Integrated strategies to accelerate the adoption of cycling for transportation

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ABSTRACT

This study synthesizes academic social psychological behaviour change literature with reports on the practical, community-based application of cycling programs. We identify the combination of psychological tools demonstrated to lead to changes in behaviour in the target population. We compare these tools with reports demonstrating evidence for success from monitored programs to encourage cycling adoption. Based on the alignment between these two literatures, we developed an adaptable, evidenced-based strategy for program developers to most effectively accelerate the adoption of cycling for transportation in areas where physical barriers are few. A brief case study affirms the effectiveness of this approach.

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1. Introduction

Traffic congestion is a growing problem for cities in Canada and around the world, causing air pollution, greenhouse gas emissions and long commuting times which together damage human health, environmental quality, urban sustainability and the economic viability of our urban centres. The transportation sector accounts for 30% of overall carbon dioxide emissions by OECD countries (European Conference of Ministers of Transport, 2007). The health impacts of air pollution were estimated to cost USD 1.7 trillion in 2010 in OECD countries. Transport is estimated to represent 50% of that cost (OECD, 2014). This represents a substantial opportunity for new models of movement within these countries to reduce greenhouse gas emissions and improve public health. There is a growing consensus that modal shift from automobiles to human-powered, active transportation, combined with public transit for longer distances, will address this problem and the considerable financial costs arising from environmental damage, poor health and long commuting times (Bell, Garrard, & Swinburn, 2006; Dekoster & Schollaert, 1999; Garrard, Crawford, & Hakman, 2006; Jones et al., 2009; Toronto Board of Trade, 2010). Research into modal shift, has, however, mostly focused on physical infrastructure, including transitways, bike lanes and street design (Aultman-Hall, 2009; Cervero, Sarmiento, Jacoby, Gomez, & Neiman, 2009; Garrard, Rose, & Lo, 2008; Ligtermoet, 2006; Pucher & Buehler, 2006; Pucher & Dijkstra, 2003; Winters, Davidson, Kao, & Teschke, 2010).

Political barriers and financial controversies have slowed progress. In the North American context, many cities continue to be defined by their automobile-centered design and are grappling with the controversies inherent in attempting to distribute investment in new ways that promise to substantially alter existing infrastructure (Blickstein, 2010).

Evidence from around the world, particularly the Netherlands, Denmark and Germany, indicates three crucial elements interact, in a powerful way, to foster cycling as a healthy, clean, efficient transport mode. These are urban design, as it favours

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or limits cycling trips by diverse users; urban rules and policies, ranging from responsibility in the event of accidents through traffic calming and requirements for short-and long-term cycle parking; and accepted norms of behaviour, including the social infrastructure and social capital that support cycling culture. To date, attempts to encourage modal shift towards active transportation and cycling have focused on physical infrastructure, particularly visually or physically separated cycle lanes and cycle parking. Yet the growing popularity of cycling in many cities around the world demonstrates that behavioural change is possible, even where investment in infrastructure is minimal or less than optimal (Pucher & Buehler, 2011; Reid, 2009). In some cities such as Toronto, cycling for transport has grown with few significant improvements in infrastructure. From 2001 to 2006, the number of Torontonians cycling grew by more than 30% (Toronto Public Health, 2012). More recent data indicates an even more substantial rise in cycling mode share, to 7% in the downtown core (TPH, 2012) with habitual cyclists reaching 5.7% of the overall mode share in the city (Share the Road Cycling Coalition, 2014). The lack of improvement in cycling infrastructure during this period (though there has been some modest increase in bike lanes since 2013) suggests that culture and behaviour have played an important role in the mode shift to cycling. In other cities, where physical infrastructure is excellent, city planners acknowledge that some demographic groups do not cycle, and are keen to use new tools to encourage them to do so. This study was undertaken in response to the demonstrated role of culture and social norms in cycling adoption and the demand for tools to increase cycling in locations where policy and infrastructure are already in place and cycling levels are not increasing.

This study builds on highly successful social interventions, with documented impacts on attitudes, social norms and resource consumption (Chan, Wakefield, & Savan, 2011; Savan & Matson, 2013; Savan & Matson, 2014; Stokes, Savan, Mildenberger, & Kolenda, 2011). Significant changes in transport-related attitudes, norms and behaviours may result in immediate reductions in fossil fuel consumption, and establish the foundations for further policy, public investment and industry shifts (Jones et al., 2009; Sagaris, 2009). It explores the use of social interventions to support cycling for transportation by synthesizing theoretical and evidence-based academic behaviour change literature with reports on the practical, community-based application of cycling programs to identify the combination of psychological tools demonstrated to lead to changes in behaviour in the target population. Literature was limited to studies with evidence of success from monitored programs. Based on the alignment between these two literatures, we developed an adaptable, evidenced-based strategy to accelerate the adoption of cycling for transportation.

2. Methods

2.1. Literature analysis

A comprehensive literature review examined academic and practitioner-sourced materials identifying the social and civic infrastructure relevant to fostering cycling for daily transport. The search syntax was limited to the selected behaviour change principles and cycling promotion initiatives (see Fig. 1).

Academic journals, systematic reviews, case study reports, conference presentations, and government documents were searched during July and August 2012 using electronic databases, based on a starting bibliography developed in house and using search terms including: cycling, cycling for transportation, commuter cycling, cycling initiatives, behaviour change, behaviour change technique, promotion, modeling, social norms, behaviour modification, social infrastructure, social intervention, barriers, prompts, social supports, sustained behaviour change, community, incentives and programs. While there were no limits set on study design, size, population and location, small, location-specific interventions were not included, in favour of a focus on compendia, reviews and region/nation-wide summary reports. The literature search was limited by time constraints and language, focusing mainly on material available in English. Definitions and rationale were developed for both behaviour change techniques and cycling initiatives (Tables 1 and 2).

Literature matrices were utilized to most effectively show the intersection of each selected behaviour change technique and cycling promotion initiative. The literature and case study reports discussed here were screened for credibility, validity and rigor, based primarily on the inclusion of an evaluative framework or a comparable method for testing assumptions. Nevertheless, this topic of research forms part of a very recent body of literature, with most significant studies completed in the past 12 years. While much of the cycling literature (whether academic or practitioner in source) does address and explain different components of behaviour change, most does not test or rigorously evaluate the effectiveness of these methods. In most cases, studies fall short of an "ideal" research design to effectively evaluate particular interventions as separate entities, including before-and-after measurements, and the use of a control group. This may reflect the relatively recent application of behaviour change principles to cycling promotion, but also the difficulties in actual program evaluation and monitoring, as it is extremely difficult to isolate the 'stand-alone' impacts of improved cycling facilities or behavioural interventions, given that inputs interact and results emerge concurrently.

3. Results and discussion

This literature review finds that although still in its infancy, social psychology insight into behaviour change shows significant potential to foster cycling for transport among individuals and communities. The structured application of behaviour change theory to cycling initiatives may allow practitioners to develop more effective strategies to promote cycling. A local example provides support for this approach.
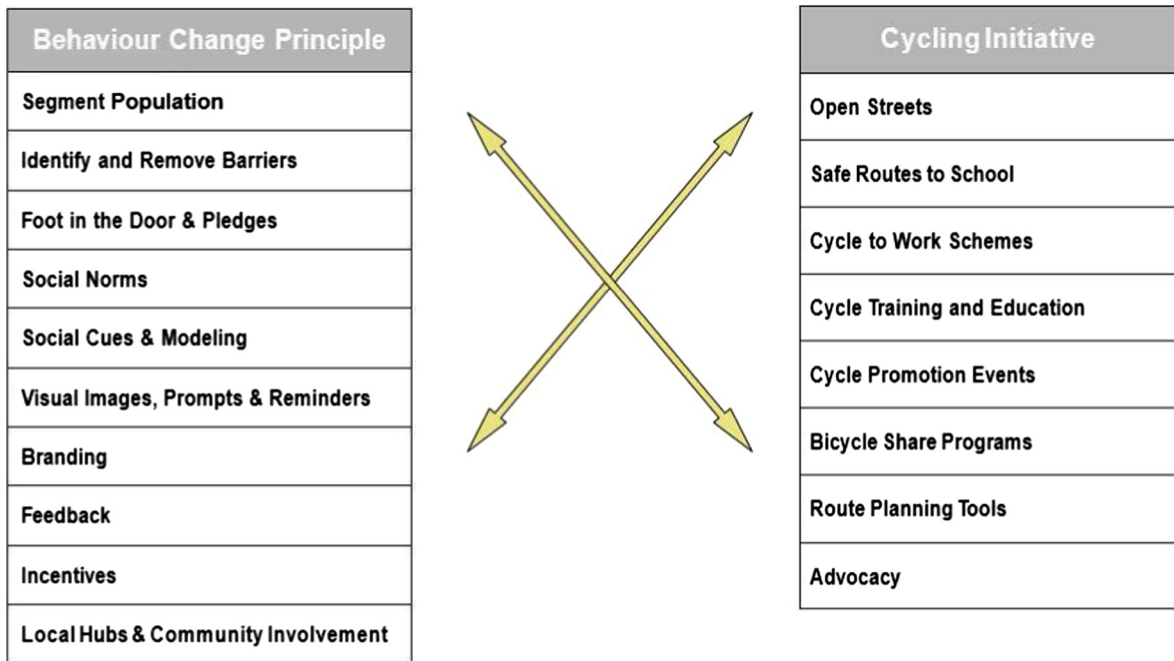
Behaviour Change Principle	Cycling Initiative
Segment Population	Open Streets
Identify and Remove Barriers	Safe Routes to School
Foot in the Door & Pledges	Cycle to Work Schemes
Social Norms	Cycle Training and Education
Social Cues & Modeling	Cycle Promotion Events
Visual Images, Prompts & Reminders	Bicycle Share Programs
Branding	Route Planning Tools
Feedback	Advocacy
Incentives	
Local Hubs & Community Involvement	

Fig. 1. Search terms and literature comparison.

3.1. Results and analysis

Based on the literature review, key elements that represented both the clear evidence based methods described in the social psychology literature as well as the successful monitored cycling adoption initiatives were chosen for inclusion in a integrated framework for program design. Five key interlocking strategies were described: (1) strategic population segmentation; (2) identification and removal of barriers; (3) the use of commitment strategies, including the foot in the door and pledge techniques described above; (4) tactics to sustain behaviour change, including visual images, prompts, reminders, social cues and modeling, social norms, branding, feedback and incentives, and; (5) ongoing social support, through modeling, local hubs and community involvement. Each is characterized below, and a list of options for implementing each strategy derived from the literature on successful cycling adoption interventions follows.

3.1.1. Strategic population segmentation

Population segmentation is increasingly recognized as an important tool in the delivery of travel behaviour change programs (Chatterjee, Sherwin, & Jain, 2011; Christensen, Chatterjee, Marsh, Sherwin, & Jain, 2012; Gatersleben & Appleton, 2007; Yang, Sahlqvist, McMinn, Griffin, & Ogilvie, 2010). Yang et al. (2010) state, "individualized, targeted marketing studies report consistent positive effects of interventions on cycling behaviour." There is a strong case for understanding behaviour change and identifying opportunities to promote change from a life cycle or *life course perspective* (Chatterjee et al., 2011; Christensen et al., 2012; Gatersleben & Appleton, 2007). This highlights the importance of individual and family histories, and particularly life- changing events and transitions as optimal for questioning past travel behaviour and considering new (desired) travel options.

Christensen et al. (2012) describe these "transitional life events" as pivotal to encouraging people to take up cycling, stating, "changes in cycling behaviour were in many cases triggered by life change events such as getting a new job, having children, moving house, having a health event or retiring." Individualized travel programs, such as *Indimark* and *Travelsmart*, highlight the importance of this segmentation and illustrate that interventions need to respond to the different motivations and deterrents within targeted groups.

Approaches, then, should be adjusted for optimal fit to specific target groups to maximize opportunities for changing travel mode choice. Personalized travel programs usually involve strategically targeted information, events and incentives (Brög, Erl, Ker, Ryle, & Wall, 2009; Davis, 2008; Office, 2005; Urbanczyk & Fenton, 2011; Yang et al., 2010). Optimal target groups embody the notion of change as "something they have already been thinking about," or "interested but concerned" (Brög et al., 2009).

As a result, cycling promotion programs should take advantage of life course transition periods as opportunities to target the intended behaviour change (Chatterjee et al., 2011), and should partner with organizations that have pre-existing relationships with the (defined) target population.

Table 1
Definitions and rationale for behaviour change techniques.

Behaviour change techniques		
Behaviour change technique	Definition and theoretical rationale	Cycling related example
Population segmentation	Prochaska's (Prochaska & Velicer, 1997) *Transtheoretical Model of Behaviour Change* (where change is a process involving sequential steps, as opposed to a solitary event) has been interpreted to incorporate practical behaviour change techniques, often in the health psychology field. This 6-step process includes: pre-contemplation, contemplation, preparation, action, maintenance and termination phases (Gatersleben & Appleton, 2007) Program design should consider where in the process participants are and/ or segment the population to target those in the contemplation or preparation stages	Cycling adoption programs have focused on recently immigrated high school students to take advantage of life transitions as a basis for contemplation of many changes in lifestyle and habits (Wittmann et al., 2015)
Identify and remove barriers	Studies have concluded that knowledge and information campaigns do not lead to behaviour change (Abrahamse et al., 2007; McKenzie-Mohr, 2000). Education can affect and shape attitudes, but barriers mediate whether they are expressed through behaviour. Since different individuals and communities face diverse impediments to behaviour change; and the impediments are often multiple, little happens until the right combination of intervention types is found. Barriers may be physical, social, financial or psychological. Once barriers are identified a more targeted and context-specific approach to promote the desired behaviour change can be implemented, ensuring best results (McKenzie-Mohr, 2000; Stokes et al., 2011)	A fear of cycling (particularly amongst females) (Horton et al., 2007), perceivedlack of comfort and convenience (Daley & Rissel, 2011; Gatersleben & Appleton, 2007; Heinen et al., 2011; Lavizzo-Mourey & McGinnis, 2003; Skinner et al., 2007) individual attitudes and perceptions (Gatersleben & Appleton, 2007; Daley & Rissel, 2011; Heinen et al., 2011; Lavizzo-Mourey & McGinnis, 2003; Skinner et al., 2007; GLPi, Metrolinx & Stepping It Up Steering Committee, 2011; The National Safe Routes to School, 2007; Weigand, 2008), habit (Garrard et al., 2006; Jan de Bruijn et al., 2009) and the interconnectedness of the physical environment and infrastructure (Baker, 2009; Cycle to Work Alliance, 2011; Dickinson et al., 2003; Garrard et al., 2006; Garrard et al., 2008; Wittmann et al., 2015)
Commitment	Cialdini (1993) discusses the concept of "starting small and building." A pledge, often in the form of a public commitment to behaviour change is a common use of this technique. Pledges encourage individuals, organizations and/or communities to make an initial commitment towards action, with the (often hidden) intention to predispose them for later, much larger concessions, leading to behaviour change – which would otherwise not have been possible (Cialdini, 1993; McKenzie-Mohr, 2000)	Employee pledge bank to bike to work (with small initial commitment requirements) (Cooper, 2007; McKenzie-Mohr, 2000; Pooley et al., 2011; Stokell, 2010; Surborg, nd) and Bike to Work events to provide "first" cycling experience (Cialdini, 1993)
Visual images, prompts & reminders	Prompts and reminders (often visual imagery) reinforce positive progress and can mitigate the effects of forgetfulness, a common barrier to behaviour change. Prompts and reminders act as reinforcements to encourage the maintenance of a recent behaviour change (McKenzie-Mohr, 2000)	Promotional packs, fun and usable prompts (McKenzie-Mohr, 2000; Surborg, nd) and large-scale cycling events (Baker, 2009; Cycle to Work Alliance, 2011; Dickinson et al., 2003; Garrard et al., 2008; GLPi, Metrolinx & Stepping It Up Steering Committee, 2011)
Social norms	Normative information is a powerful, yet often undetected form of social influence. A growing body of evidence has been developed explaining the importance and potential (positive) impact of normative influence. Social norms are the set of common beliefs and perceptions of appropriate behaviours operating within a community (Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007). These norms not only spur, but also guide and direct action and human behaviour in meaningful ways. Individuals often underestimate the extent to which their actions in a (social) situation are determined by the similar actions of others (Schultz et al., 2007)	Pervasive "streets are for cars" rhetoric in North-American cities vs. cycling as a mainstream activity in many European cities (Schultz et al., 2007)
Social cues & modeling	The impacts of social cueing and modeling stem from the notion of positive deviance. Modeling is used to actively emulate a new and desired behaviour; which can help a target audience envision a (realistic) change in behaviour (Spreitzer & Sonenshein, 2004). The creation of a positive, social space, built on the principles of encouragement is shown to motivate participation (Cleary & McClintock, 2000; De Geus et al., 2008; O'Fallon, 2010)	Workplace cycling ambassadors and "champions," (Cialdini, 1993; De Geus et al., 2008; O'Fallon, 2010; Spreitzer & Sonenshein, 2004; Surborg, nd) parents and teachers as important models of behaviour (Aldred & Jungnickel, 2012; GLPi, Metrolinx & Stepping It Up Steering Committee, 2011; Transport Canada, 2009; Weigand, 2008)
Branding	Branding establishes and nurtures a relationship with a customer and/or a target population. Brand recognition and image control are often integral for successful program design and implementation. Program name, logo and key "tagline" are important principles for a successful branding strategy and must be clearly connected to desired initiative (Cooper, 2007)	Make use of clear, concise and consistent program identity (Abrahamse et al., 2007; Cooper, 2007; Spreitzer & Sonenshein, 2004; Yang et al., 2010), targeted marketing packages (Brög et al., 2009; Davis, 2008; Office, 2005; Urbanczyk & Fenton, 2011; Yang et al., 2010) and place-based cycling branding strategies (Sarmiento et al., 2010;

Table 1 (continued)

Behaviour change techniques		
Behaviour change technique	Definition and theoretical rationale	Cycling related example
		Spreitzer & Sonenshein, 2004)
Social support	The creation of supportive community hubs that encourage civic involvement. This collective approach, most evident in a "face-to-face" environment fosters and supports groups' motivational commitment to their action and resilience in behaviour change (Bandura, 2000). Local level involvement in behaviour change initiatives is best and most effectively encouraged with the promotion of an accessible, fun and inclusive group dynamic, highlighting the importance of the group and social conversations and interactions (Aldred & Jungnickel, 2012; Sloman et al., 2010)	Creation of cycling culture (De Geus et al., 2008; O'Fallon, 2010; Sloman et al., 2010; Telfer et al., 2006), community social networks (Aldred & Jungnickel, 2012; Handy, 2010; Telfer et al., 2006) and the creation of a social space via cycling initiatives (Cleary & McClintock, 2000; O'Fallon, 2010; Spreitzer & Sonenshein, 2004)
Feedback	The creation of mechanisms to allow participant interaction and the valuable exchange of information. Feedback techniques engage participants by encouraging two-way communication, based on the social psychological notions of reciprocity (Abrahamse et al., 2007)	Bicycle user groups (BUGs) Godefrooij, 2007 and individualized travel planning programs (Brög et al., 2009; Davis, 2008; Office, 2005; Urbanczyk & Fenton, 2011; Yang et al., 2010)
Incentives	Early attention was given to the use of incentives and disincentives as techniques to effectively promote environmentally responsible behaviour (De Young, 2000). Some studies found that appealing to people's noble values is more effective than offering financial incentives. On the other hand, some studies found that offering financial incentives can act as a disincentive for altruistic behaviour. There is strong evidence that incentives and information interact, with the combination sometimes being much more effective than the sum of the two interventions (Stern, 1999)	Mileage clubs Stokell, 2010, prizes (Cooper, 2007; Davis, 2008), discounts, gifts, tax exemptions and small monetary payments (Cycle to Work Alliance, 2011; Ogilvie et al., 2004; The Tools of Change Highlight Series, 2012; Wardman et al., 2008)

Table 2
Definition and Rationale Cycling Initiatives

Cycling Initiatives		
Initiative	Definition and rationale	Notable examples
Open streets	Open Streets programs refer to the act of temporary closing city streets to vehicular traffic and encouraging citizens to walk, run, rollerblade or bike and reclaim their streets as public space. Open Streets serves as the umbrella term for Car-free Days, Sunday Parkways, Pedestrian Days and Ciclovías (Cities, 2010)	Bogota's Ciclovía, Portland and Chicago's Sunday Parkways (Cervero et al., 2009; Cities, 2010; Nelson & Scholar, 2006)
Safe routes to school	Safe Routes to School (SRTS) programs include education, encouragement, infrastructure, and enforcement programs aimed at increasing the safety and number of students who walk and bicycle to school (Pucher et al., 2010)	Active and Safe Routes to School, bike bus to school (Aldred & Jungnickel, 2012; GLPi, Metrolinx & Stepping It Up Steering Committee, 2011; Tools of Change Landmark Case Study, 2009; Transport for London, 2010; Weigand, 2008)
Cycle to work schemes	Schemes or promotional interventions that encourage commuters to cycle to work. Components may include free breakfasts, contests, giveaways, cycling activities and other incentives (Pucher et al., 2010)	Cycle to Work Guarantee (Cycle to Work Alliance, 2011),Bike Busters 70], Challenge for Change (Stokell, 2010)
Cycle training and education	Bicycle training schemes aimed at teaching existing or potential cyclists bike handling, cycle repair, maintenance skills and education on the safe, lawful use of the roads (Pucher et al., 2010). Cycle training and education will serve as the umbrella term for skills workshops, training programs, safety campaigns and cycling manuals	Learn to ride courses, Bikeability training (Aldred & Jungnickel, 2012; Handy, 2010; Sloman et al., 2010)
Cycle promotion events	Group, community or city-wide promotional events for all things bike-related (Pucher et al., 2010). Serves as the umbrella term for recreational events, theme rides and cycling festivals and celebrations	Biker's breakfasts, community (Pucher & Buehler, 2006; Rose, 2003) events, Bike to Work Week celebrations (Luton, 2008)
Bicycle share programs	Bicycle sharing service where bicycles are made available for shared use amongst citizens, for utility purposes, particularly in urban areas (Beroud, 2010)	Bixi, Bicing, Vélib systems (Beroud et al., 2010; Kessler, 2011)
Route planning tools	Map-making or trip planning tool for journeys that can be completed by bicycle (Richards, Murdoch, Reeder, & Rosenby, 2010)	mapmyride.com, Ride the City (Richards et al., 2010)
Advocacy	Individuals, groups and communities showing a committed and active involvement with cyclists, cycling promotion, cycling infrastructure, and/or cycling related public policy (van Bekkum et al., 2011)	Cycle Toronto, Critical Massgroups (Blickstein & Hanson, 2001), bicycle user associations (Bandura, 2000; De Geus et al., 2008; Sloman et al., 2010)

Program designers should collaborate with other sectors and local organizations to access target groups and individuals at transition points, such as community support centres, workplaces, schools, settlement service agencies, local real estate offices and healthcare centres (Chatterjee et al., 2011), especially where physical barriers are few and cycling is a realistic option.

3.1.2. Identification and removal of barriers to change

Individuals' attitudes and perceptions of cycling act as a common, deep-rooted barrier to cycling. The stereotype or "image of cycling" is often negative, particularly amongst those who have not contemplated cycling as a mode of transport (Daley & Rissel, 2011; Gatersleben & Appleton, 2007; Heinen, Maat, & van Wee, 2011; Lavizzo-Mourey & McGinnis, 2003; Skinner & Rosen, 2007). A consistent pattern of gender differences and women's lower participation in utility cycling is evident. This is primarily attributed to the risks (actual and perceived) associated with cycling in countries with relatively poor cycling infrastructure, policies, regulations and low cycling prevalence (Baker, 2009; Cycle to Work Alliance, 2011; Dickinson, Kingham, Copsey, & Pearlman Hougie, 2003; Garrard et al., 2006; Garrard et al., 2008; Wittmann, Savan, Ledsham, Liu, & Lay, 2016). There are gendered aspects to perceived danger, as women can perceive barriers such as darkness and road danger to be a greater threat than men do (van Bekkum, Williams, & Morris, 2011). The perception of the threat of motor vehicles on the road can prompt gendered responses as well, where males may see cycling risks as a challenge or competition, and not as a barrier (Steinbach, Green, Datta, & Edwards, 2011). Furthermore, challenges can arise in integrating a feminine identity with the practical demands of cycling and a perceived necessity to exhibit assertive behaviour on the roads (Steinbach et al., 2011). Fear is also constructed by the prevalence and contents of cycle and road safety training courses, which often focus excessively on the risks of cycling. For many, this fear constitutes a significant emotional barrier to cycling (Horton, 2007). Parents' attitudes, perceptions and misperceptions of cycle safety and suitability of cycle facilities acts as a significant barrier to cycling uptake by younger populations, as parents often do not permit their children to cycle to school (GLPi & Stepping It Up Steering Committee, 2011; The National Safe Routes to School, 2007; Transport Canada, 2009; Weigand, 2008). Habit strength, particularly in adults, is a strong predictor of bicycle use (Jan de Bruijin, Kremers, Singh, Bas van den, & Van Mechelen, 2009). Car use is often perceived as convenient, habitual and normal in low cycling cities, encompassing a powerful internal barrier to change (Jan de Bruijin et al., 2009; Pooley et al., 2011).

Behaviour change programs are most effective when both internal and external barriers can be reduced to the minimum. Studies have concluded that knowledge and information campaigns alone do not change behaviour (Abrahamse, Steg, Vlek, & Rothengatter, 2007; McKenzie-Mohr, 2000). Education can affect and shape attitudes, but barriers and opportunities mediate whether they are expressed through behaviour. Once barriers are identified, a more targeted and context-specific approach to promote the desired behaviour change can be implemented, ensuring best results (McKenzie-Mohr, 2000; Stokes et al., 2011). Initiating group training rides with an emphasis on efficient route planning and creating a supportive, fun group cycling culture as well as on road safety, can ease worries of fear and negative image perception (Aldred & Jungnickel, 2012; Cleary & McClintock, 2000; Sloman et al., 2010; Telfer, Rissel, Bindon, & Bosch, 2006).

Women-only cycle initiatives, such as women-only bike fix-it programs, group rides and route-planning activities can increase female cycling, as can tactics to incorporate additional activities such as shopping and child pick-up and drop-off en-route (Baker, 2009; Cycle to Work Alliance, 2011; Dickinson et al., 2003). Strategic use of group activities is particularly important, not only due to social influence, but also because there is strong evidence that this impacts positively on safety (Jacobsen, 2003). Targeted cycle training workshops for parents, aiming to differentiate perceptions from reality especially around the areas of distance and safety can mitigate barriers for children. Specifying the distance to be cycled and identifying local cycling facilities in a fun group ride can enhance social networks (Handy, 2010; The National Safe Routes to School, 2007) and peer support for cycling, as can incorporating images of "similar others" on bicycles in media campaigns to promote the initial contemplation phase and to break down image (mis) perceptions Gatersleben & Appleton, 2007. A local media or community-led marketing campaign to promote cycling as a mainstream activity, undertaken by "normal, everyday people," without the need for special clothing, expensive equipment or limited to purpose built facilities (Daley & Rissel, 2011) can also help to establish cycling as a transportation rather than merely recreational activity.

3.1.3. Commitment strategies

Soliciting commitment is critically important in moving people from intention to action. Foot-in-the-door strategies, requiring a small initial commitment, have proven successful at encouraging new and occasional cyclists to "give it a try" (Bowles, Rissel, & Bauman, 2006; Rose, 2007; Stokell, 2010). Stokell (2010) explains, giving participants a fun, quick 10-min cycling experience quickly breaks down negative perceptions about cycling and replaces them with new, more positive attitudes – this is often the ideal first step to encourage more people to ride. These 10 min are a "commitment" of time to a new behaviour. A cycling promotion event, targeted at low ability and novice cyclists, can be used as a foot-in-the-door strategy to attract continued involvement in cycling (Bowles et al., 2006; Rose, 2007). Cycle-to-work schemes play an important role in helping new cyclists "get started" and "keep motivated" (Cycle to Work Alliance, 2011; Luton, 2008; Rose, 2007; UK Eastern Region Public Health Observatory, 2011). Pledges encourage collaboration, build trust, generate excitement and catalyze future action (Cooper, 2007; Surborg, nd; UK Eastern Region Public Health Observatory, 2011). When pledges are public, and therefore social, the commitment is particularly effective in linking to action and change (McKenzie-Mohr, 2000). Pledges provide a valuable platform to track and sustain behaviour change, by creating a new database of participants for future targeted interventions, including prompts and reminders (Stokell, 2010). Modest incentives encourage initial involve-

ment in cycling programs. Cooper (2007) and Davis (2008) reference incentives, such as balloons, candy and bike accessories, as particularly effective to attract school-age children. Mass cycling events, often fun, community-based promotional activities, are known to attract new and novice cyclists and get them interested in cycling and the cycle community (Bowles et al., 2006; Mason et al., 2011; Rose, 2007; Sloman et al., 2010; The National Safe Routes to School, 2007). Bowles et al. Bowles et al. (2006) describe mass cycling events as having the potential to "trial" new behaviours in a safe, non-competitive, controlled and enjoyable environment. Greater commitments could encourage "new recruits" to a cyclist program to sign a pledge committing them to reduce their car use by as much as possible and to use cycling in its place (Surborg, nd). Tracking of commitment campaigns allow incorporation of prompts and reinforcements and recognition of those who fulfill their pledge (Cooper, 2007).

3.1.4. Maintenance of Changed behaviour

"Maintenance is important for behaviour change to be sustained – it does not just happen" (Rose, 2003). The use of public prompts, modeling and positive social reinforcements and cues are proven strategies to promote and sustain cycling behaviour change (Cleary & McClintock, 2000; De Geus, De Boureaudhuij, Jannes, & Meeusen, 2008; O'Fallon, 2010; Rose, 2003). Positive feedback is an important motivator to sustain and potentially increase cycling behaviour change (Gatersleben & Appleton, 2007; O'Fallon, 2010). Year-round and recurring events provide compelling visual imagery and constant reminder of cycle activity (Sloman et al., 2010; Transport for London, 2010). City-wide events, such as Ciclovías and Open Streets serve as mass marketing tools and provide recurring public reminders of cycling and walking and reinforce evolving social norms (Cervero et al., 2009). These initiatives close city streets to cars and open them to the public to cycle or walk, usually on Sundays due to lower traffic volumes. Open streets initiatives are multivariate in purpose and have recently been recognized as promising, large-scale interventions to promote cycling, physical activity, build social capital, enhance social inclusion and facilitate exposure to new and nearby communities (Mason et al., 2011; Sarmiento et al., 2010). They have been strongly supported by the World Health Organization, particularly in Latin America, where they originated, and have grown exponentially in recent years.

Following major cycling events, post-event initiatives and activities reinforce and maintain recent travel behaviour change (Rose, 2003). Monthly cycle breakfasts, skills training, targeted reminder packages, and public displays of continued program participation (Rose, 2003) can encourage sustained behaviour change. Follow-up events like a wrap-up party create a sense of celebration. Ongoing events can include bike decoration days, biker's breakfasts, bike-to-work weeks, community bikefests, etc. (Pucher & Buehler, 2006), and cycling promotion elements can be incorporated into existing successful community events such as bike repair or "do it yourself" locales, urban cycling 101, workshops at local festivals.

Cycling ambassadors programs, including the recruitment of well-trained cyclists (from different age, ethnic and other population groups) who visit residential neighbourhoods and/or target group areas, serve as role models of safe cycling and help with cycling promotion, route planning, distribution of newsletters and information (Davis, 2008). "On-the-road" group cycle training and general proficiency development highlights supportive social networks (Telfer et al., 2006). Additionally, prompts coming from within a community, such as action posters and lawn signs will reinforce community commitment to behaviour change. Combinations of attractive marketing materials and "easy-to-read" information promote interventions to target groups (Yang et al., 2010).

Fun and usable prompts are a means of reinforcement and reminder, and may include tote bags, water bottles and notepads or bicycle accessories such as bells and lights (Cooper, 2007). Monetary incentives, such as small, daily payments, tax exemptions and discounts can motivate and reward travel behaviour change in adults (Cycle to Work Alliance, 2011; Marshall & Booth, 2000; Ogilvie, Egan, Hamilton, & Petticrew, 2004; Wardman, Tight, & Page, 2008). Incentives should be paired with information and other cycle programming, such as special events and (public) pledges. Stern (1999) finds strong evidence that incentives and information interact, with the interaction sometimes significantly more effective than could be expected from the simple sum of two interventions. A compelling media and marketing presence, combined with a clear, concise and consistent program identity have proven integral to cycle promotion program success (Cooper, 2007; Lavizzo-Mourey & McGinnis, 2003; O'Fallon, 2010; Yang et al., 2010). O'Fallon (2010) and (Tools of Change Highlight Series, 2012) explain that program name, logo and brand consistency are important to secure community engagement, as are public and private sponsorships and partnership, particularly during program "start-up".

3.1.5. Ongoing social support through modeling, local hubs and periodic events

Creating social support networks through behaviour modeling and social cues correlates positively with increased cycling for transport (De Geus et al., 2008; Titze, Stronegger, Janschitz, & Oja, 2008). Cycling visibility, particularly in one's own "social" group displays potential to increase its "normality" and subsequently, its popularity (Christensen et al., 2012). Dill and Voros (2007) found, "people who live in households with other cyclists, had co-workers who cycled to work or saw adults cycling in close proximity to their house were more likely to cycle themselves."

Local hubs and encouragement for local community involvement are integral to creating an accessible, positive and supportive environment, which promotes and sustains cycling, and cycling behaviour change through programming and events (Aldred & Jungnickel, 2012; Bauman et al., 2008; Sloman et al., 2010; Thogersen, 2007). The development of a community-based approach to program implementation encourages embeddedness - a sense of program ownership in the community. Community partnerships should connect local organizations and businesses to allow the program message to be delivered by complementary sources already familiar to the target population, demonstrating pro cycling peer norms. Partnerships with

multiple community organizations enhance exposure and visibility, foster program sustenance, and may lead to greater results (Cooper, 2007). Within organizations the presence of an enthusiastic cycling facilitator or program "champion" helps to facilitate program implementation and offers encouragement to other participants (O'Fallon, 2010; Stokell, 2010; Cleary & McClintock, 2000; Aldred & Jungnickel, 2012;). This "champion" should be someone who rides a bicycle and who understands and is able to communicate program objectives, steer through controversial initiatives, and is comfortable handling local media attention (Cleary & McClintock, 2000). While the effectiveness of local, active organizations and citizen involvement (often in the form of cycling hubs, advocacy and community-based cycling promotion) is not conclusive in the literature, the message is that robust and meaningful civic involvement can be influential, particularly in transitioning (cycling) cities, through the creation of relevant citizenship skills, community partnerships, and political lobbying (Aldred & Jungnickel, 2010; Aldred & Jungnickel, 2012; Batterby, 2003; Blickstein & Hanson, 2001; Buis, 2012; Cooper, 2007; Despacio, 2007; Godefrooij, 2007; Sagaris, 2009; Sagaris & Arora, 2010).

Diverse local groups -- students' clubs at schools, enthusiastic employees at work, etc. – can be encouraged to build their own groups to organize and maintain initiatives, beyond the timespan of a specific, catalyzing intervention. School-travel planning and school- based cycle promotion instill lifelong travel behaviour change (The National Safe Routes to School, 2007; Tools of Change Landmark Case Study, 2009; Transport for London, 2010), reinforcing emerging social norms regarding cycling. For high school students, bike clubs engage young people at a critical transition point and provide social support. Workplace cycle challenges incorporate and track pledges and take advantage of modeling, social cues and group encouragement that exists in a workplace environment (Cycle to Work Alliance, 2011; Luton, 2008; Rose, 2007; UK Eastern Region Public Health Observatory, 2011).

Public bike sharing programs function as prompts to continue cycling culture growth (particularly in burgeoning cycling cities). These systems serve an important function to maintain and extend increases in cycling modal split. Their public nature legitimizes cycling. Public bike sharing systems provide opportunities to broaden target group scope and move beyond the initial 'easy' targets (Urbanczyk & Fenton, 2011).

3.2. Discussion

Following the literature review, the behaviour change strategies identified above were sequenced and integrated to form the basis of a framework for changing cycling behaviour. Fig. 2 describes the series of steps for adoption and reinforcement of cycling for transportation. These elements are presented in sequence, but users should keep in mind that repeating many steps, interventions and techniques throughout the process is part of the strategy's effectiveness. In particular, options in the *ongoing social support through modeling, local hubs and periodic events* section, provide suggestions for inclusion and repetition throughout program implementation.

It is worth noting that our framework reinforces many of the elements emphasized by the emerging Social Practice Theory (Ogilvie et al., 2007; Shove, Pantzar, & Watson, 2012). Recent work has applied this theoretical framework to cycling, which focuses on the practice of riding a bicycle, rather than on the individual, who is merely a carrier of the activity (Hargreaves, 2011; Nettleton & Green, 2014). In particular, reliance on the embedded knowledge of mentors and community

Fig. 2. Cycling adoption theory cycle.

groups is consonant with the competence defined by Shove, and the provision of bicycles through loan programs, car free streets with ciclovias, as well as the targeting of areas with a large existing share of short trips, and reasonable densities of residences and destinations, recognizes the importance of the material environment in the emergence of new practices. Finally, meaning is closely related to the social norms and modeling of cycling behaviour emphasized in our social support strategy. Recent work relating Social Practice Theory to cycling acknowledges the lack of tools enabling the application of Social Practice Theory in the practical realm. The framework described here may help advance the development of such tools.

Key findings from the literature review suggest some fundamental considerations when adapting and applying these strategies. A mix of approaches works best, "where a greater range and intensity of measures are implemented together, an amplifier effect is created" (Pucher, Dill, et al., 2010). Case studies show that cities adopting multifaceted packages of measures work better than one, stand-alone intervention (O'Fallon, 2010; UK Eastern Region Public Health Observatory, 2011). This suite of strategies must be adapted and fine-tuned to fit the social context of both delivering agencies and target populations. The participation of local partners with ties to the targeted community provides on the ground knowledge of local barriers and facilitators and a source of role models and ideas for local activities that are linked to existing community events. The variety of methods outlined for each stage of the process provide scope for local agencies and community representatives to adapt the process to their particular circumstances. Building a powerful appeal to (often deeply-entrenched) collective social norms is a slow, steady process. Nelson and Scholar (2006) state the greatest impact is achieved through combining soft policies, such as promotion and education campaigns, with hard policies, such as building new cycling infrastructure. It is imperative to identify and mediate the interplay of the built environment, cycling infrastructure, relevant policies and cycle activity (Badland & Scholfield, 2006; Bauman et al., 2008; Nelson & Scholar, 2006; Parkin, Ryley, & Jones, 2007; Pucher, Dill, & Handy, 2010).

3.3. A local example

The cycling adoption theory cycle presented in Fig. 2 was explicitly applied in a recent community based intervention carried out by University of Toronto researchers in collaboration with the Toronto Centre for Active Transportation for the Region of Peel, a suburban region just west of Toronto. Researchers used mapping and population segmentation to identify neighbourhoods within the Region of Peel with active transportation potential using data such as mode share, trip distances, and bicycle infrastructure provisions. Then, researchers from the University of Toronto, facilitated by staff from the Region of Peel who were familiar with local groups, met with potential community partners who were interested in promoting healthy living and bicycling within the neighbourhoods identified earlier. After establishing partnerships with two local community groups with the support of the Region of Peel, the PedalWise cycling mentorship program loaned free bicycles to participants for 16 weeks between June and September 2015. The community partners recruited program participants, drawing on their existing connections within the community, strong language skills within their staff base, and recognizable organizational brand. There were 35 participants in the PedalWise program and 26 completed both entrance and exit surveys. Within the group that completed both surveys, ages ranged from 25 to over 65 and 60% were male while 40% were female. Over half of the participants lived in a home with at least one child aged 17 and under and 75% had been in Canada for more than 5 years at the time of the intervention.

Before the program began, the researchers identified two critical barriers for participants: bicycle ownership (few interested participants owned bicycles) and lack of confidence riding on the street as opposed to sidewalks and trails. To address the two critical barriers, the group worked to establish a community bicycle hub to refurbish donated used bicycles, which were then provided as loaner bikes for the summer. Safety equipment and structured programming were provided. Experienced community cyclists were trained as cycling mentors and then supported new cyclists in multiple local rides and route planning. Volunteers developed and taught bicycle maintenance and mechanics.

Group celebrations and large and small group rides reinforced cycling, provided visible role models and social interactions. In an effort to increase retention, program participants made a public pledge and signed a small card to keep in their wallet as a commitment to cycling throughout the duration of the program. This card also contained the contact information of their mentors. Participants were required to record weekly cycling trips in a calendar to both keep themselves on track and provide mode share and trip data for research. At the end of the program, mentors were provided with a gift card in appreciation of their time and a celebration meal with mentors and participants was held. Participants were allowed to keep the helmets given to them by the program while bikes and locks were returned to the community organizations for use in future programming.

Despite the low density urban form and lack of cycling infrastructure, cycling for transportation increased dramatically among the program participants, compared to their previous travel behaviour and also when compared to a control group of 55 respondents with similar transportation patterns. For program participants, at program exit, trips taken by motor vehicle (drive, getting a ride, motorcycle and taxi combined) had declined from 54% of trips at entry to 42% of trips while trips by bicycle accounted for 5% of trips at entry and 25% of trips at exit (Fig. 3). To demonstrate the potential sustainability of the behaviour change we asked respondents about their willingness to spend on bicycles and accessories and measured this in dollars. The willingness of participants to invest in bicycles and accessories grew by 69% while the willingness of the control group to spend on bicycles and accessories actually declined (Fig. 4). Health, social, environmental and economic benefits were also realized through this program. Results are currently being prepared for academic publication.
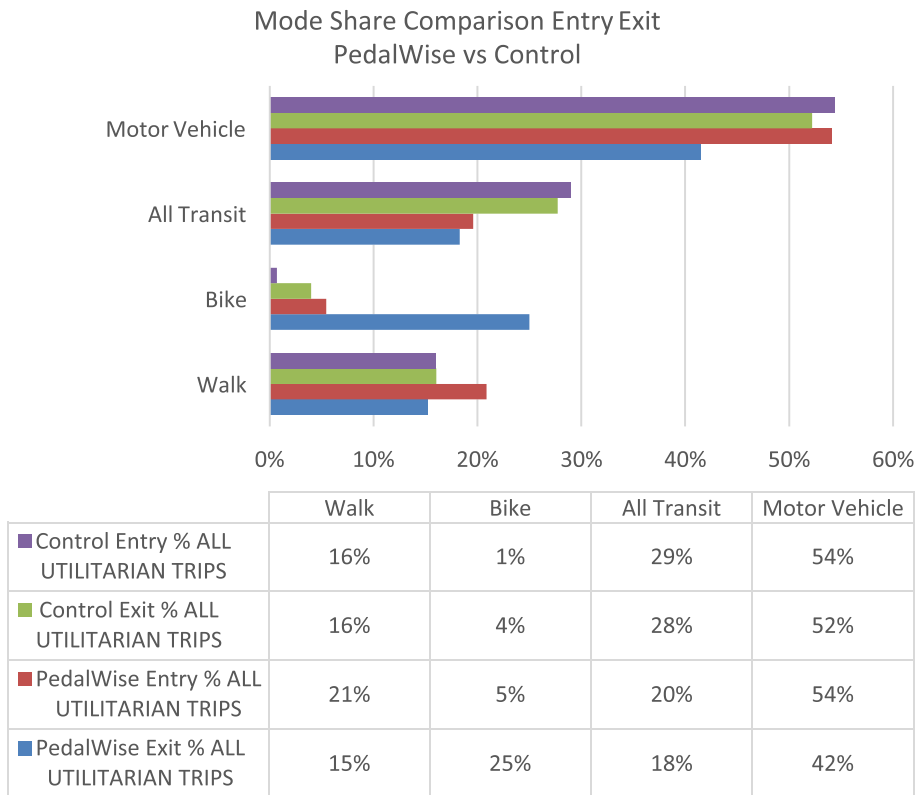
Mode Share Comparison Entry Exit PedalWise vs Control

	Walk	Bike	All Transit	Motor Vehicle
Control Entry % ALL UTILITARIAN TRIPS	16%	1%	29%	54%
Control Exit % ALL UTILITARIAN TRIPS	16%	4%	28%	52%
PedalWise Entry % ALL UTILITARIAN TRIPS	21%	5%	20%	54%
PedalWise Exit % ALL UTILITARIAN TRIPS	15%	25%	18%	42%

Fig. 3. PedalWise mode share comparison. *Data source:* PedalWise entry/exit surveys and Control entry/exit surveys, Toronto Cycling Think and Do Tank.

Average Change in Willingness to Spend on Bicycles and Accessories 2015 PedalWise vs Control

	Bicycle	Accessories (helmets, racks, locks)	Total
PedalWise Average % change	63%	84%	69%
Control Average % change	0%	-4%	-1%
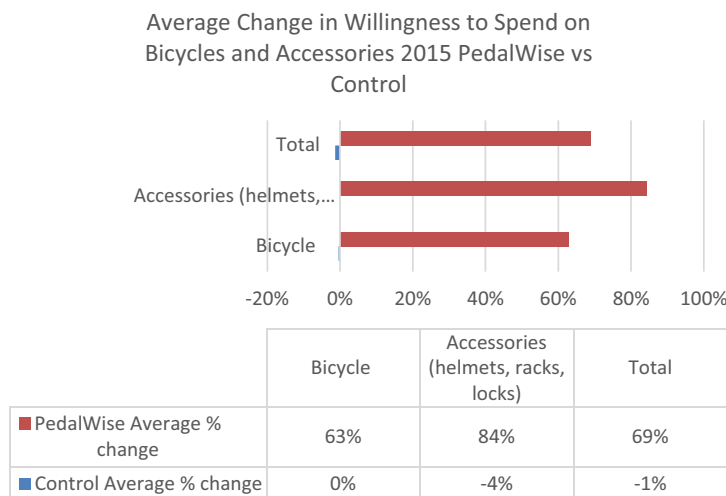
Fig. 4. PedalWise Change in Willingness to Spend on Bicycles and Accessories. *Data source:* PedalWise entry/exit and Control entry/exit surveys, Toronto Cycling Think and Do Tank.

4. Conclusions

Although still in its infancy, social psychological and social practice insights into behaviour change show significant potential to foster increased cycling for transport. Based on the literature available, program design for social interventions to increase utilitarian cycling needs to take a mixed method, multi-staged approach. Analyzing current programming gaps in a community using this five- part model and then integrating ongoing activities into strategically designed and targeted pro-

grams that leverage all five elements using multiple tools for change will allow communities to more effectively use scarce active transportation resources.

Although there is a growing literature about cycling promotion, there is a gap in the behaviour change approach to cycling promotion in the academic literature. In particular, there is a paucity of studies that investigate and rigorously evaluate the independent effects of behaviour-based cycling promotion initiatives (Bird, Baker, Powell, & Mutrie, 2012; Ogilvie et al., 2007; Pucher et al., 2010; Yang et al., 2010). Given the significant public health, economic and climate impacts of transportation behaviour this gap deserves close attention from researchers and funders.

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