

Article

Cycling for a Sustainable Future. Stimulating Children to Cycle to School via a Synergetic Combination of Informational and Behavioral Interventions

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Abstract: This paper explores how communication interventions can be designed to motivate children to choose more sustainable commuting options (cycling) to go to school. One-hundred and eighty-six children (between 8 and 11 years old) from Flanders, Belgium, participated in an intervention study testing the effectiveness of using informative versus behavioral interventions and the moderating role of motivational messages. The study employed a between-subjects research design with 3 types of interventions (informational versus behavioral versus a combination of informational and behavioral interventions) and 2 types of motivation (autonomous versus controlled motivation). Findings revealed that the average change in the number of times the child indicated to commute by cycling was biggest after being exposed to a combination of informational and behavioral interventions. The type of motivation (autonomous versus controlled) did not have an impact on the average change in the number of times the child indicated to commute by cycling, nor moderated these effects. Additionally, including age and gender as covariates in the model did not alter the results. The study's findings provide more insights in how sustainable commuting can be promoted among children. It shows the benefits of combining informational and behavioral interventions in public awareness programs (such as in schools).

Keywords: sustainable transportation; children's sustainable behavior; persuasive communication; educational campaigns; nudging

1. Introduction

Transport emissions have a major impact on the worldwide climate problem [1,2]. The World Health Organization (WHO) even declared the transportation sector as the fastest growing contributor to climate emissions, as it (among other factors) leads to long-lived carbon dioxide emissions and short-lived black carbon [3]. This affects people's futures, but also their current quality of life, as it has an impact on health (e.g., automated transport decreases a person's physical activity level and it degrades the air-quality due to polluted emissions), safety (e.g., more cars on the road lead to more traffic and accidents), and well-being (e.g., traffic leads to more noise pollution) [1,4]. The WHO calculated that air pollution is even the biggest environmental risk to health, and showed that in 2016, 4.2 million deaths could globally be attributed to ambient air pollution [5]. What is even more worrying is that the 2019 report of The Lancet Countdown on health and climate change states that across the world, children are among the worst affected by climate change [6]. Watts et al. [6] warn that they

are affected during adolescence and beyond by factors such as air pollution, mainly caused by the excessive use of fossil fuels.

Stimulating more sustainable transportation is thus essential, for example, by reducing automated transportation, and stimulating walking or cycling. Rojas-Rueda et al. [7] estimated that—apart from safety advantages due to a reduction in road traffic accidents—shifting cities towards more cycling can lead to significant decreases in deaths from air pollution and annual carbon dioxide emissions [7]. Besides being a transportation method less polluting than car use is, cycling provides many advantages. For example, cycling increases the level of exercise and the activity grade, and also affects the time people spend outdoors. For children specifically, cycling stimulates their level of independent mobility, which is described as children's level of autonomy due to the increase of control and freedom when cycling or walking [8]. Despite these advantages, cars are still more often used as a transportation method to go to school [8,9]. Over the last decades, studies have even reported a decline in children's cycling, and a rise in car use as a means of school commuting [8,10]. Fyhri, Hjorthol, Mackett, Fotel, and Kyttä [8] show that in Denmark, Finland, Great Britain, and Norway, increases in car use go hand in hand with decreases in cycling and walking.

Shifting towards more sustainable transportation methods, such as cycling, is a complex problem, influenced by a large number of factors such as policy and regulations, road safety, social influences, urbanization, transportation access, etc. While some of those factors can be controlled by the individual (such as personal preferences), others are beyond their control (such as policy, regulation, infrastructure). These factors are, for example, recognized in the Ecological Systems Theory of Bronfenbrenner [11,12]. This theory encompasses that human development occurs within a specific context, and is shaped by different types of environmental systems. As such, people's individual behavior is affected by social influences, relationships, cultural context, socio-economic status, etc. Although external factors have an immense impact on people's behavior, research of Heinen et al. [13] suggests that, specifically for cycling, individual factors (such as perceptions, attitudes, and opinions) may have more effects than originally assumed. Heinen, Van Wee, and Maat [13] even suggest that these individual factors should be considered as main contributors to the transportation decision-making process. To that end, this paper explores how interventions that focus on some of these individual factors can have an effect on people's cycling behavior.

We will more specifically focus on children and their parents. Exploring children's transportation methods and the ways in which measures can be taken to steer them is important, especially since children's transportation has an impact on several levels. For example, children are tomorrow's world citizens, so they will be the ones that have to face the consequences of today's transportation choices. Additionally, children's current transportation choices have an impact on their future behavior, as the transportation methods used in childhood correlate with the means of transportation in adulthood [14]. Additionally, creating communication campaigns that reach children directly can even lead to parental behavioral changes. Children's mobility, for example, has a major impact on their parents' traveling behavior [14], and children can also be influential on parents' decisions by asking their parents to let them go by bike.

Since the transportation sector is so polluting, and since sustainable commuting options such as cycling have an impact on the environment via a decreased use of more polluting transportation alternatives (for example, the car), stimulating parents and children to cycle more often when commuting to school is an important challenge. This paper will therefore explore how communication interventions can be designed to motivate children to choose more sustainable commuting options (e.g., cycling) to go to school.

2. Theoretical Background

2.1. Children as a Target Group for Sustainable Transportation Interventions

Research exploring how children's transportation methods can be steered to support the previously described shift to more sustainable transportation is necessary. First of all, because research exploring children's own view about their transportation remains rather limited. Past research mainly focuses on parental views about their child's mobility, or ways in which parents can be stimulated to alter their children's school commuting. This is the case because children's school commuting is often reliant on their caretakers, especially when they go to school by car [14,15]. Therefore, this paper emphasizes interventions that target children directly, as they are the ones whose potential behavior shifts can have a large impact in the short (via their own behavior and their parents' behavior) as well as in the long run (via future behavior).

Second, when exploring research that looks into stimulating cycling among children, children are often encouraged to bike due to health or safety motivations (e.g., speed reducing). What is less often explored, however, is whether children can also be motivated to bike after seeing messages that stress environmental elements.

Third, children of 8–11 years old are a particularly relevant target group to communicate sustainable transportation to, for a number of reasons. Children of 10–11 years old are at an age at which they want more autonomy in several aspects of their lives. Their need for independent and autonomous travel is increasing [14]. If interventions would be able to tap into the behavior of children of 8–11 years, they are able to target children just before or during the time when this striving for more transportation autonomy becomes prominent. If the bike is promoted at that exact time, habits and longer lasting attitudes might be created. Research also suggests that at the age of 6–12 years old, the mean distance from home to school is 4.87 kilometers in Flanders (the part of Belgium where the study in this paper was also conducted). This distance rises to 8.33 kilometers for children of 13–17 years old, a rise that is possibly due to the fact that children in Belgium typically change schools at the age of twelve (going from elementary to secondary education) and that there are less secondary schools, which are often centralized in the bigger cities. Therefore, when one solely looks at the previously described benefits and the distance to school, cycling would be a preferred transportation method for most of these children (making subtraction of individual parameters), possibly outclassing walking, given that the routes are somewhat too long for the average distances. This is in line with previous research that looks into the stimulation of sustainable transportation methods. Festa and Forciniti [16], for example, claim that although the bike is obviously not an adequate mode of transport for all users under all types of circumstances, it does seem to overlap with a lot of contexts, making it a good sustainable transportation method—fit for most purposes and circumstances. It has also become more and more safe to cycle in some areas. For example, Belgium has made enormous progress in actually reducing both serious injuries and road deaths since 2010, for example, by introducing a 30 km/h speed limit in urban areas [17]. In sum, this paper will take this into account and will explore which communication interventions, including sustainable motivations, can be most effective to target children of 8–11 years old to cycle to school.

2.2. Combining Informational and Behavioral Communication Methods

Stimulation of individual behavioral change is needed in order to make the necessary changes towards more sustainable transportation [18]. To do this, governments, non-profit organizations, etc., have been using several mechanisms to stimulate people to adopt more sustainable habits. Education and information transfer is one of these paths. Several recent publications, among which the paper of Grosseck et al. [19], see education as a primordial step in achieving sustainable goals, and a major driver of change towards environmental sustainability, as is described, for example, in the Sustainable Development Goals (SGD4) and the UN Secretary General's Global Education First Initiative 2012–2016 [19–21]. The effect of focusing on knowledge, information, and skill transfer as a

way to alter people's behavior is embedded in various behavioral change theories. Several of these theories see behavior as a consequence of diverse factors, such as perceived benefits and costs of desired and current behavior (e.g., Health Belief Model [22,23], Social Cognitive Theory [24], Health Action Process Approach [25]). Attempts to alter people's behavior should also try to optimize each of these factors (e.g., stress the benefits of the behavior in interventions). Programs in which knowledge is transferred, such as educational programs, reflect these theories, as they can provide people with information and knowledge about a diverse number of factors about the topic [26] and can make the benefits of sustainable food choices more concrete, visible, and feasible [27]. This paper therefore explores if informational interventions with informative content about the benefits of cycling and the environmental impact of automated transport can steer children's behavior towards more cycling.

Although focusing on education, knowledge, information, and skill transfer, has been shown to be an effective strategy, there are also downsides. For example, people often experience an information overload [28], as they are daily confronted with a multitude of information, whereby not all information can be considered. Many messages are therefore quickly considered unimportant. Additionally, informational programs rely on conscious processes, while behavioral change does not always happen consciously and rationally. Recent insights therefore emphasized the importance of unconscious processes in inducing behavior change and explored the impact of direct behavioral stimulation (thereby bypassing knowledge transfer). This latter strategy focusses on behavioral driven-techniques that directly stimulate actions. Techniques residing under this strategy are "nudges", which refer to small changes in the environment that people might automatically and unconsciously react upon to perform a particular behavior, and can be used to trigger children's pro-environmental behavior [29,30]. Hansen [31] argued that nudges operate free from the provision of factual information and rational argumentation. These automatic and unconscious processes inducing behavioral change (like nudging) could have advantages over more conscious interventions like educational programs. Nudges, after all, do not rely on conscious processes, and recent insights emphasized the importance of unconscious processes in inducing behavioral change [28,32]. Accordingly, the behavioral economics viewpoint [32,33] argues that unconscious processes influence economic decisions and that individuals do not always make rational choices, since cognitive biases can direct behavior. Nudges overcome these biases, as they may be very effective at inducing implicit and automatic behavioral-driven, rather than controlled and self-aware, types of decision making [34]. Nudges have been proven to be effective in promoting sustainable behavior, such as promoting energy reduction among adults [35] and sustainable energy use in children [30,36]. A drawback of nudges, however, is that they are less able to build sustainable literacy and food attitudes, which require more deliberate processing.

We can therefore expect that informational interventions and behavioral interventions (such as nudging) are both effective, as they both tap into different processes and contribute to behavior in a different manner. Additionally, we suggest that a combination of informational and behavioral interventions will be most effective in changing children's commuting behavior. This is because the behavioral nudge can induce cycling in a direct way, whereas the informational intervention can provide people arguments for why cycling may be the best option. These arguments can be used by children to convince their parents to change the commuting behavior. We propose following hypothesis:

Hypothesis 1 (H1). *Combining an informational with a behavioral intervention will be most effective in increasing the number of times children commute to school by cycling (compared to an informational or a behavioral intervention alone), whereas an informational intervention and a behavioral intervention will be equally effective.*

2.3. Autonomous Versus Controlled Motivation Messages

Literature shows that some motivational claims have better effects than others if one wants to stimulate a certain desired behavior [37,38]. Self-determination theory (SDT, [37–39]) makes a comprehensive overview of different types of motivations. It is described by Deci and Ryan [39] (p. 416) as "a theory of human motivation and personality in social contexts that differentiates motivation in

terms of being autonomous and controlled". It consists of a spectrum of types of motivation, in which autonomous motivation and controlled motivation are central [40]. Vansteenkiste et al. [41] describe thoughts, feelings, or behaviors stemming from autonomous motivation as self-chosen and reflecting a sense of psychological freedom. It represents choices that are personally relevant [42] and in which people are fully supportive of their own actions [40]. Thoughts, feelings or behaviors stemming from controlled motivation, on the other hand, refer to the idea that people feel as if they have no other option than to conduct the behavior that is presented. The behavior that is imposed is seen as the only option, and the choice to perform that behavior is often made under pressure [42]. It is described as an obligation that is either imposed from outside (external regulation) or comes from within (introjected regulation). This type of motivation is often accompanied by feelings of stress and pressure [41,43], where the provided behavior is then believed to be the way to avoid these feelings.

These types of motivations can also be stimulated by using messages that contain information related to autonomous or controlled motivations. Vansteenkiste, Soenens, Sierens, and Lens [41] and Vansteenkiste, Simons, Lens, Sheldon, and Deci [43] exemplify that controlled motivation is, for example, induced by controlling or forcing language ("you must"; "we expect you to"). On the other hand, autonomous motivation is induced by language that leaves the decision to the person him/herself and encourages the person to make his/her own decisions ("we ask you to . . . ", "you can try to do your best . . . ") [41,43]. In their study on smoking cessation, Cupertino, Berg, Gajewski, Hui, Richter, Catley, and Ellerbeck [42] (p. 640) exemplify this as follows: "I am here to help you make the best decision for yourself. I am going to give you some facts about smoking, and you make the final decision what to do with your smoking".

Messages with autonomous and controlled motivations lead to different outcomes [40]. Autonomous motivation often leads to more health benefits and long-term effectiveness [40]. Several authors, among which, for example, Ryan and Deci [44], argue that stimulating people's sense of autonomous motivation (in contrast with their controlled motivation) by, for example, giving them freedom of choice, allows them to feel more self-direction in their behavior, which can lead to being more intrinsically motivated. This has been shown to be true for children in classroom studies, where teachers who have a more autonomous (versus controlled) style are better able to increase their students' intrinsic motivation, curiosity, and desire for challenge. Including autonomous motivations in persuasive interventions might therefore be more effective at stimulating behavioral change. The following hypothesis is proposed:

Hypothesis 2 (H2). *Messages with autonomous motivations will be most effective in increasing the number of times children commute to school by cycling (compared to controlled motivations).*

Most of the work on autonomous versus controlled motivation explored conscious processing, and sees motivation as being consciously processed and shaped [45]. Methods to induce conscious processing are, for example, the informational and educational ones explained previously. They focus on informational processing, knowledge transfer, etc. However, some research examined how these motivations operate via non-conscious and more automatic processes [40]. These studies include methods that do not rely on thoughtful decision making, but rather rely on priming methodologies, implicit methods, etc. We can consequently expect that motivational claims can be integrated in both informational as well as behavioral campaigns. Although previous studies did include experiments where autonomous and controlled motivations were manipulated [43,46], to the best of the authors' knowledge, no studies opposed these motivations in informational versus behavioral interventions.

When exploring previously mentioned literature on the effects of information transfer, these programs seem to be able to transfer both autonomous as well as controlled motivations. They might even be more suitable to transfer opinions and motivation of why a certain behavior is beneficial—more so than nudges are, since nudges tap into behavioral aspects directly and work rather automatically, reducing its informational impact. As such, we might also argue that children will find nudging interventions with controlled motivational claims more offensive and intrusive than controlled

motivational claims in informational interventions, as the nudging intervention gives no further information about the reason why a certain action must be done or can be worthwhile. Related to this, literature on nudging (which is believed to be a method that relies mainly on unconscious processing) identifies autonomy as one of the baseline aspects of its theory [32,33,47]. Nudges should be voluntarily performed, and the behavior should be seen by the participant as autonomously performed, or the nudge becomes an instruction, which actually defies the essence of nudging theory. Controlled motivational claims in behavioral interventions might perhaps reduce the effectiveness of the campaign, as people feel manipulated to perform the behavior. As such, we propose following hypothesis:

Hypothesis 3 (H3). *The effect of the type of intervention on the increase in number of times children commute to school by cycling will be moderated by the type of motivation endorsed in the intervention (autonomous versus controlled). We will explore if interventions that include a combination of informational and behavioral interventions will always be more effective, and if behavioral interventions will only be equally as effective as informational interventions when autonomous motivations are used in the campaigns, and if they are less effective than informational interventions when controlled motivations are included.*

3. Materials and Methods

3.1. Design

The intervention study had a randomized pretest-post-test design with a two-week follow-up, and was conducted from February to June 2019. The study employed a 3 (Type of intervention: Informational intervention versus behavioral intervention versus combination of informational and behavioral intervention) by 2 (type of motivation: Controlled versus autonomous motivation) research design. Each of the respondents was therefore exposed to one of six interventions (see Table 1).

Table 1. Overview participants per experimental condition.

Type of Intervention	Controlled Motivation	Autonomous Motivation	Total
Informational Intervention	34	32	66
Behavioral Intervention	29	30	59
Combination of Informational and Behavioral Intervention	31	30	61
Total	94	92	186

3.2. Respondents and Consent

The intervention study was done in six elementary schools in Flanders, the Dutch-speaking northern part of Belgium. Five of the six schools were located in smaller sub-parts, and one in the center of a Flemish city. This city was chosen because it is not located in one of the most population-dense areas of Flanders (it had 19,693 inhabitants in 2019). This makes it a good place to stimulate biking. Additionally, a monitoring report of the Flemish Government of 2018 indicates that only 28% of the city's inhabitants think the city has an insufficient number of bike paths (whereas 48% believes the city does have sufficient bike paths and 24% had no opinion), and only 30% of the city's inhabitants think it is unsafe to cycle in the city (whereas 47% believes it is safe and 23% had no opinion) [48].

One-hundred and eighty-eight children originally participated in the study. Two of them were excluded from the analysis because they did not complete the dependent variables adequately (this is further explained in 3.3). As such, 186 children between 8 and 11 years old ($M_{age} = 9$, $SD_{age} = 0.69$) from the third ($N = 73$, 39%) and fourth grade ($N = 113$, 61%) are included in the study. The sample was balanced across gender ($N_{boys} = 90$, 48%; $N_{girls} = 96$, 52%). Children were only allowed to participate if parents explicitly gave their written informed consent. Written parental permissions were obtained by providing parents with a complementary letter in which a description was given of the study, and in which parents were asked not to talk about the study or its topic with their children. This letter was provided to parents via the school communication (children took the letter home in their agenda).

Upon completion of the parental consent, we also presented parents with an additional question assessing the extent to which their child has an impact on the choice to cycle to school and asked them to indicate their age and gender. While all parents gave their consent for the study, 140 of them also answered the additional questions ($M_{age} = 39$, $SD_{age} = 3.99$; $N_{men} = 24$, 17%; $N_{women} = 116$, 83%).

Schools and teachers also consented to the study. Children were informed about the study at both intervention points and were each time told that they were able to drop out at any time and were ensured response anonymity. The study protocol was approved by the Ethics Committee of Ghent University, Faculty of Economics and Business Administration, code number FEB 2020 E.

3.3. Questionnaires

Two paper and pencil questionnaires were collected in two points in time: One questionnaire was completed at the beginning of the study, one questionnaire was collected after two weeks. At the beginning of the study, at time 1, we recorded children's gender, age, bike possession ("do you personally have a bike"), and cycling skills ("I think that I . . . "—"am not good at cycling at all—am not good at cycling—am reasonably good at cycling—am good at cycling—am very good at cycling").

The dependent variable of the study was a measure of children's cycling behavior. In the first questionnaire (T1), children were asked "How do you usually go to school and back home? Think of an ordinary week in autumn, winter and spring. Indicate how many times in such a week you go to school and back and in what way." In the second questionnaire (T2), children were presented with the same question, but this time we added "How do you usually go to school and back home after seeing the video or after participating in the sticker action?". Respondents at both times filled out a grid in which three weeks were presented (one in autumn, winter, and spring). For each week we asked them to indicate how many times of that week they would go by bike. In that way, for each time (T1 and T2), we obtained 6 data points for each child, namely the number of times a child went to school and back home by bike in autumn, winter, and spring. We chose to ask children about a typical week in each of the seasons because this reduces biased results due to specific circumstances that may occur in one specific week (e.g., weather circumstances, illness). A summer week was left out of the phrasing of the question, as children in Belgium have two holiday months in the summer period (July and August), which would result in a biased representation of the measure. The six data points (to school and home in each of three seasons (autumn, winter, spring) were added and divided by 6 to obtain one average score representing the average time in a typical week a child biked to school and home. Finally, a variable was constructed that depicts the change in cycling from before to after the intervention (i.e., the analyzed behavior at $t2$ minus the behavior at $t1$). As such, the average change in the number of times the child indicated to commute by cycling was used as a final dependent variable.

As a control mechanism, we also asked children to indicate how many times they went on foot, by car, and via public transportation (at T1 and at T2, via the same questions as the ones used for cycling). This measure was used to verify if all of the children's transportation methods and days added up (we checked if they indicated to come to school in each season for exactly five times a week by means of any transportation method). The data of one child was excluded, because s/he indicated to come to school on 6 days in the school week, and we therefore cannot know for sure if and how this response was miscalculated. One child did not respond to the transportation questions in the second questionnaire (after the manipulation) and was also excluded from the analysis.

When parents gave their consent, we also asked their gender and age, and additionally asked them to indicate to what extent they agreed with following statement: "My child can decide for him/herself to cycle to school" ("completely disagree—disagree—neither disagree, nor agree—agree—completely agree").

3.4. Stimuli Materials

Informational intervention (Educational Video). To provide children of this age group with educational information that captures their attention and interest for this topic, we opted for short, self-constructed

animation videos. The videos were created with the video construction program "Animaker", and lasted three minutes. The video portrayed a fictional protagonist (Febe) that appears in the clip together with her bike (Appendix A).

Behavioral intervention (Nudge). The behavioral nudging intervention consisted of a reinforcement method to motivate children to use the bike to come to school. Children received a sticker card that was designed to match the lay-out of the informational interventions (also consisting of an animation with the same fictional protagonist (Febe) with her bike). Children received a sticker to put on their card every time they came to school by bike. Because previous literature debated about using incentives in nudging campaigns [31] and to not intrude with the motivational manipulation, we did not associate any reward or incentive with a full sticker card. In that way, rewards or incentives did not affect the results (Appendix B).

Controlled and Autonomous Motivations. Children were exposed to one of two types of motivations, a controlled motivational claim or an autonomous one. These claims were integrated in the intervention the children saw: Either in the informational intervention (Appendix A), in the behavioral intervention (Appendix B), or in both. As such, two videos and two behavioral interventions were made to manipulate the motivational orientation of children.

The videos first explained what the environment is, what environmental pollution is, what its effects are, what the antecedents are, and explored transportation as one of its contributors. To keep possible influencing factors constant as much as possible, the only difference between the videos was the level of motivation, which was manipulated. Both videos lasted approximately 3:20 minutes. The video with the controlled motivational claim showed measures (cycling in particular) that children "must" take to solve these transportation problems (e.g., "we have to use the bike more often"). The video with the autonomous motivational claim stressed what children "can" do to solve these issues (e.g., "we can try to use the bike more often").

The behavioral interventions were also similar, except for a motivational slogan that was added. The controlled motivational nudge made use of a sticker card including the claim "Cycling with Febe: Save the environment together!", which indicates an instruction and an obligational message. The autonomous motivational nudging made use of a sticker card including the claim "Cycling with Febe: Try to think of the environment together!". By using this claim, children were given more free choice to perform the behavior.

3.5. Pretest of the Stimuli Material

Twenty-two children (8–11 years old, $M_{age} = 9$, $SD_{age} = 0.79$) from the third ($N = 12$, 54.5%) and fourth grade ($N = 10$, 45.5%), ($N_{boys} = 13$, 59.1%; $N_{girls} = 9$, 40.9%) participated in a within-subjects experimental design that pretested the motivational claims in the stimuli material. None of the participating children of this pretest participated in the actual study. Each child was exposed to four manipulations and thus saw (1) an informational intervention with controlled motivation, (2) an informational intervention with autonomous motivation, (3) a behavioral intervention with controlled motivation, (4) a behavioral intervention with autonomous motivation. After exposure to an intervention, children completed a one-item measure about the level of autonomous versus controlled motivation of each intervention. This item was self-constructed, based on previous studies of, for example, Pulfrey et al. [49], where one of the elements to assess controlled motivation was to have respondents fill out if they "did the exercise mainly because they had to" and "because they thought it would be useful for them" [49]. To measure the level of induced autonomous versus controlled motivation of each intervention, children indicated to what extent they believed the intervention reflected an obligation (have to do something) versus a choice (can do something) and indicated their answer on a five-point bipolar scale ranging from "have to do" to "can do". As such, higher scores indicate autonomous motivation (can do something), lower scores indicate controlled motivation (have to do something).

Repeated measures ANOVA showed that the manipulation of motivation was successful ($F(3,60) = 49.54$, $p < 0.001$). Follow-up contrasts showed that children believed the informational

intervention with controlled motivation ($M = 2.05$, $SD = 0.67$) stressed autonomous motivation (i.e., can do something) less than the informational intervention with autonomous motivation ($M = 3.95$, $SD = 0.74$) ($F(1,20) = 69.87$, $p < 0.001$) and the behavioral intervention with autonomous motivation ($M = 4.05$, $SD = 0.81$) ($F(1,20) = 64.62$, $p < 0.001$), but as much as the behavioral intervention with controlled motivation (as was expected) ($M = 2.05$, $SD = 0.67$) ($F(1,20) = 0$, $p = 1$). Children also indicated that the informational intervention with autonomous motivation stressed autonomous motivation (i.e., can do something) more than the behavioral intervention with controlled motivation ($F(1,20) = 69.87$, $p < 0.001$), but as much as the behavioral intervention with autonomous motivation ($F(1,20) = 0.28$, $p = 0.61$). The behavioral intervention with controlled motivation was perceived as stressing autonomous motivation (i.e., can do something) less than the behavioral intervention with autonomous motivation ($F(1,20) = 52.5$, $p < 0.001$). The pretest was therefore successful and showed that the messages did in fact stress the claimed types of motivation.

4. Results

4.1. Descriptive Variables

First, we evaluated if the children in our sample owned a bike, and assessed their perceived cycling skills. We found that all but one child owned a bike (99.5%, $N = 185$). Children perceived their cycling skills as very high, as none of them thought they were bad at cycling, only 0.5% indicated that they were not good at cycling, and 6.5% thought of themselves as being only reasonably good at cycling, while 29% said they were good, and 64% that they were very good at cycling. The majority of children (93%) therefore believed their cycling skills were very high.

Second, we assessed how parents evaluated the extent to which their child can decide for him/herself to cycle to school. This question had a mean value of 3.63 ($SD = 1.35$). Since the scale ranged from 1 to 5, it suggests that parents are not completely reluctant to let children make this decision.

4.2. Randomization of Conditions

A control measure tested the randomization across conditions. We first verified if children's cycling behavior before any of the interventions was equal across conditions (this should be the case as we assumed random distribution of the participants to the conditions). A univariate ANOVA analysis showed that the cycling behavior before the interventions did not differ across the type of intervention ($F(2,182) = 0.74$, $p = 0.48$) nor the type of motivation ($F(1,182) = 0.15$, $p = 0.70$). Crosstab analyses showed that there was optimal gender randomization across the manipulation of the type of intervention ($\text{Chi}^2(2) = 3.57$, $p = 0.17$) and the type of motivation ($\text{Chi}^2(1) = 1.07$, $p = 0.30$). However, ANOVA analyses showed that the distribution across age was balanced for the type of motivation ($F(1,182) = 2.52$, $p = 0.11$), but imbalanced over the type of interventions ($F(2,182) = 3.82$, $p = 0.02$). Follow-up planned contrasts showed that children in the nudging intervention were older ($M = 9.27$, $SE = 0.09$) than children in the informational intervention ($M = 8.96$, $SE = 0.08$) ($p = 0.01$) and children in the intervention combining the informational and the behavioral content ($M = 9.00$, $SE = 0.09$) ($p = 0.03$). There was no age difference between children in the informational intervention and children in the intervention combining informational and behavioral elements ($p = 0.71$).

4.3. Hypothesis Testing

We next tested the hypotheses and first verified if the type of intervention (informational versus behavioral versus combination of informational and behavioral intervention) and the type of motivation (autonomous versus controlled motivation) had an effect on the number of times the children indicated to commute by cycling. The average change in the number of times the child indicated to commute by cycling (averaged across the different seasons and the path from home to school and from school back home) was used as a dependent variable. Predictor variables were the type of intervention and the type of motivation. To analyze this effect, an Analysis of Variance (ANOVA) was employed. The assumption

of homogeneity of variance was not supported (Levene's test based on mean $F(5, 180) = 8.44, p < 0.01$) as was the test of normality (Shapiro Wilk informational intervention = 0.49 (66), $p < 0.05$, Shapiro Wilk behavioral intervention = 0.75 (59), $p < 0.05$, Shapiro Wilk combination informational and behavioral intervention = 0.84 (61), $p < 0.05$, Shapiro Wilk controlled motivation = 0.78 (94), $p < 0.05$, Shapiro Wilk autonomous motivation = 0.66 (92), $p < 0.05$). To overcome these potential distribution issues, the ANOVA analyses were followed up by pairwise comparisons using bootstrapping (1000 iterations with Bias Corrected Accelerated Confidence Intervals). This technique is suggested by, for example, Wright et al. [50] as a corrective robustness measure to more accurately estimate standard errors and confidence.

Results indicated a main effect of the type of intervention on the average change in the number of times the child indicated to commute by cycling ($F(2,182) = 15.84, p < 0.001$). Bootstrapped pairwise comparisons revealed that the change was bigger after being exposed to a combination of an informational intervention and a behavioral intervention ($M = 0.65, SE = 0.09$), than after being exposed to an informational intervention alone ($M = 0.13, SE = 0.06$) ($SE = 0.11, p < 0.01$, BCa 95% CI = $[-0.72, -0.29]$) or a behavioral intervention alone ($M = 0.24, SE = 0.05$) ($SE = 0.10, p < 0.01$, BCa 95% CI = $[-0.61, -0.20]$). There was no difference between exposure to an informational intervention alone versus a behavioral intervention alone ($SE = 0.08, p = 0.20$, 95% BCa CI = $[-0.26, 0.05]$).

Results showed that there is no main effect of type of motivation ($F(1,182) = 0.87, p = 0.35$). As such, seeing a message with an autonomous ($M = 0.38, SE = 0.06$) versus a controlled motivational message ($M = 0.30, SE = 0.05$) did not affect the average change in the number of times the child indicated to commute by cycling. There was also no interaction effect between the persuasive messages and the type of motivation ($F(2,180) = 0.11, p = 0.90$) on the average change in the number of times the child indicated to commute by cycling.

Additionally, age, gender, and the extent to which parents believed their child can decide for him/herself to cycle to school were added as covariates to the model, but they did not significantly alter the previously described results (see Appendix C).

5. Discussion and Limitations

Concerns are rising about the use of automated transportation, as it is linked to numerous sustainability threats. Apart from, for example, overall policy changes, investments of industry in more sustainable transportation methods, etc., changes in individual human behavior towards more sustainable transportation methods are necessary. As such, stimulating individuals to cycle more is an important challenge. Cycling seems to be favorable for a number of reasons, as it could, for example, bring about health advantages, but also poses less environmental issues. Although altering children's behavior could have a major impact on the problem at hand (e.g., their commuting behavior has a big impact on their current, as well as their future habits, and on their parent's current behavior), children are rarely regarded as main target groups for interventions trying to alter their transportation behavior. This can be the case because children are usually not the ones that make the main transportation decisions. Mostly, parents are targeted in an effort to change children's behavior. As the literature overview, however, outlines, children do have a big role to play in solving these transportation challenges. This is because of the impact on their current behavior, but also on their future behavior (as they are tomorrow's world citizens) and on their parents' behavior. This study explored which specific types of intervention are promising in reaching children, and explored two techniques. First, the paper studied if nuances in informational interventions versus behavioral interventions had an effect. Second, the paper tapped into motivational differences (autonomous versus controlled motivation) included in communication interventions.

The combined effect of using informational (e.g., educational videos) and more behavioral directed interventions (e.g., nudges) seems to have most merits, since we show that after seeing these types of interventions, children indicated the largest behavior shift in cycling. These findings are important for studies on the effectiveness of persuasive social communication interventions, and merit more

future research. For example, underlying processes should be identified to explain why this combined effect occurs (e.g., exploring if informational interventions heighten topic knowledge and if behavioral interventions facilitate behavior). The results can, for example, provide public policy and school programs with concrete tools to facilitate children's cycling behavior, as the study shows that they should invest in the simultaneous use of educational as well as behavioral materials.

This paper contributes to the stream of research, public policy efforts, and school programs that target children directly for social marketing campaigns and educational programs on sustainable behavior. The paper shows that—although children are not often solely responsible for their mobility choices (since parents have a large impact on these choices)—targeting children directly is effective in changing their current cycling behavior. This is interesting because it highlights that interventions can be successful despite of potential parental overweight on children's choices. Future studies should, however, take into account what role parents play in the change in cycling behavior of their children (for example, in our study: Did they facilitate the behavior, were they already convinced of the behavior, but were children reluctant before the intervention, etc.). Perhaps children are able to talk about these kinds of campaign with their parents and convince them to let them cycle to school more often. Likewise, although parents have a large impact on their children's behavior, the intervention was still effective, so perhaps children also impacted parental decision-making and indirectly affected their parents' vision on the topic. This process, where children impact on parental norms, beliefs, and behavior, is described as reversed socialization in previous research on pro-environmental behavior [51–53]. Future studies could thus explore if children have an educating role towards their parents and if parents even alter their own behavior after communication interventions have targeted their children.

The literature overview also pointed out that children are tomorrow's world citizens, so directing campaigns towards them and altering their behavior not only has an impact now, but also has future perspectives. Our study only worked with a short time lapse between the two moments at which the questionnaires were collected, so we cannot deduce long-term effects of the intervention. However, it does give insights into which interventions are successful and shows merits of campaigns that combine informational and behavioral stimulation. As such, future studies should gain more insights in how behavioral and informational interventions can have an impact on more long-term behavior of children and how these behaviors are capable to last in the future and shift children's transportation methods to a permanent state.

Before concluding, some limitations of the present paper should be noted. First, motivational messages in the interventions did not affect children's cycling. Several reasons can explain this null-effect. The design of the study is the first possible influential factor. Despite the successful pretest, perhaps children did not pay enough attention to the motivational messages, or maybe the difference between the two interventions was insufficient. However, the finding can also mean that motivational messages might simply not be sufficient to alter children's cycling. A second potential constraint of the study lies in the exposure time of the manipulations. Children who received the informational intervention, were only exposed to the intervention once (at the time of the intervention), whereas children who (also) received the nudge, could watch this intervention for a longer period of time. As such, exposure time differed between the manipulations, which might explain part of the effects. Future research could take this duration effect into account. Third, actual behavior was not measured, as children were asked to indicate how often they use a certain transportation method in a particular time frame (autumn, winter, spring) before and after the intervention. Actual behavior might thus be different from the behavior that was reported by children themselves. However, this effect occurs across conditions, so even if this study only captured intentions instead of actual behavior, the differences in effects still stand. Fourth, children might not have a big influence on their own biking behavior, as parents might have the final say. Even though this study asked parents if their child can decide for him/herself to cycle to school and found a mean score of 3.65 on this five-point scale, it is still only a moderate score. Parental input on this decision should thus be considered in future studies. Fifth, this study did not take all contextual factors into account that could explain why children might not be in

the ability to change their behavior. Steg and Vlek [18] argue that there are a lot of contextual factors that may either facilitate or constrain certain types of sustainable behavior (e.g., the quality of the infrastructure). As for cycling, Bagloee et al. [54], for example, showed that safety is one of the most prominent issues keeping people from cycling more often (especially when cycling near motorized traffic). Hume et al. [55] find that knowing people in a neighborhood are important, as well as the presence of traffic lights and pedestrian crossings. Davison et al. [56] report that children bike and walk to school more when the distance to school is shorter, and when it does not interfere with parents' work schedules or children's after-school commitments. Festa and Forciniti [16] showed that people avoid cycling because they cannot ride a bike, do not have a bike, perceived the quality of the bike network as insufficient, or lack bike racks to store their bike. Although we did control for bike use and cycling skills (and found that all but one respondent in our sample owned a bike, and 93% of the respondents claimed to be good bikers), and even though inhabitants of the city where the data was collected positively evaluate the city's biking safety [48], other factors, such as quality of the bike network, safety of the road around the schools, etc., were not taken into account. These kinds of contextual factors might be very important, and could thus explain a large part of the potential behavioral change. It is therefore important to recognize the limitations in terms of generalizability of this study. Future studies could explore these factors more into depth. Sixth, although interventions such as the ones used in this study may influence children and parents in terms of attitudes and behavior, we cannot neglect the external factors that may facilitate or restrict this behavior. For example, as described by Bronfenbrenner [11,12], the macrosystem in which behavior takes place (e.g., cultural values, beliefs), but also the exosystem (e.g., government), can be impactful in shaping children's and parents' cycling intentions and behavior. We also need to recognize the limitations that interventions bring in terms of impact on the climate problem. As such, the power of interventions targeting individuals may also not be overestimated, as these interventions might lead to rather incremental changes. Apart from using these techniques to incite people to cycle, efforts in several system domains will be needed, such as for example policy reinforcing methods (discouraging automated travel for example), but also efforts to improve road safety, the installation of safe and sufficient bike paths, etc.

6. Conclusions

Stimulating children to use the bike more often as a transportation method has important health and environmental benefits. Policy makers, governments, schools, and non-profit organizations are looking for ways to stimulate this behavior via various communication techniques. This paper shows that combinations of informational and behavioral interventions can be successful at stimulating children to cycle more when commuting to school. These types of interventions not only tap into information transfer, but also rely on direct stimulation of the behavior, for example via incentive programs. Finding effective ways to stimulate children towards more sustainable transportation, and overall behavior in general, remains a topic with a high priority. Future research is therefore indispensable, and more insights are needed in how specific communication approaches, such as combinations of educational and behavioral stimulation, can facilitate significant and sustained behavioral changes. More optimal communication and educational techniques that are embedded into educational programs and social marketing interventions of governments and non-profit organizations will be able to deliver important environmental benefits (e.g., more children cycling can contribute to less traffic; leading to less traffic jams and less air pollution). Since social ecological models [11] argue that human development and human behavior is influenced by the entire ecological system of the individual, and since the here discussed interventional methods are dependent on these external factors, results of this paper cannot be generalized to all contexts and circumstances. As such, future studies are needed to reflect on whether and how these types of campaigns are effective when taking these factors into account. Intervention campaigns are likely to only be successful when contextual and external elements facilitate, instead of limit, the individual behavior. Sustainable transportation,

such as cycling, should thus for example be included in policy initiatives, should be integrated in a societal norm and cultural pattern, etc.

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Appendix A. Informational Interventions



Figure A1. Screenshots Video with Controlled Motivation.



Figure A2. Screenshots Video with Autonomous Motivation.

Appendix B. Behavioral Interventions

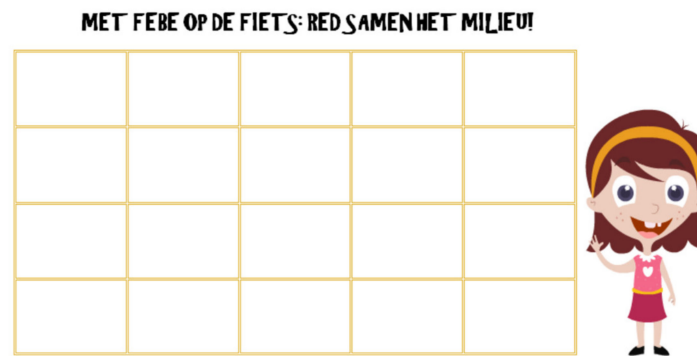


Figure A3. Behavioral Intervention with Controlled Motivation.



Figure A4. Behavioral Intervention with Autonomous Motivation.

Appendix C. Analyses with Age, Gender, and Extent to Which Parents Believe Their Child Can Decide for Him/Herself to Cycle to School Included as Covariates

We first added age and gender to the model as covariates. Results again show a main effect of the type of intervention on the average change in the number of times the child indicated to commute by cycling ($F(2,180) = 15.43, p < 0.001$). Bootstrapped pairwise comparisons revealed that the change is bigger after being exposed to a combination of an informational intervention and a behavioral intervention, than after being exposed to an informational intervention alone ($SE = 0.10, p < 0.01, BCa\ 95\% CI = [0.29, 0.68]$) or a behavioral intervention alone ($SE = 0.10, p < 0.01, BCa\ 95\% CI = [0.23, 0.62]$). There was no difference between exposure to an informational intervention alone and a behavioral intervention alone ($SE = 0.09, p = 0.52, 95\% BCa\ CI = [-0.13, 0.23]$). Results showed that there was no main effect of type of motivation ($F(1,180) = 0.34, p = 0.56$), nor an interaction effect between the persuasive messages and the type of motivation ($F(2,178) = 0.10, p = 0.91$) on the average change in the number of times the child indicated to commute by cycling.

Next, we present the results of the model when adding the extent to which parents believe their child can decide for him/herself to cycle to school as a covariate. This variable was not included in the covariate model described above (including age and gender), because only the respondents for which parents also completed the survey are included here (however, the findings remain similar when adding all three covariates). Results again show a main effect of the type of intervention on the average change in the number of times the child indicated to commute by cycling ($F(2,134) = 11.38, p < 0.001$). Bootstrapped pairwise comparisons revealed that the change is bigger after being exposed to a combination of an informational intervention and a behavioral intervention, than after being exposed to an informational intervention alone ($SE = 0.13, p < 0.01, BCa\ 95\% CI = [0.29, 0.78]$) or a behavioral intervention alone ($SE = 0.13, p < 0.01, BCa\ 95\% CI = [0.18, 0.68]$). There was no difference between exposure to an informational intervention alone and a behavioral intervention alone ($SE = 0.10, p = 0.19,$

95% BCa CI = [−0.33, 0.06]). Results showed that there was no main effect of type of motivation ($F(1,134) = 1.37, p = 0.24$), nor an interaction effect between the persuasive messages and the type of motivation ($F(2,132) = 0.03, p = 0.97$) on the average change in the number of times the child indicated to commute by cycling.

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