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Final dissertation

URBAN ENVIRONMENT, EMOTIONS AND SPATIAL REPRESENTATIONS: AN EXPERIMENTAL STUDY

AMBIENTE URBANO, EMOZIONI E RAPPRESENTAZIONI MENTALI: UNO STUDIO SPERIMENTALE

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ABSTRACT

In the domain of cognitive psychology, literature suggests that both individual differences and types of environment play an important role in the creation of mental spatial representations. The current research mainly aims at exploring spatial performance in different environmental characteristics; it also intends to analyze whether emotional aspects, such as spatial anxiety and affective states play a role in the relationship between the type of environment navigated and spatial performance. Moreover, the study also explores the restorativeness effects of natural environments, which are thought to allow individuals to replenish their cognitive energies and perform better on spatial tasks. The research consisted of two sessions: in the first one, participants completed a series of questionnaires mainly designed to assess navigational attitudes, as well as a short version of the mental rotation test, index of visuospatial skills critical for environmental learning. In the second session participants walked six experimental routes (two situated in natural environments, two in built ones, two in mixed ones) and were then asked to estimate the distance between the starting and ending point, as well as to evaluate their emotional variations during the experimentation. Results showed that restorativeness perception is higher in green than in built routes, and that positive affects are a significant predictor when reporting this feeling of regeneration. Finally, a direct relationship was found between spatial anxiety and distance estimation performance, as well as one mediated by the raise of negative affect. The same relationship was not found to be significant when holding restorativeness perception as dependent variable.

CHAPTER 1

Environment learning, navigation, and internal mental representation

1.1 How do we navigate the environment

In everyday life people are constantly moving towards goals and needs, freely traveling in the environment. Being able to interact with it and to successfully travel throughout it implies a series of psychophysical requirements including perception, cognition, and motor behavior. Taken together, these are the factors building *navigation*: coordinated and goal-directed movement through the environment involving firstly movement planning and secondly movement execution. According to researchers, these two moments underlie the two components of navigation: wayfinding and locomotion (Darken & Peterson, 2001). If, on the one hand, it is crucial to actually be able to coordinate our movements without getting hurt or running into obstacles, preliminary planning, information organization, and storage play a critical role in one's ability to navigate the environment. In fact, wayfinding cognitive requirements extend beyond the encoding and usage of information given by the sensory and motor systems, including mechanisms such as decision making, problem solving, and memory, all necessary for the movement itself and consequently for goal completion (Montello, 2005). Another difference between the two aspects is that, while locomotion is relatively automatic, wayfinding tasks demand controlled and complex processes, reckoned as reasoning rather than mere perception (Montello, 2005).

As one can expect, the increasing complexity of the world we live in and the ever-growing amount of stimuli we are exposed to demands a selection of what and how we process, all depending on our current goals and means of pursuing them. Lynch (1960) identified some elements that are salient and useful for optimal environment navigation. First of all, the presence of the so-called *landmarks*, important or recognizable features, plays a crucial role both in the efficiency of wayfinding and in the emotional experience of the subject. Secondly, spatial relationships between landmarks are made understandable by *routes* or *paths*, which connect them and allow one to efficiently move from one to another. Moreover, in order to comprehend the structure of the environment and hence proficiently navigate it, users can also benefit from *nodes*, the junctions between different routes. Finally, environments are conceptually separated into different *districts*, bounded by *edges* between them, that limit or inhibit movement.

All this spatial knowledge must then be organized so that it can be used for movement planning, and therefore for wayfinding. Seigel and White first (1975) and Thorndyke and Goldin soon after (1983) observed that people might make different uses of these elements, discriminating between two wayfinding strategies. As we will discuss later in this study, the type of strategy used could be linked both to individual differences and to external environmental factors, such as experience, exposure to certain kinds of stimuli, and culture (Lawton & Kallain, 2002; Frank, 2009).

The first one, named *route strategy*, is centered around an egocentric subject perspective and implies a continuous updating of information as it consists only of information that is readily available at one moment in time. Moreover, this strategy implies a series of instructions (i.e. "turn left after the bridge") and is therefore closely related to mnemonic cognitive mechanisms (Walkowiak, 2015). On the other hand, the *survey strategy* implies an allocentric point of view, in which people also efficiently employ cardinal points. Thus, this strategy offers a from-above-representation and allows one to integrate all possible routes and connections between spatial positions keeping a sense of their position with respect to them (Lawton, 1994). The survey strategy, therefore, is the one granting the formation of a mental representation of spatial information, a concept first introduced by Tolman's experiments on rats (1948) and described with the term *cognitive map*.

1.2. Mental spatial representations

The hypothesis formulated by Tolman (1948) when talking about cognitive maps (initially in rats but analogously in humans as well) is that people construct a representation built as a cartographic map. Tolman's findings marked a turning point in the field of cognitive psychology, as they opened new ways of interpreting human minds and their consequent behaviors. Up to that point, in fact, the nervous system was seen by behaviorist as a black box, impossible to explore or study. With his studies on rats, Tolman was only the first of many researchers who tried, over the years, to identify, study and define the mechanisms underlying spatial knowledge organization, as cognitive maps are the principal mean by which psychologists and other scientists attempt to understand acquiring, processing, storing and decoding of geographical information (Downs & Stea, 1973). For this reason, and for the multidisciplinary nature of the topic, multiple definitions have been put forward over the years, each adding a new building block towards the comprehensive understanding we have of them nowadays. Their presence is blatantly necessary for an efficient interaction with the environment and some researchers reckon that cognitive maps are evolutionary adaptive, as they give an advantage in dealing with a dangerous world (Kaplan, 1973). Moreover, mental spatial representations are dynamic and develop with age and experience, constantly integrating new data and updating the one previously stored (Golledge & Timmermans, 1990). Furthermore, for reasons that will be explained later in the chapter, it is important to underline that, besides denoting relative positions, cognitive maps also hold values and meanings, integrating images with attitudes about the environment (Spencer & Blades, 1986) and hence making them highly dependent on different influencing factors. Finally, the generalization and approximation aspects of cognitive maps must be mentioned, so not to think about them as complete and picture-like representations, but as schematized, distorted and incomplete ones (Down and Stea, 1973).

In order to explore how primary (i.e., walking in the environment) and secondary (i.e., consulting a map) sources of information interact in the creation of a mental spatial representation, many approaches have been implemented. In the last few years neurological approaches have been increasingly used (measuring neural activity during the undertaking of spatial, problem-solving tasks; Hartley et al., 2003; Li & King, 2019) as well as qualitative methodologies consisting for example in verbally describing routes or other stimuli (Kitchin, 2001). Although, in general, the most widely implemented approach is using tasks involving the management of spatial information, such as recognition tasks (De Goede & Postma, 2015; Iachini et al., 2009; Afrooz et al., 2018), pointing tasks (Meneghetti et al., 2017; Muffato & Meneghetti, 2020; Brunyé et al., 2015), map drawing tasks (Muffato & Meneghetti, 2020), shortest route finding tasks (Labate et al., 2014), and distance estimation tasks (De Goede & Postma, 2015; Evans & Pezdek, 1980). In particular, this study will focus on this last-mentioned operationalization of one's cognitive map, the distance estimation aspect.

1.2.1 *Distance estimation*

Before discussing the methodologies used to obtain estimation from the participants, it is important to clearly define cognitive distance, key concept for the current study. Cognitive distance is described as the perception of distances between places in large-scale spaces, which require some sort of movement and therefore data integration over time.

Previous literature proposes five classes of measurement method when dealing with distance estimation (Montello, 1991), with the most frequently used one being psychophysiological ratio scaling. In particular, this measuring method is employed through the technique of magnitude estimation in which participants have to make use of familiar units such as meters. Another highly used method is the mapping technique, consisting in the depiction of the relative location of stimuli (or in our case, routes) in a smaller scale environment compared to the real one.

According to MacEachren (1980) it would be possible to identify a functional relationship between cognitive and objective distance, which can be mediated by a number of factors. These influencing aspects include stimulus-centered factors (environmental characteristics), subject-centered factors (individual characteristics) and subject/stimulus-centered factors (interaction between the characteristics of the observer and the settings). Literature thoroughly exploring the degree of impact of these aspects although, is lacking; since the topic needs a deeper level of understanding, this study will focus on the variables potentially impacting distance estimation performance.

CHAPTER 2

Influencing factors on mental spatial representations

As mentioned in the previous chapter, cognitive maps (or mental spatial representations, interchangeably used in literature and in the current study) are highly influenced by multiple factors which can explain the substantial variability in spatial tasks. In the following section, some of them will be explained and discussed, with special focus on the variables which will later be analyzed for the sake of the current study.

2.1. Individual differences

Over the years, the study of spatial cognition was enriched by the large amount of research that slowly added to the understanding of spatial knowledge acquisition. In particular, studies have focused on the solid variability of spatial performance between subjects, exploring which individual aspects might have an influence on it. Proportionally, the largest body of study focuses on gender; results are mixed across studies, usually showing a slight advantage in male subjects. The meta-analysis by Nazareth (2019) reports that large or non-existent differences are rarely found in literature, mostly showing a small to medium effect size of gender on spatial performance. The difference between genders in spatial performance seems to be more than quantitative, qualitative: Montello and colleagues (1999) proved that males' performance was better in distance estimation and direction pointing tasks, while women were better at remembering landmarks and where they are located. Most researchers point out that these results might be attributed to the fact that men make an increased use of survey strategies, much more efficient for information organization and movement planning (Boone et al., 2018). The explanation of the differences in spatial navigation strategies might be found in the evolutionary roles of the two sexes, which developed different hippocampal substructures for the use of directional and proximal elements (Jacobs & Schnek, 2003).

Therefore, even if the gender factor will not be considered in the current study, it remains important to keep it in mind when talking about wayfinding behaviors.

Familiarity, defined as our “ability to identify a place by naming it, recognizing it pictorially, and knowing where it is located” (Golledge, 1992) is also thought to play an important role in the elaboration of mental maps. In fact, greater familiarity leads to the formation of a more detailed representation, and consequently to a better performance in spatial tasks (Muffato & Meneghetti, 2020). Although, some studies underline that the the degree of influence of familiarity might change depending on the type of task (De Goede & Postman, 2015) with the largest impact seen when inferring distance or direction of landmarks and organizing them in a representative structure (Thorndyke & Hayes-Roth, 1982).

Another variable largely relating, supporting and predicting environmental learning and consequently mental spatial representations are visuospatial factors, a multi-component construct implying both basic and higher-order spatial skills (Hegarty & Waller, 2005). In general, they are defined as skills needed to generate, retain and transform abstract visual images (Lohman, 1988), and range from visuospatial working memory to spatial perception, visualization and mental rotation (Muffato & Meneghetti, 2020). In particular mental rotation, reckoned to be a small-scale spatial ability (Hegarty et al., 2006), is defined as a psychological imagery process during which a mental image is rotated on an imaginary axis (Zacks, 2008). When testing for this ability, usually asking to identify two perspective figures representing the same three-dimensional object, it is observed that time needed for task completion increases almost linearly with the degree of angular rotation (Shepard & Metzler, 1971). These results suggest that there is an analog mental representation of the object, which is rotated in a way which highly reflets the real one, with intermediate steps between the starting and the ending point of rotation (Zacks, 2008).

Another influencing aspect, distinct but related to visuospatial cognitive abilities, is represented by self-reported preferences and wayfinding inclinations, such as sense of direction (Pazzaglia et al., 2000), pleasure in exploring (Meneghetti et al., 2014) and spatial anxiety (Lawton, 1994). The combination between the two was found to contribute to spatial performances, once again to a variable degree with respect to the type of task to complete (Muffato et al., 2017). Specifically, the current study will focus on the emotional factors impacting performance; in the following section, therefore, a more detailed account of current knowledge about their influence on mental spatial representations and wayfinding will be presented.

2.1.1. ***Affective states***

According to the somatic marker hypothesis (Damasio, 1996), which was supported by a number of studies, cognition and emotion are highly intertwined, resulting in influences on attention, memory and decision making. All of these factors are crucial for wayfinding; when exploring the individual differences in wayfinding skills, it is therefore important to take emotional factors into account, as they are considered to be crucial for environmental learning (Schmitz, 1997). According to previous literature, our perception and encoding of the surroundings differs based on how we feel in that moment, but also on the emotions that might be cued by emotionally laden stimuli in the environment and on the affective meaning derived from it. In a study conducted using virtual reality for example, Ruotolo and colleagues (2019) show how the presence of positive or negative landmarks (such as pictures of smiling babies or guns) leads to different distance estimation as well as routes drawing: participants in the negatively laden condition, in fact, judged distances to be larger compared to the positive and neutral condition, suggesting that the emotional value of landmarks does indeed play an important role on memorization, elaboration and representation of environments. In the study by Palmiero and Piccardi (2017), which aimed at analyzing the efficiency of path learning, results show that both positive and negative emotional landmarks led to a better performance, but that only the positive ones allowed benefits for an allocentric-based topographical memory. The explanation for these findings can be attributed to the type of processes emotions elicit: Gasper and Clore (2002) suggest that positive affect (i.e. happiness) promote a more global perception of the environment, while negative affect (i.e. sadness) favor a more local and detailed processing. In addition to the meaning of targets or landmarks, affective judgements of a place are thought to be the results of multiple intertwining factors: the gradient of influence, for example, makes it so the furthest away from a negatively laden stimulus the less negatively the environment is judged; the inclusion/exclusion criterion similarly, determines how information about the target can be applied to the context as a whole or used as anchor point for comparison (Blaison & Hess, 2016).

Affective states, defined as complex multidimensional psychophysiological constructs (Harmon-Jones et al., 2011) can moreover be divided in two continuous components: arousal (high vs low), being the intensity of emotional experience, and valence (positive vs negative), representing the direction of affective experience (Lang, Bradley & Cuthbert, 2008). Previous literature has explored the impact these two components have separately on spatial performance, leading to inconsistent results and different explanations. Ruotolo and colleagues (2021) showed that the two factors can have an interactive or independent role based on the type of task to be completed: the valence of the stimulus has an impact on spatial length judgements, while arousal influences route drawing and temporal length judgements, with better performance in high arousal conditions. This is explained by means of emotional context elicited by the arousing stimulus, which allows a better encoding and a stronger bound to the spatio-temporal dimension. However, other studies led to opposite results, suggesting that when arousal increases, attention is devoted to a narrowed range of cues and elements relevant for the current goal, impacting the encoding of peripheral information and leading to detrimental effects on short- and long-term memory and consequently on spatial performance (Gardony et al., 2011). As for valence, literature generally explains the benefits of positively laden stimuli on spatial performance with the impact emotions have on spatial working memory, worsened when subjects experience a negative emotion, and therefore resulting in slower navigational performance (Balaban et al., 2014).

All these evidence supports the idea that spatial mental representations of environments result from the interaction between cognitive and emotional processes, including metacognitive experiences, thoughts, moods and bodily sensations. One of the explanations is given by the feelings-as-information theory (Schwarz, 2012), which suggests that all subjective experiences are attended as a source of information, but that the information inferred from them is context sensitive and flexible and might therefore lead to the contradictions discussed above.

2.1.2. *Spatial anxiety*

Self-reported wayfinding anxiety, defined as a situation-specific personality trait, has been proved to negatively influence spatial performance (Lawton, 1994). Walkowiak and colleagues (2015), investigating the impact of spatial anxiety in a maze navigation study, hypothesized a slower performance as well as an increased number of errors in participants with higher scores on the Spatial Anxiety Scale (Lawton, 1994). Indeed, not only they took longer to complete the task, but they also covered longer distances, confirming a larger amount of mistakes during navigation. Spatial anxiety, moreover, correlates negatively with mental rotation tasks performance, spatial perception tasks and pointing accuracy (Lawton, 1994). The negative impact on the wayfinding performance can probably be attributed to a reduced attention given to features of the environment, or to the impairment of an efficient encoding ability in the given context (Saucier et al., 2002).

A large amount of studies has looked into this aspect of navigation, investigating all facets of the construct, but especially lingering on its interrelation with sex (or gender, as we will see later). Most research, in fact, underline how, cross-culturally, women exhibit more spatial anxiety compared to man (Lawton & Kallai, 2002), expressed in a reduced desire to explore and low self confidence in general navigation (Gabriel et al., 2010). Moreover, women report higher levels of environmental confusion (LaGrone et al., 1969) and low confidence when asked to draw a map of a floor plan (O'Laughlin & Brubaker, 1998). The reason why spatial anxiety is irrefutably higher in women compared to men might be found in different exposure to early wayfinding experiences. In fact, Lawton and Kallai (2002) found that men report much more childhood wayfinding experiences, and greater exposure to games involving a larger need of spatial skills implementation. According to Schmitz' interactive model (1997), there is a relation between experience bias in children's environmental development, affective disposition (higher levels of anxiety for girls) and the favored use of a particular navigational strategy. Malinowski and Gillespie (2001), point out that given equal levels of spatial anxiety among male and female participants, males still outperformed women in the spatial task, suggesting that nervousness cannot completely account for these differences and giving therefore credit to an interaction possibility.

Therefore, as can be seen, when talking about spatial anxiety it remains unclear whether these individual differences are sex-related and therefore biological or are shaped by the environment and related to gender stereotypes. Even though the origin or explanation cannot be pointed out with certainty, the influence on spatial performance remains irrefutable.

2.2. Environmental factors: natural vs built environments

If, on one hand, spatial mental representations can be influenced by individual factors, environmental ones can play just as an important role, since navigation implies close contact between the person and the environment. Some visual and structural features were in fact found to significantly influence wayfinding performance (Carpman & Grant, 2002). Generally, three factors are recognized to ease (or impair) navigation: differentiation, or the amount of difference and similarities between the parts of the environment, visual access, or the degree of sight openness towards different directions, and layout complexity, or the articulation or intricacy of the environment (Weisman, 1981; Weiner & Pazzaglia, 2021). Environments would be easier to navigate when more differentiated (in color, shape, style because of the better memorability), with greater visual access and a simple layout.

Another difference in spatial performance, barely explored in literature, is the one found when the task is carried out in natural or built environments; since this will be one of the main topics explored in the current research, the state of art is thoroughly described in the next paragraphs.

Over the course of evolution, humans became more and more molded to the world, preserving although their instinct towards the natural one. Previous literature has shown that psychophysiological functions are differently affected by built and natural environments, with nature having beneficial effects on affection and cognition (Bratman et al., 2015). Respectively, these two types of benefits are explained by two of the most renowned theories in the field of environmental psychology. Stress Reduction Theory (SRT; Ulrich, 1981) explains affective changes, positing that natural environments, given the role they had in evolution, promote recovery from stress and reduction of arousal, activating one’s parasympathetic nervous system. Bratman and colleagues (2015) for example, found a decrease in anxiety, rumination and negative affect when walking in a natural environment compared to an urban one. In fact, the metanalysis done by McMahn and Estes (2015) underlines how exposure to nature positively correlates with positive emotions such as interest, calm and pleasantness, and negatively correlates with negative ones such as anger, anxiety and fear. Moreover, psychophysiological stress can also strongly impact cognitive performance, decreasing the effectiveness of the efforts put in a task. Cognitive benefits of natural exposure are explained by Attention Restoration Theory (ART; Kaplan & Kaplan, 1989) which relies on the division of attention between directed (governed by cognitively controlled mechanisms) and involuntary (captured exogenously by intriguing or important stimuli) firstly proposed by James (1892). According to this theory, natural environments activate involuntary attention, giving the opportunity to replenish directed-attention mechanisms. On the other hand, exposure to built environments demands a larger use of cognitive resources, worsening performance in tasks that depend on focused directed attention, which is a mechanism that declines with prolonged use. For example, past literature suggests that attention, working memory, cognitive control and concentration improve when participants walk in a natural environment compared to when they walk in a built one (Berman et al., 2008; Berman et al., 2012; Gidlow et al., 2016; Hartig et al., 2003) and that the effect is motivated the presence of several specific characteristics. Four of them particularly stand out in literature: fascination, or the ability to attract involuntary attention, being away, or the feeling of being distant from every day's duties, extent, or the combination of perceived coherence and scope, and compatibility between one's expectations and observed reality (Pasini et al., 2014).

Even if these two theories draw from different perspectives, they are not mutually exclusive and are in fact both linked to one important concept: biophilia. The term, firstly introduced by Wilson (1984) describes the innate tendency humans have to affiliate with nature and with other living things, and drives (together with cultural and individual factors) our environmental preferences. Biophilia is strongly rooted in humans, as they are genetically programmed to function efficiently in natural environments and evolved adapting to them during the course of evolution (Berto et al., 2017). ART and SRT, moreover, also tap into the arousal theory (Wohlwill, 1974; Meharabian & Russel, 1974) which suggests that natural settings are perfect for recuperation from excessive arousal, as their properties such as lower movement, complexity and intensity, are usually low in arousal compared to the characteristics of the built ones (Berto et al., 2014).

All the beneficial effects put forward in the chapter can be summarized in the definition of the term *restorativeness,* defined as the renewal of physical and psychological adaptive resources depleted in ongoing efforts to meet the demands of everyday life (Hartig, 2004). Even if these beneficial effects of natural exposure on cognition are now known, the direct impact on spatial cognition has not been thoroughly explored yet. Given the affective and cognitive implications although, some researchers posit that the different characteristics of natural and built environments might also influence the creation of different cognitive maps: the regularity of the built environment (usually composed mainly of horizontal and vertical lines) contrasts with the curved lines and irregular shapes of the natural one, ending in an homogeneous perception of the whole scene (Montello & Sas, 2006). Another important point to take into account is the potential role of individual differences, which is not clear in previous studies. Factors such as stage of life, familiarity with the environment, personality characteristics could be of crucial importance in determining the perception of natural restorativeness first, and of cognitive spatial performance consequently.

CHAPTER 3

The research

3.1. Objectives of the study

The present thesis aims at analyzing different aspects of spatial performance. The first goal was to analyze whether the characteristics of an urban environment such as the presence of green or built elements are related to the mental spatial representation, the emotions experienced during exploration and the perception of restorativeness.

Moreover, the present study also intended to explore the role of individual factors (age, gender, familiarity with the given environment, connectedness to nature, spatial anxiety, sense of direction) and of emotions experienced (before the start of experimentation and during the completion of the experimental tasks) in predicting distance estimation abilities and restorativeness perception. In particular, the main intent was understanding whether and how spatial anxiety (independent variable) is related to the ability of estimate the distance walked and to the perception of restorativeness (dependent variables), especially inspecting whether this relationship might me mediated by the negative affective states raised during the completion of the route by the environment.

3.2. Participants

The sample consisted of a total of 147 participants, of which 52 males (35,37%) and 95 females (64,63%), aged from 18 to 31 (males: *M*= 22.20; *SD*= 2.74, females: *M*= 20.50; *SD*= 1.30). Participants were recruited by means of word of mouth, allowing for low to absent costs and a fast collection of data. As for educational level, the participants were mostly students of the Psychology Bachelor at the University of Padua and participated voluntarily in the study. The experiment was approved by the Ethical Committee for Psychological Research at the University of Padova, and all participants were asked to carefully read a consent form stating all the important information about the study, in accordance with the Declaration of Helsinki (World Medical Association, 2013). Out of the total sample, 45 participants were personally tested by me.

3.3. Materials

3.3.1. *Questionnaires*

Spatial anxiety questionnaire (QAS; Lawton, 1994; De Beni et al., 2014)

The Spatial Anxiety questionnaire aims at exploring the severity of anxiety different environmental situations would raise in participants. It is made up of 8 items and judgments are expressed on a 6-point Likert scale (1= no anxiety at all, 6= extreme anxiety). One item, for example, recites "Finding my way out of a complex building which I have never visited before". The final score, obtained from the sum of the items, ranges from a minimum of 8 to a maximum of 48.

Attitudes Towards Orientation Tasks Questionnaire (ATOT; De Beni et al., 2014)

This questionnaire comprises 10 items exploring participants' attitudes towards orientation-based activities, in particular whether strong tendencies towards known versus unknown situations could be observed. Answers were given on a 6-point Likert scale (1=not true at all, 6=completely true). An item example is "When I travel from one city to another I am able to picture where the destination is located with reference to the departure point". The final score, obtained from the sum of the items, ranges from a minimum of 10 to a maximum of 60.

Connectedness to Nature Scale (CNS; Berto et al., 2018)

The Connectedness to Nature Scale explores the degree to which participants feel one with the natural world through 14 items assessed on a 4-point Likert scale (1= not true at all, 4= absolutely true). One of the items, for example, recites “When I think about my place in the world, I consider myself the apex of the natural hierarchy”. The final score, obtained from the sum of the items, ranges from a minimum of 14 to a maximum of 56.

Wayfinding Self-Efficacy Questionnaire (Mitolo et al., 2015; Pazzaglia et al., 2017).

This questionnaire is composed of 8 items providing a measure of participants’ global spatial self-efficacy, specifically in the ability to complete environmental tasks. Answers were given on a 6-point Likert scale (1= not at all, 6= very much). Out of the others, an example of an item is “Finding a car in a large parking lot”. The final score, obtained from the sum of the items, ranges from a minimum of 8 to a maximum of 48.

Sense of Direction and Spatial Representation scale (adapted from Spatial Orientation Questionnaire, De Beni et al., 2014).

The Sense of Direction Questionnaire means to explore different beliefs and perceptions about one’s orientation abilities and knowledge about cardinal points. It consists of 13 items assessed on a 5-point Likert scale ranging from “completely disagree” to “completely agree”. One item, for example, asks “Family and friends consider you as someone with a good sense of direction”. The final score, obtained from the sum of the items, ranges from a minimum of 13 to a maximum of 65.

Trait Positive and Negative Affective Status (PANAS; Terraciano et al., 2003)

The PANAS consists of a self-report adjective checklist comprising two 10-item subscales created to measure positive and negative affect respectively. The 4-point Likert scale (1= very slightly or not at all, 4= extremely) assessed the degree to which participants felt a give emotion at that present moment. Adjectives such as alert and proud (positive affect) and guilty and hostile (negative affect) were used to assess this dimension. The final score, obtained from the sum of the items, ranges from a minimum of 20 to a maximum of 80. In order to complete some analysis, the two subscales were kept separate for the negative and positive affect, with a minimum score of 10 and a maximum score of 40 each.

Perceived Restorativeness Scale (PRS-11; Pasini, Berto, Brondino, Hall, e Ortner, 2014)

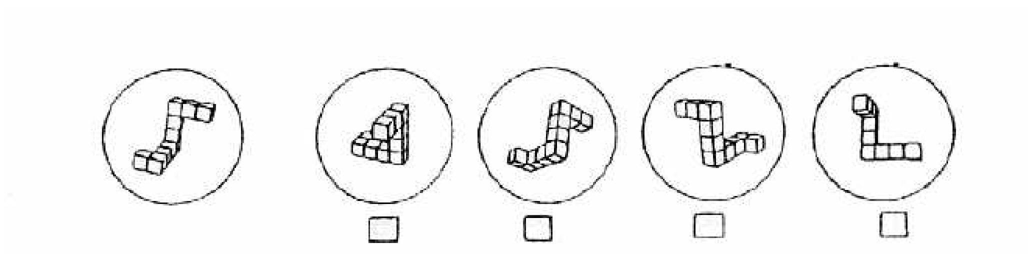
The Perceived Restorativeness Scale, based on the Attention Restoration Theory (ART; Kaplan, 1995), aims to measure individual perception of four restorative factors in the target environment. Firstly, being away (allowing physical or psychological distance from directed-attention requiring settings), is explored with items such as "To stop thinking about the things that I must get done I like to go to places like this". Fascination (the effortless attention drawn by interesting stimuli), is instead assessed using items like "In places like this it is hard to be bored". Thirdly, coherence (organization and orderliness of the stimuli), is described with items such as "There is a clear order in the physical arrangement of places like this". Finally, scope (lack of stimuli that would restrict movements) is measured with items like "That place is large enough to allow exploration in many directions. It consists of 11 items assessed on a 10-point Likert scale (0= not at all, 6= rather much, 10= very much). The final score, obtained from the sum of the items, ranges from a minimum of 0 to a maximum of 110.

3.3.2. *Visuospatial cognitive tests*

Short Mental Rotation Test (sMRT; Vandenberg & Kuse, 1978; De Beni et al., 2014)

The Mental Rotation test consists in matching rotated 3D figures composed of cubes with a target one. More specifically, in the short version 10 items comprising one target and four options each were shown to the participants. Within five minutes of time, they were required to identify which two figures, out of the four presented, depicted the target but rotated. An example of item can be seen in Figure 1.

Figure 1. Item of mental rotation test. Participants were required to identify two rotated versions of the target object presented on the far left.



3.3.3. *Single questions and tasks related to the routes*

Familiarity and sensorial valence

Two extra questions were asked at the end of each route. The first one, detailing a list of sensorial characteristics of the environment, asked "What struck you while walking this route?"; on the other hand, familiarity with the covered route was assessed using a visual analogue scale ranging from 0 to 100, with 0 being "I never experience this environment" and 100 being "I always experience this environment".

Ad hoc questions on distance and time estimation

In order to observe how different variables impacted the perception of walked distance and passed time, two questions were posed after each of the six routes ("How long do you think you have walked?"; "How much do you think you have walked?"). Participants were required to indicate the perceived distance in meters and the perceived time in seconds. The order of the two questions was counterbalanced across participants. Finally, two questions were used to investigate whether participants used any strategy to be facilitated in the time or distance estimation ("Did you use any strategy to estimate distance?"; "Did you use any strategy to estimate time?"). In order to operationalize these constructs, the deviation from the correct distance and time was calculated, representing therefore an absolute measure of error.

Sketch map

A blank map only indicating the position of two university buildings and of the nearby river was administered to participants to assess their global understanding of the environment around them. They were required to draw using a pen, tracing straight lines, where the routes were situated, and to color any green area seen during the experimental trials.

3.3.4. *Description of the routes*

For this experimental study, 18 routes were chosen. All of them were situated around the General Psychology Department at the University of Padua and varied in length, ranging from a minimum of 70 m to a maximum of 126 m. Moreover, routes differed in their environmental characteristics, and were categorized as green, built, or both (with an indication on whether they were mainly green or built). Figure 2 shows the location of the 18 experimental routes, while Table 1 displays the individual characteristics of each of them. Each participant covered 6 out of the 18 routes. Two natural, two built, and two mixed routes were chosen randomly, and they were covered in a clockwise direction. Moreover, each route was reached making sure none of the other five experimental routes was walked on.

Figure 2. Map of the 18 experimental routes.

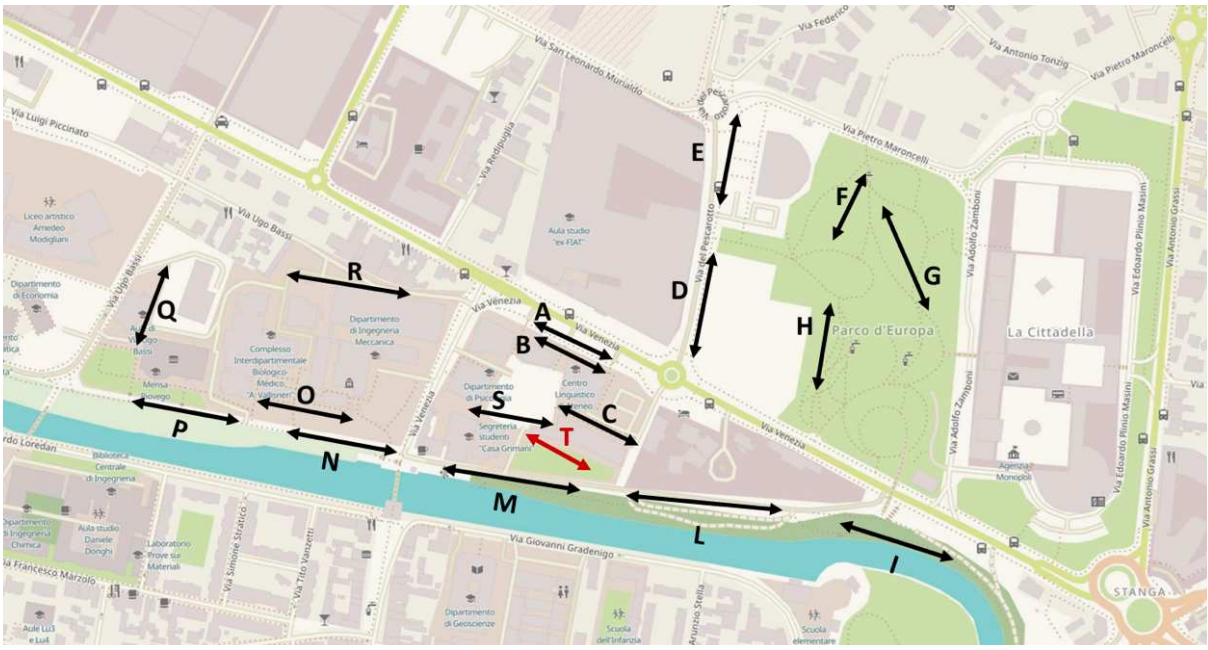


Table 1. Measures of length and greenery of the 18 experimental routes

Route identification letter	Length in meters	Percentage of greenery
A	101	Both (built)
B	93	Built
C	87	Built
D	100	Built
E	98	Both (built)
F	72	Green

G	107	Green
H	84	Green
I	78	Green
L	79,5	Both (green)
M	120	Both (green)
N	97,5	Green
O	92	Both (green)
P	119,5	Green
Q	83,5	Built
R	126	Built
S	70	Built
T	83	Both (green)

3.4. Procedure

A few days before the actual testing moment, all participants received a Qualtrics link through which they could access five questionnaires and one visuospatial test (QAS, QACO, CNS, Wayfinding Self-Efficacy Questionnaire, Spatial Attitudes Questionnaire, sMRT), comprising the first session of the study, which had to be completed before the agreed upon time of experimentation. During the second session they then received a second Qualtrics link, through which data about their mental spatial representations could be collected during the six routes. Before starting the experimental routes, two baselines routes were covered in order to let participants familiarize with the task and to have an idea of their distance and time perception. The first part of the questionnaire, consisting of the PANAS (Terraciano et al., 2003), had to be filled twice, before starting and after finishing the two baseline routes. Participants were asked to walk in a straight line, with their usual walking speed, to the red cone in front of them. At arrival, perceived walking time and distance was verbally assessed and recorded. Feedback about the actual data was given at the end of each baseline. The starting point of the first route was then reached, and after the same instructions were given, participants walked the route and completed six tasks. First of all, the PANAS was completed once more; afterwards, perceived distance and time were asked. Then, participants had to report what stroke to them while walking the current route (i.e., colors, noises, buildings). Subsequently, the Perceived Restorativeness Scale was completed, and familiarity with the covered route was assessed. Since the current study is characterized by a within-subject design, each participant followed the identical procedure for six of the eighteen routes (two natural, two built, and two mixed ones), chosen through randomization. At the end of the sixth route, two questions about strategies used in either time or distance estimation were asked. The last part of the study consisted in the completion of the sketch map task where participants were asked to indicate with straight lines the six routes, trying to be as accurate as possible in both location and length, and the green areas on which the experiment was carried out. Finally, participants were thanked and asked to not talk about the experiment with their colleagues.

3.5. Statistical analysis plan

Before starting with the analysis, the potential presence of outliers detected and the assumptions underlying each statistical test were verified. The entire analysis plan was performed with the software R. The current study is characterized by a within subject design, in which the statistical analysis was carried with the aim of comparing the performance of the subjects across conditions. In order to explore the first research question, namely the difference between green and built environments in terms of emotions raised, restorativeness perceived, time and distance estimation, an ANOVA was performed. In other words, the ANOVA was carried out to explore whether green and built environments differently influenced mental spatial representations (in terms of distance and time estimation), restorativeness perception and experienced emotions. In this analysis, distance estimation performance, scores on the restorativeness perception scale and positive and negative affects raised were treated as dependent variables, while the type of environment (green vs built) represented the independent variable. Secondly, a linear regression was conducted with the aim of exploring the predictive power of individual factors (independent variables) on distance estimation and restorativeness perception respectively (dependent variables). Predictors were orderly added one at the time in the following order: gender, age, distance estimation ability at baseline, familiarity with the given environment, attitudes towards orientation tasks, spatial anxiety, connectedness to nature, negative and positive affective states at baseline, negative and positive affective states during exploration and restorativeness perception. Finally, a mediation analysis was carried out in order to explore whether distance estimation abilities and restorativeness perception might be influenced by participants' spatial anxiety and negative affect. In both of these two models run, spatial anxiety represented the predictor and negative affect represented the mediator, while distance estimation performance and restorativeness perception were the dependent variables respectively.

3.6. Results

3.6.1. *ANOVA*

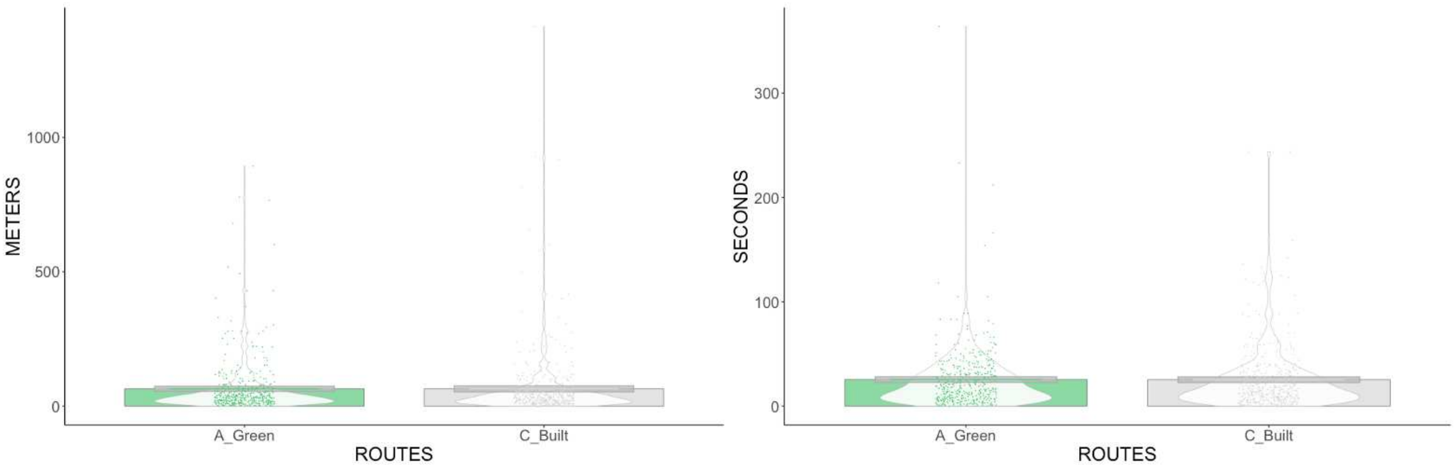
As can be seen in Table 2, the ANOVA results failed to report any significant difference between the two types of environments (green vs built) in terms of distance estimation, time estimation and positive and negative affective states. However, a statistically significant difference emerged for restorativeness perception, which was significantly larger in green environments (M = 62.50, SD = 20.40) than in built environments (M = 43.34, SD = 18.31, F = 303.5, p<.001). Participants' scores distributions are represented in Figure 3.

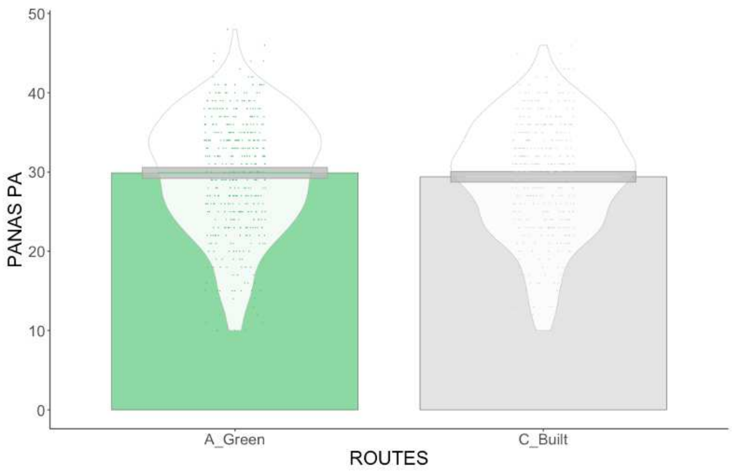
Table 2. Descriptive statistics divided by type of route.

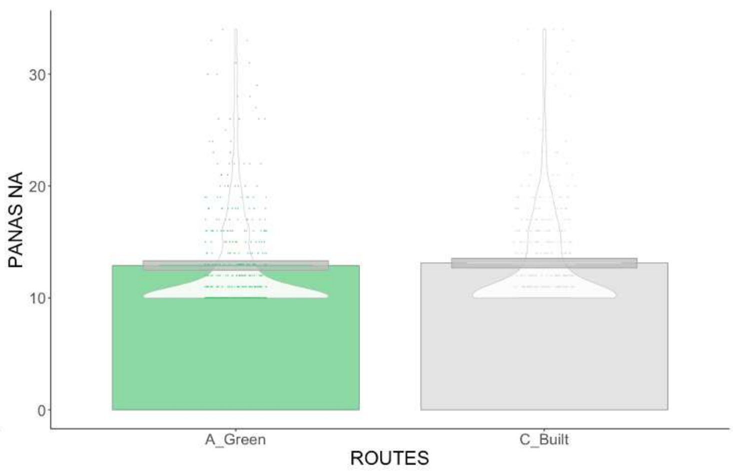
	Green routes		Built routes			
	Mean	SD	Mean	SD	F	*p*
Meters	53.818	67.187	48.778	58.109	1.973	0.161
Seconds	25.612	30.016	25.356	29.387	0.175	0.676
PANAS PA	29.711	7.305	29.220	7.203	3.134	0.077
PANAS NA	12.888	4.547	13.128	4.616	0.947	0.331
PRS-11	**62.504**	**20.397**	**43.342**	**18.314**	**303.5**	**<.001**

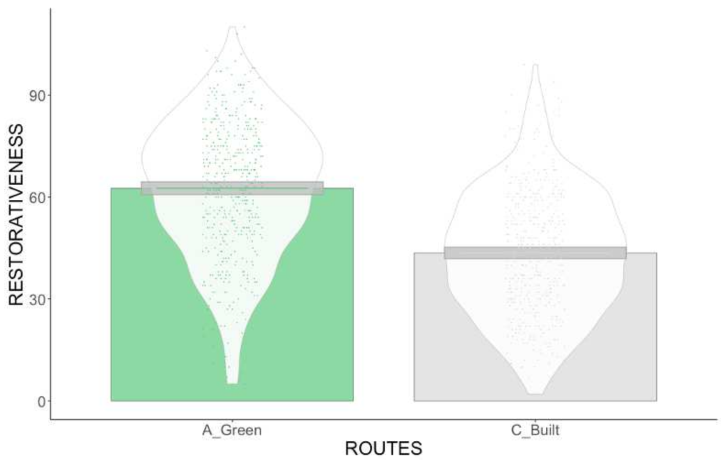
Note: significance in bold.

Figure 3. Scatterplots divided by type of route.









3.6.2. *Linear models and mediation analysis*

As for distance estimation, results show that none of the individual factors are statistically significant predictors (see Table 3). On the other hand, positive affective states raised during experimentation have been found to be a significant predictor of restorativeness perception (b= .22, p<.001). Similarly to the previous model, all the other predictors were found to be not statistically significant (see Table 4).

Table 3. Linear regression model analyzing predictors of distance estimation ability.

	DISTANCE ESTIMATION				
Predictors	*Estimates*	*std. Beta*	*CI*	*standardized CI*	*p*
(Intercept)	-6.59	0.11	-236.06 – 222.89	-0.08 – 0.30	0.955
Gender	-29.37	-0.27	-67.07 – 8.33	-0.63 – 0.08	0.127
Age	1.30	0.03	-6.95 – 9.56	-0.13 – 0.19	0.757
Distance estimation (baseline)	1.66	0.04	-4.20 – 7.52	-0.11 – 0.19	0.578
Familiarity	0.02	0.01	-0.12 – 0.17	-0.04 – 0.06	0.754
QOS	0.50	0.03	-1.79 – 2.78	-0.12 – 0.19	0.671
QAS	1.63	0.11	-0.58 – 3.83	-0.04 – 0.26	0.148
CNS	0.26	0.02	-1.85 – 2.36	-0.14 – 0.17	0.812
PANAS NA (baseline)	-1.88	-0.13	-3.98 – 0.22	-0.28 – 0.02	0.079
PANAS PA (baseline)	1.00	0.05	-1.30 – 3.31	-0.07 – 0.18	0.393
PANAS PA	0.18	0.01	-0.93 – 1.28	-0.06 – 0.09	0.752
PANAS NA	-0.69	-0.03	-2.38 – 1.00	-0.10 – 0.04	0.423
Restorativeness	-0.15	-0.03	-0.39 – 0.10	-0.08 – 0.02	0.238

Table 4. Linear regression model analyzing predictors of restorativeness perception.

	RESTORATIVENESS PERCEPTION				
Predictors	*Estimates*	*std. Beta*	*CI*	*standardized CI*	*p*
(Intercept)	10.76	-0.03	-18.19 – 39.70	-0.33 – 0.27	0.466
Gender	1.17	0.05	-3.28 – 5.61	-0.15 – 0.26	0.606
Age	0.38	0.04	-0.60 – 1.37	-0.06 – 0.13	0.444
Distance estimation (baseline)	0.55	0.07	-0.13 – 1.24	-0.02 – 0.16	0.114
Familiarity	0.03	0.05	-0.01 – 0.07	-0.02 – 0.12	0.181
QOS	0.16	0.05	-0.11 – 0.43	-0.04 – 0.15	0.254
QAS	-0.05	-0.02	-0.32 – 0.21	-0.11 – 0.07	0.679
CNS	0.15	0.05	-0.10 – 0.40	-0.04 – 0.14	0.246
PANAS NA (baseline)	0.16	0.06	-0.10 – 0.42	-0.03 – 0.15	0.219
PANAS PA (baseline)	0.03	0.01	-0.30 – 0.36	-0.08 – 0.10	0.857
PANAS PA	**0.65**	**0.22**	**0.43 – 0.86**	**0.15 – 0.29**	**<0.001**
PANAS NA	-0.27	-0.06	-0.61 – 0.07	-0.13 – 0.02	0.123

Note: significance in bold.

Finally, as can be seen in Figure 4, the mediation analysis shows that there is indeed an indirect relationship between spatial anxiety and distance estimation (measured as the deviation from the correct answer, or absolute error), which is mediated by the negative emotions raised during experimentation.

Differently, no significant relationship was found between spatial anxiety and restorativeness perception (Figure 5), as the experience of negative emotions did not relate significantly with feelings of restoration.

Figure 4. Mediation model exploring distance estimation performance.

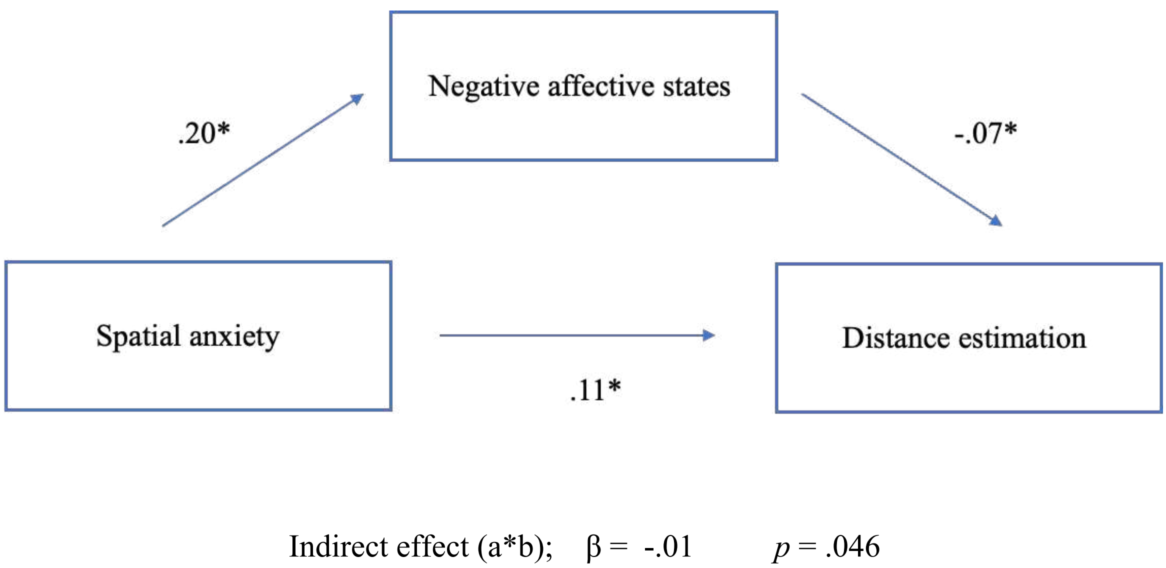
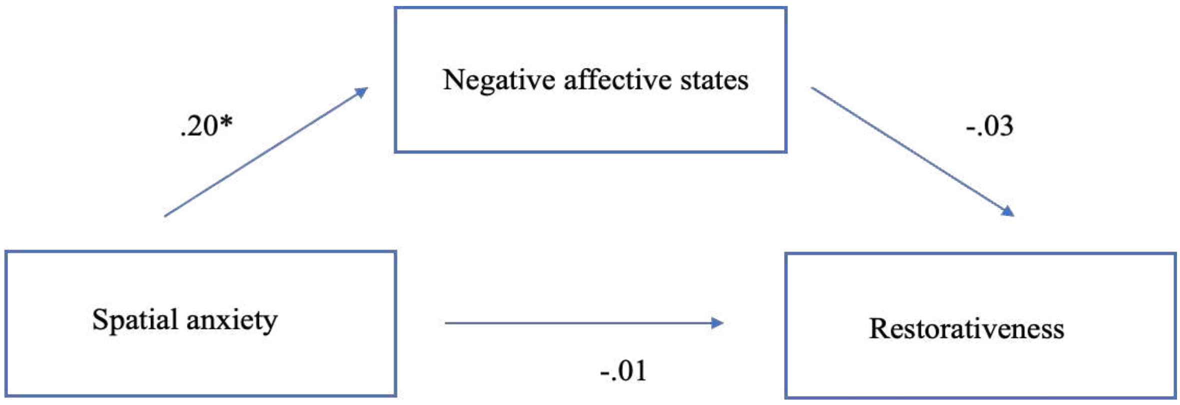


Figure 5. Mediation model exploring restorativeness perception.



Indirect effect (a*b); β = -.01 p = .350

CHAPTER 4
Discussion and conclusion

The present research aimed at exploring the intrinsic relationships intertwining characteristics of the environment, individual differences, mental spatial representations and restorativeness perception. In the first part, the focus was put on analyzing whether there are any differences in spatial performance, emotions, and perception of restorativeness after the navigation in a built or natural urban environment. The characteristics of the environment did not seem to significantly affect any of the measured constructs, besides from the perception of restorativeness, which significantly differed between exposition to a natural environment and a built one. The given results are in line with the idea that nature has an innate restorative potential for humans, which finds its base in the roots of our evolutionary history (Menardo & Bondino, 2021). This finding is also in line with previous literature about the topic, which found self-ratings of restorativeness of natural environments to be significantly larger compared to the ones of a built environment (Gifford, 2014). The novelty added by the current study consists in the observation of perceived restorativeness in natural environments that are although situated in urban settings, proving that the beneficial effects of natural elements are not exclusive of uncontaminated places, but can be easily implemented in cities as well.

Differently from evidence given by previous literature, which suggest that natural environments enhance positive emotions and reduce negative ones (Ulrich et al., 1941; Zuckerman, 1977; Ulrich, 1979), the current study fails to show a significant difference compared to built environments; in fact, no differences in positive and negative affect emerged. These results could be linked to the intrinsic properties of the navigated environments: all of the 18 experimental routes (natural and built) were situated around the Department of General Psychology, where students spend most of their time. The factors of familiarity and individual emotions might have had a role in the completion of the experiment, overstepping the emotional influences of experiencing nature. Furthermore, participants spent a short amount of time in each route, making changes in affective states more difficult.

Moreover, the characteristics of the surroundings also seem to not be related to cognitive performance; both distance and time estimation performances did not significantly differ between the two types of environment suggesting that the larger restorative perception found in experiencing nature might indeed only be restricted to the perceptual facet, not influencing the cognitive domain. Previous studies on the current topic observe an increased performance in tasks requiring attentional and cognitive mechanisms (Tennessen, 1995; Berto, 2005; Berman, 2008) but underline that there is not necessarily a direct relationship between perception of restorativeness and the actual performance. It can be argued that the cognitive task to be completed by participants (estimating distance and time walked) could have been not cognitively demanding enough. The definition of "stressor" or "mental fatigue" and the choice of cognitive task in past literature varies extensively (Pearson & Craig, 2015), making it unclear what threshold it has to cross in order to result in an impaired performance that can consequently be enhanced by the restorative effects of nature. Another possible point of attention is, again, the amount of time spent in the natural environments: as it is unclear whether physiological and cognitive benefits vary with the length of exposure, it could be possible the results are influenced by the limited time spent in nature while walking the routes. Therefore, the assumption that restorativeness perception directly links to an actually increased performance has to be carefully argued, considering the operationalization and tasks implemented in each study independently. In order to be able to generalize and compare results from different studies in fact, it would be necessary to reach an understanding of the amount of cognitive effort needed to be able to observe a beneficial effect of experiencing a natural environment. Moreover, comparing studies that explored different cognitive mechanism might lead to incorrect conclusions about the impact of environments on cognition.

The second part of the study focused on exploring whether and which individual factors have a role in determining distance estimation performance and restorativeness perception. As for the distance estimation, no predictors were found to be statistically significant. Since factors such as familiarity (Piccardi et al., 2011) and gender (Nazareth, 2019) were found to be predictive of spatial performance in previous literature, in the current study these factors were treated as covariate and controlled for as it is known that they might have some sort of influence on cognitive performance.

On the other hand, the model analyzing restorativeness perception showed positive affective states as the only significant predictor. Therefore, the experience of positive emotions during the experimentation, regardless of which environment the route was situated in, led to a higher perception of restorative properties. Drawing from the results of the previous analysis, in this study natural and built environments did not differ significantly in the enhancement of positive emotions, suggesting that the city-like ones were also able to produce positive affective states. Previous studies proved that positive emotions such as fascination can also rise in built environments such as museums (Kaplan et al., 1993) and monasteries (Oullette et al., 2005) and other scenarios, as long as they do not overload the attentive system (Abdulkarim & Nasar, 2014). Therefore, it can be concluded that there might be a series of characteristics or elements, common to natural and built environments, which give rise to positive emotions such as fascination, and consequently to the perception of restorativeness (Karmanov & Hamel, 2008). The fact that all the other factors resulted to not be significant predictors of restorativeness perception is in line with past research: familiarity seem to not correlate with perceived restorativeness (Hernandez et al., 2001; Staats et al., 2003), as well as gender and age (Berto et al., 2007) confirming the intrinsic essence of this specific feeling.

Finally, the third aim was to investigate whether spatial anxiety might be directly or indirectly related to distance estimation abilities and restorativeness perception. The first model, holding negative affective states as mediator variable between spatial anxiety and distance estimation, proves to be statistically significant in all of its relations. Higher scores on the questionnaire measuring spatial anxiety significantly predicted the experience of negative emotions, which in turn significantly influenced the distance estimation performance. Other than the indirect relationship, spatial anxiety and distance estimation seem to hold a direct one as well. Therefore, it is possible to suggest that, in accordance with past literature, spatial anxiety impairs spatial performance also through the rise of negative affective states. These findings are of particular interest when considering the development of healthy environments in which people are required to complete navigation tasks. In fact, these results stress the importance of both anxiety as an independent and individual trait, but also of the negative emotions created by the environment, which could be tackled with the right design choices.

On the other hand, the model having restorativeness as dependent variable does not show a significant relationship between negative affective states and perception of the restorative properties of nature. It also fails to show a direct relationship with the levels of one's spatial anxiety. These results strengthen the concept according to which the perception of restorativeness in a natural environment is intrinsic and innate of the human being, regardless of the emotions experienced at the moment of judgement. It is important to stress that this statement does not apply to situations where emotions are on extremes of a spectrum: previous literature has shown that when a natural environment is perceived as dangerous it loses its restorative component (Herzog & Kutzli, 2002; Van den Berg et al., 2005). This implies that severe emotions such as fear might influence the perception of restorativeness, but this is not the case of the emotions raised in the current study.

Given the importance of the current results, both in confirming pre-existing knowledge and in adding new one, it is also important to underline some of the noticeable limitations of the research. Firstly, the strengths of conducting the experimentation in real environments instead of using virtual reality equipment inevitably implies the intervention of a number of factors that are difficult to control. Between the others, weather conditions might have had an impact on the participants' focus and performance: the experimentation was carried out over the course of a few months, straddling autumn and winter. Therefore, the data was collected with different temperatures, and sometimes with different degrees of lighting: previous literature showed that the characteristics of light significantly influence restorativeness perception (Nikunen et al., 2014) and that weather has a significant impact on one's mood as well as cognition (Keller et al., 2005). In this study, weather conditions have been recorded and will be controlled for in future work that will develop from the current project. Future studies should also take this factor into account, either controlling the experimental conditions or making use of virtual reality to simulate a specific weather.

A second possibly influencing factor is the presence of a variable amount of people during testing, based on the time the experiment was carried out: since the experimental routes were situated around the university buildings some of them were not covered in a linear manner due to the need to avoid other people in the environment. Moreover, there were some instances in which the red cone indicating the end of the route was not visible from the starting point: the lack of a visual reference might have influenced the cognitive process in some way. Other than the practical disadvantages of walking around people, an emotional and motivational component might be in play as well, and future research should consider controlling this aspect, for example using once again virtual reality.

Other than considering the variables which could have been of impact in the current study, multiple implementations would help have a better understanding of the topic: in addition to self-report questionnaires and cognitive tests, psychophysiological measures could also be implemented. Collecting data about changes in heart rate and acceleration and skin conductance would give a more accurate account of how different environments influence one's physical parameters and would also help understand which kind and levels of stress are needed to observe an actual decrease in spatial performance and a consequent improvement after the exposure to natural environments.

In conclusion, the results cumulatively add to previous research on mental spatial representations and spatial performance, being of possible use in multiple psychology fields. Firstly, the understanding of the perception of restorativeness, regardless of the lack of objective cognitive improvements, can keep being implemented in recovery therapies and interventions for a series of psychophysical issues. Moreover, this knowledge gives us the possibility to develop urban environments that are cognitively and emotionally appropriate for dealing with the ever-growing stress experienced in cities.

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