A couple of people thought that funding would be an issue, and that whilst they could make things safer, it would depend on who is going to pay. If the crossings were brought into legislation, where it had to be installed in certain areas based on certain criteria, then it would need to be taken into consideration whenever a site was reviewed, and this would link it to funding.

Finding the right sites is essential. Four interviewees talked about the suitability of the trial sites and the difficulties with finding sites in Hull which matched the conditions in Liverpool. For the night-time economy, there were no signalised crossings in the areas where there are pedestrian collisions, and it was felt that the night-time economy moves so pedestrian risk is not always in the same places. The worst performing sites in Hull didn't share the characteristics of Liverpool.

There were mixed views on how Councillors might feel about adopting them. One person thought that some wards in Hull are a bit more old-fashioned than others and that the crossing designs might not work in local surroundings. Others felt that Councillors were behind the trial and that they would be likely to take a risk and implement them. One Councillor was reported to have been excited about the crossings and wanted to be a world leader.

Finally, someone suggested that consultation would be required before permanent installation, ensuring that residents had a say and would understand why it was being implemented.

Participation in the trial

Overall, interviewees thought the trial went well and that it was a positive experience. It was deemed to be well-organised and well-run, with a group who were invested in it. Several of them had been converted to the concept, as they tended to be quite traditional in their thinking but the process of being involved in the trial had fascinated them and they were keen to get the results. One person said So-Mo and the wider project team had done a fantastic job of persevering through all the challenges and project managing the trial.

Thinking about the organisation of the trial, two interviewees thought that there were a few too many meetings and that, from an engineering perspective, it should have been straightforward and not required so much conversation. However, despite the quantity of meetings, there were concerns about internal communications outside of the project team and that local stakeholders were not always briefed. It wasn't always clear if agreed actions had been completed by colleagues in the local authorities, despite stating that they had been at meetings.

This was linked to leadership, with one person thinking that it is was more difficult trying to deliver this across two local authority areas, as this meant that no single council owned the project and led on it.

There were practical challenges which were noted, with the Covid-19 pandemic mentioned by a couple of interviewees. This led to lots of interruptions and challenges, however, one person saw this as an advantage as it allowed the slow time that councils often work in.

Time was mentioned by another interviewee, who recommended that longer timescales should be built in for this kind of project when it involves local authorities. Decision making and quotes for anything out of the ordinary complicates the procurement process and means it takes longer.

It would have been beneficial to involve someone from the permits team earlier as new or amended permits were required as the trial dates changed. If they were on the project team, they would have understood why the changes were required.

Using fixed cameras at sites would ensure that a fixed view was gained, rather than using public area cameras which are used to point in different directions.

A formal Memorandum of Understanding might have been useful to set out the expectations of all the partners, so it was clear who is doing what. It was suggested that this could be facilitated by The Road Safety Trust who requests clarity on roles at inception.

Thinking about paperwork, one person did raise the topic of litigation and that implementation of this sort of intervention could lead to members of the public taking action against the Council and individual officers. This can be a barrier to implementing novel initiatives.

Accessibility concerns were raised in several interviews. The 3D effect of the night time design could cause issues for those who semi-visually impaired or those with dementia and this should be considered. This was echoed by someone else who said that even if these crossings do work, they might not be appropriate because of accessibility issues. The art crossings in London were mentioned by two people and that these crossings were not about making the environment pretty and were installed for a reason. However, if they do cause issues for those with disability, there was a question of how this is resolved with casualty reduction aims.

The final thoughts were about the benefits of running a trial and that it is not possible to know what might work without testing it. Two interviewees felt that "this has won whatever the results" because even if the crossings didn't work, the process of collecting the evidence would help others to learn.

WRAP UP MEETING AND LESSONS LEARNT EXERCISE

A wrap up meeting between So-Mo, Liverpool City Council, Hull City Council, Safer Roads Humber, and Agilysis occurred on 13th July 2023. The purpose was to discuss the findings shared in this report and to discuss what was discovered. It was also to explore what lessons had been learnt from participating in the study.

The finding that there was no increase in correct crossings whilst the interventions were in place at the Liverpool night time site and the Hull high street site caused initial disappointment for the stakeholders.

However, during the discussion it soon became clear there were positives to be had from these results. The purpose of the trial was to identify whether the interventions were replicable in other locations. If only one site had been studied, it would not be possible to know whether it would be effective at any other locations. The result for the Liverpool high street could have been seen as suggesting that any signal-controlled crossing on four lanes of traffic would be a suitable site for the high street intervention. By trying to match locations in different cities by finding similar sites but then identifying differences in their use, the local land use, and the sociodemographic backgrounds of those living around it, the study has shown that context is important to effectiveness. The stakeholders agreed that it would not be appropriate to place these behavioural interventions at all signal-controlled crossings and that the findings show that the location and its potential influencing factors need to be considered.

As a group, there was agreement that this is a good learning for other interventions being deployed in the road safety sector: that understanding the problem fully before trying to solve them is essential and that there are many factors which influence levels of risk.

A virtual whiteboard was used to capture thoughts on the lessons learnt. Figure 7 shows that there were thoughts on planning and ensuring that there is a Plan B in place for data collection, and good planning for engaging with hard-to-reach groups and the media. It was felt that it had been good to work with other partners and to learn from each other, as well as to combine procurement and resources.

The participants provided some advice to other authorities considering running a similar study, and these included thinking about site location, having a proactive communications strategy, and ensuring there is enough time to implement the works, as the process is lengthy.

Finally, there were some really positive thoughts about learning something from a piece of research like this, even when the results are not all positive.

Figure 7 - Lessons learnt whiteboard

:Padlet

Tanya Fosdick + 3 • 1m

Lessons Learnt

Challenges/positives/things you would do differently when running an on-road trial

Plan ahead on who may need additional engagement - think about any particular user groups who may be harder to engage with.

site observations ahead of confirming the sites (much easier without Covid)

More on plan B

Be aware that not everything goes to plan and that the press coverage moves faster than you can get an authorised response.

Always have a Plan B

Having back up plans for data collection and really thinking through how data collection could be impacted is essential - you only have one-shot!

Challenges/positives of working with such a range of partner organisations

Efficient use of resources

Combining some elements of contractor procurement across authorities helped reduce impact on staff resources.

Yes - it's really good to work with a wide range of people across a wide range of different professions

Really valuable to learn about experiences from elsewhere, especially what is similar and how it is being addressed.

Understanding what has already been tried and whether it worked/to what extent it achieved the desired outcome

Advice you would give to other authorities running an on-road trial

Site location

Ensure the sites chosen are fully appropriate for the trial. If there doesn't appear to be a suitable site this should be accepted and the trial should not proceed.

Communication

I agree about the communication strategy, we should of spent a bit more time making sure that all stakeholders were kept informed. The press moved faster than we could.

Comms strategy is key, even if you can't communicate the detail. FAQs are helpful to have in place, especially if the local Press are not friendly!

Start the on-site delivery preparations as early as possible, earlier than you think you need to.

Other things you learnt by participating in this project

That a negative outcome is equally important to a positive outcome if you learn from it. So treat everything as a potential learning point.

something valuable is always learned, even if it isn't the outcome anticipated

PROJECT TEAM REVIEW

Alongside the wider partner review, So-Mo also performed an internal reflection exercise to share the lessons they learned throughout this project.

Site Selection

To determine replicability of the designs, meaningful comparator sites are essential. The project team spend a lot of time reflecting on the suitability of the comparator sites in Hull and for anyone attempting to do something similar in the future, there are some useful lessons which they wanted to share.

It is essential to be careful about the site selection criteria. There was a focus on identifying sites based on key criteria which included crossing type, road design, and the availability of CCTV. With the high street site, the context was key as the interventions were designed to overcome hidden barriers that were very context specific and related to both people and place. The site selection criteria focused on identifying a crossing in an area of deprivation when the focus should probably have been on finding a site used by people who were similar to those at the site in Liverpool (e.g., living in an area of deprivation and using a local high street).

More analysis of the backgrounds of those using the crossing would have been informative to understand the differences in types of people at the sites in Liverpool and Hull. Postcodes of those injured at sites were available but the numbers of people injured at a crossing are a small proportion of all people using a site and therefore may not be representative of all those crossing (although trends in casualties might provide insight into those most at risk). However, other sources of home residency data for those walking around a city are not readily available. It is therefore a challenge to find a site which matches another, based on the backgrounds of those using it. This could form some sort of primary research before final site selection is agreed (collecting information from a sample of pedestrians at a suitable time of day at a potential site). Furthermore, the team felt focusing on the right site, instead of directly matching crossing type, would have led to better comparators.

The comparator site for the night time design looked good on paper, but observations revealed that not only was the crossing not on a desire line but was also not visible to pedestrians, due to placement and poor lighting. If site visits were undertaken to observe behaviour at the times the interventions were designed for, the differences between Hull and Liverpool would have been evident at the site selection stage. However, this was not possible because of Covid restrictions.

A key lesson is that final agreement on site selection should come after observational verification is performed.

Contingency Planning

There were many unexpected challenges which affected this project. The Covid-19 pandemic delayed the project significantly as normal pedestrian behaviour was required to measure the effect of the interventions. Whilst not impacting on the timing of the trial itself, there were pressures on the project team, particularly So-Mo, who also had other challenges to overcome. There was sadly a fatal collision at the night time site in Hull, involving a pedestrian in the night-time economy, only weeks before the start of the trial. This required a great deal of communication with the bereaved family and with the media to determine whether the trial could continue at this site. At the high street site in Liverpool, a giant sink hole appeared close to the crossings in the months before the trial, requiring emergency remedial work. Obviously, the data loss could have had catastrophic consequences for the trial and ended the project, and a large amount of work was undertaken by So-Mo to devise and propose and carry out an alternative methodology to allow the study to continue. None of these incidents could have been planned for and were all unexpected, however, they required the use of additional resources to overcome and contingency budget planning at the outset of the project could have mitigated the impact of these, especially for a small company like So-Mo.

Another challenge which had the potential to derail the project was procurement delays, especially when two local authorities are trying to tender for the same services which need to be delivered concurrently on opposite sides of the country. The project team felt that there were various ways in which this could have been avoided. Perhaps for initial research, comparator sites within Liverpool would have been more appropriate and that the project was too ambitious by testing in two cities, especially two cities so far apart. Building in more time for the procurement process for materials and installation would have also been beneficial. Lastly, it may have been useful to bring in specialist expertise regarding roads engineering to support the behavioural science team (who had no prior experience with planning roadworks).

It was testament to the resilience of So-Mo that the project continued through these challenges.

Subcontractors and individual officers

It is critical to identify good subcontractors who are reliable and are experts in their field. A key lesson is about bringing in additional expertise when needed; this was invaluable during the data loss and also when there was a change in the design company.

There were also individuals from partner organisations who were dedicated to the project and who understood their role and would deliver within the agreed timeframes. There were others who required chasing.

Partnership working

There were positives from working with such a large array of partners and over time, a strong partnership was formed between the local authorities and the project delivery partners. This was invaluable when the real challenge in Phase 4 was experienced with the data loss. One way of increasing the sense of partnership was through giving one of the local authority representatives the role of Chair for the project meetings. There was real value in providing this level of ownership and it meant that local authorities could use a common language.

There were some steps which could have improved the partnership. Firstly, Hull were new to the project as Liverpool had been working on the adult pedestrian issue with So-Mo for some time. It may have been useful to provide some behavioural science training or workshops at the beginning to help their understanding of the topic.

It is essential that all partners have the internal resource to dedicate to a project of this size and duration and identifying the right people to participate should be a task completed at the beginning. It would probably be useful to have more deliberate and formal agreements on the roles and contributions of all partner members, making sure those with the skills and experience are leading on delivering those tasks.

Communications were also important and early identification of whether the local authorities' press offices have the experience and resource to handle media attention of a project like this is essential. If there is not the capacity to provide media support, then costing in for a bespoke resource is an alternative.

Communications

Related to the point about having communication resource, this was particularly relevant when it came to social media attention. There was a lot of social media interactions about the crossings and many of the posts were negative and could be seen as 'trolling'. Having more access to support and guidance from experienced local authority press offices would have helped to manage the social media attention. It became evident that the best response was to control the conversation and not to engage with those who were trying to subvert the conversation. A lesson learnt here would be to check whether there is capacity amongst partners to actively support potential high social and press interest and if not, to make provisions for it within the budget. This is especially true for innovative projects which may gain high levels of public attention.

The challenges with the social media platforms did not mean there was no role for public engagement, but careful planning is required to ensure the key points are clearly conveyed. So-Mo gave successful interviews to Cities Today and BBC You and Yours to provide a positive counterpoint.

CONCLUSIONS

The aims of this study were:

1. To determine if a behavioural science informed nudge-based intervention can be used to modify pedestrian crossing designs in order to:

    - increase the number of crossings made by pedestrians inside a 30-metre distance at the crossing site.
    - increase the number of pedestrians who make a 'correct crossing'.

2. To determine if the effect of the embedded nudges varies across locations, time of day and type of nudge-based intervention.

3. To determine if there are any unintended consequences of installing novel and innovative crossing designs, for pedestrians or other road users (feasibility and acceptability) and if they vary by location.

4. To determine whether this type of nudge-based intervention can be rolled out in line with local authority priorities and demands.

The analysis found that the effect of these interventions does vary across location and type of intervention, with high street site in Liverpool achieving a 14% increase in correct crossing. The equivalent site in Hull did not achieve any improvement, nor did the night time site in Liverpool. These are important findings, as despite strict criteria to match conditions between the two cities, local context, and the way in which specific crossings are used (and by whom) influences how effective these types of interventions can be.

The analysis presented here has shown that a behavioural science informed nudge-based intervention can be used to modify pedestrian crossing designs to increase the numbers of correct crossings by an amount unlikely to have been down to chance. A measurable effect was only determined at one of out of the three sites. Arguably, results may have differed if the sites selected for replicability testing were more closely aligned with the pedestrians and conditions at sites in Liverpool. However, as discussed on pages 32 and 39, this identification of matched sites is a difficult undertaking that requires hard data to be reinforced with other forms of data, such as observational data and in context interviews. The trial was over a short period of time so it would be interesting to determine if the measures would sustain a prolonged effect on behaviour over a longer period, which would suggest the interventions had a sustained effect on unconscious decision making, rather than being a conscious novelty. This would require a study conducted over many months to determine how long effects last and if they are permanent. Furthermore, it would be interesting to understand which of the nudge measures incorporated into the design had the most impact or whether it was due to the combination of elements. This may require a study which only measures the impact of particular design components or different combinations. This would be a significant undertaking.

A larger and/or longer study may address some of the uncertainty around the effect of the interventions. With the night time site, there was an initially a decrease in correct crossings which appeared not to be due to chance, however, this was reduced in the regression model when weather was accounted for. Likewise, the reduction in correct crossings at the Hull high street site was close to a level of significance which is worthy of further exploration. At this site, the limitation was the number of available slices of footage for coding.

With the night time design, a challenging outcome was trying to be achieved: nudging impaired people into altering their behaviour. The hope here was that the behavioural intervention would cut through the competing sensory inputs and encourage safe crossing. However, given the difficulties of achieving such nudges, to take a Safe System approach to reducing risk for impaired pedestrians, highways authorities should consider alternative measures such as temporary closures of streets in night-time economy areas or reducing speeds significantly to reduce the impact of collisions.

The study found no unintended consequences from these interventions, with no increases in reported injury collisions, or observed collisions or anti-social behaviour. A longer-term study would be needed to see any significant changes in collision levels or anti-social behaviour. There were no changes in traffic flow or vehicle speeds which might have indicated a change to driver behaviour through distraction or avoiding the area of the crossing and the volume of traffic analysed was deemed high enough to have detected any such changes.

Through interviews in Hull, it was deemed that this type of intervention could be rolled out in line with local authority priorities and demands and that they might be receptive to their installation. Site selection remains key.

Whilst the interventions did not achieve significant improvements across all sites, the study partners recognised the benefits of participating in such a project and that there are benefits to learning from negative results. There can be a level of uncertainty around behavioural change projects: there are multiple factors which can influence the way in which human beings behave on the roads and achieving positive change can be difficult. Many road safety interventions designed to change behaviour are never evaluated or are evaluated through studies in a laboratory setting. By testing the interventions in the real world, this project was, by nature, complex, with a requirement to bring together practical considerations alongside robust data collection methods. The project faced multiple practical challenges, including data loss; the Covid-19 pandemic; a fatality near one of the sites; a sink hole near another site; and the difficulty of trying to match conditions in the real world. The insights gained from this study, in relation to the lessons learned and the insights gained regarding innovative crossing designs, should prove useful to other authorities looking to influence pedestrian behaviour.

APPENDIX 1: SELECTED SITES (MAPS AND INTERVENTIONS IN SITU)

HIGH STREET (FASTER BOARDING)

Prescot Road, Liverpool

Figure 8 - Prescot Road Site Plan (Source: Imagery © 2023 Google)

Anlaby Road, Hull

Figure 9 - Anlaby Road Site Plan (Source: Imagery © 2023 Google)

NIGHT TIME (COMPLI-CROSSING)

Hanover Street, Liverpool

Figure 10 – Hanover Street Site Plan (Source: Imagery © 2023 Google)

Lowgate, Hull

Figure 11 - Lowgate Site Plan (Source: Imagery © 2023 Google)

APPENDIX 2: CODING METHODOLOGY

Primary Outcome

Correct crossing

Correct crossings were identified in the same way across all sites. To ensure reliability, this was a strict definition: namely, the pedestrian had to always remain inside the crossing boundary (crossing boundary is marked in red lines on Figure 12) and cross when the traffic lights signalled traffic to stop.

Figure 12 - Correct and incorrect crossing boundary lines for counting

*The area between the red lines represents the crossing area, while the areas between the red and blue lines on the left and right sides represent the area outside of the crossing area

Incorrect crossing

There were two types of incorrect crossings: 1) Crossed at the crossing but without a signal for the traffic to stop; 2) Crossed proximate to the crossing but not on the crossing itself (i.e., between the red and blue lines on each side, see Figure 12).

Coders counted the number of crossings in a one-minute slice of footage for high footfall sites and the number of crossings per ten-minute slice for lower footfall sites. Coders also captured the date and time the extract began, light condition (night/day) and whether there were severe weather conditions (yes/no).

Reliability

A reliable coding method was devised, manualised, and shared with coders. Coders counted the number of correct crossings; and the number of incorrect crossings at the crossing (when the traffic lights were signalling amber/green to traffic (Puffin crossings) or during a flashing amber/flashing green figure (Pelican crossings)) and when crossings were made outside of the crossing area completely. These two types of incorrect crossings were summed to give the total number of incorrect crossings overall and the number of correct and incorrect crossings were summed to give the total number of crossings.

Reliability between Coder 1 & Coder 2 (see Table 16) was confirmed using 14 extracts of video footage comprising approximately 400 crossings.

A consensus dataset was created that contained 30 extracts where the Behavioural Scientist & Assessor 1 agreed on coding. Where there was disagreement, a third judge (Dr Holly Hope-Smith) was brought in to achieve consensus. The remaining coders (3, 4, 5) read the manual and their reliability was assessed against this consensus footage. Reliability was tested on ten extracts, representing approximately 400 crossings coded independently. Coders achieved reliability if their coding of the primary outcome, correct crossings, achieved an intra-class correlation coefficient of 0.8 or higher, indicating very good reliability.

Initially, coders were given five extracts; these were reviewed by So-Mo's Head of Behavioural Science and Behavioural Scientist, and if acceptable, a further five extracts were provided. If unacceptable, feedback was given, and ten new extracts provided. If reliability was not achieved after 30 extracts, they did not proceed to coding the main footage.

Neither the consensus nor reliability datasets contributed to the main analysis. Table 16 describes the reliability achieved for primary and secondary outcomes. Overall, coders achieved excellent reliability on the primary outcome (correct crossings ICC= 0.91-0.99), and acceptable to good reliability on the secondary outcome (incorrect crossings ICC = 0.70 to 0.79).

Table 16 - Reliability of coders who contributed to the main footage.

			Intra-class correlation coefficient (ICC)				
Coder	**Extracts**	**Comparator**	**Correct**	**Total**	**Incorrect**	**Crossed without a signal**	**Crossed outside of crossing**
1	14	**2**	0.98	0.98	0.77	0.77	0.87
3	10	Consensus	0.97	0.91	0.79	0.86	0.68
4	10	Consensus	0.94	0.92	0.76	0.67	0.88
5	10	Consensus	0.99	0.99	0.70	0.62	0.87

Data quality

After reliability, feedback was given to explain to coders where their count deviated from the consensus dataset. Data quality checks were made every time a coder started a new site/phase and for the site with most footfall, random checks were made throughout to ensure quality was maintained. Coder 1 and Dr Holly Hope Smith were available to Coders 3, 4, and 5 throughout to respond to queries should new scenarios arise.

APPENDIX 3: STATISTICAL ANALYSIS

HIGH STREET SITES (FASTER BOARDING)

Table 17 shows the results of the Poisson regression analysis carried out on data from the Hull high street site. The results of the regression suggest that the differences in the numbers of correct crossings between the baseline period and the intervention period were likely to have been due to chance. The statistical model suggests that there was a 15% reduction in the number of correct crossings after the intervention was installed. Whilst this falls a little short of the conventional probability of this effect occurring by chance (p=0.06 vs 0.05), it is close enough that further investigation is warranted.

Adverse weather conditions (if there had there been any) had no effect on correct crossings (p=0.69). However, correct crossings at night were 38% lower than those during the day, and this effect was unlikely to have occurred by chance (p = 0.0000419).

The estimated value of the intercept β_0 suggests that the expected number of correct crossings at the Hull high street was 61% lower than the total number of crossings. Equivalently, the model suggests that that an expected 38% of all crossings at this site would be correct.

Table 17 - Hull high street - Poisson regression analysis

Hull high street	Estimate	p-value	Significance Level	Relative Effect
Intercept (β_0)	-0.940	<2.2e-16*	<0.001	-61%
Intervention (β_i)	-0.167	0.0625		-15%
Night (β_n)	-0.485	0.0000419*	<0.001	-38%
Adverse Weather (β_w)	-0.031	0.698		-3%

*p-value significant at 0.05

Table 18 shows the results of the Poisson regression analysis carried out on the data from Liverpool's high street site. The model suggests that the expected proportion of correct crossings increased by 14% during the intervention period, relative to the baseline. Furthermore, this change is unlikely to have occurred by chance (p=0.00318). The coefficient indicating presence of adverse weather conditions is small and is unlikely to have had a measurable effect (p=0.17). The coefficient β_n (indicating day/night) was ignored as a parameter as all samples from Prescot Road were taken during the day.

The intercept β_0, showing the relative difference between the expected number of correct crossings and the total number of crossings used as an offset in the model, suggests that an expected 62% of all crossings at this site would be correct.

In addition to the Poisson regression, VanderWeele E-values have been calculated to assess the potential impact of unmeasured confounding factors. The observed effect of a 14% increase in correct crossings corresponds to an E-value of 1.548. That is to say that the effect of the intervention could only be explained as the result of an unmeasured confounding factor if said factor had an impact of at least 54% on correct crossings, with weaker confounding unable to fully account for the observed effect.

Table 18 - Liverpool high street - Poisson regression analysis

Liverpool high street	Estimate	p-value	Significance Level	Relative Effect
Intercept (β_0)	-0.483	2.2e-16*	<0.001	-38%
Intervention (β_i)	0.134	0.00318*	<0.01	+14%
Night (β_n)	-	-	-	-
Adverse Weather (β_w)	0.088	0.168		+9%

*p-value significant at 0.05

NIGHT TIME SITE (COMPLI-CROSSING)

Table 19 shows the results of the Poisson regression analysis carried out on the data from in the night time site in Liverpool. This table shows the estimated value of each coefficient (β) from the regression model, the p-values, statistical significance, and the relative effect ($\exp(\beta)$) each coefficient has on the proportion of correct crossings, expressed as a percentage change.

The intercept β_0 shows the relative difference between the expected number of correct crossings and the total number of crossings used as an offset in the model. The regression model suggests that the expected number of correct crossings at the night time site was 37% lower than the total number of crossings, or equivalently that one would expect 63% of all crossings to be correct at this site.

Unlike the initial testing on the proportions of correct crossings, the regression model suggests that, although the expected proportion of correct crossings is 5% lower during the intervention period, this change is likely to be due to chance. Likewise, the presence of adverse weather conditions had a small enough effect that it could not be distinguished from random variation. The model ignored the coefficient β_n as a parameter as all samples from this site were taken at night.

Table 19 - Liverpool night time - Poisson regression analysis

Liverpool night time	Estimate	p-value	Significance Level	Relative Effect
Intercept (β_0)	-0.457	0.00000000764*	99.9%	-37%
Intervention (β_i)	-0.046	0.163		-5%
Night (β_n)	-	-	-	-
Adverse Weather (β_w)	-0.045	0.557		-4%

*p-value significant at 0.05

APPENDIX 4: STAKEHOLDER INTERVIEW GUIDE

Topics		Prompts
Introductions	Introductions	I am [name], [role] of Agilysis and I am leading the evaluation of the two enhanced crossings that were recently installed in the city. This interview will take between 30 and 60 minutes – hope that is OK. I would like to record the conversation, if I may, as this makes note taking easier. Please be open and honest about your experiences within this project. We value your opinion, but we won't directly attribute it to any named individual! There are some questions which may not be relevant to your role so we can touch upon them and if you have no experience or nothing to add on that topic, we can move on.
	Explanation of interventions	Just to give a reminder of the interventions we're talking about. We have Compli Crossing on Lowgate/Hannover Street, which is aimed at pedestrians, who are in the city at night for social and leisure purposes, these include: groups of students, residents on a night out, and visitors to the city e.g. hen and stag parties. Often these groups are crossing whilst under the influence of drugs/ and or alcohol. We also have Faster Boarding on Anlaby Road/Prescot Road, which is aimed at daytime pedestrian road users who are crossing the road to access shops and services in a suburban area divided by multiple lanes of traffic, typically with high traffic flow in and out of the city. Despite these being highly risky roads to cross, puffin crossings were observed to be poorly used. Locals in these areas may not perceive the risk they face due to a number of cognitive limitations and biases.
	Explanation of role	Please can you tell me your job role and the organisation you work for? And what was your role in this study, if you had one?
Feasibility	Installation	So, thinking about installation, did you encounter any issues during the installation of the interventions (equipment, traffic management, etc.)? If we were to repeat this work, how could we mitigate these issues? And did you encounter any positives during installation of the interventions (ease of installation, etc.)? What could we do to ensure these positives were repeated in similar studies?

	Implementation	Now thinking about the trial period, did you encounter any issues during the five-week study (anti-social behaviour, road safety implications, complaints or public enquiries, etc.)? How could these issues have been mitigated in advance? And were there any positives encountered during the five-week study period (public engagement, observed positive behaviour, etc.)?
	Durability and design	If either of the interventions were found to be effective at improving pedestrian crossing behaviour, do you have any specific comments on the durability of the equipment used in the trial? Do you have any suggestions for refining the design to make it more durable?
Acceptability	Effectiveness	What are your feelings on how effective the designs of the intervention were? Do you think one design was more effective than the other? Why? Do you have any suggestions on how the design could be refined to be more effective?
	Limitations	Do you have any thoughts on what might negatively influence the long-term effectiveness of the intervention? Why? What could be done to address these limitations? How likely do you think it is that the interventions (or refined versions) would be adopted locally in the long-term? Why do you think that?
Close	Final Comments	Do you have any final comments on the designs or the experience of participating in the trial itself?
	Thank you	Thank you so much for your time. We really appreciate everything you have done for the study and for taking the time to reflect on the process.

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