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Physical environmental factors that invite older adults to walk for transportation

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ABSTRACT

Knowledge on the physical environmental factors that invite older adults to walk for transportation is limited. The current study aimed to investigate the relationships between environmental factors and invitingness to walk for transportation and the potential moderating effects of gender, functional limitations and current walking for transportation behavior. Sixty older participants evaluated 40 panoramic photographs on their invitingness in two ways: a forced choice (first impressions) and a rating task (more deliberate evaluation). Presence of vegetation, benches, and surveillance significantly positively related to both invitingness-measures. Upkeep and presence of historic elements significantly positively related to the assigned invitingness-ratings. For the forced choice task, significant positive relationships emerged for land use and separation between sidewalk and cycling path, but only in functionally limited participants. Environments offering comfort, safety from crime, and pleasantness may attract older adults to walk for transportation. Experimental and on-site studies are needed to elaborate on current findings.

1. Background

Worldwide the population of older adults (≥65 years) is growing and many of them suffer from one or more chronic diseases (Christensen, Doblhammer, Rau, & Vaupel, 2009; Spirduso, Francis, & MacRae, 2005; U.S. Census Bureau, 2013). These chronic diseases, such as cardiovascular diseases, cancers, and diabetes type 2, are the main causes of older adults' disability and premature death (Murray, Vos, Lozano, AlMazroa, & Memish, 2012). Engagement in 30 min of moderate-to-vigorous physical activity (e.g. brisk walking) on at least five days/week reduces the risk for developing chronic diseases (Chodzko-Zajko et al., 2009). Furthermore, physical activity has been linked to better mental well-being (Windle, Hughes, Linck, Russell, & Woods, 2010), cognitive functioning (Eggermont, Milberg, Lipsitz, Scherder, & Leveille, 2009), and overall quality of life (Balboa-Castillo, Leon-Munoz, Graciani, Rodriguez-Artalejo, & Guallar-Castillon, 2011). Despite this multitude of benefits, older adults are the least physically active age group with 60–70% not reaching the recommended levels of physical activity (Centers for Disease Control and Prevention, 2013; Eurobarometer, 2010; Tafforeau, 2008). Therefore, integrating physical activity into older adults' daily routines is an important goal for maximizing older adults' health and managing health care costs (Leung et al., 2008; Vogel et al., 2009). Walking is an ideal activity to promote in older adults as it is well-liked, has proven

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health benefits, and does not require specific skills or equipment (De Fré, De Martelaer, Philippaerts, Scheerder, & Lefevre, 2009; Manson et al., 2002; Murtagh, Murphy, & Boone-Heinonen, 2010). In particular, stimulating walking for transportation (e.g. walking to a shop or to a friend's home) is promising as this is easy to integrate into an older adult's daily routine.

To stimulate walking for transportation among older adults, we need knowledge of its determinants (Baranowski, Anderson, & Carmack, 1998). Since 2000, research on the determinants of physical activity is guided by a social-ecological framework (Rhodes & Nasuti, 2011). These social-ecological models posit that health behaviors are shaped by a complex interplay between individuals and their surrounding environments (Alfonzo, 2005; Sallis et al., 2006; Stokols, 1996). Studies typically conceptualized the physical environment as the objective and perceived characteristics of the physical context in which people spend their time (e.g. neighborhoods and streets), including aspects of urban design (e.g. residential density), traffic density and speed, distance to and design of venues for physical activity (e.g. parks and public open spaces), crime, and safety (Davison & Lawson, 2006). Physical environmental factors can be organized into four major categories that possibly affect walking choice: accessibility (e.g. distance to destinations, presence of a sidewalk), comfort (e.g. sidewalk evenness, separation from traffic, benches), safety from crime (e.g. surveillance, hiding places), and pleasantness (e.g. vegetation, historic elements, mixed land use) (Alfonzo, 2005).

A social-ecological approach that is especially relevant to older adults' walking for transportation is described in press-competence models. These models emphasize the importance of the match between environmental pressure (or environmental barriers) and the person's competence to overcome this pressure. Hence, it explicitly assumes that when people become more functionally limited and competence decreases, the sensitivity to environmental pressure and barriers increases (Wahl & Lang, 2003). This assumption has received empirical support by some studies reporting stronger environment–physical activity relationships in more, compared to less, functionally limited older adults (Forsyth, Oakes, Lee, & Schmitz, 2009; Rantakokko et al., 2009; Rantakokko et al., 2010). However, this moderating effect was not replicated by others (King et al., 2011). The physical environment cannot only hinder walking for transportation, it can also attract older adults to go outdoors and walk for transportation. This idea forms the core of the theory of "affordances". Affordances are perceptible properties of the environment that have functional significance for an individual (Heft, 2010). For example, Sugiyama, Thompson, and Alves (2009) found that the presence of high quality paths to neighborhood open spaces supported (or afforded) overall walking among British older adults. The importance of possible individual moderating factors is emphasized in this theory by stating that an environmental characteristic will only afford a certain activity if it is of functional significance for the individual (Heft, 2010). This is highlighted in Warren's definition of affordances (Warren, 1984): 'The critical and optimal values of an environmental property, relevant to performing an action are an invariant proportion of some aspect of each actor's body scale'. Hence, whether or not a certain environmental factor will afford walking for transportation depends on the characteristics of the perceiver. For example, the presence of a bench might afford walking for transportation for functionally limited older adults who need the possibility to rest during a walk to their local store. However, this bench might not be a relevant affordance to a fit older adult who does not need to rest during this walk. Relationships between physical environmental factors and walking for transportation might not only be moderated by the presence of functional limitations but also by gender and actual walking for transportation level (Kremers et al., 2006).

Despite the relevance of the topic, knowledge on which physical environmental factors that afford or do not afford walking for transportation among (subgroups of) older adults is limited (Thompson, 2013; Van Cauwenberg et al., 2011). Recent studies have observed positive relationships between older adults' walking for transportation and a walkability-index, a macro-scale environmental characteristic including residential density, street connectivity, land-use mix, and retail floor area (Frank, Kerr, Rosenberg, & King, 2010; King et al., 2011). For example, Frank et al. (2010) reported residents of high-walkable neighborhoods to be twice as likely to walk for transportation compared to residents of low-walkable neighborhoods. Other measures of access to possible walking destinations (e.g. perceived distance to amenities) have also been consistently linked to walking for transportation levels among older adults (Salvador, Reis, & Florindo, 2010; Van Cauwenberg, Clarys, et al., 2012). These findings support the idea proposed by Alfonzo (2005) that accessibility is a basic need that has to be fulfilled in order for older adults to walk for transportation. However, while several qualitative studies highlight the importance of micro-scale environmental characteristics related to the other major environmental categories (i.e. comfort, safety from crime, and pleasantness) (Gallagher et al., 2010; Lees et al., 2007; Lockett, Willis, & Edwards, 2005; Strath, Isaacs, & Greenwald, 2007), results from quantitative studies are inconclusive (Van Cauwenberg et al., 2011). These micro-scale environmental characteristics are more amenable to change compared to access to destinations and are, therefore, particularly relevant for urban planners aiming to promote walking for transportation. Consequently, more research is needed to inform policy makers and urban planners on which specific micro-scale environmental characteristics they should focus, in order to produce environments that invite older adults to walk for transportation.

The inconsistent findings for micro-scale environmental characteristics observed in previous research might relate to several methodological issues. First, previous studies typically examine relationships between physical activity and objective or perceived neighborhood environments. Measuring the objective or perceived neighborhood environment strongly rely upon the operationalization of "the neighborhood". However, until now there is no consensus on how to define an older adult's neighborhood (Brownson, Hoehner, Day, Forsyth, & Sallis, 2009; Spittaels et al., 2009). For example in English adults, the perceived walkable neighborhood area was estimated to be around 400 m (Smith, Gidlow, Davey, & Foster, 2010). One might expect it to be smaller in older adults. However, most of the previous studies used larger radii to define older adults' neighborhoods (Van Cauwenberg et al., 2011). Hence, there might have been a mismatch between the environment and the behavior (i.e. walking for transportation). Second, relationships in previous studies might have been obscured by limited environmental variation (De Vries, 2010). Furthermore, there is the issue of environmental co-variation, the tendency of environmental factors to co-occur, which makes it difficult to tease out the influence of one separate environmental factor (Wells, Ashdown, Davies, Cowett, & Yang, 2007). Third, the assessment of environmental perceptions by questionnaires requires a level of cognitive awareness of perceptions during exposure which respondents may not recall (Carpiano, 2009). These assessments typically involved rating tasks (e.g. rating the quality of a sidewalk on a 5-point scale), which assume that individuals make very rational decisions about where (not) to walk for transportation. However, in real-life situations decisions concerning where (not) to walk for transportation probably involve less rational choices that are guided by first impressions.

While responses to photographs might not completely capture the active process of environmental perception (Heft, 2010), the use of photographs offers the possibility to overcome all of the above described limitations; and studies confirm that responses to color photographs generalize well to on-site response (Nasar, 2008; Stamps, 1999; Stamps, 2010). Furthermore, the current research base of environment–physical activity relationships is limited to cross-sectional studies (Ding & Gebel, 2012) with the exception of some rare natural experiments (Giles-Corti et al., 2013; Ogilvie et al., 2012). Within this research area, experimental studies are very expensive and time-consuming and researchers heavily depend on the cooperation of various actors (i.e. policy makers, urban planners, contractors, etc.). To overcome these issues, Nasar (2008) suggested to experimentally manipulate environmental factors depicted in photographs. This would allow researchers to study cause and effect relationships between environmental factors and environments' invitingness to walk for transportation. It is our aim to conduct such experimental studies in the future. However, while the use of photographs to study environmental preferences is common in the field of environmental psychology, it has not been used yet to study environment–physical activity relationships among older adults.

Therefore, the current study used 40 panoramic (non-manipulated) photographs depicting street environments that varied in 19 environmental factors. We aimed to find out which environmental factors were related to environments' invitingness to walk for transportation among older adults and, hence, which environmental factors are of key interest to manipulate in future experimental studies. In the current study, invitingness to walk for transportation was measured in two ways; a forced choice task and a rating task. Additionally, the moderating effects of gender, functional limitations and current walking behavior on the relationships between the physical environmental factors and invitingness to walk for transportation were investigated.

Since accessibility (i.e. distance to destinations) has an important influence on older adults' choice to walk for transportation, but is difficult to change in existing neighborhoods, we standardized for accessibility in the current study protocol. We hypothesized that environments with higher levels of comfort, safety from crime, and pleasantness would be perceived as more inviting to walk for transportation. Second, based on press-competence models, we hypothesized that these relationships would be stronger for older adults with more compared to less functional limitations. Given the absence of specific theories and comparable previous research, we could not formulate hypotheses for the possible moderating effects of gender and current walking behavior. Similarly, no hypotheses could be formulated for possible differences between the two measures of invitingness (i.e. the forced choice and rating task).

2. Methods

2.1. Participants

Sixty Flemish older adults were recruited by purposeful convenience sampling (targeting an inclusion of 50% women and physically active as well as inactive older adults). Older family members and relatives of the research team were contacted and invited to participate. Snowball sampling was used to recruit additional participants. Inclusion criteria were: being 65 years or older and retired, community dwelling, able to walk independently and reside in an urban (>600 inhabitants/km^2) or semi-urban (300–600 inhabitants/km^2) municipality (Lenders, Lauwers, Vervloet, & Kerselaers, 2005).

Table 1 presents the sample's characteristics. The participants had a mean age of 73 (±5) years and 57% were women. Most participants were married (63%) and held a degree of secondary education (58%) and 47% had held a white collar job. Forty percent of participants reported to be limited in two or more activities of daily living, 68% of the participants met the PA recommendations, and 48% of the participants currently walked for transportation (did any walking for transportation during the last 7 days).

2.2. Protocol

After initial contact and agreement to participate in the study, a researcher visited the participant at home. The researcher explained the protocol and obtained informed consent. The home visit took approximately 1 h and had three parts: a structured interview, a forced choice task, and a rating task. Data collection was performed by trained researchers in March 2012. The study protocol was approved by the ethical committee of the (Brussels and Ghent) university hospital.

2.3. Photographs

For the second and third part of the home visit (a forced choice and rating task, respectively), the study used 40 panoramic photographs [see additional file 1]. They were developed based on results from a previous qualitative study in which researchers accompanied (semi-)urban Flemish older adults during a walk for transportation (Van Cauwenberg, Van Holle, et al., 2012). During these walks the older respondents discussed the encountered environmental factors that influenced their walking for transportation (i.e. walk-along interviews were conducted). For the current study, we took 40 panoramic photographs that displayed the 19 discussed environmental factors while maximizing variation

Table 1
Descriptive characteristics of the participants.

Age (M ± SD)	73.0 ± 5.1	Main occupation (%)	
Female (%)	56.7	-Household	21.7
Born in Belgium (%)	98.3	-Blue collar	31.7
Marital status (%)		-White collar	46.7
-Married	63.3	Functional limitations	
-Widowed	30.0	-N° of functional limitations (M ± SD)	1.6 ± 1.4
-Divorced	5.0	- ≥2 Functional limitations (%)	40.0
-Cohabiting	1.7	Physical activity	
Car ownership (%)	78.3	-Moderate-to-vigorous PA (M ± SD)[a]	362.7 ± 295.3
Education (%)		-Meeting PA recommendations (%)	68.3
-Primary education	16.7	-Walking for transportation (M ± SD)[a]	53.2 ± 119.6
-Secondary education	58.3	Current walking behavior	
-Tertiary education	25.0	-Walkers (%)[b]	48.3

M = Mean; SD= Standard Deviation.
[a] In minutes/week.
[b] % Of participants that reported to have walked for transportation during the last week.

and combinations in these 19 factors. The panoramic photographs were taken from a pedestrian's viewpoint (i.e. from a sidewalk when present) at eye level. To standardize weather conditions, all photographs were taken on dry and lightly clouded days. No other persons were depicted in the photographs.

To define the environmental factors present in the photographed environments, the environments were judged on the 19 environmental characteristics using two questionnaires [see table 2 and additional file 2]. The first questionnaire was used by experts to rate twelve environmental characteristics and the second questionnaire was used by the research team to rate the photographs on an additional seven environmental characteristics that were easier to objectify. These questionnaires were based upon the following existing environmental assessment tools: The Irvine–Minnesota Inventory (Day, Boarnet, Alfonzo, & Forsyth, 2006), SWEAT (Cunningham, Michael, Farquhar, & Lapidus, 2005), SWEAT-R (Michael et al., 2009), SPACES (Pikora et al., 2002), and a questionnaire used by Hanyu (2000). A first questionnaire was used by five experts in the field of PA-environment research to rate the environments on the following twelve environmental characteristics: sidewalk width, sidewalk upkeep, sidewalk evenness, presence of driveways (crossing the sidewalk), safety to cross, surveillance (i.e. residents having a view of the sidewalk from inside their houses), presence of hiding places (i.e. places near the sidewalk where potential offenders can hide), overall upkeep (of street, buildings and gardens), vegetation, openness (i.e. depth and width of view), presence of new elements (e.g. recently built houses, monuments, street pavements) and presence of historic elements. The order of the ratings was randomized across the five experts. The mean or modus (for categorical data) of the five expert ratings was calculated for each environmental characteristic in each environment. A second questionnaire was used by the first and second author (JVC and VVH) to judge the environments on another seven environmental characteristics, which were more easy to objectify: presence of benches, sidewalk type, separation sidewalk-cycling path, obstacles on sidewalk (e.g. parked bicycles), number of traffic lanes, presence of traffic calming devices (e.g. speed bumps), and land use. This separate study resulted in the development of 40 panoramic photographs that are all defined on 19 environmental factors. The current study will use these photographs to examine how these 19 environmental factors relate to the environments' invitingness to walk for transportation using two invitingness measures: a forced choice task and a rating task.

Table 2 describes the environmental characteristics of the panoramic photographs as judged by the experts and the research team. Additionally, their corresponding ICCs presented. All environmental factors showed good to excellent inter-rater reliability (ICC > 0.70), except for "new elements" (moderate reliability, ICC = 0.66).

2.4. Interviews

2.4.1. Structured interview

The structured interview assessed demographics, functional limitations, and physical activity. To measure functional limitations, the study used the physical functioning scale of the validated Short-Form 36-item Health Survey (Haywood, Garratt, & Fitzpatrick, 2005; Ware, Kosinski, & Keller, 1994). It had participants indicate how limited they were by their health in performing ten activities of daily living (e.g. climbing stairs, washing and dressing etc.): severely, somewhat or not limited. Activities in which participants reported to be severely or somewhat limited were summed to create the variable 'number of functional limitations'. This variable was dichotomized around the median (=2 functional limitations, range = 0–9) to create the dummy coded variable 'functional limitations' with the two categories: <2 functional limitations (coded 0) and ≥2 functional limitations (coded 1). To assess engagement in different PA domains and total PA, the International

Table 2
Descriptive characteristics of the photographs and corresponding intraclass correlation coefficients (ICCs).

Comfort		ICCs	Safety from crime		ICCs
Benches (% yes)[a]	10.0				
Sidewalk type (%)[a]			Surveillance (%)		0.94
-No sidewalk	10.0		-No person	20.0	
-Separated from traffic by curb	25.0		-Few persons	42.5	
-Separated from traffic by distance	15.0		-Many persons	37.5	
-Separated from traffic by 1 barrier	45.0		Hiding places (% yes)	52.5	0.73
-Separated from traffic by 2 barriers	5.0		Land use (%)[a]		
Sidewalk width (%)		0.87	-Residential	67.5	
-Small	32.5		-Mixed residential – shops	17.5	
-Medium	50.0		-Other	15.0	
-Wide	17.5		Pleasantness		
Sidewalk upkeep (/5; $M \pm$ SD)	3.3 ± 0.9	0.90	Overall upkeep (/5; $M \pm$ SD)[b]	3.6 ± 0.7	0.92
Sidewalk evenness (/5; $M \pm$ SD)	3.3 ± 1.0	0.82	Vegetation (%)		0.96
Separation sidewalk – cycling path (%)[a]			-No vegetation	55.0	
-No separation	10.0		-Built > vegetation	22.5	
-Separation by markings/color	10.0		-Built = vegetation	20.0	
-Separation by curb	35.0		-Built < vegetation	2.5	
-Separation by distance	7.5		-Predominantly vegetation	0.0	
-Separation by barrier	37.5		Openness (/5; $M \pm$ SD)	2.5 ± 1.0	0.90
Obstacles on sidewalk (% yes)[a]	37.5		New elements (%)		0.66
Presence of driveways (%)		0.87	-No new elements	77.5	
-No driveways	67.5		-Few new elements	22.5	
-25% Of houses	7.5		-Many new elements	0.0	
-50% of houses	10.0		Historic elements (%)		0.89
-Most houses	15.0		-No historic elements	85.0	
N° of traffic lanes ($M \pm$ SD)[a]	2.1 ± 1.0		-Few historic elements	10.0	
Traffic calming devices (% yes)[a]	7.5		-Many historic elements	5.0	
Safety to cross (/5; $M \pm$ SD)	3.0 ± 0.7	0.77			

ICCs = Intraclass correlation coefficients; M = mean; SD = standard deviation.
[a] Environmental factors rated by the research team, consequently no ICCs were calculated for these factors.
[b] Overall upkeep was obtained by calculating the mean of the scores on upkeep of buildings, houses and gardens and upkeep of the street.

Physical Activity Questionnaire (IPAQ, long form, last 7 days, interview version) was adapted (a separate question targeting cycling for recreation was added) and used. The IPAQ has been validated in older adults (Hurtig-Wennlof, Hagstromer, & Olsson, 2010) and has been used in several previous studies in older adults (Berke, Koepsell, Moudon, Hoskins, & Larson, 2007; Bird et al., 2009; Salvador et al., 2010). Weekly minutes of walking for transportation was dichotomized around the median (=0 min/week in past seven days, range = 0–840) to create the dummy coded variable 'current walking behavior' with the two categories: 'non-walkers' (coded 0) and 'walkers' (coded 1).

2.4.2. Forced choice task

During the second part of the home visit, participants performed a forced choice task on a laptop. The forced choice task was developed using the software Inquisit 3 (Millisecond Software). Participants were asked to choose the environment they preferred to walk for transportation out of two photographed environments. To provide the participants with a specific context (Aspinall, 2010) and to standardize for accessibility (i.e. distance to the destination), the following instructions were displayed on the laptop screen and read aloud by the researcher: "Imagine yourself walking to a friend's home located 10 min from your home during daytime. The weather is ideal to walk, it is not too warm, not too cold, there is no wind and it is not raining. You are feeling well and you have no unusual physical problems that hinder your walking. Two photographs of streets will be presented to you, one in the upper part of the screen and another one in the lower part of the screen. It is the purpose that you indicate as fast as possible which street you would choose to walk along. The distance to your friend's home is the same along both streets. When you prefer the upper street you should press 't', when you prefer the lower street you should press 'b'. Try to choose as fast and correct as possible." Participants were asked to respond as fast and accurate as possible in order to obtain a response that was not too cognitively rationalized, but rather reflected their first impression of the environment's invitingness to walk for transportation.

In order to present all possible combinations of paired photographed environments from a total of 40, 780 choices had to be made by the participants. The forced choice task consisted of four blocks. First, a practice block of 10 choices was carried out to familiarize the participants with the task. Then, three test blocks were provided, each consisting of 260 choices. The combinations of two environments were presented in a random order and were randomly presented in the upper and lower part of the screen. Size of the photographs was 34.5 × 7.5 cm with a resolution of 72 dpi. Between the four blocks a pause was provided. Participants decided themselves how long this pause lasted. After the pause the instructions were first repeated and a new block was started.

The frequency that each participant selected each environment was tallied. Then, that tally was divided by the number of times each environment was presented (39) to obtain the proportion of times the participant chose it. This proportion was used as the dependent variable of the forced choice task. While strictly spoken the results obtained from a forced choice task can be interpreted in terms of preference, we used the term 'invitingness' for both the forced choice and the rating task for reasons of consistency and readability.

2.4.3. Rating task

Finally, participants scored the same 40 environments for their invitingness to walk for transportation on an 11-point scale ranging from 0 to 10. They saw each environment separately in random order in Microsoft PowerPoint on a laptop. Similar to the forced choice task, the researcher described the following context: 'Imagine yourself walking to a friend's home located 10 min from your home during daytime. The weather is ideal to walk, it is not too warm, not too cold, there is no wind and it is not raining. You are feeling well and you have no unusual physical problems that hinder your walking. How inviting are the following environments to walk along to your friend's home? This time you don't have to respond as fast as possible, you can look at the photographs quietly and award them a score from 0 (not at all inviting) to 10 (very inviting).' The researcher recorded each reported score. These scores act as the dependent variable for the rating task. A similar scale has been used previously by Wahlgren & Schantz (2012) to assess the invitingness of cycling routes.

2.5. Analyses

Prior to analyzing the relationships between the 19 environmental factors (as judged by the 5 experts and research team) and the two measures of invitingness (derived from participants' forced choice and rating task), inter-rater reliability was assessed. The inter-rater reliability of the environments' ratings on twelve characteristics by the five experts was analyzed by calculating intraclass correlation coefficients (ICCs).

To adjust for the clustering of the dependent variables (proportions and scores) within participants and environments, multilevel cross-classified linear regression models were applied using MLwiN 2.25 (Fielding & Goldstein, 2006). Model parameter estimates were obtained via Markov Chain Monte Carlo (MCMC) procedures applying an orthogonal parameterization (Browne, 2012). The analyses consisted of four consecutive steps performed separately for the two dependent variables. First, the main effects of the environmental factors and first order interaction effects with gender, functional limitations and current walking behavior were analyzed for all 19 environmental factors separately. Second, all main and interaction effects with a $p < 0.10$ in the first step were combined into one model. Third, a model was built including all main and interaction effects that resulted in a $p < 0.10$ during the second step. Lastly, a final model was constructed by allowing random slopes. Models were compared using the Deviance Information Criterion (Browne, 2012). Preliminary analyses showed that occupation and marital status were significantly related to the invitingness-scores derived from the rating task, therefore the final model for this dependent variable adjusted for these two demographic covariates. Significance level was determined at alpha = 0.05.

3. Results

3.1. Results for the forced choice task (proportion)

Table 3 presents the results of the final model for the forced choice task. Within comfort, we observed significant relationships for the presence of benches and separation between sidewalk and cycling path. Participants preferred environments with benches over environments without them, as evidenced by the significant positive relationship for benches. Participants with two or more functional limitations preferred environments where markings/colors separated the sidewalk and cycling path over environments where no separation was present ($B = 0.20$, $p < 0.01$). However, separation between sidewalk and cycling path was not significantly related to invitingness (as assessed by the forced choice task), in other subgroups. Within safety from crime, significant relationships were observed for surveillance and land use. Environments where few and many persons can see the sidewalk from their houses were preferred over environments where no person can see the sidewalk. The difference in invitingness between many and no

Table 3
Final model for the forced choice task (proportion).

	B	S.E.	*p*
Constant	0.13	0.08	
Current walking behavior	−0.03	0.02	0.11
Gender (ref. = male)	0.02	0.01	0.15
Functional limitations	−0.07	0.02	<0.01
Comfort			
Benches (ref. = no)	**0.19**	**0.06**	**<0.001**
Separation sidewalk-cycling path (ref. = no separation)			
-Markings/color	0.06	0.07	0.39
-Curb	0.05	0.05	0.34
-Distance	0.07	0.09	0.41
-Physical barrier	0.05	0.06	0.42
-Markings/color*functional limitations	**0.14**	**0.03**	**<0.001**
-Curb*functional limitations	0.04	0.03	0.16
-Distance*functional limitations	0.04	0.04	0.24
-Physical barrier*functional limitations	0.05	0.03	0.08
Safety from crime			
Surveillance (ref. = no)			
-Few persons	**0.24**	**0.06**	**<0.001**
-Many persons	**0.17**	**0.06**	**<0.001**
-Few persons*Current walking behavior[c]	0.02	0.02	0.28
-Many persons*Current walking behavior	**0.05**	**0.02**	**0.02**
Land use (ref. = residential)			
-Residential & shops	0.05	0.04	0.31
-Other	0.01	0.07	0.92
-Residential & shops*functional limitations[a]	**0.09**	**0.02**	**<0.001**
-Other*functional limitations	0.03	0.02	0.14
Pleasantness			
Vegetation (ref. = no)			
-Built > vegetation	**0.20**	**0.04**	**<0.001**
-Built = vegetation	**0.28**	**0.05**	**<0.001**
-Built < vegetation	**0.30**	**0.07**	**<0.001**
-Built > vegetation*gender[b]	**−0.04**	**0.02**	**0.05**
-Built = vegetation*gender	−0.03	0.02	0.15
-Built < vegetation*gender	−0.03	0.03	0.27
	Var/covar	**S.E.**	
Level: participant			
-Constant/constant	0.0002	0.00006	
Level: photograph			
-Constant/constant	0.0071	0.0023	
Level: measurement			
-Constant/constant	0.0299	0.0009	
% Variance explained	38.21		

Mean response latency was 2434.8 (±170.0) ms.
S.E. = Standard Error.
Bold value signifies $p < 0.05$.
[a] Reference category = ≤ 2 functional limitations.
[b] Reference category = males.
[c] Reference category = no walking for transportation.

persons was significantly greater in walkers compared to non-walkers. There was no significant difference in preference between environments with few and many persons seeing the sidewalk from their houses ($B = 0.07$, $p = 0.08$). Participants with two or more functional limitations preferred environments with residences and shops over environments with an exclusively residential land use, evidenced by the significant relationship for land use in this subgroup ($B = 0.14$, $p < 0.01$). However, no significant relationships were observed between land use and invitingness in participants with less than two 2 functional limitations. Within pleasantness, environments with vegetation were preferred over environments without vegetation. When the environments contained vegetation, there were no significant differences in invitingness between the three categories of vegetation ($p > 0.12$). The difference in invitingness between the category "built > vegetation" and "no vegetation" was significantly smaller in females compared to males. The final model for the forced choice task explained 38.21% of the total variance in proportions.

Eight of the 19 environmental factors were not significantly related to invitingness (as assessed by the forced choice task) to walk in a certain environment: sidewalk width, obstacles on sidewalk, presence of driveways, number of traffic lanes, safety to cross, hiding places, new elements, and historic elements. The following six environmental factors were found to be significantly positively related to choice when analyzed separately, but were not significant in the combined models: sidewalk type, sidewalk upkeep, sidewalk evenness, presence of traffic calming devices, overall upkeep, and openness.

3.2. Results for the rating task (score/10)

Table 4 presents the results of the final model for the rating task. Within comfort, environments where benches were present received significantly higher invitingness-scores. Within safety from crime, environments with surveillance were preferred over environments without surveillance. Environments where few and many persons see the sidewalk from their houses were both associated with significantly higher scores compared to environments where no one sees the sidewalk. There was no significant difference in scores between environments with few and many

Table 4
Final model for the rating task (score/10).

	B	S.E.	*p*
Constant	2.62	0.42	
Occupation (ref. = household)			
-Blue collar	1.04	0.29	<0.01
-White collar	1.13	0.32	<0.01
Gender (ref. = male)	0.58	0.24	0.02
Comfort			
Benches (ref. = no)	**0.90**	**0.31**	**<0.001**
Safety from crime			
Surveillance (ref. = no)			
-Few persons	**1.07**	**0.27**	**<0.001**
-Many persons	**0.72**	**0.29**	**0.01**
Pleasantness			
Overall upkeep	**0.75**	**0.16**	**<0.001**
Vegetation (ref. = no)			
-Built > vegetation	**1.25**	**0.24**	**<0.001**
-Built = vegetation	**1.43**	**0.31**	**<0.001**
-Built < vegetation	**1.64**	**0.37**	**<0.001**
-Built > vegetation*gender[a]	**−0.41**	**0.15**	**0.01**
-Built = vegetation*gender	−0.18	0.18	0.31
-Built < vegetation*gender	−0.12	0.22	0.60
Historic elements (ref. = no)			
-Few	**0.85**	**0.30**	**<0.001**
-Many	**1.09**	**0.47**	**0.02**
	Var/covar	**S.E.**	
Level: participant			
-Constant/constant	0.71	0.15	
-Constant/many persons	−0.12	0.11	
-Many persons/upkeep	−0.10	0.08	
-Many persons/Many persons	0.45	0.13	
-Constant/upkeep	−0.24	0.10	
-Upkeep/upkeep	0.48	0.11	
Level: photograph			
-Constant/constant	0.25	0.08	
Level: measurement			
-Constant/constant	2.12	0.06	
% Variance explained	34.06		

S.E. = Standard Error.
Bold value signifies $p < 0.05$.
[a] Reference category = males.

persons seeing the sidewalk from their houses ($B = -0.35$, $p = 0.16$). Within pleasantness, three environmental factors were significantly related to the invitingness-scores: overall upkeep, vegetation, and historic elements. Environments with better upkeep received higher scores, this appeared from the significant positive relationship between overall upkeep and the awarded invitingness-scores. Environments with vegetation were awarded with significantly higher invitingness-scores compared to the reference category (no vegetation), but mutually the three categories of vegetation did not differ significantly ($p > 0.06$). The difference in scores between the category "built > vegetation" and "no vegetation" was significantly smaller in females compared to males. Environments with few and many historic elements received significantly higher invitingness-scores compared to when no historic elements were present. There was no significant difference in scores between environments with few and many historic elements ($p = 0.64$). The final model of the rating task explained 34.06% of the total variance in invitingness-scores.

Eleven of the 19 environmental factors were not significantly related to the awarded invitingness-scores: land use, sidewalk width, separation sidewalk-cycling path, obstacles on sidewalk, presence of driveways, number of traffic lanes, traffic calming devices, safety to cross, hiding places, openness and new elements. Three environmental factors were found to be significantly positively related to the awarded invitingness-scores when analyzed separately, but were no longer significant in the combined models: sidewalk type, sidewalk upkeep, and sidewalk evenness.

4. Discussion

The current study was the first to use photographs to investigate the relationships between physical environmental factors and invitingness to walk for transportation in older adults. Our results confirmed our primary hypothesis: environments with higher levels of comfort, safety from crime, and pleasantness were perceived as more inviting to walk for transportation. We used a forced choice task to assess the first impression of invitingness and a rating task to assess invitingness to walk for transportation in a more cognitive and deliberate manner. For both measures, we found that streets that offered comfort (through benches), safety from crime (through surveillance), and pleasantness (through vegetation) were preferred to walk for transportation above streets lacking these characteristics.

The importance of benches as opportunities to rest during a walk has been reported in several qualitative studies (Gallagher et al., 2010; de Groot & Fagerstrom, 2011; Stathi et al., 2012). However, this was not yet confirmed by quantitative research (Borst et al., 2009; Van Cauwenberg, Clarys, et al., 2012). Probably, visualizing the benches in the current quantitative study has led to a more accurate assessment of their relationship with an environment's invitingness to walk for transportation. Future studies should reveal if and how the presence of benches can stimulate older adults' walking for transportation. Surveillance by residents through the windows of their houses might influence walking for transportation by affecting feelings of safety. In the current study, the presence of surveillance was associated with a higher invitingness measured both by the forced choice and rating task. This confirms the finding by Borst et al. (2009) who found that the presence of blind walls (low surveillance) was associated with a decreased use of a street for walking for transportation in Dutch older adults. We observed no difference in invitingness between few and many persons having a view of the sidewalk, suggesting that a relatively low degree of surveillance is sufficient to invite older adults to walk for transportation. Similarly, any presence of vegetation was associated with higher levels of invitingness measured by the forced choice as well as rating task compared to when no vegetation was present. The presence of additional vegetation was not associated with a further increase in perceived invitingness. This suggests that the presence of a relatively small amount of vegetation might be sufficient to positively affect older adults' walking for transportation. A general human preference for vegetation and greenery is well documented (van den Berg, Koole, & van der Wulp, 2003; Hur, Nasar, & Chun, 2010; Kaplan & Kaplan, 1989). Furthermore, the importance of vegetation to promote older adults' walking for transportation has emerged in several qualitative studies (Gallagher et al., 2010; Grant, Edwards, Sveistrup, Andrew, & Egan, 2010; Lees et al., 2007; Van Cauwenberg, Van Holle, et al., 2012) and the presence of vegetation has been linked to perceived attractiveness of streets to walk along (Borst, Miedema, de Vries, Graham, & van Dongen, 2008). However, the objectively measured presence of trees was unrelated and the presence of green strips was negatively related to the use of streets for walking for transportation in Dutch older adults (Borst et al., 2009). These findings seem to suggest that older adults prefer to walk in streets with vegetation but in practice other characteristics of "green streets" (e.g. absence of destinations, absence of other people) might negatively affect older adults' walking for transportation levels. Furthermore, it has been shown that certain configurations of greenery evoke a perceived lack of safety by providing hiding places for possible offenders (Herzog & Kutzli, 2002; Jorgensen, Hitchmough, & Calvert, 2002). In the current study only the presence of greenery (e.g. trees, grass, bushes) was assessed and its configuration was not taken into account. However, the presence of hiding places was found to be unrelated to both invitingness-measures.

Generally, the use of a forced choice or a rating task to assess the invitingness to walk for transportation lead to similar results and the explained variances in both measures were comparable (34.06 vs. 38.21%). This suggests that there are no substantial differences between perceived invitingness by first impression and more rational forms of perceived invitingness to walk for transportation. However, some environmental variables were exclusively related to one invitingness-measure. Two environmental variables were related to invitingness as assessed by the forced choice task (but not by the rating task), but only in functionally limited participants. Environments with a mix of residences and shops were preferred over exclusively residential environments. This might suggest that older adults with functional limitations prefer to walk along streets with human activity so that they can be helped in case of a fall or other safety issues. A separation between sidewalk and cycling path by markings or color was also associated with a higher invitingness compared to when a separation was absent in participants with two or more functional limitations. However, it is unclear why higher degrees of separation (i.e. by a curb, distance or physical barrier) were not associated with a higher invitingness. The importance of a clear separation between sidewalk and cycling path has been reported in qualitative studies (Grant et al., 2010; Van Cauwenberg, Van Holle, et al., 2012). Possibly, this is more relevant for older adults with functional limitations as they might feel less capable of avoiding collisions with approaching cyclists and might be more fearful from falling. These findings provide some support for our hypothesis that relationships between environmental factors and invitingness to walk for transportation would be stronger in older adults that are more functionally limited. However, none of the other relationships were moderated by functional limitations. Possibly, environment–physical activity relationships are only moderated when a certain degree of functional disability is reached. Our sample might have been too functionally fit to observe such moderating effects.

In addition to vegetation, two other aesthetic features of the environment were related to invitingness as measured by the rating task (but not by the forced choice task): upkeep and historic elements. Environments with well-maintained streets, gardens and houses received higher invitingness-scores than environments that were less maintained. This is in concordance with previous qualitative research (Gallagher et al., 2010; Grant et al., 2010; Lees et al., 2007) and a study by Borst et al. (2009), who reported a negative relationship between the presence of litter and use of a street for transportation walking. Upkeep might not only influence walking for transportation by making places more aesthetically appealing, but also by influencing feelings of safety (Foster & Giles-Corti, 2008). Higher invitingness-scores were also awarded to environments with historic elements. This supports the findings from our prior qualitative study using walk-along interviews (Van Cauwenberg, Van Holle, et al., 2012). In that qualitative study the presence of new elements was also mentioned as attractive to walk along, however this finding was not replicated in the current study.

Characteristics of walking facilities emerged as important facilitators of walking in previous qualitative studies (Gallagher et al., 2010; Lees et al., 2007; Lockett et al., 2005; Strath et al., 2007; Van Cauwenberg, Van Holle, et al., 2012), whereas findings from quantitative studies are inconsistent (Van Cauwenberg et al., 2011). In the current study, the analyses for the environmental factors separately showed some significant relationships for upkeep and evenness of sidewalks and separation between sidewalk and traffic. However, these factors were not significant after adjusting for other environmental factors. This seems to suggest that characteristics of walking facilities are less important for older adults' walking for transportation compared to other environmental factors (e.g. vegetation, benches…). On the other hand, certain characteristics of the sidewalk (e.g. evenness of the sidewalk) might be difficult to capture in photographs, which might explain the absence of relationships for these characteristics. Similarly, traffic speed is difficult to display in photographs. In this study number of traffic lanes was used as a proxy measure of traffic speed. This measure might not accurately represent traffic speed, which might explain the absence of relationships for this variable. Future studies could use video material to solve this issue.

The current study used a forced choice task to examine which environmental factors are related to invitingness to walk for transportation based upon a first impression of the environment. By asking participants to respond as fast as possible, deliberate as well as automatic (unconscious) processes were possibly involved to make a fast and correct choice. With this study we did not intend to examine truly unconscious processes, but rather wanted to compare a very deliberate form of environmental assessment (the rating task) with a less deliberate form guided by a first impression of the environment (the forced choice task). Future research might go into the involvement of unconscious processes by explicitly analyzing response latencies (e.g. Implicit Association Task) (Eves & Hoppe, 2009; Greenwald, McGhee, & Schwartz, 1998).

Some strengths and weaknesses of the current study should be acknowledged. This was the first study using photographs to investigate the relationships between physical environmental factors and walking for transportation among older adults. Some of the issues responsible for the inconsistent findings in previous studies could be solved by using photographs. First, environmental perceptions are typically assessed using a questionnaire targeting environmental perceptions of the participant's neighborhood. However, there is no consensus on how to define an older adults' neighborhood (Brownson et al., 2009; Spittaels et al., 2009). By presenting photographs, the researcher and participants exactly know which environment is under consideration. Second, as exposure to and assessment of the environments of interest occurs simultaneously, the problem of recall bias is eliminated (Carpiano, 2009). Third, by carefully selecting the photographed environments, problems of limited environmental variation and environmental co-variation could be avoided (Wells et al., 2007). In a next phase, photographs will be manipulated to investigate the causal effects of changes in all possible combinations of environmental factors on invitingness to walk for transportation. The downside of using photographs is that the participants act as passive spectators as opposed to active users of the environment (Heft, 2010). Possibly, certain environmental factors are perceived differently in static photographs as opposed to dynamic real-life situations. For example, the presence of vegetation can be easily detected in photographs whereas other factors are difficult (or impossible) to capture in photographs (i.e. sidewalk evenness, noise, traffic speed, etc.). As argued by Heft (2010), perception is an active process that is influenced by movement through the environment during which our eyes can focus upon changing distances and angles. Therefore, studies using photographs should not stand alone, but should be complemented with studies that gather data in real environments. For example, in a foregoing study we conducted walk-along interviews to collect context-sensitive information on older adults' perceptions and experiences while walking for transportation in their everyday physical environments (Van Cauwenberg, Van Holle, et al., 2012). Future studies might also compare ratings of photographs with ratings of video material or on-site visits to examine the external validity of photographic ratings (Heft & Nasar, 2000). The investigation of possible moderating effects necessary to design targeted and effective interventions is another strength of this study. The present study was limited by the convenience sampling resulting in the inclusion of participants that were more physically active and functionally fitter than the population of Flemish older adults (Tafforeau, 2008). As it is not well understood yet how physical activity level moderates environment-PA relationships (Van Cauwenberg et al., 2011), it is not clear how this might have influenced our results. However, the participants' relatively high level of functional fitness might explain why we observed only a few moderating effects for "functional limitations". Furthermore, the present study did not include rural older adults. Hence, one should be cautious in translating our findings to rural dwelling, less educated, less physically active and less functionally fit older adults. Second, we specifically focused upon walking to a friend's house and the majority (67.5%) of our photographs were of residential streets. Studies focusing upon walking to other destinations (e.g. shops) in various settings are needed to confirm current findings. Furthermore, since the (semi-) urban environmental context differs between countries or continents, findings of the current study may not apply to other regions of the world. Third, in order to eliminate the influence of weather conditions, all photographs were taken on dry and lightly clouded days. Future research should investigate if other results emerge under other weather conditions (e.g. rain, wind etc.).

In conclusion, our findings confirmed the importance of comfort, safety from crime and pleasantness in affecting older adults' walking choices. Environments that offer comfort (through benches), safety from crime (through surveillance), and pleasantness (through vegetation, upkeep, and historic elements) offer properties that may attract older adults to walk for transportation. We observed few moderating effects, which suggest that men and women, functionally fit and functionally limited and those who already walk and those who do not walk for transportation might benefit equally from the same environmental interventions. From a policy and public planning perspective, it was also a promising finding that low degrees of vegetation, surveillance and historic elements already resulted in significant increases in invitingness to walk for transportation. This suggests that relatively simple and cheap environmental modifications can change environments from non-supportive into supportive for walking for transportation among older adults. However, future experimental and on-site studies are needed to elaborate on current findings.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jenvp.2013.12.012.

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