# Does Taking a Walk in Nature Enhance Long-Term Memory?

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In press, *Ecopsychology* [accepted Sept 24, 2015]

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Final publication is available from Mary Ann Liebert, Inc., publishers
http://dx.doi.org/10.1089/eco.2015.0042

**Abstract**

Given recent evidence that contact with nature can enhance cognitive processes, we measured whether students who took a brief on-campus walk in a natural environment showed improved retention of learned materials. Using a within-subjects design, we compared the effects of 10-minute walks in nature, urban, and indoor environments on long-term memory for word lists. Recall and recognition for word lists were tested in the indoor environment either after each walk (Experiment 1) or before each walk (Experiment 2). We failed to find an influence of walk type on either memory test in either experiment. Thus, contact with nature did not enhance students' long-term memory under the conditions we tested. Our results contrast with a recent study in which learners showed better memory for lecture materials learned in a nature-enhanced classroom than in a control classroom. We identify potential explanations for our null findings and suggest future research directions.

*Keywords:* nature; environment; memory; recall; recognition

**Does Taking a Walk in Nature Enhance Long-Term Memory?**

The populations of the United States and Canada living in urban environments have more than doubled since the end of the $19^{th}$ century—and both continue to rise (Iowa Community Indicators Program, 2010; Statistics Canada, 2011). Urban living is associated with a number of negative health outcomes, including increased cancer rates, body mass index, mortality, and depression (Berrigan, Tatalovich, Pickle, Ewing, & Ballard-Barbash, 2014; Ewing, Meakins, Hamidi, & Nelson, 2014; James et al., 2013; Miles, Coutts, & Mohamadi, 2012). If contact with nature reduces the negative impacts of urban environments, then city planners could consider incorporating more natural spaces during development.

From a biopsychosocial perspective, it is also important to consider the psychological outcomes of built environments, given that physical ailments are often linked to psychological processes. For example, obesity has been linked to increased time spent commuting to work as cities grow (Zhang et al., 2014), but it is also linked to psychological factors such as increased stress and mood disorders (Ganley, 1989; Jauch-Chara & Oltmanns, 2014; Moore & Cunningham, 2012; Preiss, Brennan, & Clarke, 2013). Healthcare studies have demonstrated psychological benefits of spending time in natural environments. As examples, geriatric care patients showed improved concentration after resting in an outdoor garden relative to an indoor setting (Ottosson & Grahn, 2005), and women with breast cancer showed improved attention after spending 2 hours per week in a garden (Cimprich & Ronis, 2003).

Even simply being exposed to pictures of natural environments can reduce negative psychological states such as fear arousal, negative affect, and sadness (Ulrich, 1979), and can also increase positive psychological states such as a sense of wellbeing (Ulrich, 1981). Having access to natural outdoor spaces at the workplace can increase positive attitudes towards work and reduce perceived psychological stress levels (Lottrup, Grahn, & Stigsdotter, 2013). Participants who viewed three-dimensional videos of a city street reported a linear improvement in stress recovery as a function of tree canopy density (Jiang, Li, Larsen, & Sullivan, 2014). Patients who viewed pictures of plants in a hospital waiting room showed similarly reduced stress as those exposed to real plants (Beukeboom, Langeveld, & Tanja-Dijkstra, 2012). Recovery from stress, based on physiological measures, is also greater after exposure to videos of natural (vs. urban) environments (Ulrich et al., 1991).

Additionally, there is evidence that contact with natural environments can improve cognitive processes such as attention and working memory, which are used to perform many everyday tasks (e.g., Carriere, Cheyne, & Smilek, 2008; Forde & Humphreys, 2000). Much of this literature has been framed using Attention Restoration Theory (ART; Kaplan, 1995, 2001). This theory proposes that directed attention drains cognitive capacity and thus impairs performance on subsequent tasks. ART further suggests that certain environments allow a more rapid recovery of directed attention—enabling a process of restoration. Restorative environments are distinct from one's typical environment, are extensive enough to maintain this distinctness, are compatible (i.e., enjoyed or preferred), and provoke fascination (i.e., invoking involuntary attention). The theory proposes that natural environments may be more restorative than urban environments because they are more abundant in these criteria, particularly fascination.

Several studies have reported improved cognitive processing after exposure to natural environments, consistent with ART. For example, Berto (2005) found that attentional capacity in a Sustained Attention to Response Test was restored after exposure to restorative pictures (e.g., natural scenes), but not after exposure to non-restorative pictures (e.g., urban areas). Berman, Jonides, and Kaplan (2008) found improved backwards digit span (a measure of working memory performance) following a nature walk, but not following an urban walk, when attention was first depleted. They obtained similar results when participants simply viewed digital images of either nature or urban settings for 10 minutes. A recent meta-analysis by Bowler, Buyung-Ali, Knight, and Pullin (2010) confirmed these attentional benefits of exposure to nature. Strikingly, Atchley, Strayer, and Atchley (2012) reported a 50% improvement on the Remote Associates Test, a measure of creativity, after a youth sample spent several days on a backpacking trip in nature without their electronic devices relative to their baseline performance before the trip.

Central to ART is the idea that attentional capacity must be depleted for spending time in a restorative environment to be restorative. Although this hypothesis has provoked much research, less research has assessed whether spending time in nature benefits cognitive processes when cognitive capacity has not been depleted. One exception is Hartig, Evans, Jamner, Davis, and Gärling (2003), who found an improvement in directed attention after participants walked in a natural area, and a declined after they walked in an urban area, even when directed attention was not first depleted by requiring participants to perform another directed attention task.

Our study aimed to contributed to this area of research by exploring whether students at a typical large, suburban campus would show improved retention of learned materials by taking a walk in a natural environment. This seemed to us to be a reasonable possibility given that memory is influenced both by one's environment (i.e., context; e.g., Smith & Vela, 2001) and one's internal state (i.e., mood; e.g., Eich, 1995). This question also has an applied appeal, given that students would no doubt like to maximize the effectiveness of their study breaks when preparing for a test.

Surprisingly, little research has been done to assess the potential long-term memory benefits of contact with nature. One exception is Holden and Mercer (2014), who tested learners' memory for an archery lesson that took place either in a “nature-infused” classroom with natural light and large windows, a natural scent, and plants, or in an “artificial” classroom lacking these features. Memory for the lesson was tested immediately (in the original learning environment) and 1 week after the lecture (online) via multiple-choice questions (i.e., a recognition memory test). Recognition accuracy was higher for participants who received the lesson in the natural environment. However, this benefit was significant only on the immediate test.

Our study contributed to our understanding of the potential benefits of a nature walk on long-term memory in five ways. First, the effects of a typical on-campus nature walk were compared to two other common on-campus walks: an urban walk and an indoor walk. Second, memory was tested in the same (indoor) environment in all conditions (cf. Holden & Mercer, 2014). Third, we measured long-term memory using both free recall and two-alternative-forced-choice recognition tasks. Free recall requires self-initiated retrieval of items from memory, which in turn requires more attentional resources than recognition (e.g., Craik, 1983). In contrast, forced-choice recognition is a very easy and highly-sensitive memory test; each test trial presents one old item and one new item such that small differences in memory strength for the two items can bias accurate “old” responses. By using both tests we hoped to capture the expected benefits of a nature walk. Fourth, and for the same reason, across Experiments 1 and 2 we varied whether participants took their walks *after* or *before* encoding the study materials. And fifth, our nature and urban walks were intended to be “typical” rather than “pure”. We chose walks of the sort available to students on most large, urban/suburban campuses. Thus the walks were also similar to those accessible to most urbanites from their school, work, or home.

## Experiment 1: Walk After Encoding

### Method

**Participants.** The participants were 24 undergraduates (mean age = 22 years; 20 female) from the University of Calgary (a public university with a student population of 30,000 students in a city of 1.2 million) who participated in exchange for Psychology course credit. They signed up for a 1.5 hour study called "The effects of environment type on memory" which was described as requiring three walks on and around campus, each followed by a test of memory for a different word list.

**Walks.** Each participant completed three 10-minute walks on the University of Calgary campus (see Figure 1). Each walk began and ended in the lobby of the modern, open-concept EEEL Building. The walks were completed in one of 6 counterbalanced orders (4 participants per order). They took place weekday mornings or afternoons in September and October 2014 under typical weather conditions (-5°C to 21°C). The *nature walk* led participants through a number of stands of trees, bushes, and grassy areas along a relatively quiet asphalt path on campus. In contrast, the *urban walk* led participants on a concrete sidewalk along a busy four-lane road, which they followed off campus toward a shopping mall on the other side of a bridge that crosses the Alberta 1A highway. The *indoor walk* led participants through hallways on three floors of the EEEL building and did not provide much exposure to natural or urban outdoor elements (see Tennessen & Cimprich, 1995). The length of each route was approximately 0.5 km, although walk distance depended on the participant's pace.

**Word lists.** A pool of 180 common words (mostly nouns; all 5 letters in length) was randomly assigned to 3 sets of 60 words (Appendix A). Each set was then subdivided into 2 subsets of 30 words. Sets were randomly assigned to walks, and the subset serving as the studied list versus distractor list on the recognition test was counterbalanced across participants.

**Procedure.** The first author tested participants individually. They were greeted in the EEEL building lobby and provided a brief reminder and overview of the study. Specifically, they were told that for each of three walks they would study a word list, do some math problems, go for a 10-minute walk, return to the lobby, have their memory for the word list tested, and rate their mood. Participants put their cell phones on airplane mode and were asked to avoid distracting activities during the walks including eating or drinking, listening to music, texting, making calls, or talking to others. They then began the first of three study-walk-test phases, each of which was identical except for the study and test lists used and the walk taken. To begin each phase, a 30-word list was presented one word at a time in 44-point Calibri font using PowerPoint on a laptop. Words were displayed for 2 s each with a 1 s blank screen between words. No specific encoding instructions were provided. After the list, participants did addition problems for 1 minute to clear working memory. A map of the walking route was then reviewed briefly and given to participants. Most participants reported consulting the map at least once, but none reported having trouble following the routes. Participants were asked to head back after 5 minutes, so that each walk lasted about 10 minutes.

After participants returned to the lobby their memory for the word list was tested. For the *free recall* test they were given 2 minutes to write down as many of the words as they could from the current study list on a sheet of paper. The *forced-choice recognition* test was then presented on the laptop using PowerPoint. On each of 30 trials, a pair of words (one studied, one new; left-right order randomized) appeared on the screen and participants indicated verbally whether the left or right word had been studied. The trials were presented in the same randomized order for all participants. The experimenter recorded responses on a sheet of paper. Free recall always preceded the recognition task, as is typical in memory research, to prevent contamination of free recall by a second exposure to each word during the recognition task. Although Berman et al. (2008) did not find that contact with nature influenced mood, mood was assessed as an outcome measure via self report on an 11-point scale (-5 = very negative, 0 = neutral, +5 = very positive).

After the three phases were complete, a questionnaire was administered to allow participants to indicate any issues with their data (e.g., distractions, issues with the walks), and to determine whether they referred to the route maps. Finally, they were also asked to indicate which walk was: (1) most enjoyable, (2) most beautiful, and (3) least distracting.

**Results**

An alpha level of .05 was used to determine significance. Appendix B provides the means by walk order. Walk order did not influence percent recall, percent correct recognition, or mood ratings in preliminary analyses, and thus it was not included as a factor in the reported analyses. One-way ANOVAs on the means provided in Figure 2 did not yield a significant difference in memory for the word lists across the nature, urban, and indoor walks either for recall, $F(2, 46) = 0.57$, $MSE = 7.32$, $p = .57$, or recognition, $F(2, 46) = 0.75$, $MSE = 168.91$, $p = .48$. Bayesian estimates of the probability that a null model (i.e., one assuming no effect of walk type) was preferred over a model assuming an effect of walk type were conducted for each memory test (Masson, 2011). The probability that the null model was preferred ($p_{BIC}$) was 95% for recall and 94% for recognition. Thus, there was strong support for the null model given the obtained data. Consistent with Berman et al. (2008), mood ratings also did not differ following the nature, urban, and indoor walks, $F(2, 46) = 0.01$, $MSE = 1.70$, $p = .99$.

Previous research has found that environmental preferences and belief in restorative ability can influence cognitive benefits (van den Berg, Hartig, & Staats, 2007; van den Berg, Koole, & van der Wulp, 2003). Therefore, we examined whether participants who preferred the nature walk showed improved memory following the nature walk. The 21 participants who answered the “beauty” and “enjoyable” questions were divided into two subgroups: those who chose the nature walk as both most beautiful and enjoyable (*nature subgroup*; n = 11) and those who did not choose the nature walk for both questions (*other subgroup*; n = 10). Memory following the nature walk was compared across subgroups. Recall was similar for the nature and other subgroups (26% vs. 30%), $F(1, 19) = 0.66$, $MSE = 122.27$, $p = .43$, as was recognition (87% vs. 87%), $F(1, 19) = 0.38$, $MSE = 8.86$, $p = .85$.

## Experiment 2: Walk Before Encoding

Experiment 1 did not reveal a memory advantage for taking a nature walk over either an urban or indoor walk, on either recall or recognition, even among students who preferred the nature walk. Experiment 2 provided a second test of whether taking a nature walk can benefit memory. Experiment 2 was identical to Experiment 1, except participants took each walk before encoding each word list. This change eliminated the potential for differential rehearsal of the lists across walk types, which could have mitigated an influence of walk type in Experiment 1. Moreover, to the extent that contact with nature can enhance attentional resources, taking a nature walk before encoding might enhance attention to the study list, and hence enhance its encoding (e.g., Craik, Govoni, Naveh-Benjamin, & Anderson, 1996). If so, benefits of a nature walk on memory might emerge in Experiment 2 despite their absence in Experiment 1.

### Method

The participants were 24 undergraduates (mean age = 22 years; 19 female) who did not participate in Experiment 1. The method was identical to Experiment 1 except participants went on each walk before studying each word list (i.e., a walk-study-test design was used).

### Results

As shown in Figure 2, Experiment 2 also yielded null results. Walk order (see Appendix B for the means) again had no significant effect on percent recall, percent correct recognition, or mood ratings in preliminary analyses, and was thus not included as a factor. There was no significant difference between the nature, urban, or indoor walks on recall, $F(2, 46) = 0.17$, $MSE = 168.30$, $p = .48$, recognition, $F(2, 46) = 1.46$, $MSE = 77.97$, $p = .24$, or mood, $F(2, 46) = 0.63$, $MSE = 85.67$, $p = .54$. The Bayesian estimates again showed strong support for the null model given the obtained data, both for recall ($p_{BIC} = 0.98$) and recognition ($p_{BIC} = 0.97$). As in Experiment 1, the nature subgroup (n = 12) did not perform better than the other subgroup (n = 11) after the nature walk either for recall (26% vs. 30%), $F(1, 19) = 0.66$, $MSE = 122.27$, $p = .43$, or for recognition (87% vs. 87%), $F(1, 19) = 0.38$, $MSE = 8.86$, $p = .85$. In summary, Experiment 2 also failed to find evidence that a nature walk benefitted long-term memory for word lists.

## General Discussion

We assessed whether taking a brief walk in a natural environment of the type easily available in many urban/suburban settings would improve retention of learned materials. There was reason to entertain this possibility, given that other cognitive processes such as attention can be enhanced by contact with nature (e.g., Berman et al., 2008; Berto, 2005; Hartig et al., 2003), and given that attention facilitates encoding and memory (e.g., Craik et al., 1996). Participants encoded a different word list either after (Experiment 1) or before (Experiment 2) taking a nature, urban, or indoor walk. No differences in free recall, forced-choice recognition, or mood ratings were found as a function of walk type in either experiment. Bayesian analyses confirmed strong support for a null effect of walk type given the obtained data, indicating that our null effects were not likely due to an insufficient sample size.

Contrary to our null findings, Holden and Mercer (2014) reported improved memory for materials from an archery lesson received in a nature-enhanced (vs. control) classroom. Before noting the potential limitations of our study, it is important to note that the two classrooms used in their study differed in many ways other than “nature-enhancement” including size, location, furnishings (moveable vs. fixed seating), windows (and hence ambient lighting), and the infusion of a scent (see their Figure 1). Thus, it is possible that such differences, as well as other limitations noted by the researchers, were responsible for the memory effect they obtained.

Alternatively, our null effects could have been due to limitations in our study. To begin, our nature and urban walks may not have been pure or long enough to elicit a nature benefit. Indeed, these walks were adjacent and overlapping, and began and ended in the same building where the indoor walk and memory tests occurred. The nature walk, though typical of a campus setting, may have been too contaminated by urban factors (e.g., traffic sounds, views of roads and buildings), and vice versa for the urban walk (e.g., views of grass, trees, hills), for a difference to emerge. Second, our materials (word lists) and/or memory tests (free recall, recognition) may not have been ideal for revealing benefits of a nature walk on memory. Materials of more relevance to students, or use of another type of memory test (e.g., an implicit memory test such as word-stem completion) might reveal benefits. Third, our repeated-measures design confounded walk order with test practice. Although walk order was counterbalanced and did not yield systematic effects, carryover and practice effects likely increased error variance. Effect sizes for the effects of nature contact can be small, at least when a cognitively taxing manipulation is not used (Hartig et al., 2003). Thus, use of a between-group design and/or separate testing sessions (e.g., Berman et al., 2008) may be preferable. Fourth, our participants may not have exerted enough cognitive effort at encoding or retrieval to invoke sufficient demands on executive attention. Berman et al. (2008) found nature benefits only when the central executive was taxed. Future studies should examine whether depleting attentional resources reveals restorative effects of contact with nature on long-term memory.

In conclusion, despite evidence of beneficial effects of natural environments on cognitive processes such as attention (e.g., Berman et al., 2008), it is not yet clear whether exposure to natural environments can enhance long-term memory. Holden and Mercer (2014) succeeded in obtaining such evidence, whereas we did not—but both reports acknowledge several potential limitations. To the extent that further research demonstrates that cognitive processes including memory are improved by spending time in nature, architectural design and urban planning might be able to capitalize on such findings to potentially improve people's wellbeing and productivity.

**Acknowledgements**

The Natural Sciences and Engineering Research Council of Canada supported this research through Discovery Grant RGPIN-2015-04131 to the second author.

**Authors Disclosure Statement**

Both authors declare that they have no competing financial interests.

**Figure Captions**

*Figure 1.* Top: Google Earth image overlaid with the nature (blue) and urban (red) walks. Both walks began and ended in the building where the indoor walk and testing took place. Bottom (clockwise from top left): nature walk, urban walk, indoor walk, test location (taken July, 2015).

*Figure 2*. Mean percent recall (A), percent recognition (B), and mood rating (C) for each walk by experiment. Error bars show the standard error of each mean.

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## Appendix A

## Study List Word Sets and Subsets

***Set A, Subset A***: boost, brand, candy, cause, chalk, clamp, dairy, focus, gland, hotel, issue, level, light, major, medal, motel, paper, point, porch, press, radio, ready, river, slope, snack, sound, stock, thorn, visit, watch

***Set A, Subset B***: adapt, alive, birth, board, clump, cover, draft, fruit, greed, grill, guest, heavy, march, model, power, scene, sense, spice, steam, strap, sweat, table, thing, trade, trial, truck, union, valid, wheat, women

***Set B, Subset A***: bleed, couch, crime, doubt, eager, earth, enter, fault, field, honey, lunch, match, money, mouse, peace, piece, plant, rebel, scalp, scent, shaft, spray, staff, stage, stamp, stand, teeth, thief, wagon, while

***Set B: Subset B***: batch, block, blush, cabin, chest, child, chunk, clown, creek, crust, daisy, diver, event, faith, flick, grass, horse, image, limit, mouth, music, plate, scrap, skill, slump, space, study, value, voice, wrist

***Set C, Subset A***: actor, angle, blank, brick, brute, chief, chili, chore, corps, court, curve, droop, final, flash, floor, glide, group, human, month, night, north, pilot, plane, prize, roast, sauce, slang, sting, story, timid

***Set C, Subset B***: apple, beach, black, boxer, break, brown, class, clean, craft, delay, drive, flock, glory, growl, heart, house, leash, lemon, order, party, price, range, round, salad, spear, spoon, tally, torch, water, worry

## Appendix B

**Mean (SE) Recall, Recognition, and Mood Ratings by Walk Order for each Experiment**

| | Percent recall | | | Percent recognition | | | Mood rating (-5 to +5) | | |
|---|---|---|---|---|---|---|---|---|---|
| Exp/Order | Nature | Urban | Indoor | Nature | Urban | Indoor | Nature | Urban | Indoor |
| Exp. 1 | 28 (11) | 32 (13) | 30 (14) | 89 (9) | 87 (9) | 92 (9) | 2.6 (1.5) | 2.5 (1.1) | 2.5 (1.3) |
| INU | 23 (6) | 28 (2) | 24 (4) | 89 (2) | 86 (6) | 87 (2) | 2.0 (0.4) | 3.0 (0.4) | 2.0 (1.0) |
| IUN | 33 (3) | 45 (6) | 41 (9) | 93 (3) | 93 (3) | 100 (0) | 3.5 (0.3) | 2.8 (0.3) | 3.0 (0.4) |
| NIU | 21 (5) | 35 (7) | 31 (7) | 86 (5) | 90 (6) | 94 (2) | 3.0 (0.4) | 3.5 (0.6) | 2.8 (0.5) |
| NUI | 21 (5) | 28 (3) | 26 (3) | 83 (8) | 83 (2) | 83 (4) | 2.0 (1.4) | 3.5 (0.3) | 2.3 (0.9) |
| UIN | 38 (7) | 40 (8) | 38 (8) | 94 (2) | 91 (4) | 94 (4) | 1.0 (0.7) | 1.0 (0.4) | 1.5 (0.6) |
| UNI | 29 (3) | 18 (3) | 19 (6) | 86 (4) | 81 (4) | 82 (4) | 3.3 (0.3) | 3.0 (0.0) | 3.0 (0.4) |
| Exp. 2 | 35 (15) | 33 (13) | 34 (16) | 89 (9) | 93 (7) | 92 (10) | 2.5 (1.4) | 2.4 (1.4) | 2.1 (1.9) |
| INU | 39 (3) | 35 (6) | 29 (7) | 92 (3) | 97 (1) | 92 (7) | 3.5 (0.6) | 4.3 (0.5) | 3.8 (0.6) |
| IUN | 24 (4) | 25 (4) | 33 (6) | 87 (7) | 92 (4) | 87 (7) | 1.3 (0.9) | 1.8 (0.5) | 1.8 (0.5) |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| NIU | 28 (3) | 33 (4) | 36 (5) | 85 (4) | | 95 (3) | 96 (2) | 1.8 (0.8) | 2.0 (0.9) | 2.0 (0.9) |
| NUI | 34 (9) | 33 (3) | 22 (4) | 89 (5) | | 89 (6) | 90 (6) | 2.5 (0.6) | 2.0 (0.7) | 2.0 (1.4) |
| UIN | 43 (6) | 41 (6) | 47 (6) | 93 (4) | | 94 (4) | 96 (4) | 2.8 (0.5) | 2.0 (0.6) | 2.5 (1.2) |
| UNI | 44 (14) | 33 (13) | 37 (15) | 88 (6) | | 92 (4) | 93 (4) | 2.3 (0.6) | 2.3 (0.6) | 1.8 (0.9) |

Notes: N = nature walk, U = urban walk, I = indoor walk. Order listed indicates order of the walks. Top row for each experiment provides the means (SEs) averaged across walk order. Each cell mean (SE) is based on 4 participants.

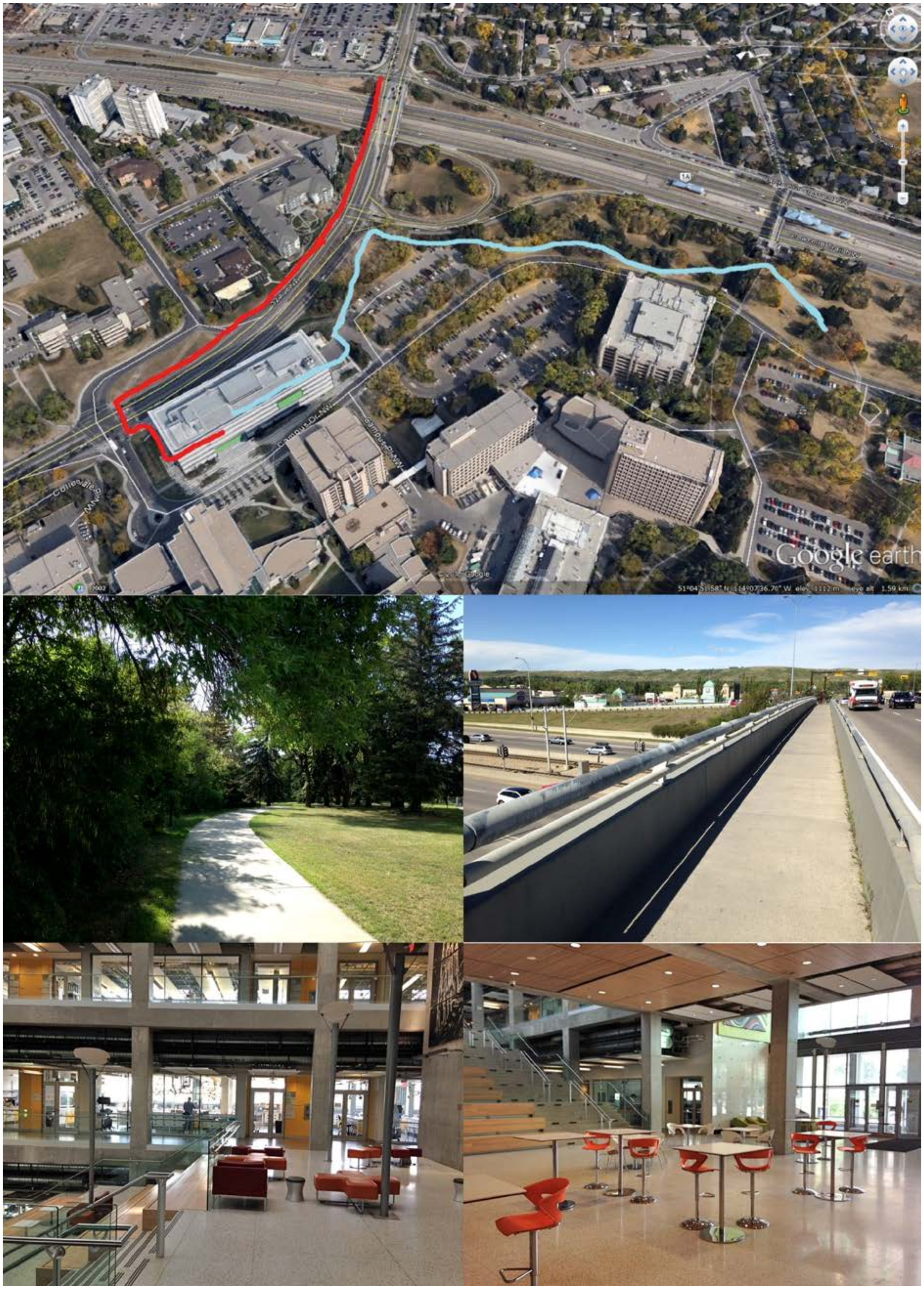

Figure 1.

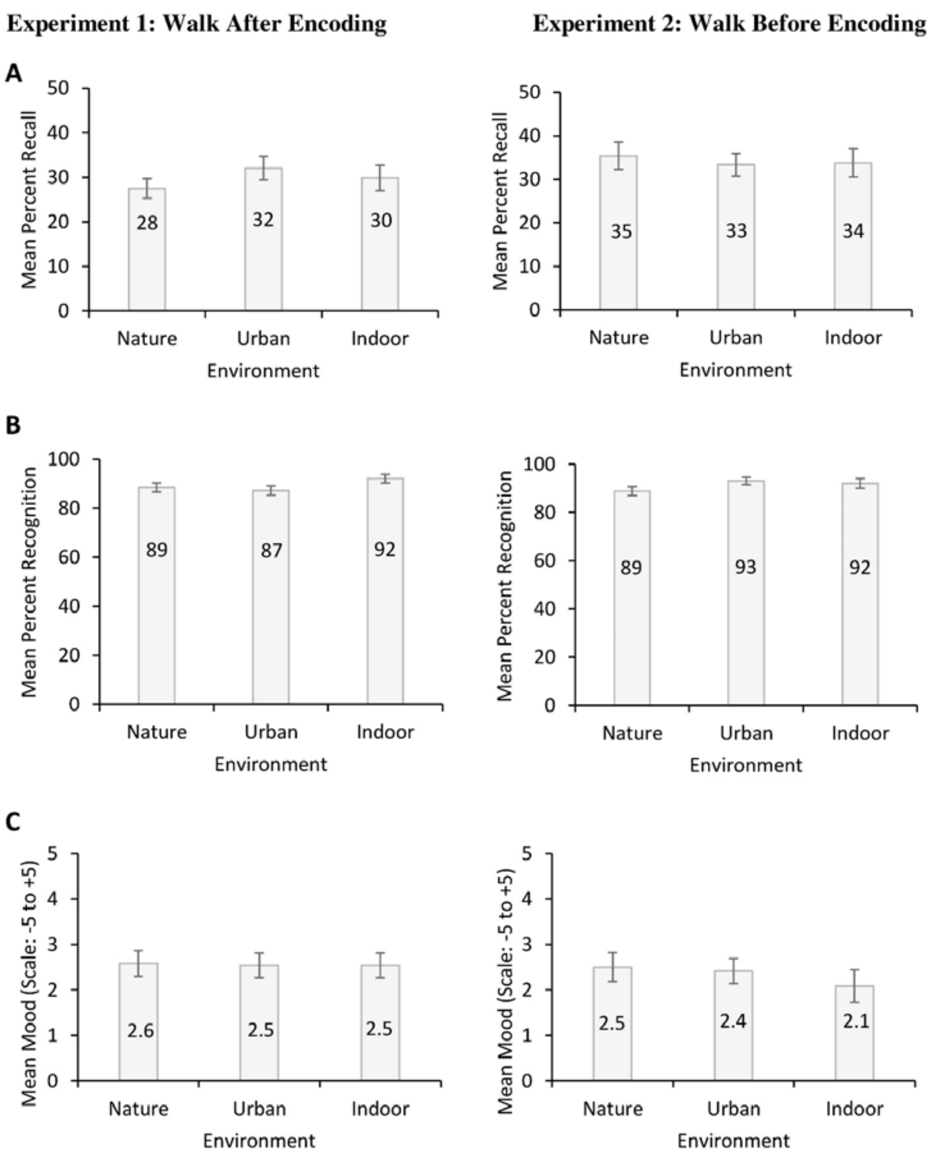
Experiment 1: Walk After Encoding
Experiment 2: Walk Before Encoding
A
Mean Percent Recall
50
40
30
20
10
0
28
32
30
35
33
34
Nature
Urban
Indoor
Environment
B
Mean Percent Recognition
100
80
60
40
20
0
89
87
92
89
93
92
C
Mean Mood (Scale: -5 to +5)
5
4
3
2
1
0
2.6
2.5
2.5
2.5
2.4
2.1

Figure 2.