Accident Analysis and Prevention 133 (2019) 105295

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Formative research identifying message strategies for a campus bicycle safety campaign using self-determination theory and the social norms approach

Andrew Grayson[a,*], Daniel S. Totzkay[b], Brandon M. Walling[c], Jalyn Ingalls[d], Greg Viken[e], Sandi W. Smith[f], Kami J. Silk[g]

[a] Klein Buendel, Inc. 1667 Cole Blvd. Ste. 225, Golden, CO 80401 United States
[b] West Virginia University, Department of Communication Studies, 108 Armstrong Hall, P.O. Box 6293 Morgantown, WV 26506, United States
[c] Michigan State University, College of Communication Arts and Sciences, Department of Communication, 404 Wilson Road, Room 473, East Lansing, MI, 48824
[d] Colorado Health Institute, 303 E. 17th Avenue, Suite 930, Denver, CO 80203 United State
[e] PO Box 130, Buies Creek, NC 27506 United State
[f] Michigan State University, College of Communication Arts and Sciences, Department of Communication, 404 Wilson Road, Room 473, East Lansing, MI, 48824 United State
[g] University of Delaware, Department of Communication, 250 Pearson Hall, Newark, DE 19716, USA

ARTICLE INFO

Keywords:
Bicycle safety
Accident prevention
Message intervention
Social norms approach
Self-determination theory
Formative research

ABSTRACT

This formative study investigates the utility of the social norms approach (SNA) and self-determination theory (SDT) in framing safe bicycling messages with the goal of increasing intention to use bicycle lanes on a university campus. In Study 1, observational data showed that the majority of campus bicyclists did not use designated bike lanes while cycling; thus, intention to use bicycle lanes was chosen as the dependent variable for Study 2. Survey data (n = 168) collected from college students measured SNA and SDT constructs related to intention to use bicycle lanes, including descriptive norms, injunctive norms, autonomy, competence, and relatedness. Results indicate that different aspects of both the SNA and SDT are viable approaches for developing bicycle safety campaign messages, as competence, relatedness, and injunctive norms were significant predictors of intention to use bicycle lanes. Implications for the development of campaign messages are discussed, and information is presented to assist other groups so they can use the same process to develop relevant campaign messages.

1. Introduction

Bicycle safety is a growing concern on university campuses. University students are among the most likely to bicycle (Pucher et al., 2012) and commute to their campuses daily in a concentrated, multimodal transportation system comprised of other bicyclists, motor vehicles, and pedestrians (Grembek et al., 2014). In this complex system, bicyclist fatalities are increasing with 818 reported deaths in 2015 in the United States (NCSA, 2017). In addition, in the summer of 2002, an estimated 2 million bicyclists reported experiencing an injury while bicycling, with nearly a quarter of those injuries being attributed to a collision with a motor vehicle (NHTSA and BTS, 2002). The present research focuses on bicycle lane usage, as this practice can substantially reduce accidents and fatalities (Cohen, 2013; Marshall and Garrick, 2011; Morrison et al., 2019; Parker et al., 2013; Reynolds et al., 2009; Teschke et al., 2012; Walljasper, 2015). However, little previous research has focused on bicyclists' attitudes and perceptions of using bike lanes with respect to informing bicycle safety campaign messages. Therefore, this formative research aims to inform bicycle safety interventions through a better understanding of student attitudes, previous behaviors, and intent to engage in safe bicycling behaviors. Further, it examines the utility of the social norms approach (SNA) (Berkowitz, 2004) and self-determination theory (SDT) (Moller, Deci & Ryan, 2006; Deci and Ryan, 2012) as frameworks to guide the development of safe bicycling messages for university students.

1.1. Formative research on bicycle safety

Observational studies examining campus bicyclist behavior have found extremely high rates of traffic violations, with over 90% of

* Corresponding author at: Klein Buendel, Inc. 1667 Cole Blvd. Ste. 225, Golden, CO 80401. Tel.: (330) 819-9585.
E-mail addresses: agrayson@kleinbuendel.com (A. Grayson), daniel.totzkay@mail.wvu.edu (D.S. Totzkay), wallin30@msu.edu (B.M. Walling), ingalls7@msu.edu (J. Ingalls), viken@campbell.edu (G. Viken), smiths@msu.edu (S.W. Smith), kamisilk@udel.edu (K.J. Silk).

https://doi.org/10.1016/j.aap.2019.105295
Received 23 August 2018; Received in revised form 15 June 2019; Accepted 9 September 2019
Available online 04 October 2019
0001-4575/

observed bicyclists committing at least one safety violation while riding (Lavetti and McComb, 2014; Silk et al., 2015) such as bicycling on sidewalks or in areas marked for pedestrians in multi-use paths (Loukaitou-Sideris et al., 2014). In addition, self-report crash data from three university campuses show that bicyclists reported the highest number of crashes compared to all other modes of transportation. This data reported 23.1 crashes per 100 cyclists, which was more than four times that of walking (Loukaitou-Sideris et al., 2014). Bicyclists reported that crashes were often due to inattention (either of the motorist or pedestrian involved in the crash, or the bicyclist, her/himself; 56.6%); excessive speed (23.3%); and trying to avoid another bicyclist, pedestrian, or vehicle (22.1%) (Loukaitou-Sideris et al., 2014). Given the increase in U.S. bicyclist fatalities noted previously (NCSA, 2017), and the fact that 88% of bicyclists in a survey of almost 10,000 riders felt threatened by motorists (NHTSA & BTS, 2002), it is crucial to promote safe conditions for bicyclists. Indeed, the state in which the present research was conducted has the fifth highest bicyclist mortality rate for bicyclist-motor vehicle collisions (NCSA, 2017).

Bicyclists are at a risk for injury or death. Attitudinal/behavioral change is essential to ensure the safety of bicyclists and other university commuters. As noted previously, research has established that the consistent use of bicycle lanes and paths greatly reduces accidents and fatalities (Cohen, 2013; Marshall and Garrick, 2011; Morrison et al., 2019; Parker et al., 2013; Reynolds et al., 2009; Teschke et al., 2012; Walljasper, 2015). Thus, using bicycle lanes and paths is a realistic mechanism for improving commuter safety, and should be a focus of interventions. However, before a formal communication campaign can be planned, a baseline of this behavior, in addition to other relevant high-risk behaviors (e.g., riding bicycles on sidewalks), must be obtained via a formative research process (Glazer et al., 2010). Along with the enactment of bicycle-related behavior (e.g., using bicycle lanes), base rates of psychosocial variables relevant to the decision-making process of safe bicycling are needed. To guide this effort, the behavior change frameworks of the SNA (Berkowitz and Perkins, 1986; Berkowitz, 2004; DeJong and Smith, 2013) and SDT (Moller et al., 2006; Ryan et al., 2008) were applied. These theories can inform message appeals in order to best influence the psychological processes leading to positive behavioral intentions to ride in a designated bicycle lane (Atkin & Freimuth, 2013; Palmer, 1981).

1.2. Social norms approach

The SNA states that behavior change occurs when misperceptions of norms pertaining to a behavior are corrected. The SNA specifically focuses on a behavior's perceived frequency, or *descriptive norm*, and perceived acceptability, or *injunctive norm* (Berkowitz, 2004; Berkowitz and Perkins, 1986). Discrepancies between the behavior's actual and perceived frequency or acceptability are considered *misperceptions,* which can be corrected via SNA campaigns. The goal of these campaigns is to leverage the dynamic between perceived peer behavior and attitudes to open unique persuasive channels (Perkins, 1997).

SNA messages can affect attitudes and behavior indirectly by correcting misperceptions through promoting the actual norms that are collected from surveying representative samples of a given population (see Glazer et al., 2010). This approach increases the salience of the positive behavior, ultimately altering personal attitudes and normative perceptions to prompt more regular enactment of the desired behavior (Berkowitz, 2005; Glazer et al., 2010; Perkins, 1997, 2002). Examples of norm messages from a campus campaign targeting excessive drinking on Halloween read: "90% of students eat food before or while drinking on Halloween" (DeJong and Smith, 2013, p. 182), targeting descriptive norms, and "94% of students disapprove of drinking to the point of passing out, and 55% disapprove of getting wasted" (p. 182), targeting injunctive norms. These examples note that a majority of a referent population (i.e., students) regularly enact a positive behavior (i.e., eating before drinking), and hold unfavorable attitudes toward the problem behavior (i.e., excessive drinking). If individuals determine that a particular behavior is favorable among a majority of their referent group, they will be more likely to perform that behavior, and vice versa.

Some research has studied the role of social norms in bicycle behavior (see Willis et al., 2013), but mostly focused on intention to wear a helmet while riding or the general intention to ride in non-U.S. or non-student populations. To date, there has not been an application of the SNA to bicycle lane behavior even though the previously cited research suggests bicycle-related behaviors have a normative component, thereby indicating SNA-style messages might be influential. According to the SNA, individuals should intend to ride in a bicycle lane based on how frequently they perceive a majority of their social group uses bicycle lanes (descriptive norm) and approves of using bicycle lanes (injunctive norm; Berkowitz, 2004).

1.3. Self-determination theory

Another way to address the problem of low bicycle lane use is to determine whether students are motivated to use bicycle lanes on campus. SDT posits that an extrinsically-motivated behavior, and thus individuals' intention to enact that behavior, can be incorporated into one's self-concept, and be volitionally sustained when one's needs for autonomy, competence, and relatedness are satisfied (Ryan et al., 2008). In SDT, *autonomy* refers to one's perception of having control over his or her own actions, is able to follow his or her own values and passions, and feels as though he or she is not being forced to perform an action (Moller et al., 2006); *competence* is the perception that one can effectively perform a behavior, given his or her own abilities and/or access to resources and skills; finally, *relatedness* is the perception that one is socially connected and valued by a motivator or message sender (Ryan et al., 2008). When a message source shows respect for an individual's right to choose, provides the needed skills or knowledge, and demonstrates interpersonal warmth and understanding, prosocial behavior is more easily facilitated (Deci and Ryan, 2012).

A review of communication campaign literature shows sparse application of SDT, despite its potential utility in designing messages to change behavior and behavioral intention (Pelletier and Sharp, 2008) with its focus on basic psychological needs, which parallel the constructs of other behavior change theories. The most notable of these constructs in health-related theories is the need for competence and self-efficacy (Bandura, 2004), or the perception of having the skills to accomplish goals. Next, the need for autonomy is seen in psychological reactance theory (Brehm and Brehm, 1981; Dillard and Shen, 2005), the perception that a message threatens a person's freedoms drives restoration of freedoms. Likewise, in theories of face/facework (Brown and Levinson, 1978; Lim and Bowers, 1991), autonomy is a basic human need, and a threat to autonomy is likely to interfere with persuasion. Finally, a need for relatedness can be seen in theories concerning normative influence (Azjen, 1988; Lapinski and Rimal, 2005) and social support (Burleson, 2003a; Holmstrom and Burleson, 2011), which note the need to feel connected to some referent other(s) when interpreting messages. Given the similarities to notable theories used in communication campaigns, as well as the relationship between its need constructs and an increased likelihood of enacting and sustaining behavior (Hagger and Chatzisarantis, 2009), SDT appears to be fit for communication campaigns. SDT predicts an individual will intend to use designated bicycle lanes when they perceive their needs for autonomy, competence, and relatedness are satisfied.

1.4. Integration of SNA and SDT

The SNA and SDT appear to focus on separate, but related, components of a decisional process such that SNA addresses only normative perceptions, and SDT addresses only individual cognitive states. Most behavioral theories predict behavioral intention with some

combination of attitude, perceived norms, and perceived behavioral control (Fishbein and Yzer, 2003). With these in mind, a model combining SNA and SDT constructs could predict intention to use bicycle lanes. Prior to examining a combined model of SNA and SDT, an initial study of observational data is needed for formative research purposes. A second study provides an analysis of psychological variables which might predict intention to use bicycle lanes.

2. Study 1 research question

RQ1: *At what frequency do student bicyclists use bicycle lanes at one midwestern university?*

3. Study 1 methods

The first part of this formative research involves collecting observational data on a midwestern university campus to assess the state of bicycling behaviors, including the extent of bicycle lane (mis)use.

3.1. Sample

Study 1 participants were bicyclists on campus observed by research assistants. Research assistants coded only bicyclists who looked young enough to be a student. Research assistants were instructed to use their discretion in determining bicyclists' age such that if any bicyclists appeared to be faculty or staff, these bicyclists were not coded as student bicyclists.

3.2. Materials

Instruments used were paper data collection sheets on which research assistants recorded frequencies of bicyclist use of bicycle lanes/paths and bicyclist use of sidewalks.

3.3. Procedures

Observational data were collected by research assistants over two days at three different high-traffic intersections in late September of 2015. Each day included distinct time slots to account for variable traffic patterns throughout a given day (i.e., morning commute, lunch time commute, or evening commute), resulting in a total of six observational data sets. During each session, research assistants stood at one corner of a respective intersection (i.e., an observation site) and noted the frequency of bicyclists' behavior at the particular observation site. In order to come into contact with the observation site, a bicyclist could bicycle directly adjacent to the observation site, could bicycle straight through the observation site's intersection in the direction of the observation site, or could perform a turn at the observation site's intersection. All of these actions were considered as the bicyclist coming into contact with the observation site. Once a bicyclist came into contact with the observation site, the behaviors recorded were use of bicycle lanes and roadways (according to campus ordinance, students should ride in the roadway when bicycle lanes are not present), and use of sidewalks continuously or briefly. Other recorded items were time of day and weather conditions.

Descriptions of observation sites (see Fig. 1) are as follows: 1) Site 1 is a four-way stop with stop signs at all four entries into the intersection with existing bicycle lanes traveling in all directions, 2) Site 2 is a four-way stop operated by traffic signal with bicycle lanes being installed in the future, and was chosen to observe bicyclists' behavior without a bicycle lane present; and, 3) Site 3 is a four-way stop operated by traffic signal with existing bicycle lanes traveling in three out of four possible directions. Two observational data sets were collected at Site 1 (one lunchtime commute, one evening commute). Two observational data sets were collected at Site 2 (one morning commute, one evening commute). Two observational sets were collected at Site 3 (one lunchtime commute, one evening commute).

4. Study 1 results and discussion

Research question 1 aimed to determine the frequency of student bicycle lane use at the present university. To answer this question, observations are parsed by observation site, and presented in Table 1. At Site 1, where bike lanes are present in all directions, 26.50% of observed bicyclists were recorded riding in the bicycle lane, 72.95% were recorded riding on the sidewalk continuously, and .55% were recorded riding on the sidewalk briefly. At Site 2, where there are no bicycle lanes in any direction, 4.01% of observed bicyclists were recorded riding in the roadway, 95.69% were recorded riding on the sidewalk continuously, and .30% were recorded riding on sidewalks briefly. Finally, at Site 3, where bicycle lanes were present in three of four possible directions, 8.03% of observed bicyclists were recorded riding in the bicycle lane, 91.51% were recorded riding on the sidewalk continuously, and .46% were recorded riding on sidewalks briefly. No bicyclists were recorded riding in the roadway where no bicycle lane was present at Site 3.

Overall, these results demonstrate a widespread lack of bicycle lane usage on the present campus. However, when bicycle lanes are available for use in all possible directions for bicyclists (i.e., Site 1), it appears that bicyclists may tend to utilize bicycle lanes more often than when bicycle lanes are present in only some possible directions, or not present at all, and there is mixed research on which types of factors promote use of bicycle lanes (Duc-Nghiem et al., 2018; Hull and O'Holleran, 2014; Kaplan, 2015; Ransdell et al., 2013).

Nevertheless, the results of Study 1 indicate that intention to use bicycle lanes was an important dependent variable to further investigate when seeking to correct improper bicycle lane use on the university campus under study.

5. Study 2 hypothesis and research question

H1

A combination of SNA (i.e., descriptive norms and injunctive norms) and SDT constructs (autonomy, competence, relatedness) will positively predict student bicyclists' intentions to use bicycle lanes at one midwestern university.

RQ2: Is the intention to use bicycle lanes at one midwestern university better predicted by a SNA, SDT, or both?

6. Study 2 methods

In order to further assess students' perceptions of bicycling on campus and test the proposed hypotheses and remaining research question, a survey was distributed to undergraduate students.

6.1. Sample

Participants (n = 168) had a mean age of 19.52 (SD = 1.34) years, and were predominantly female (58%). Participants largely identified as White/Caucasian (79.9%), followed by Asian-American/Pacific Islander (5.9%), African-American (5.3%), Hispanic/Latino (4.1%), Multiracial (2.4%), and Other (2.4%). The sample consisted of college Freshman (33.7%), Sophomores (20.7%), Juniors (25.4%), and Seniors (20.1%).

6.2. Materials

The instrument used was an online survey created through Qualtrics. The survey was distributed to a convenience sample of undergraduate students participating in a research pool for course credit.

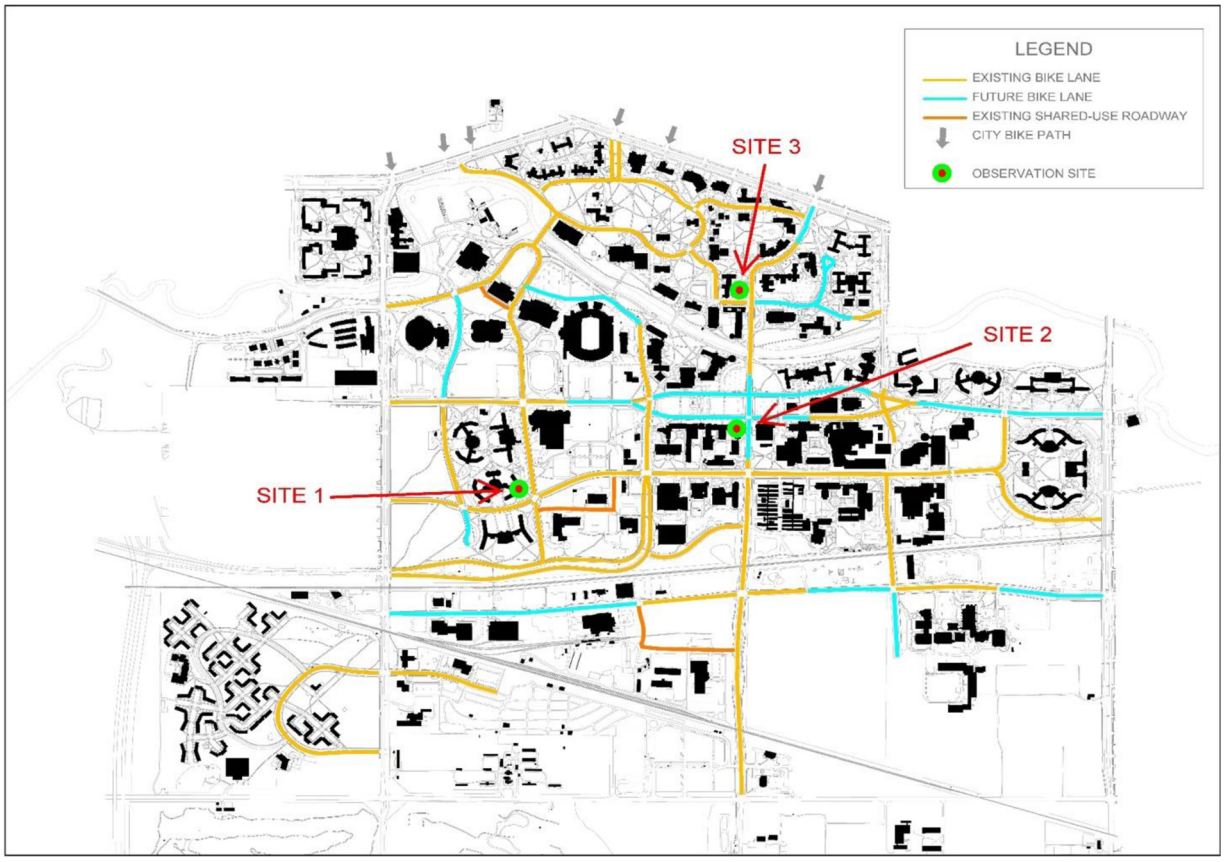

Fig. 1. Campus map with observation sites, bike lanes, and shared-use roadways.

Table 1
Frequency of observed bicycle behaviors for Site 1 (bike lanes only), Site 2 (roadway only), and Site 3 (bike lanes and roadway).

	Site 1	Site 2	Site 3
Riding on Sidewalks Continuously (**n = 2213**)	72.95% (**n = 526**)	95.69% (**n = 1288**)	91.51% (**n = 399**)
Riding on Sidewalks Briefly (**n = 10**)	.55% (**n = 4**)	.30% (**n = 4**)	.46% (**n = 2**)
Riding in Bike Lane (**n = 226**)	26.50% (**n = 191**)	–	8.03% (**n = 35**)
Riding in Roadway (**n = 54**)	–	4.01% (**n = 54**)	0%
Total Observations by Site (N = 2503)	n = 721	n = 1346	n = 436

6.3. Procedures

Data were collected from two separate samples, once in late September 2015 (n = 336), concurrently with Study 1's observations, and once in late October/early November 2015 (n = 334), approximately one month later. Both samples were filtered such that only individuals indicating they had a bicycle on campus, and had only taken the survey once, were included to capture the range of attitudes, behaviors, and perceptions of bicycle safety behavior of actual student bicyclists. Data were then compiled into one dataset using SPSS. Finally, an anomalous number of participants failed to complete the injunctive norm measure, perhaps due to similar wording and appearance of the scale used in the descriptive norm measure. A complete explanation is not available in the present data, and the participants that did not complete the injunctive norm measure (n = 502) were removed from the final sample included for analyses. Thus, the final sample was reduced to 168 participants (n = 168).

6.4. Survey measures

Survey measures included questions regarding participants' transportation behaviors on campus, their bicycle safety behaviors, their knowledge of bicycle safety ordinances on campus, and questions informed by SNA and SDT constructs. Other measures concerned participant intentions to engage in safe bicycling behaviors such as riding in bicycle lanes, as well as their demographic information.

The focus of this research is on SNA and SDT constructs as they relate to intention to use bicycle lanes; thus, only those measures, their reliability coefficients, and their validity assessment are presented.

6.4.1. SNA constructs

Perceptions of descriptive and injunctive norms were assessed with one item each on 0 to 100 sliding scales. These single-item sliding scales have been utilized in studies regarding college drinking (i.e., Glazer et al., 2010; Park et al., 2011) in which respondents rated from 0-100% what percentage of fellow students engage in or approve of a particular behavior. These one-item measures have been used to calculate misperceptions of norms, using self-reported behavior/approval within the respective sample (Park et al., 2011). In addition, they were correlated with psychometric variables like sensation seeking and used as predictors for actual behavior (Glazer et al., 2010). These measures read: "In your estimation, what percentage of University X's students who ride bicycles ride in bike lanes when they are an option?" and "In your estimation, what percentage of University X's students do you think approve of riding in bike lanes?," respectively.

6.4.2. SDT constructs

Autonomy support (α = .82) was measured with five 5-point, Likert-type items (1 = strongly disagree, 5 = strongly agree) adapted from validated scales used in past SDT research (i.e., Williams et al., 1996,

Table 2
Scales, item wordings, and factor loadings.

	Factor Loading
Autonomy Support	.59
1 "I feel University X's campus gives me alternatives to biking on sidewalks."	.71
2 "I do not feel that I have many options when it comes to biking safely on campus."	
3 "I feel that I do not have a choice in where I can ride my bike."	.75
4 "In general, I do not feel that I have any options other than riding	.60
5 my bike on the sidewalk."	.58
6 "When it comes to being safe while biking on campus, I feel I have multiple ways to do so."	.68
Competence Support	.57
1 "How confident are you in your ability to ride exclusively in the bike lanes and on the roadway when bike lanes are not present?"	
2 "How confident are you in your ability to stay safe while riding a bike on campus?"	.67
3 "How confident are you that you know the bike ordinance on University X's campus?"	.58
Relatedness Support	.78
1 "How interested are you in becoming a part of University X's bike culture?"	.71
2 "To what degree do you feel connected to other bicyclists?"	
3 "How interested are you in interacting with bicyclists on University's X's campus?"	**83**
Descriptive Norm	*NA*
1 "In your estimation, what percentage of University X's students who ride bicycles ride in bike lanes when they are an option?"	
Injunctive Norm	*NA*
1 "In your estimation, what percentage of University X's students do you think approve of riding in bike lanes?"	
Intention to Use Bicycle Lane	*NA*
1 "I intend to ride my bicycle exclusively in the bicycle lanes wherever they are an option."	

1998; Williams et al., 2004), including "University X's campus gives me alternatives to biking on sidewalks," and "I do not feel that I have many options when it comes to biking safely on campus" (Ryan et al., 2008). Measures for competence support and relatedness support are less consistent than those for autonomy support and, as such, required the application of measures not previously validated. *Competence support* (α = .70) was measured with three 5-point Likert-type items (1 = not at all confident, 5 = completely confident) that reflected the dimension of competence, which was concerned with confidence or perceived ability regarding the execution of a referent behavior (i.e., using bike lanes) (Standage et al., 2005; Williams et al., 1998, 2004). Past SDT theorizing and related research has demonstrated that competence and self-efficacy (i.e., confidence in one's ability to enact a behavior) conceptually and empirically overlap (Losier and Vallerand, 1994; Martinek and Kipman, 2016; Ryan and Deci, 2000; Sweet et al., 2012). An example measures states, "How confident are you in your ability to ride exclusively in the bike lanes and on the roadway when bike lanes are not present?" (Ryan et al., 2008). While this item represented a double-barreled question (i.e., "bike lanes and on the roadway"), it was used to reflect the campus ordinance specifying that bicyclists are to use the roadway wherever bike lanes are not an option. *Relatedness support* (α = .82) was measured with three 5-point Likert-type items (items 1 and 3: 1 = not at all interested, 5 = very interested; item 2:1 = not at all connected, 5 = very connected) reflecting theorizing that focuses on an, "integration of the individual into a larger social whole" (Deci and Ryan, 2000, p. 253), including "To what degree do you feel connected to other bicyclists?" (Ryan et al., 2008). Full item wording can be found in Table 2.

6.4.3. Validity of theoretical measures

Confirmatory factor analysis was performed to assess the validity of these SDT measures, employing the centroid solution to assess internal consistency and parallelism (Hunter & Gerbing, 1982) in the corCFA function in the lavaan R package. The theoretical measurement model fit the data well according to a number of fit indices. A standardized root-mean square residual (SRMR), measuring the discrepancy between the theoretical model and the sample, of less than or equal to .08 demonstrates acceptable model fit (Hu and Bentler, 1999). Incremental fit indices, like the comparative fit index (CFI), indicate the relative improvement in a model's fit with the data compared to the null model in which there is no covariance among observed variables (Kline, 2016). The closer this value is to 1.0, the better the fit with the data; it is generally acceptable when above .90. Another fit index used to evaluate a model's fit with the data is the root mean square error of approximation (RMSEA), which is a "badness-of-fit" index that is parsimony-adjusted, such that model complexity penalizes the measure. The closer the RMSEA is to 0, the better, and should be at least below .10 (see Kline, 2016). Finally, the model χ^2 tests the null hypothesis of exact or perfect fit such that a nonsignificant test indicates good fit. CFA results found the 3-factor model using SDT items fit the data well, $\chi^2(51) = 103.37$, $p < 0.001$, CFI = .91, RMSEA = .08 90% CI [.06, .10], SRMR = .07.

6.4.4. Behavioral intention

Intention to use bicycle lanes was assessed with one 5-point Likert-type item reading: "I intend to ride my bicycle exclusively in the bicycle lanes wherever they are an option." This one-item measure was chosen to reflect past cross-sectional SDT studies that examined the role of need supports on behavioral intention (i.e., Hagger et al., 2011). Although multiple items to measure an underlying construct are preferred, the purpose of this paper was to test SDT relationships as they have been applied in past research. Further, one-item measures have

Table 3
Correlations, means, standard deviations, and reliability estimates of SDT and SNA constructs and intention to use bicycle lanes.

	M(SD)	1.	2.	3.	4.	5.	6.
1. Autonomy	3.32 (.73)	(α = .82)					
2. Competence	2.28 (.81)	.244*	(α = .70)				
3. Relatedness	1.51 (.70)	.001	.356*	(α = .82)			
4. Descriptive Norm	43.08 (21.32)	.191*	.166*	.166*	–		
5. Injunctive Norm	62.50 (23.96)	.187*	.034	.024	.367*	–	
6. Intention	2.64 (1.21)	.090*	.270*	.269*	.134*	.133*	–

* = $p < .05$.

Table 4
Regressions of intention to use bicycle lanes on social norms approach and self-determination theory constructs for student bicyclists.

	B(SE)	β
Descriptive norm	−.001 (.005)	−.014
Injunctive norm	.016* (.004)	.305*
Autonomy	−.083 (.111)	−.054
Competence	503* (.125)	.299*
Relatedness	.372* (.113)	.299*
Constant	.168 (.432)	–
R^2	.283	
Adj. R^2	.261	
F (df)	12.861* (5, 163)	

*$= p < .05$.

demonstrated reliability across various research settings (Wanous et al., 1997; Zimmerman et al., 2006).

7. Study 2 results

A correlation matrix of relevant variables, with means and standard deviations, can be found in Table 3.

7.1. Hypothesis testing

Hypothesis 1 posited that a combination of SNA (i.e., descriptive norms and injunctive norms) and SDT constructs (autonomy, competence, relatedness) would positively predict intention to use bicycle lanes. To test this, bicycle lane use intention was regressed onto the perception of support for descriptive norms, injunctive norms, autonomy, competence, and relatedness. As shown in Table 4, a significant proportion of the variance in bicycle lane use intention was predicted, $F(5, 163) = 12.86$, $p < .05$, Adj. $R^2 = .26$, supporting Hypothesis 1, with injunctive norms, competence, and relatedness emerging as significant predictors.

7.2. Research question

Research question 2 asked if the intention to use bicycle lanes was better predicted by SNA, SDT, or both. To answer this, individual regression coefficients from Table 4 were inspected. As can be seen, the intention to use bicycle lanes was significantly predicted by injunctive norm perception, $\beta = .31$, $p < .05$, competence support, $\beta = .30$, $p < .05$, and relatedness support, $\beta = .23$, $p < .05$, but not descriptive norm perception, $\beta = -.01$, $p = .81$ nor autonomy support, $\beta = -.05$, $p = .46$. Therefore, constructs from both the SNA and SDT predict behavioral intention, suggesting the combination of the two theoretical frameworks is most appropriate.

8. General discussion

It was discovered that bike lanes were utilized by only a small contingent of student bicyclists, while the majority of student bicyclists rode their bikes on sidewalks. These findings reflect past observational research (Lavetti and McComb, 2014; Silk et al., 2015) showing that one of the most consistent high-risk behaviors while bicycling on university campuses is not using designated bicycle lanes/paths. Therefore, as a dependent variable, intention to use bicycle lanes possesses value when trying to promote bicycle safety on university campuses.

Given the low frequency of bicycle lane use in past research (e.g., Lavetti and McComb, 2014; Silk et al., 2015) and in Study 1, it is worth examining why bike lanes are used so infrequently. Lavetti and McComb (2014) conducted an observational study on a college campus in which they found that 100% of the observed bicyclists violated rules and laws. They then conducted an interview study in attempt to discern reasons for this. While not focusing only on bike lane usage, the most frequent reason offered by 89% of the interviewees for not complying with bicycle use laws was that they did not agree with the rules, or they simply disregarded them.

In addition to this personal focus, there might be various social aspects responsible for determining why individuals choose to use bicycle lanes. In examining the results of Study 2, it is possible that student bicyclists may need to perceive a sense of approval from their peers that using bikes lanes is acceptable (i.e., injunctive norm). They also might need to feel confident in their ability to use bike lanes safely to protect themselves from motorists (i.e., competence) before they are comfortable enough to use them. Additionally, they may need to feel a sense of belonging to the bicycling/greater university community regarding bicycle lane use (i.e., relatedness). Given that Study 2's significant predictors belong to two distinct theories, it could also be that a combination of these constructs is needed to accurately capture students' motivation(s) for using bike lanes, and thus to properly inform a message campaign that aims to increase behavioral intention to use bike lanes.

8.1. Theoretical implications for message development

In this study, individuals' perceptions of how acceptable it is to use bicycle lanes (i.e., the injunctive norm), their competence or confidence with respect to using bike lanes, and their relatedness or connectedness to others while using bike lanes, predicted behavioral intention to do so. According to past research, most cities and countries were not promoting the installation of bicycling infrastructure until approximately 20 years ago (Buehler and Dill, 2016; Pucher et al., 2012). On the same token, an attitudinal and behavioral survey conducted by the NHTSA in the summer of 2002 found that only five percent of trips (n = 2.48 billion trips) taken by bicyclists were in a bike lane, confirming that the presence of bike lanes, and subsequently their use, was relatively new at that time (NHTSA & BTS, 2002). Given the relatively recent installation of bicyclist infrastructure, and that the injunctive norm predicted intention to use bike lanes, it could be that the public perception of bike lane use is not yet fully integrated into transportation-related norms. With the knowledge that injunctive norms may play a role in promoting bicycle lane use, peer approval should be considered in message design.

Comparably, relatedness and injunctive norms somewhat overlap to a degree in that both constructs involve an individual's desire to participate in a socially-approved behavior. By participating in this socially-approved behavior, a sense of relatedness can be fostered. Given that relatedness was also a significant predictor of intention to use bike lanes, it should be evaluated as a construct that could inform message design.

The fact that descriptive norms did not predict the intention to use bicycle lanes is informative. Campaigns using normative appeals require that the promoted norm is at a frequency higher than half of the population, or else the normative appeal will not have the anticipated effects on an individual (see Glazer et al., 2010). Given the observed frequency (*actual* descriptive norm) of bicyclists using the bicycle lane was exceptionally small in Study 1, there is little reason for students to believe the behavior is popular. Additionally, inspection of Table 3 will show that the mean value of descriptive norm perception falls below 51% in Study 2, which indicates that students believe a minority of student bicyclists use campus bicycle lanes on their campus. These two findings demonstrate that if normative appeals are employed on the campus under study, focus should be put on the injunctive norm and not the descriptive norm. However, this formative investigation was conducted on only *one* campus. Past research has demonstrated that descriptive norms have been effective at promoting other healthy behaviors on university campuses (DeJong and Smith, 2013; Glazer et al., 2010). If a similar formative methodolgy like the one utilized here was conducted on another campus, researchers may find the descriptive

norm to be a powerful tool to promote bicycle lane use for their student population if a majority of students engage in the behavior and perceive that others do as well.

The null effect of autonomy support is also instructive, especially given that competence and relatedness were significant predictors of intention to use bike lanes. Most SDT research deems perceptions of autonomy to be the driving force in the internalization process (Ryan et al., 2008), at times focusing only on it. The present null finding might indicate that autonomy support matters much less in this context. The use of campus bicycle lanes might be a behavior that is more "introjected" rather than "internalized" (Deci and Ryan, 2000), meaning that the behavior is not fully a part of one's self-concept. Introjected behaviors are subject only to relatedness- and competence-satisfaction, not autonomy-satisfaction (Deci and Ryan, 2000). This means that desiring to be connected to a group or individual that promotes a behavior like bicycle lane use could be particularly relevant (relatedness) for the campus under study, as could perceiving that one is able to ride in bicycle lanes (competence).

Despite the two null findings presented above, this research demonstrates potential for designing a message strategy combining individuals' perceptions of how fellow students view bicycle lane use (i.e., injunctive norm), along with cues to promote audience members' sense of competence and community (i.e., competence and relatedness), may prove fruitful.

8.2. Applied implications for message development

For Study 2's significant predictors of bicycle lane use (i.e., injunctive norms, competence support, and relatedness support), there are multiple ways in which these constructs could be utilized in message development for increasing intention to use bicycle lanes. One way would be to create three separate message interventions guided by each construct individually. For example, messages that support competence might state, "Using bicycle lanes is the safest way to cycle," or "Vehicles are required by law to yield to bicyclists when no bicycle lane is available." Ultimately, these messages are about making people feel able and competent in performing a behavior, and creating awareness of the tools at their disposal that could promote that sense of confidence or competence (Deci and Ryan, 2012). A message supporting relatedness might read, "Using bicycle lanes keeps all motorists, bicyclists, and pedestrians safe!" This message inspires a sense of connectivity to fellow bicyclists and to other modes of transportation that might have otherwise been perceived as hazardous by bicyclists, as well as trust for the message source (Deci and Ryan, 2012). Finally, an injunctive norm message might state, "Nearly 2/3 of University X's students approve of riding in the bicycle lanes." This message employs an injunctive norm in that greater than 51% of University X's population believes others *should* use bicycle lanes. In creating three separate messages interventions, internal validity would remain strong across the constructs, and measurement of the interventions' effectiveness would be parsimonious. This would also allow for comparisons between the intervention conditions to see which intervention has the strongest effect on bicycle lane behavior.

Another message intervention could combine competence support and relatedness support into one message intervention considering they both stem from SDT. With this combination of messages, measurement of effectiveness could remain relatively parsimonious in that competence support and relatedness support are similar in nature. A final combination includes all three constructs in one message intervention. This combination could be beneficial because competence support and relatedness support (significant components of SDT) attempt to change a person's behavior from within that individual, whereas an injunctive norm (significant component of SNA) tries to alter an individual's behavior by highlighting society's view of an appropriate way to carry out a specific behavior. In this way, developing a message intervention based on the significant constructs of a SNA and SDT has the advantage of enacting an individual's motivations alongside peer opinion of what he or she should do. In this type of combined approach, steps would need to be taken to ensure that all three constructs could be measured independently and effectively.

There are several combinations of significant predictors that might be useful to researchers on a different campus or context when employing the same research methods. For instance, it is possible that descriptive norms and autonomy support could be significant predictors for another campus. A descriptive norms message promoting bicycle lane use could read, "More than 75% of University X's students use bicycle lanes." This message utilizes the necessary majority of a referent population for an effective social norms campaign (i.e., the behavior in question is utilized by more than 51% of the population), and is focused on what students *actually* do (i.e., descriptive norm). Furthermore, an autonomy-supportive message might read, "My campus gives me plenty of options when it comes to using bike lanes safely." Similar to the message strategy recommendations above for the current study, these messages for a different campus could also be used independently of each other in separate interventions, or they could be used together. If used together, these messages could be particularly powerful in that the descriptive norms message highlights that a majority of a student's peers are already using bike lanes, and the autonomy-supportive message indicates that the individual student has many options to use bicycle lanes safely on campus. In having a student feel like there are many options to utilize bike lanes safely, while a majority of their peers are already doing so, has potential for high salience; the student's individual level of perceived control is high due to the many options to utilize bike lanes safely (i.e., autonomy support), and he or she has an already-existing, compelling example of doing so in his or her peer group (i.e., descriptive norm).

These constructs, both significant and non-significant, should be explored in future research in order to effectively design message inductions that will encourage university students to utilize bike lanes.

8.3. Limitations

As discussed above, one limitation of this research is that only one campus is studied. Thus, its location, size, and traffic infrastructure are unique to the campus itself, so the findings are not as generalizable as a study that has the resources to examine traffic dynamics across a larger sample of university campuses, with a range of sizes, locations, and traffic infrastructures. This manuscript does, however, show how other groups could use the same process to develop relevant campaign messages at their home sites.

Additional limitations of this research are the imprecision of age judgment for student bicyclists by research assistants, as well as the lack of data collected on the intentions or perceptions of campus motorists and pedestrians.

9. Conclusion

Formative research is extremely beneficial when studying message development in unique environments like university campuses (Atkin & Freimuth, 2013; Palmer, 1981). Traffic safety researchers on other campuses might consider using the same formative methodology to determine their campus' most unsafe traffic behavior(s), and ascertain which SNA and SDT message inductions could mitigate any negative effects resulting from these behaviors. Future research should strive to implement campaign research to investigate whether the significant predictors of the SNA and SDT frameworks are effective in increasing intention to use bicycle lanes or other identified behaviors, and if those increased intentions lead to behavior change. In addition to further investigating the SNA and SDT frameworks with respect to increasing intention to use bicycle lanes, future research should consider collecting data on the intentions and perceptions of motorists and pedestrians with respect to commuting alongside bicyclists. This could allow future

research to ascertain a more complete understanding of multimodal traffic systems like the one studied here.

Finally, past research has clearly demonstrated that without designated traffic zones that include bicycle lanes, campus traffic will remain crowded and hazardous. Thus, future strategic communication and campaign research is recommended to help facilitate the safe installation of these campus traffic systems.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of competing interest

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

Acknowledgements

There are none to disclose.

References

Atkin, C.K., Freimuth, V., 2013. Guidelines for formative evaluation research in campaign design. In: Rice, R., Atkin, C. (Eds.), Public Communication Campaigns. Sage Publications, Inc, Thousand Oaks, CA, pp. 53–68.

Berkowitz, A.D., 2004. The Social Norms Approach: Theory, Research and Annotated Bibliography. Retrieved from:. http://www.alanberkowitz.com/articles/social_norms.pdf.

Bandura, A., 2004. Health promotion by social cognitive means. Health Educ. Behav. 31, 143–164. https://doi.org/10.1177/1090198104263660.

Berkowitz, A.D., 2005. An overview of the social norms approach. In: Lederman, L.C., Stewart, L.P., Goodhart, F., Laitman, L. (Eds.), Changing the Culture of College Drinking. Hampton Press, Cresskill, NJ, pp. 143–214.

Berkowitz, A.D., Perkins, W.H., 1986. Resident advisers as role models: a comparison of drinking patterns of resident advisers and their peers. J. College Student Personnel 27, 146–153. Retrieved from: http://eric.ed.gov/?id=EJ334056.

Brehm, S.S., Brehm, J.W., 1981. Psychological Reactance: a Theory of Freedom and Control. Academic, New York.

Brown, P., Levinson, S., 1978. Universals in language usage: politeness phenomena. In: Goody, E. (Ed.), Questions and Politeness. Cambridge University Press, Cambridge, UK, pp. 56–310.

Buehler, R., Dill, J., 2016. Bikeway networks: a review of effects on cycling. Transp. Rev. 36, 9–27. https://doi.org/10.1080/01441647.2015.1069908.

Burleson, B.R., 2003a. Emotional support skills. In: Greene, J.O., Burleson, B.R. (Eds.), Handbook of Communication and Social Interaction Skills. Lawrence Erlbaum Associates, Inc, Mahwah, NJ, pp. 551–594.

Cohen, E., 2013. Segregated bike lanes are safest for cyclists. Can. Med. Assoc. J. 185, E443–E444. https://doi.org/10.1503/cmaj.109-4468.

Deci, E.L., Ryan, R.M., 2000. The "what" and "why" of goal pursuits: human needs and the self-determination of behaviour. Psychol. Inq. 11, 227–268. https://doi.org/10.1207/S15327965PLI1104_01.

Deci, E.L., Ryan, R.M., 2012. Self-determination theory. In: Van Lange, P.A.M., Kruglanski, A.W., Higgins, E.T. (Eds.), Handbook of Theories of Social Psychology. Sage Publications, Inc, Thousand Oaks, CA, pp. 416–437.

DeJong, W., Smith, S.W., 2013. Truth in advertising: social norms marketing campaigns to reduce college student drinking. In: Rice, R., Atkin, C. (Eds.), Public Communication Campaigns. Sage Publications, Inc, Thousand Oaks, CA, pp. 177–187.

Dillard, J.P., Shen, L., 2005. On the nature of reactance and its role in persuasive communication. Commun. Monogr. 72, 144–168. https://doi.org/10.1080/03637750500111815.

Duc-Nghiem, N., Hoang-Tung, N., Kojima, A., Kubota, H., 2018. Modeling cyclists' facility choice and its application in bike lane usage forecasting. Accid. Anal. Prev. 42, 86–95. https://doi.org/10.1016/j.iatssr.2017.06.006.

Fishbein, M., Yzer, M., 2003. Using theory to design effective health behavior interventions. Commun. Theory 13, 164–183. https://doi.org/10.1111/j.1468-2885.2003.tb00287.x.

Glazer, E., Smith, S.W., Atkin, C., Hamel, L.M., 2010. The effects of sensation seeking, misperceptions of peer consumption, and believability of social norms messages on alcohol consumption. J. Health Commun. 15, 825–839. https://doi.org/10.1080/10810730.2010.522222.

Grembek, O., Medury, A., Fink, C., Loukaitou-Sideris, A., Shafizadeh, K., Wong, N., Orrick, P., 2014. Crashes on and near college campuses: a comparative analysis of pedestrian and bicyclist safety. J. Am. Plan. Assoc. 80, 198–217. https://doi.org/10.1080/01944363.2014.978354.

Hagger, M.S., Chatzisarantis, N.L., 2009. Integrating the theory of planned behaviour and self-determination theory in health behaviour: a meta-analysis. Br. J. Health Psychol. 14, 275–302. https://doi.org/10.1348/135910708X373959.

Hagger, M.S., Lonsdale, A.J., Hein, V., Koka, A., Lintunen, T., Pasi, H., Lindwall, M., Rudolfsson, L., Chatzisarantis, N.L.D., 2011. Predicting alcohol consumption and binge drinking in company employees: an application of planned behaviour and self-determination theories. Br. J. Health Psychol. 17, 379–407. https://doi.org/10.1111/j.2044-8287.2011.02043.x.

Holmstrom, A.J., Burleson, B.R., 2011. An initial test of a theory of esteem support messages. Communic. Res. 38, 326–355. https://doi.org/10.1177/0093650210376191.

Hu, L.T., Bentler, P.M., 1999. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Struct. Equ. Model. A Multidiscip. J. 6, 1–55. https://doi.org/10.1080/10705519909540118.

Hull, A., O'Holleran, C., 2014. Bicycle infrastructure: can good design encourage cycling? Urban Plann. Transp. Res. 2, 369–406. https://doi.org/10.1080/21650020.2014.955210.

Kaplan, D.H., 2015. Transportation sustainability on a university campus. Int. J. Sustain. High. Educ. 16, 173–186. https://doi.org/10.1108/IJSHE-03-2013-0023.

Kline, R.B., 2016. New York: Guilford. Principles and Practice of Structural Equation Modeling, 4th ed. .

Lapinski, M.K., Rimal, R.N., 2005. An explication of social norms. Commun. Theory 127–147. https://doi.org/10.1111/j.1468-2885.2005.tb00329.x.

Lavetti, E., McComb, S.A., 2014. Examining bicycle safety on a college campus: observations and rationale for unsafe cycling. Hum. Factors Ergon. Soc. 58, 1371–1375. https://doi.org/10.1177/1541931214581286.

Lim, T., Bowers, J.W., 1991. Facework: solidarity, approbation, and tact. Hum. Commun. Res. 17, 415–450. https://doi.org/10.1111/j.1468-2958.1991.tb00239.x.

Losier, G.F., Vallerand, R.J., 1994. The temporal relationship between perceived competence and self-determined motivation. J. Soc. Psychol. 134, 793–801. https://doi.org/10.1080/00224545.1994.9923014.

Loukaitou-Sideris, et al., 2014. Crashes on and near college campuses: a comparative analysis of pedestrian and bicyclist safety. J. Am. Plan. Assoc. 80, 198–217. https://doi.org/10.1080/01944363.2014.978354.

Marshall, W.E., Garrick, W.N., 2011. Evidence on why bike-friendly cities are safer for all road users. Environ. Pract. 13, 16–27 doi: http://dx.doi.org.proxy1.cl.msu.edu/10.1017/S1466046610000566.

Martinek, D., Kipman, U., 2016. Self-determination, self-efficacy and self-regulation in school: a longitudinal intervention study with primary school pupils. Soc. Study 6, 124–133. https://doi.org/10.17265/2159-5526/2016.02.005.

Moller, A., Ryan, R., Deci, E., 2006. Self-determination theory and public policy: improving the quality of consumer decisions without using coercion. J. Public Policy Mark. 25, 104–116. https://doi.org/10.1509/jppm.25.1.104.

Morrison, C.N., Thompson, J., Kondo, M.C., Beck, B., 2019. On-road bicycle lane types, roadway characteristics, and risks for bicycle crashes. Accid. Prev. Anal. 123, 123–131. https://doi.org/10.1016/j.aap.2018.11.017.

National Center for Statistics and Analysis, 2017. Bicyclists and Other Cyclists: 2015 Data. (Traffic Safety Facts. Report No. DOT HS 812 382). Retrieved from:. National Highway Traffic Safety Administration, Washington, DC. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812382.

National Highway Traffic Safety Administration & Bureau of Transportation Statistics, 2002. National Survey of Bicyclist and Pedestrian Attitudes and Behavior. (Report No. DOT HS 810 971). Retrieved from. National Highway Traffic Safety Administration, Washington, DC. https://one.nhtsa.gov/Driving-Safety/Research-&-Evaluation/National-Survey-of-Bicyclist-and-Pedestrian-Attitudes-and-Behavior.

Palmer, E., 1981. Shaping persuasive messages with formative research. In: Rice, R.E., Paisley, W. (Eds.), Public Communication Campaigns. Sage, Beverly Hills, CA, pp. 227–242.

Park, H., Smith, S.W., Klein, K.A., Martell, D., 2011. College students' estimation and accuracy of other students' drinking and believability of advertisements featured in a social norms campaign. J. Health Commun. 16, 504–518. https://doi.org/10.1080/10810730.2010.546481.

Parker, K.M., Rice, J., Gustat, J., Ruley, J., Spriggs, A., Johnson, C., 2013. Effect of bicycle lane infrastructure improvements on ridership in one New Orleans neighborhood. Ann. Behav. Med. 45, 101–107. https://doi.org/10.1007/s12160-012-9440-z.

Pelletier, L.G., Sharp, E., 2008. Persuasive communication and proenvironmental behaviours: How message tailoring and message framing can improve the integration of behaviours through self-determined motivation. Can. Psychol. 49, 210–217. https://doi.org/10.1037/a0012755.

Perkins, H.W., 1997. College student misperceptions of alcohol and other drug norms among peers: exploring causes, consequences, and implication for prevention programs. Designing Alcohol and Other Drug Prevention Programs in Higher Education. Higher Education Center for Alcohol and Other Drug Prevention, Department of Education., Newton, MA, pp. 177–206.

Perkins, H.W., 2002. Social norms and the prevention of alcohol misuse in collegiate contexts. J. Stud. Alcohol 14, 164–172. Retrieved from: https://www.ncbi.nlm.nih.gov/pubmed/12022722.

Pucher, J., Buehler, R., Seinen, M., 2012. Bicycling renaissance in North America? An update and re-appraisal of cycling trends and policies. Transp. Res. Part A Policy Pract. 45, 451–475. https://doi.org/10.1016/j.tra.2011.03.001.

Ransdell, L.B., Mason, S.G., Wuerzer, T., Leung, K.M., 2013. Predictors of cycling in college students. J. Am. Coll. Health 61, 274–284. https://doi.org/10.1080/07448481.2013.799479.

Reynolds, C.C.O., Harris, M.A., Teschke, K., Cripton, P.A., Winters, M., 2009. The impact of transportation infrastructure on bicycling injuries and crashes: a review of the literature. Environ. Health A Glob. Access Sci. Source 8https://doi.org/10.1186/

1476-069X-8-47. 47-47.
Ryan, R.M., Patrick, H., Deci, E.L., Williams, G.C., 2008. Facilitating health behavior change and its maintenance: interventions based on self-determination theory. Eur. Health Psychol. 10, 2–5. Retrieved from: http://sdtheory.s3.amazonaws.com/SDT/documents/2008_RyanPatrickDeciWilliams_EHP.pdf.
Ryan, R.M., Deci, E.L., 2000. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am. Psychol. 55, 68–78 doi: 10.1037110003-066X.55.1.68.
Silk, K., Sheff, S., Totzkay, D., Medina, A., Holzman, G., Potter, T., Holton, R., Ingalls, J., Cox, J., Hoffman, A., Lynch, K., 2015. Super-diffused motivation: synthesizing self-determination theory and super-diffusers to motivate cycling compliance in an on-campus intervention. Poster Presented at the 2015 DC Health Communication Conference in Fairfax, VA.
Standage, M., Duda, J.L., Ntoumanis, N., 2005. A test of self-determination theory in school physical education. Br. J. Educ. Psychol. 75, 411–433. https://doi.org/10.1348/000709904x22359.
Sweet, S.N., Fortier, M.S., Strachan, S.M., Blanchard, C.M., 2012. Testing and integrating self-determination theory and self-efficacy theory in a physical activity context. Can. Psychol. 53, 319–327. Retrieved from: http://selfdeterminationtheory.org/SDT/documents/Testing_and_Integrating_Self-Determination_Theory_and_Self-Efficacy_Theory.pdf.
Teschke, et al., 2012. Route infrastructure and the risk of injuries to bicyclists: a case-crossover study. Am. J. Public Health 102, 2336–2343. https://doi.org/10.2105/AJPH.2012.300762.
Walljasper, J., 2015. The safest streets. Planning 81, 14–16. 18-21. Retrieved from: http://ezproxy.msu.edu.proxy2.cl.msu.edu/login?url=http://search.proquest.com.proxy2.cl.msu.edu/docview/1681933758?accountid=12598.
Wanous, J.P., Reichers, A.E., Hudy, M.J., 1997. Overall job satisfaction: How good are single-item measures? J. Appl. Psychol. 82, 247–252. https://doi.org/10.1037/0021-9010.82.2.247.
Williams, G.C., Grow, V.M., Freedman, Z.R., Ryan, R.M., Deci, E.L., 1996. Motivational predictors of weight loss and weight-loss maintenance. J. Pers. Soc. Psychol. 70, 115–126. Retrieved from: http://selfdeterminationtheory.org/SDT/documents/1996_WilliamsGrowFreeRyanDeci.pdf.
Williams, G.C., Freedman, Z.R., Deci, E.L., 1998. Supporting autonomy to motivate patients with diabetes for glucose control. Diabetes Care 21, 1644–1651. https://doi.org/10.2337/diacare.21.10.1644.
Williams, G.C., McGregor, H.A., Zeldman, A., Freedman, Z.R., Deci, E.L., 2004. Testing a self-determination theory process model for promoting glycemic control through diabetes self-management. Health Psychol. 23, 58–66. https://doi.org/10.1037/0278-6133.23.1.58.
Willis, D., Manaugh, K., El-Geneidy, A., 2013. Cycling under influence: summarizing the influence of attitudes, habits, social environments and perceptions on cycling for transportation. In: Paper Presented at the 92nd Transportation Research Board Annual Meeting. Washington, D.C., USA.