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Gamification in transport interventions: Another way to improve travel behavioural change

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ABSTRACT:

Gamification is dramatically transforming how behaviour change interventions are delivered. The design of gaming products in the field of transport, a field which is perceived as having derived demand, is largely underdeveloped. This paper explores gamification in the context of transport, proposes a conceptual theoretical framework that explains why and how gamification may be designed and evaluated, and synthesises current practice regarding the range of interventions offered thus far. The conclusions identify strategies and implications for the improvement to existing schemes as well as guidance for future research into gamification.

KEY WORDS: ***gamification; gamified schemes; incentives; derived demand; motivation; travel demand management***

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1. Introduction

Gamification is often defined as the use of game design elements in non-game contexts (Deterding et al., 2011a:1). Gamification introduces competition and social activity into behavioural interventions so, for example, participants become "players" who can win individual or group rewards if they adjust their behaviour. The concept of gamification has been implemented in many fields including education (Foster et al., 2012; Li et al., 2012; Denny, 2013), marketing (Hamari and Lehdonvirta, 2010; Lucassen and Jansen, 2014; Huotari and Hamari, 2016) and health and wellness (Cugelman, 2013; Coombes and Jones, 2016). Within the transport field, the term gamification has been rarely used to date, but the concept has existed for many years, especially in the field of aviation. The most obvious example is airline customers' loyalty programs (Gilbert, 1996; Liu and Yang, 2009; Dolnica et al., 2011; Yilmaz and Coskun, 2016) although there is a question as to whether these really do conform to the gaming definition rather than being a simple incentive that is used to provoke certain behaviour without gameful design (this is discussed in more depth below). Other examples can be found in attempts to reduce private car use, for example, the *Active School Travel* program in Brisbane, Australia, which uses class and school leader-boards to encourage sustainable travel and active transport in turn reducing air pollution and relieving congestion.

Most previous gamification studies in the literature pay attention to two dimensions: the development of a conceptual framework (Deterding et al., 2011a, 2011b; Huotari and Hamari, 2016) and empirical case studies (Nelson, 2012; Denny, 2013; Jones at al., 2014; Bittner and Shipper, 2014; Rey et al., 2016). As yet, there is no standard definition of gamification (Seaborn and Fels, 2015). Moreover, Blohm and Leimeister (2013), and Seaborn and Fels (2015) indicate that there are very few research studies that have explored the theories underpinning gamification, for example, the theory of self-determination (Ryan and Deci, 2000a; Ryan et al., 2006) or intrinsic and extrinsic motivation (Ryan and Deci, 2000b; Zichermann and Linder, 2010). This suggests most empirical research has been designed and implemented with limited theoretical foundation. A more systematic development of the theory of gamification is needed to understand how to develop appropriate incentives, whether these incentives should be pecuniary or non-pecuniary and how gamification might be framed for the transport context. This is the gap addressed by this paper.

In many cases transport prices are not truly reflective of economic scarcity. The presence of externalities means that the market will over or under provide in terms of output. For example, the provision of free roads means that congestion can exist where there is a divergence between private and social costs. Often the first best solution is not socially or politically acceptable, for example the imposition of a tax in the case of congestion. As a result, transport operators, planners and policy makers are, as an alternative, seeking "softer" measures of changing travel behaviour. Gamification can help in creating an environment where these "softer" measures are

more effective. Gamification approaches can be used to improve engagement, increase motivation and encourage participation in specific programs to engender travel behaviour change. The evidence is that gamification schemes in some transport areas could have rather dramatic behaviour change impacts at low cost although this evidence comes from stated preference experiments (Marcucci, 2016) or micro simulation exercises for metering traffic inflow to special traffic lanes (Olarte, and Haghani, 2016) rather than real experiments. This current paper focuses on integrating findings from gaming studies into existing and potential future transport research by providing a robust theoretical framework that can be used to underpin this management of individual behaviour and, in particular, travel behaviour.

The paper is structured as follows. First, a state of the art review of the literature on gamification concepts and theories is undertaken, highlighting research gaps. Second, theories of gamification are explored with a view to understanding how each might address the specific characteristics of transport demand so as to see how the theory might underpin adoption of gamification in the transport field. These theories are illustrated by case studies. The penultimate section reviews what may be considered early uses of gamification in the transport field and discusses the links between the theoretical framework and how this theoretical framework implies changes to improve the outcome of the case studies. The paper concludes with a discussion and avenues for further research.

2 What is special about gamification?

2.1 Game or Gamification?

As already identified, the term gamification still does not have a clear definition. Its concept is clearly derived from games, in which a range of descriptions and conceptual research can be found (Crawford, 1984; Huizinga, 2000; Caillois, 2001; Juul, 2003; Salen and Zimmerman, 2004). The definitions of games are diverse but have one central element in common: a game is engaging and voluntary. Caillois (2001) defines a game as "an activity that is voluntary and enjoyable, separate from the real world, uncertain, unproductive in that the activity does not produce any goods of external value, and governed by rules" (Caillois, 2001; p.4). Caillois (2001) also proposed a classification framework for gamification, which distinguishes between *paidia* and *ludus* as two kinds of activities. While *paidia* (playing) refers to free-form, expressive and improvisational behaviour, *ludus* (gaming) characterises rule-based playing under pre-determined goals. For gamification, *paidia* and *ludus* are highly related, for example, *paidia* can be added to *ludus*. The basketball game is a good example of paidia being added to ludus. The basketball game is governed by a series game rules but players follow game rules intrinsically, where intrinsic motivation refers to behaviour driven by internal-to-the-person rewards (Holbrook, 1999). Seaborn and Fels (2015) further conclude that gamification is an emerging strategy which has gained in acceptance because of the

medium of digital games. Deterding et al. (2011a, 2011b) refer to gamification as the selective incorporation of game elements into an interactive system without having a fully-fledged game as the end product. The literature suggests that young adults and children do participate in gamified schemes, and this is reflected by the way in which gamification has been applied in the field of education (for example, Erenli, 2013) and video games (for example, Simões et al., 2013). This literature suggests that children and young adults may be more susceptible to gamification, maybe because they are yet to be influenced by the need for self-support through earning or perhaps because reacting to the value of simple financial incentives is not yet part of their behaviour.

The concept of gamification has brought together many disciplines and professionals, including game designers, psychologists, sociologists, computer engineers and others (Mora et al., 2015). Most empirical studies adopt their definitions from Deterding et al.(2011) but, in addition to this, there is a body of literature that categorises gamification schemes. Mora et al. (2015) split current studies into three categories according to a three-dimension perspective according to their background (academic/non-academic); scope (complete gamification processes or focussing only on a specific part or step) and approach (applicable to a wide spectrum of environments [generic] or designed for a specific business context). Huotari and Hamari (2016) categorise previous research into three levels of contribution: research informing games as systems; research identifying game characteristics but not necessarily of relevance to all games (such as rules, variables and uncertain outcomes); and research exclusive to understanding games. This categorization is useful in terms of developing a theoretical framework to understand how gamification works and how it can contribute to better soft policies in transport.

2.2 Incentive or gamification?

Both incentives and gamification can be used to make travel demand management strategies, form part of transport policy or to otherwise improve the take up of travel behavioural change. Incentives are used to provoke change in, or maintain certain behaviour; it is important to be able to distinguish between a ‘simple’ incentive and an incentive which is part of a gamified framework. As mentioned earlier, the most obvious example of a simple incentive is the airlines’ customer loyalty programs’ where points are allocated for travel. Incentives are often adopted as part of a travel demand management (TDM) instrument where rewards are provided for travel behaviour change (for example, off-peak fare discount for public transport). ‘Simple’ incentive programs are characterised by financial rewards or economic benefit (that is redeemable by points) or some form of concession that is known fully in advance. For example, a loyalty scheme may provide a given number of points for a particular purchase. Incentives can be varied in the sense that airlines, for example, give different numbers of points for a journey between A and B, depending on the class of booking.

However, airlines are still, even with this differentiation, providing a 'simple' incentive since the level of points is known at booking. This sort of 'simple' incentive can deliver extrinsic motivation where individuals are motivated to a behaviour simply to earn a reward (for example, travelling only on a particular carrier even if this delivers more expensive or longer journeys, just to keep gathering loyalty points with that airline) or avoid some negative consequences.

Incentives that promote intrinsic rather than extrinsic motivation are viewed as better because they promote behaviour where activity is undertaken because it is personally rewarding or carried out for its own sake. 'Simple' incentives can detract from an individual's desire to undertake an activity simply because they find it interesting or rewarding and so can be detrimental to intrinsic motivations, autonomy, and creativity (Deci et al., 1999; Hamari 2013). Kohn (1999) showed that for some incentive programs pleasure is not additive and that rewards can backfire (Groh, 2012). Lepper et al. (1973) demonstrated these effects when finding that if children are paid for drawing, as an incentive, they will draw more pictures but with lower quality and, very worryingly, when the incentive is ceased the children will not like to draw as much as they did before. Lepper et al. (1973) called this an 'overjustification' effect where intrinsic motivation is shifted towards the less desirable extrinsic motivation.

Gamification aims to provide more than the simple incentive where the outcome for the player is always known at the start. With a gamification framework, the outcome may not be known in advance, although of course, the rules of the game need to be well specified. In proposing a gamification framework, some finesse is required as the aim must be to go beyond the intrinsic value of the simple incentive via a suitable intrinsic motivation design that has three innate requirements: relatedness, competence, and autonomy (Deci et al., 1999; Hamari 2013). A lottery-based gamification scheme is a good example of showing how it is possible to improve motivation. A lottery-based gamification scheme harnesses intrinsic motivation because it keeps participants who opt-in voluntarily (autonomy) to play together (relatedness) for a small number of big prizes (competence). Separately from a lottery, other programs encourage participants to team up or introduce the game that requires teams to be set up in advance, where participants ('players') group together as a collective or peer group (a 'team'), and then make specific trips or behaviour that meets the transport agency's preferences (such as travelling outside peak hour). For teaming up, the participants may have their collective number of game points increased or be able to redeem team only rewards. The design of a "team game" introduces *social connectedness* components into a program to as this is shown to provide a stronger incentive to participants to change their behaviour. Moreover, "who will play the game" is another area to explain the difference between simple incentive and the one with gamified design. Introducing game elements into an otherwise 'simple' incentive structure is useful for a transport agency paying for the incentive since the outcome and cost to them are certain but the gameful design provides greater interest for

participants who face uncertain outcomes or who are motivated to become a participant the game via some game design element, for example, the peer pressure that bring by *social connectedness*.

This section has set out some definitions and characteristics of gamification. However, it has not defined specific game elements nor has it explored how an individual is motivated by gameful design. The next section discusses the theory of gamification to fill this research gap.

3. The theory underpinning gamification

The supporting theory for gamification (the application of game design elements to non-game contexts) is not well established in the literature despite the large amount of attention its application has received recently. In simple terms, success with gamification involves determining which games are preferred by individuals, how schemes may be organised and what the effects are likely to be. In this context, where gamification is used as part of a policy instrument design, designers are placing it between identifying objective, motivating for change and the achievement of behaviour change. This is suggested by Figure 1 where a gamified design is introduced to improve behaviour change outcomes. There are, of course, different types of players and game types. In the case of public transport, players could be classified by trip purpose to commuting, education, leisure and game types could be off-peak fare discounts and/or volume rebates. The matching between the players and game type is an essential element of gameful design since it will influence how well the gamified scheme can achieves its policy goal or goals.

At a very basic level, gamification procedures intervene between the objectives of a policy or strategy and the achievement of behaviour change as shown in Figure 1. This suggests that objectives or what is intended to achieve through gamification is a first step, a gamification scheme is then designed to motivate participants to participate in the game using motivational constructs.

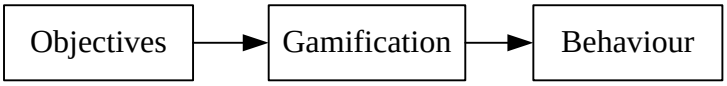

Figure 1 Gamification procedure

The central element of a game is that it should be engaging and voluntary and an understanding of motivational theory points to how to engage and encourage participation and how people respond to specific stimuli to achieve the behaviour change. The next section turns to motivation theory and this is followed by an exploration of utility theory. These together are designed to provide a framework for gamification in transport in the following sections.

3.1 Motivation Theory

The starting point for gamification, or for a game, is objective. Motivation needs to provide for participants to motivate them change behaviour. To be motivated means to be moved to do something (Ryan and Deci, 2000a). Motivation theories often distinguish two classes of motivation for the performance of an activity: intrinsic (motivation originating from internal forces) and extrinsic motivation (motivation driven by external forces). Intrinsic motivation refers to doing something because it is inherently interesting or enjoyable, and extrinsic motivation refers to doing something because it leads to a separable outcome (for example, external rewards such as monetary incentives) (Calder and Staw, 1975; Scott et al., 1988; Davis et al., 1992; Ryan and Deci, 2000a; Hennessey and Amabile, 2005).

Gamification typically uses both psychologically-orientated and design-oriented elements in combination. Significant effort is required in the game design phase, using psychological factors of a "gameful experience" such as mastery, achievement, autonomy, flow, suspense, competence, relatedness, etc. (Huotari and Hamari, 2016). Baranowski et al. (2008) and Miller et al. (2014) identify several approaches which are used to capture these factors which are intended to amplify intrinsic motivation. These include:

- *leader boards* that rank individual users and peer-group progress and achievements, creating competition;
- a *points system* to inform users of their levels and to reward progress and continue engagement;
- *rewards*, either real or virtual, achieved by reaching certain milestones;
- *challenges and quests* motivating users to continue engaging; and,
- *social connectedness and peer pressure* through team challenges and the sharing of information via social media.

Psychological factors are also used to segment players to ensure that targeting remains effective. Motivation theory appears helpful as a starting point for gamification schemes, with intrinsic motivation producing greater satisfaction for participants in changing their behaviour than extrinsic motivation. However, research is needed to validate the relationship between intrinsic and extrinsic motivation and in particular inform as to how to design and/or measure intrinsic motivation via extrinsic motivators. The following case study "*Beat the Street*" is used to show how the relationship between extrinsic motivation and intrinsic motivation might work to provide on-going travel behaviour change.

Case Study: Active Travel - Beat the Street

The "*Beat the Street*[1]*"* initiative, is found as an active travel scheme in Reading, UK. This case study illustrates how extrinsic motivation can activate intrinsic motivation to achieve

[1] http://www.beatthestreet.me/

behaviour change into the longer term. The "*Beat the Street"* initiative turns the whole town into a game where people earn points as they walk, cycle and run around (Intelligent Health, 2017). In 2016, more than 300,000 people participated in this initiative. The question here is what motivates individuals to participate in this scheme? This question can be answered through an analysis of the design of the scheme which shows there are two major design elements which make this scheme successful, and these are embodied in the scheme's experiences and the selection of participants.

"*Beat the Street"* targeted children's physical activity and was designed to encourage participants to walk and cycle in their neighbourhoods by linking walk-tracing technology to a reward scheme. Instead of using low cost smartphone apps, cutting-edge Radio Frequency IDentification (RFID) systems were put in place together with electronic readers. A physical trip reader such as this has two specific advantages over smartphone apps which are perhaps more common in other games. First, participants receive immediate confirmation of their 'reward' by a signal of flashing lights and buzzing and the immediacy of this is an important part of the gamification framework. Second, readers become social objects where multiple users congregate, ensuring interaction with other participants. In the game, participants need to 'tag-on' to these readers to record that they have undertaken travel at specific places, at specific times, as incentivised by the game. Participants are awarded a point each time they tag-on. Reward points are competed for by the groups or teams and/or individuals.

The trial in Reading started with the junior school. Each child was given several devices/cards to allow other family members to play the game as well. This meant that the game among children in the school could generate the "peer pressure" on the one hand and, on the other hand, the game among the family stimulated the "family pressure" to encourage family member(s) to play more for or play with the participating child. So, the game started from the child and linked to the family leading to the game spreading through the community as a whole. In turn, after a period of time when the benefits of the greater active lifestyle is more apparent, the game becomes self-sustaining with better health for the players and with the players getting to know each other. The expected longer term outcome is that the "*Beat the Street"* will lead to long term behaviour change and benefit health (Coombes and Jones, 2016). There is already evidence of success with "*Beat the Street"* participants showing sustained behaviour change (Intelligent Health, 2016). Figure 2 shows the percentage of participants who reached the UK governments' target for physical activity of 150 minutes a week in Reading over 2014-2015. This shows that "*Beat the Street"* increased physical activity in the first phase of the game (2014) and that one year later, people had become even more active. Further participation in the game leads to even more people reaching the target. In the framework of this paper this result is described as the gamification scheme motivating participants intrinsically.

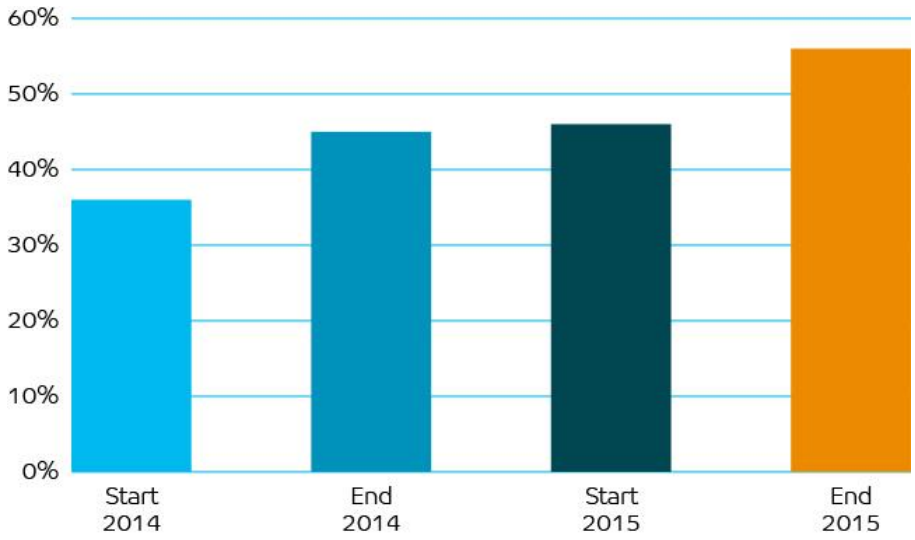

Figure 2 The percentage of participants who reached the UK government's target for physical activity of 150 minutes a week in Reading over 2014-2015 (Source: Intelligent Health, 2016)

Summary

How did "*Beat the Street"* motivate people to change their behaviour? Initially the extrinsic incentive was to benefit from the tapping on at the trip readers. But this was transferred to intrinsic motivation by introducing and maintaining peer pressure in the game and through connecting family to the game. The design allowed enlarging the exposure of the game to a greater number participants so that after a period of playing, the active travel benefit is revealed to participants. The design has been successful so that even after the extrinsic motivations (for example, rewards from the game) have been removed (the removal of the trip readers so that the game was finished), participants are still willing to maintain their behaviour. The "*Beat the Street"* program illustrates how extrinsic motivation can activate intrinsic motivation to achieve long term behaviour change.

3.2 Utility Theory

As identified above (Figure 1), gamification is at the intersection of motivation and behaviour. To evaluate the success of gamification it is necessary to evaluate an individual's behaviour both before and in response to the gamified intervention. Individual behaviour is all about personal preference and choice. Decision making serves as the foundation on which utility theory rests (Fishburn, 1970). By identifying which utility theory to use, individual behaviour and decisions can be understood. For neoclassical economics, the rational person is assumed to be a utility maximiser. Expected utility theory has played a major role in theories of measurable utility (Schoemaker, 1982) and has dominated the analysis of decision making under different situations, such as risk and uncertainty (Kahneman and Tversky, 1979),

personal identity (Akerlof and Kranton, 2000) and human motives (Loewenstein, 1999). For example, Akerlof and Kranton (2000) took identity (for example, gender) into account to consider how a person's sense of 'self' affects economic outcomes and proposed a utility function that incorporated identity as a motivation for behaviour. As to Loewenstein's (1999) work, he identified the importance of human motives in the utility function, pointing out that non-consumption-related sources of utility were powerful motivators of human behaviour. Loewenstein's used mountaineering to illustrate his framework. His argument was that mountaineering is not a pleasurable consumption utility since serious mountaineering tends to involve some unpleasant misery. But a mountaineer climbs a mountain because of human motives such as recognition, prestige or "the pleasure of good name".

Other than that, when people need to make decisions about uncertain prospects which may have small outcomes, they tend to make decisions that violate the basic tenets of expected utility theory, which is utility maximisation (Schoemaker, 1982). Usually, gameful designs such as lottery-based incentives require participants to choose between risky and often small prospects. Empirical studies have found that people tend to think of the outcome of risky prospects more as a relative change to their base position rather than relative to their final status, thus demonstrating different risk attitudes towards gains and losses. As a result we observe individuals overweighting unlikely outcomes (gains) and underweighting highly possible outcomes (losses) (Rieger and Wang, 2006). This is, of course, the basis on which the highly gamified casino business works. But similar approaches can be used by transport agencies to motivate positive outcomes.

As a gamified scheme has uncertain outcomes, for example, the "risk attitude" of participants will need to be taken into account while measuring behaviour change. In other words, risk needs to be one of the components for a gamification schemes. Although there is little evidence on this, Rey et al. (2016) comment on the impact of the outcome to participants in relation to modelled risk attitude. This also means that prospect theory is relevant to gamification because of the way in which it considers or measures utility under uncertain outcomes. Tversky and Kahneman (1992) distinguishes two phases in the choice process: framing and valuation. In the framing phase, the decision maker (the participant) analyses the offered prospects. In the second phase, or the evaluation phase, the decision maker will evaluate all the prospects in the framing phase and choose the prospect of highest value. This theory has been widely applied in economic and psychological studies. Based on the original prospect theory (OPT), Tversky and Kahneman (1992) further develop the cumulative prospect theory (CPT), which has three major elements: instead of evaluating the final wealth, payoffs are framed as gains or losses as compared to some reference point; this assumes that the value function is concave for gains but convex for loss so that individuals care more for losses than for gains. The value function that passes through a reference point (shown in Figure 3 as the origin) is asymmetric - it is steeper for losses than for gains indicating that

losses outweigh the gains. Figure 3 illustrates a typical value function of CPT showing how prospect theory is suitable for evaluating personal behaviour choice under gamification schemes.

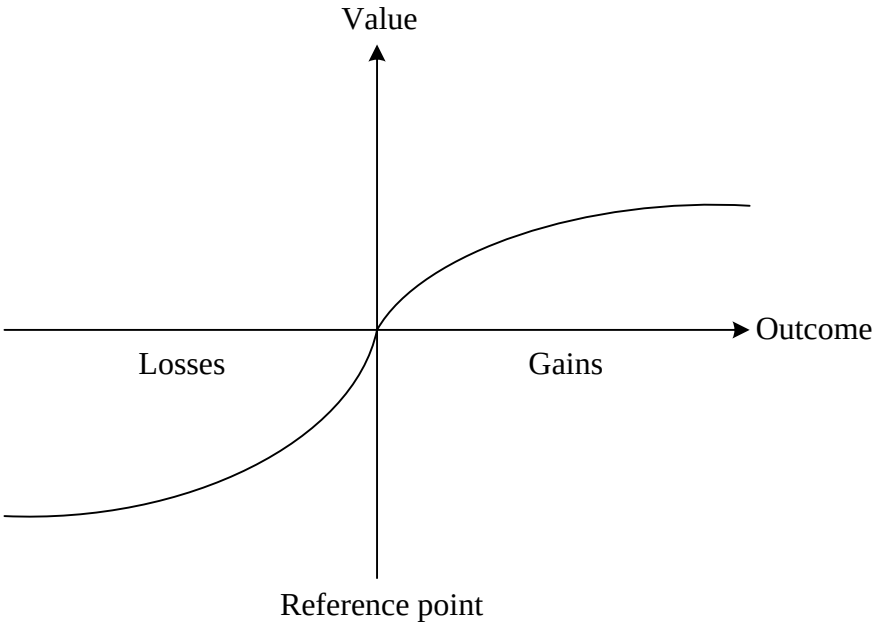

Figure 3 Value function of CPT

This section has thus introduced two different decisions, individual decisions under outcomes that might be certain but occur with different probabilities (expected utility theory) and individual decisions under uncertainty (prospect theory), respectively. The following introduces a public transport case to illustrate how these two utility theories fit into a gamification scheme design.

Case Study: Public Transport - INSINC

The *INSINC* program (https://www.travelsmartrewards.sg/) introduced a gamified approach to address the issue of public transport peak hour traffic congestion. Aiming to shift demand from peak to off-peak times on Singapore's public transport system by creating incentives for commuters to travel during off-peak periods. It began as a six-month trial in January 2012. Additional incentives were provided to users who find 'friends' to join them thus providing greater rewards for the whole group (the original peak user and their friends). *INSINC* has received successful results because of two important design elements, the reward type and social influence. The relevance of prospect utility theory can be discussed based on these two design elements.

First, there are two reward types, including random, raffle-like rewards (for example, lotteries), and personalised offers (for example, guaranteed rewards that can be redeemed by the points that participants collect through the game). Around 87.6 per cent of participants

preferred the raffle option over certain payment (Pluntke and Prabhakar, 2013). In this case, prospect utility theory is needed to understand participants preferences and decision making. To simplify the analysis, assume participants only have two options or decision alternatives, a raffle-like reward or a guaranteed reward. If expected utility theory is adopted, the participant would be expected to compare the outcome of the small but certain guaranteed outcome against the very small chance of a large raffle prize. Typical behaviour means that participants perceive the probability of winning the lottery incorrectly as high and this means more participants joining the game and all participants taking the raffle option. But, only 87.6 per cent participants chose the raffle option with the rest taking the guaranteed rewards. This suggests that this behaviour is better explained using prospect theory where each option would correspond to a simple probability measure and the utilities of the options can be computed by looking at the product of the probabilities and the outcomes. However, another question is still unanswered which is identifying the probability at which the reward should be introduced. This is the relevance of the value function (Figure 3) which will in practice vary for each participant and so for a program, the rewards need to be set at some sort of average figure that will appeal to participants.

Another issue is how to identify the impact of social influence and the associated question of how to identify the uncertain elements for decision making. This requires a question of the form: if I do *x* then the consequence *y* will result. In the *INSINC* trial this question is "if I invite my friends to join the scheme, we can play together and both benefit as this will give me bonus points and raise me in the ranking list". The *INSINC* trial thus introduced a strong social element by allowing participants to invite their friends via social network or email to join the scheme. Whether or not it is worth inviting friends can be analysed using prospect theory through the comparison of the utility of inviting friends or not and of continuing to play games to compete with friends or not.

Figure 4 shows the reported effects of the intervention on the commute start times of *INSINC* participants. In 2012, the six-month pilot scheme shifted 7.49 per cent of peak demand. Anecdotally, there was not so much shift out of the peak by peak users but the overall success was created by the ‘friends’ of the peak users who were joined to the system and who created greater rewards for all.

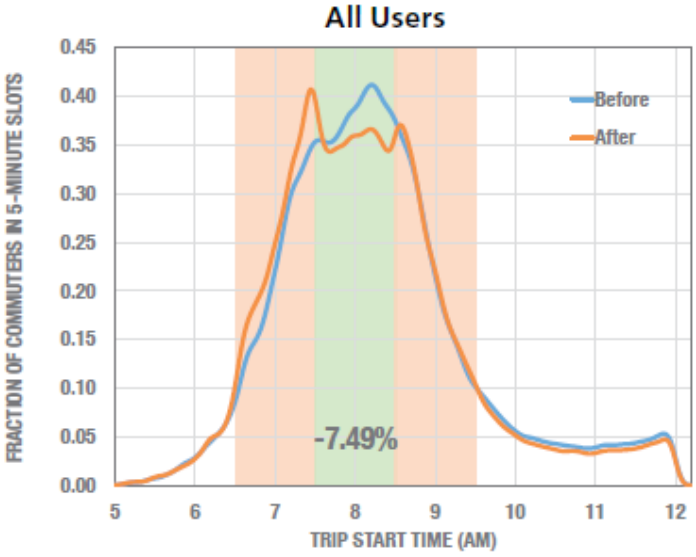

Figure 4 Probability density function of the commute start time for all users

(source: Pluntke and Prabhakar, 2013)

Summary

Changing behaviour comes from a decision which evaluates the utility of changing or not, that is evaluating the utility of each option that is available. Expected utility theory is only suitable for situations with certain outcomes which arise with given probabilities or perceived probabilities. However, if the decision making involves risk and uncertainty, personal identity and/or human motives, prospect utility theory is a better tool to explain the individual's decision making because it considers the procedure of participants decision making (that is two phases in the choice process: framing and valuation). The case of *INSINC* trial shows two types of uncertainty in the reward types and social influence with prospect theory being a better tool in explaining the motivation of participants to change travel behaviour from peak to off-peak time.

3.3. Gamification in Transport

Demand for conventional commodities or services, for example, gym or hairdressing services, is different from the demand for transport. An individual's demand for transport is essentially a derived demand with demand for transport being demanded to allow consumption at the destination for example, work, study or leisure activity. An effective gamification scheme in the transport field should consider how to incorporate transport as a derived demand instead of only considering the game itself as a final product. Figure 5 illustrates how gamification could be designed for different commodities and for derived demand. A gameful design can be targeted to different activities for both direct and derived demands. For services and/or tangible goods, gamification can be applied to the final services or goods (for example, the

club service in Figure 5). In the context of transport and its derived demand, gamification can be applied either to the derived demand itself or the product/activity as the final good or service, that is either the transport needs in Figure 5 for the former or work in Figure 5 for the latter.

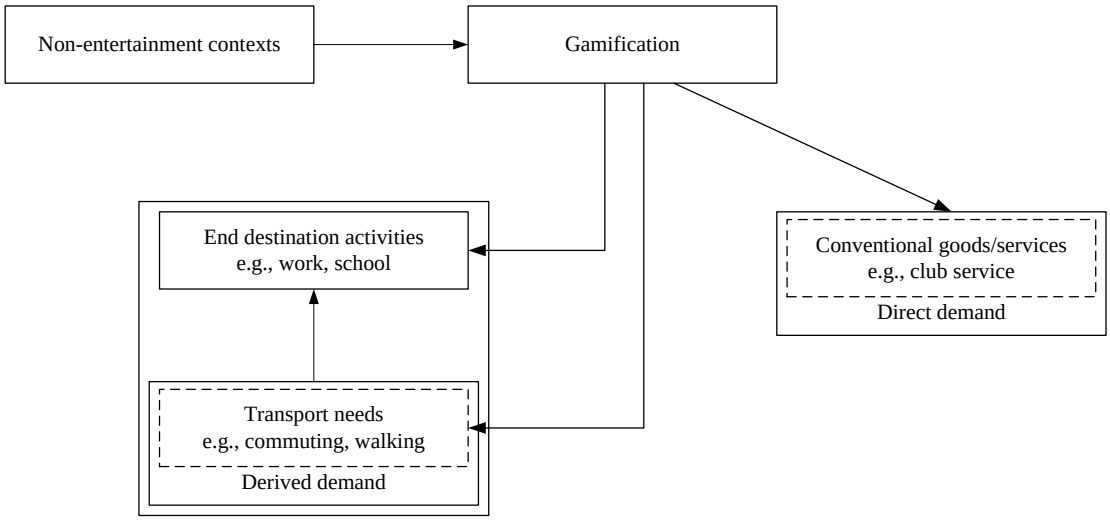

Figure 5 Gamification on direct and/or derived demand products and services

In travel demand models, travel is modelled as a function primarily of time and cost since, as a derived demand, travel time is assumed a disutility which a rational person seeks to minimise. As a result, transport policies reducing urban congestion sometimes attempt to reduce travel in peak periods by increasing its cost and/or reducing costs in off-peak periods (for example, an off-peak discount policy for all public transport) to encourage shift from peak to off-peak travel. A gameful design for a derived demand market (Figure 5) needs to either target the activities that generate the travel behaviour (that is the undertaking of the travel to consume activity at the destination) or find some way of gaming transport as part of a bundle of the good being consumed at the end of the travel. For example, if traffic congestion relief is the goal of policy makers, there can be two different designs. First, if a gamification scheme is designed for public transport as a substitute for an individual driving their private car, the game elements would focus on all variables that relate to travel behaviour, for example, travel cost, travel time, travel modes. This would be a design to tackle the behaviour to access a destination. On the other hand, if the gamification scheme is designed to be bundled with the consumption of the good at the end of travel, then a gamification structure could be framed around, for example, using the public transport to a football match, bundled in with the football match ticket, giving an entry into a lottery for a cash prize/tickets for the next match or so on when the public transport element is used. Of course, in both cases described here, gamification is providing the incentive for providing a

real experience of the alternative to the private car for car users. However, this is not peculiar to gamified structures since experiments which have required car users to try public transport have been shown to be successful in achieving change (Abou-Zeid and Fijii 2016, Ben-Elia and Ettema 2011).

As the mobilities research community reminds us, travel is an embodied experience. Travelers must often physically participate in order to opt-in to such games. For all gamification schemes, opt-in action by the individual is a fundamental requirement for participation but physical participation sometimes is not necessary. As an example of a non-physical game component, some social network platforms, such as LinkedIn, provide a progress bar and affirmatory messages as people enter key personal details. They do this in order to increase the perceived value of filling in all the details, making use of progress-related psychological tendencies (Huotari and Hamari, 2016). In contrast, gamification in transport generally requires participants to opt-in and play by changing their personal travel. It is not yet apparent quite how this changes either a person's experience of a game, or whether games may change the lived experience and cultural geography of travel. As will be shown later in Section 4, gamification has recently been applied to public transport, active travel and road safety interventions, with a gamified approach designed to make physical activity more enjoyable and to motivate participants to become more active and engaged. The next section summarises the theoretical framing so far before turning to these interventions.

3.4 Proposed gamification procedure

This paper has identified two sets of theory that can help with the understanding of gamification and its possible use in transport. We now propose an enhanced theoretical framing in Figure 6.This extends Figure 1 by showing the links between the base theories and gamification. The gamification procedure of Figure 1 is shown by the dashed line in Figure 6. In Figure 6, the starting point of gamification is how to motivate people to achieve the objectives of the policy intervention. Motivation theory, including intrinsic and extrinsic motivation, helps to provide the underpinning for the design of a gamification scheme. After a gamification scheme is formed within a derived demand market, different utility theories (for example, prospect theory) may be used to evaluate individual responses and choices to see how behaviour might change. Finally, every designed framework should have a feedback mechanism, where the evaluation of behaviour can revise the motivation design, in order to better create incentives for individuals to achieve policy goals.

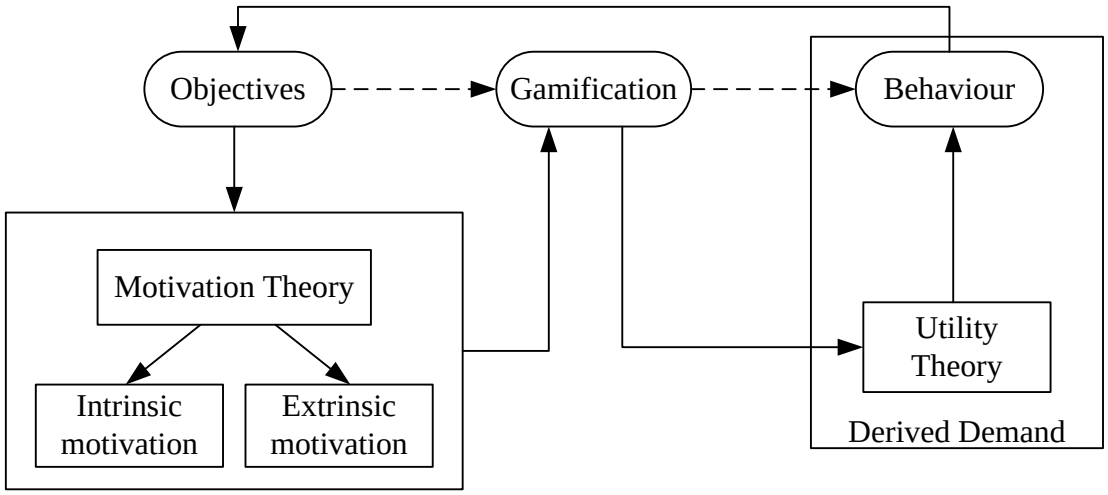

Figure 6 Proposed theoretical framework for gamification in transport

Note: ----► ***refers to elements presented in Figure 1***

Two case studies are reviewed next to show how the proposed theoretical framework of this paper might work in practice.

Case Study 1: Active Travel - PASTA project

The EU-funded project *PASTA* (Physical Activity Through Sustainable Transport Approaches)[2] is a good example to elaborate the first half of the proposed theoretical framework (that is from objectives to gamification). The *PASTA* project aims to promote active mobility in cities such as walking and cycling. However, instead of doing the trial directly like *Beat the Street*, this project focused on identifying a set of objectives and identifying participant opinions. The *PASTA* project had three phases, including identifying the indicator set, workshops & interviews with stakeholders, and finally a survey in seven EU cities. The purpose of identifying the indicator set is to provide a consistent and common standard to evaluate active mobility initiatives. The second and third phases of the project are to find out which initiatives would be best suited for both the project and its participants. In other words, these two phases are trying to find which initiatives can motivate participants the most and this is exactly the first part of the proposed theoretical framework in Figure 6. The project has not yet released its results and so this paper cannot identify the set of motivations that were identified to encourage participation but it is clear that the first stage of gamification was undertaken.

Case Study 2: Road Safety - S-Drive

S-Drive is a program that developed in 2014 by Samsung and Leo Burnett Sydney to

[2] http://www.pastaproject.eu/home/

incentivise young drivers to have safer driving behaviour. S-Drive was directly tied to smartphone use since the program designers believed this to be the strongest connection point to the young driver[3]. S-Drive awards points for staying below the speed limit and not using a phone while driving as well as introducing a "social component" of "Drive Team" for participants to team up with three friends to earn team only rewards through a chosen social media platform such as Facebook.

Figure 7 shows how the S-Drive design can be mapped to this paper's proposed theoretical framework. The proposed framework starts with the objective of the program. The objective for S-Drive is clear as motivating young drivers to drive safely. However, the design elements, such as award types or game rules, appear to be pre-determined by program designers without information as to the impact of the chosen levels raising the question, in particular, as to whether they were they fixed by reference to some understanding about motivations. Clearly it would fit better into the framework if it was clear that the design had considered aspects of motivation theory to identify how to better motivate the participants.

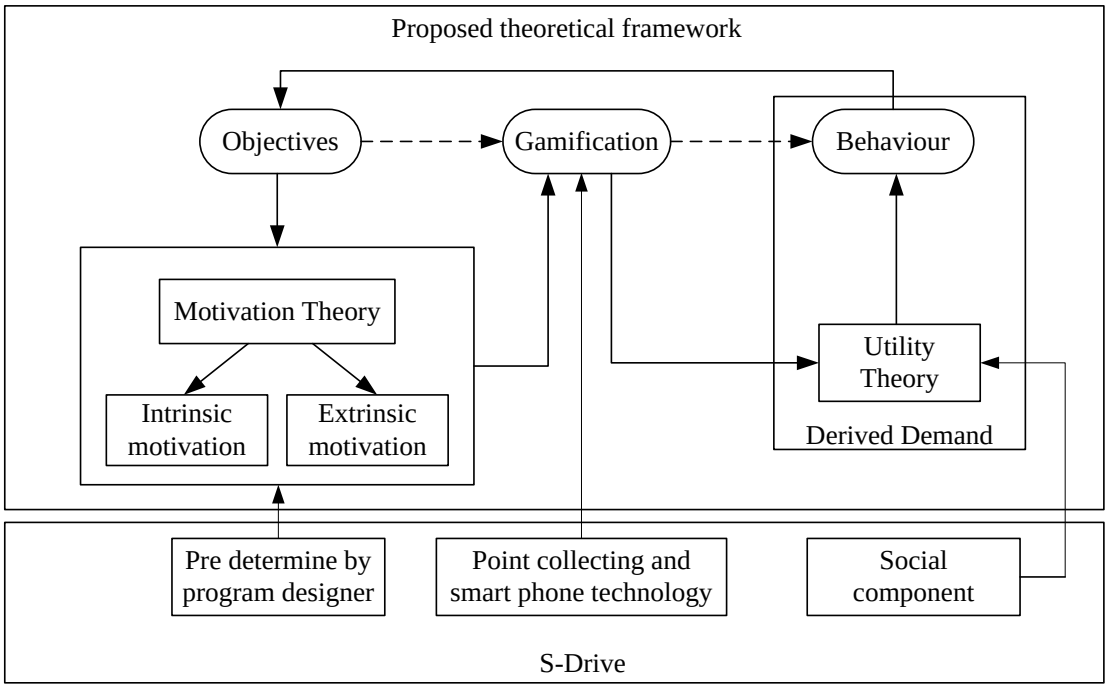

Figure 7 S-Drive in proposed gamification framework

In the gamification design stage, the S-Drive adopted a smartphone as the major tool to allow young drivers to play the game. This is in contrast to *Beat the Street* (discussed above) where

[3] https://www.leoburnett.com.au/Sydney/Case-Studies/samsung-s-drive

a physical tool (RFID reader) was adopted for participants to play the game. The choice of platform to implement the scheme must be carefully addressed in the design stage in order to link to motivational constructs. The S-Drive, like the *INSINC* program, introduced a social component to create peer support and enhance behaviour change. Creating an environment where "if I invite my friends to join the scheme, we can play team game together!" is an example of thinking which increases utility and enhances the quantum of travel behaviour change. The results show this to be the case: six weeks after the launch of the program, S-Drive had more than 4,500 active participants and 3,000,000 safe kilometres travelled. Users claimed 25,000 rewards. Crashes in the S-Drive region were down 25 per cent, while fatalities reduced 20 per cent in the 17-25 year age group compared to the previous year giving the lowest death toll in the region since 1936[4].

Perhaps more importantly, the question is whether the S-Drive program can persuade young drivers to maintain their safe behaviour. The S-Drive program does not have a program monitoring or feedback mechanism (from behaviour back to objectives) which the final part of the theoretical framework identifies as being necessary to promote long-term sustainability of outcomes.

4. Case studies

This section reviews further case studies which, although not claiming a gamified approach, are used to achieve behaviour change. The purpose of this section is to draw out the gamification elements of each case study for discussion and to use the case studies to illustrate some of the theoretical issues identified above.

4.1 Public transport

Peak hour traffic congestion and insufficient capacity on public transport are the twin most pressing issues for many public transport agencies in cities around the world. When there is insufficient capacity on public transport, it is an unattractive alternative to the private car. The need for public transport investment to address capacity or congestion issues can be deferred if existing infrastructure are used more efficiently via travel demand management (TDM). A shift of peak hour demand to off-peak periods is one way to defer infrastructure investment and there is much research and practical implementation of strategies to achieve such goals (de Palma and Lindsey, 2002; Merugu et al., 2009; Chiou et al., 2010; Gomes et al., 2012). In Australia, a price-related policy has been the predominant approach for shifting peak demand

[4] http://www.campaignasia.com/agencyportfolio/CaseStudyCampaign/387864,case-study-how-samsung-tackled-safe-driving-with-an-app.aspx#.WUEa5GiGNPY

to the off-peak with the provision of fare discounts for off-peak travel. For example, off-peak discounts are offered in South-East Queensland (SEQ) Australia. The regional transit authority Translink offers 20 per cent fare discounts in off-peak periods. Singapore's *INSINC* program (discussed in Section 3.2) introduced a gamified approach to address the issue of peak hour traffic congestion.

Rey et al. (2016) claim that their paper was inspired by an experiment in the Netherlands which was not a gamified framework, per se, but a novel approach to road pricing in which participants were rewarded for good behaviour (that is not driving in the peak) by a reduction in their road tax rather than being punished with a tax for driving in the peak. In this paper, they report on a theoretical approach in which they attempt to investigate the critical elements of a gamification approach (for example, the game rule) to peak and off-peak travel by public transport. Rey et al. (2016) evaluate a lottery-based, revenue-neutral incentive mechanism to manage congestion problems using experimental economics. The experiment used a gamified framework so that participants were repeatedly given the choice of peak or off-peak travel with monetised outcomes and with the choice of off-peak travel giving an opportunity to win, via lottery, a bigger prize. Although the gamification element is restricted to the outcome of the experiment, the experiments (albeit laboratory experiments) demonstrated that participants were prepared to shift their departure time from peak to off-peak in response to a gamified framework. In addition, the experimental framework included the identification of the risk attitude of the participants through choice modelling and changes in risk attitude appear to be related to the expected value of the outcome. Undertaking further empirical research to investigate these more theoretical approaches and their efficacy in real-world applications is needed to understand whether these schemes motive participants intrinsically or extrinsically.

If we link these cases in public transport to the proposed framework (Figure 6), there are some interesting findings. These can be discussed in two parts, game rules and rewards and behaviour measurement. The game elements of rules and rewards, such as raffle-like rewards or lottery-based game, are predetermined. How can we know if it is these game rules that will motivate the participant best (especially as Rey et al. (2016) show different rules have different outcomes in an experimental setting)? Before a gamification scheme is designed, it is important to explore participants' preferences to see how best to frame the game and to provide for some feedback possibilities for modifying the game as in the *PASTA* project described above. Second, behaviour measurement is clearly important and both case studies shown here involved risk as one of game elements. However, the "risk attitude" of the participants has not been taken into account in the same way in each case and so it is not possible to identify an optimum way of structuring public transport gamified incentives.

4.2 Active travel

Gamified design has been used in the health field to transform people's health and physical activity levels. Three key examples shown in Table 1 and are discussed below in more detail.

Table 1 Examples of gamification (trial) programs in active travel

Program Name	Year(s)	Department/ Country	Contents	Gamified design
Brisbane City Active School Travel Program (AST)	2004-current	Brisbane City Council, Queensland, Australia	Tailored program (using school travel planning) targeting primary school students and parents to leave the car at home and walk, cycle, scooter, carpool or take public transport to school; delivered via local government to a rolling sub-set of schools annually; low technology	Competition between children, classrooms, years and schools; leaderboards compiled and reported at all competition levels; low-cost rewards like stickers.
Healthy Active School Travel (HAST)	2011-2014	Department of Transport and Main Roads, Queensland, Australia	Tailored program differing slightly across participating local governments; rolling sub-set of schools; targets sustainable and active travel mode shift; low technology.	Competition between children, classrooms, years and schools; leaderboards compiled and reported at all competition levels; low-cost rewards like stickers.
Beat the street	2014-2015	Reading, UK[a]	Encourages communities to undertake increased physical activity	Players organised into teams; players and groups accrue points as they travel, progressing towards fun targets; low-cost or ephemeral rewards.

[a] Beat the Street was initially trialled in the city of Reading, UK and has been implemented across neighbourhoods in London, UK; New York, USA; Shanghai, China; and Vancouver; Canada (Coombes and Jones, 2016).

The *Beat the Street* initiative is discussed in Section 3.1. This section focuses on another active travel initiative: the *Active School Travel Program* run by Brisbane City Council (BCC) in Queensland, Australia. This program has successfully helped to convert 35 per cent of single-family car trips to participating schools to an active and healthy transport mode (Brisbane City Council, 2016). Similarly, the Department of Transport and Main Roads *Healthy Active School Travel* (HAST) program has been built on similar previous programs to deliver a set of gamified interventions across other Queensland local governments. A series of previous studies based on children's and parent's self-reported behaviour change have noted the efficacy of these programs and they have been praised for also encouraging children's independent mobility, and not just physical activity (for example, Deloitte Australia, 2015; Moghtaderi et al., 2012). Separate from any self-report data, and contrary to national trends, the Queensland Household Travel Survey revealed a significant drop in the number of children who were driven to school by private car between 2007 and 2009. Car travel declined by eleven per cent (64 per cent to 53 per cent) during the period of mass roll-out of these school interventions (Department of Transport and Main Roads, 2012), which suggests that these programs have had strong system-wide efficacy in changing travel behaviours.

Analysing these case studies can show how they links to the theoretical framework proposed

by this paper. The objectives of the case study are clear with the intention of increasing more active travel and reducing car access to school. As with the S-Drive case study, the gamified design elements are pre-determined without any information as to whether motivational theory was considered. The outcomes might have been even greater if some pre-trial analysis, such as the workshop, interview or survey in *PASTA project*, had been introduced or, given that this is an on-going program, could be introduced to enhance future travel behaviour change. In addition, after-program monitoring to provide information for the feedback mechanism (from behaviour to objectives) could still be implemented in this case to allow a game framework to be modified to better target or motivate specific group of people. For the gamification stage, this case used non-pecuniary "leaderboards" rewards to introduce one of very important game elements of competence.

4.3 Road safety

It is in road safety where there appear to be more gamified schemes and interventions being implemented, especially for young drivers. It is well established that young drivers are over-represented in numbers of road accidents in most driver demographics globally. In Australia, in 2014, people aged 17 to 25 accounted for 20.2 per cent of total road deaths but as a cohort were only 12.4 per cent of the total population (Department of Infrastructure and Regional Development, 2015). Policy responses that address individual behaviour or specific components of accidents do not always appear to work (Dekker et al., 2011) and more success has been achieved using a response which focuses on the development of accident countermeasures (Scott-Parker et al., 2015).

In order to motivate young people to drive more safely, many interventions have been developed. Some of these have been designed by car insurance companies including GAMETUNED[5] in the UK, S-Drive[6] in Australia, paying accident insurance by the kilometres driven in Holland, SmartDrive in New Zealand, a return insurance premium scheme in Norway, and a starting bonus in Sweden. These and others are summarised in Table 2.

The S-Drive case study has been reviewed above, and as can be seen below, the other road safety cases share many of the same issues. Road safety schemes are often tied to, and delivered, via new digital technologies, especially smartphone apps. Apps may be particularly useful for the young learner driver cohort to incentivise safe driving behaviour, but efficacy is not yet fully understood, especially regarding gameful design. Very little evaluation is in the public domain if undertaken at all. Commercial sensitivity prevents much information being

[5] http://gametuned.com/2011/06/the-gamification-of-car-insurance/

[6] https://www.samsung.com.au/sdrive/

available to the research community and this leaves transport agencies uncertain of what they should be looking for or how to proceed. Research is necessary to understand the critical elements that work to better motivate participants.

Table 2 Gamification interventions in road safety

Gamified schemes		Contents
Monetary rewards	GAMETUNED in the UK	Based on an in-car installed GPS that tracks driving behaviour; participants are scored on their 'dashboard' in an engaging manner; excellent drivers get discounts of up to 11%; poor drivers pay up to an additional 20%.
	Insurance 'Pay as you go' per kilometre in Holland	The insurance premium is calculated by reference to the km driven and when the km are driven using an app which is game like in which participants achieve goals and gain points. Young drivers are known to have more accidents at night and so young drivers driving at night pay a premium on each km.
	Return insurance premium scheme in Norway	Part of the insurance premium was returned to young drivers if they remained accident-free.
	Starting bonus in Sweden (pilot program)	The participants in this intervention received a 'starting bonus' in an account; for each minute that they drove faster than the limit, an amount was deducted from this starting bonus; at the end of the month the participant received the remaining amount of the bonus.
	SmartDriver in New Zealand	By using the SmartDriver app, drivers can save up to 20% on car insurance.
Reward points	S-Drive in Australia	By installing the S-Drive app on a smartphone and driving safely, participants can earn points that can be used to redeem rewards.

Gamified interventions could also be used to target recidivist driver behaviour for other groups than the predominantly learner or young drivers - for example as an add-on or alternative option to licence demerit points or suspensions. As in other areas of transport policy, creative use of a gamified approach is likely to produce a litany of approaches, with limitations identified over time, before either the entire enterprise is abandoned or standardisation occurs.

5. Discussion

Gamification has already seen some success in the transport field. The *INSINC* program in Singapore shifted 7.49 per cent peak demand to off-peak periods or the peak shoulder periods. The important questions confronting transport agencies are not if and how gamification works, but where it may be useful, what the limitations may be and how to design successful interventions. This is especially important as more is understood about the end results than the causal pathway to achieving these results. This paper provides key starting points and a

summary of current progress, and provides a better understanding of the theory underpinning a gamification framework.

The proposed conceptual framework is based on motivation theory, utility theory and demand theory. How to motivate participants is an essential part of any gamification framework. Motivation can come internally (intrinsic to the individual) or be created by external 'push' or rewards (extrinsic motivation). A well-designed gamification program should harness intrinsic motivations that are created and measured via extrinsic motivations. How to define and identify critical motivation is the key element for a successful gamification framework. Almost all of the empirical studies reviewed see motivation as a single faceted phenomenon, rather than the more realistic complex issue. The *PASTA* project sets a good example here by conducting several workshops & interviews, and undertaking a survey in seven EU cities to understand what stakeholders/policy makers can offer and what participants want so as to understand how participants can be motivated.

The theory and practical examples demonstrate there are several ways to amplify the intrinsic value. Some interventions (for example, *INSINC* and car insurance discounts) use monetary incentives. Whilst monetary incentives are not necessarily bad, Zichermann (2011) argues that monetary incentives can reduce participants' sense of intrinsic desire and so monetary rewards need to be carefully designed if they are not to reduce the performance of a gamified approach. In other words, monetary incentives do motivate people with a significant impact but once the incentives stop, participants tend to move back to their original behaviour suggesting that many monetary based games work on extrinsic motivation only which is less likely to translate to lasting behaviour change. On the other hand, the few studies that adopted non-cash incentives (for example leader board competitions and prizes in the *Active School Travel* program) have found that they can increase intrinsic motivation so longer-term effects are observed. This is also seen with the *Beat the Street* program. A critical area is gameful design, especially on how to design intrinsic motivation by using extrinsic motivators and to determine the kinds of incentives, monetary or non-monetary, that should be adopted. Here theoretical investigations with experiments can play a role (such as the *PASTA project*) (Marcucci, 2016 or Olarte, and Haghani, 2016).

Whilst gamification can be a powerful tool to change participants' behaviour, little discussion has been given to who pays for the incentives, especially when it comes to monetary rewards. In the case of public transport in Brisbane, Australia, an off-peak discount policy is already used to incentivise passengers to shift their travel time to the off-peak period. Potentially in a gamified approach, policy makers could adopt a flat fare, but provide a different form of monetary reward or incentive to passengers who change their travel time. The technology underpinning fare collection could allow for many types of gamified schemes to be trialled, which may be revenue neutral, or even revenue positive. The same principle can be applied to road safety with car insurance companies trying to incentivise safe driving to reduce their

premiums, but also to reduce the insurance company's costs. Health insurance companies share the same view and already try to motivate people to be more active so as to improve their health and reduce costs to the insurance company.

In this paper, gamification has been discussed as being a supportive way to meet policy goals. However, the private sector may or may not develop programs and/or apps that support transport agency goals. For example, *Strava* (https://www.strava.com/*)* provides a social network for active travelers but the service can, through encouraging racing via leader boards, inadvertently encourage cyclists to ride unsafely on particular street networks. However, there are many privately developed apps that are supportive and those which include user information, such as *Moovit* which could be harnessed to provide gamification. Even with the help of technology developments which may be undertaken in the private market, it is unlikely that policy-makers will be able to introduce gamified strategies for zero cost and, like TDM measures, public agencies will need to invest in gamified approaches and programs that can produce or activate extrinsic motivation to produce long term travel behaviour change.

Utility theory can be used to show how individual's decisions and behaviour are motivated by maximising utility or minimising disutility. Linking this to prospect theory shows the importance of taking risk attitudes into account because participants of a gamified framework are likely to face outcomes with different probabilities of occurrence. This is supported by theoretical and experimental approaches (for example, Ray et al., 2016). Especially in the case of lottery-based incentives, a comprehension of prospect theory is essential in order to correctly measure participants' decision making and/or predict their behaviour changes. Moreover, when social connectedness, is introduced, this can create positive utility increases for participants. The evaluation of how or why behaviour has changed is missing from evaluations reported in the literature and utility theory here is a theoretical starting point for such analysis.

However, the key question is who will pay to implement gamification in transport policy applications. If schemes are shown to be effective and outcomes can be tied to public transport operator business travel plans, or agency operational plans, then gamification and the incentives used in such schemes may be underwritten through savings. But in areas such as road safety, it is likely savings will accrue to other agencies (for example, health, insurance) rather than amongst licensing or road authorities. As such, it does seem inevitable that public agencies will need to invest in gamified approaches as policy instruments in much the same way in which current TDM schemes are funded. The advantage of a gamified framework with a set cap on incentives is, however, that the funding outcome is at least certain for the funder, if not for the players.

6. Conclusion

Gamification in the transport context is a developing method which can be used to encourage participant engagement and enjoyment in non-game contexts. Most previous literature has paid attention to empirical trials but there have been inconsistencies in the definition of gamification. Limited studies have empirically explored the effects of gamified schemes, and early works have grounded gamification in psychological theories, and paid special attention to theories of motivation. However, a gamification approach is not all about pre-game design. Gamification design analysis and effect evaluation are also critical. As Rey et al. (2016) identify "there is no systematic theory or behavioural models to inform the planning and development of these policies and evaluate its impacts." (p.47). This paper addresses this for the transport context, providing a conceptual and theoretical framework for designing and evaluating gamification. This paper also synthesises current practice regarding the range of interventions offered thus far in the transport field.

This is a rapidly growing field and a limitation of this paper is that new interventions may not have been captured. Moreover, the theoretical framing advanced needs to be tested by reference to new trials and pilot schemes. Low-cost trials can help identify which motivations and/or games are preferable, how schemes may be organised, who should run them, in what way, and what we may – and may not – be able to achieve. Lessons learned can fine-tune the transport interventions for optimal results in full scale implementation.

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