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Physical features, coherence and positive outcomes of person–environment interactions: A virtual reality study

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ABSTRACT

In this study we examined how physical features of a natural setting influenced perceived coherence and three positive outcome variables: preference, pleasure, and (self-reported) restoration. Furthermore, we examined the mediating role of perceived coherence. One hundred thirty-one students evaluated three (virtual) natural environments: an environment with metal furniture, an environment with wooden furniture, and an environment without furniture. Results showed that metal furniture negatively influenced perceived coherence as well as preference, pleasure and restoration, compared to wooden furniture and no furniture. Perceived coherence of the environment with wooden furniture was significantly higher than the environment with metal furniture, but significantly lower than the environment without furniture. We did not find support that preference for, and experienced pleasure and restoration in the environment with wooden furniture differed from the environment without furniture. Perceived coherence mediated the effect of (metal) furniture on preference, pleasure, and restoration. Scientific and practical implications are discussed.

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1. Introduction

Imagine that you have been working intensively on a difficult project for a considerable time. You experience stress and you find it hard to stay focused. You feel the urgent need to restore your energy level. Where would you go? Previous research has shown that individuals who experience stress or mental fatigue benefit more from a stay in a natural setting than an urban setting. Compared to urban environments, nature allows people to restore quicker from (psychological and physiological) stress or mental fatigue (Berman, Jonides, & Kaplan, 2008; Berto, 2005; Kaplan & Kaplan, 1989; Laumann, Gärling, & Stormark, 2003; Ulrich, 1984; Ulrich, Simons, Losito, & Fiorito, 1991), and to experience more positive and less negative affect (Hartig, Evans, Jamner, Davis, & Gärling, 2003; Hartig, Mang, & Evans, 1991). Also, people tend to have a preference for natural settings over urban settings (Laumann, Gärling, & Stormark, 2001; Pals, Steg, Siero, & Van der

Zee, 2009; Purcell, Peron, & Berto, 2001). So, being in a restorative environment (e.g. nature) has three important positive outcomes: 1) restoration from stress or mental fatigue, 2) positive affective responses (such as pleasure), and 3) positive cognitive evaluations of the environment (preference). These outcome variables seem closely connected. For instance several studies have shown that perceived restoration is closely linked to both positive affect (i.e. emotional restoration) and environmental preference (Korpela & Hartig, 1996; Purcell et al., 2001; Staats, Kieviet, & Hartig, 2003; Van den Berg, Koole, & Van der Wulp, 2003). The current study aims to examine the relationship between physical features of the environment, perceived restorative characteristics (which are explained below), and three positive outcomes of person–environment interactions: preference, pleasure, and restoration.

The Attention Restoration Theory (ART; Kaplan & Kaplan, 1989) proposes that natural environments score higher on so-called restorative characteristics, which may explain why nature has a higher restorative quality than urban environments. The first restorative characteristic, *fascination*, implies that your attention is drawn effortlessly by interesting things in the environment, for example a colorful butterfly. When you experience fascination, you

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do not need to actively direct your attention, allowing you to restore from mental fatigue. The second restorative characteristic, *being away*, implies that you are physically and mentally away from your usual surroundings. Empirical research has shown that this characteristic should be split in two sub-components: a physical component (novelty) and a psychological component (escape; Laumann et al., 2001; Pals et al., 2009). *Novelty* implies that you have the opportunity to recover if you are in a different setting than usual that allows you to be free from reminders of your daily obligations. *Escape* refers to being able to free your mind from stressful thoughts. This distinction between *novelty* and *escape* is also theoretically meaningful because being away clearly has two components (i.e. a physical component and a psychological component) that may not always both be present (or absent) in a particular environment. Therefore, in this study we will measure novelty and escape as separate components. The third restorative characteristic described by Kaplan and Kaplan (1989) concerns the amount of *coherence* or harmony between all elements in the environment. Being in a highly coherent environment requires little cognitive effort, which will positively affect restoration. Coherence was originally referred to as *extent*, which was defined in terms of scope and connectedness. Scope refers to the scale of the environment, including the immediate surroundings and the areas that are out of sight or imagined. Connectedness refers to a degree of coherence of relatedness between perceived features or elements in the environment, and if these elements contribute to a larger whole. However, in a later publication Kaplan (2001) has suggested that both scope and connectedness rely to a large extent on the coherence of the environment. Therefore, in this paper we will narrow down the definition of extent to coherence. Finally, a good match between the individual and the environment, or *compatibility*, will enhance restoration. The environment has to be compatible with an individual's inclinations or expectations. Being in a highly compatible environment requires little effort, thus restoration is more likely to occur.

Restorative characteristics (i.e. fascination, novelty, escape, coherence, and compatibility) are perceptions, and provide no clear guidelines on what physical features of environments are of key importance in the restorative process and the positive outcomes of person–environment interactions (i.e., preference, pleasure, and restoration). Coherence, for example, reflects an individual's *perception* of the level of harmony in the environment, and does not indicate what environmental features make the environment more or less coherent. Therefore the restorative characteristics do not provide clear guidelines on how to improve an environment in order to enhance its restorative potential. For practitioners, it is highly important to understand which *physical characteristics* influence perceived restoration, experienced pleasure and preference for the environment, because this reveals how such outcomes can be improved by changing particular physical features.

The current study attempts to integrate the Attention Restoration Theory, a prominent psychological approach, with the physical-perceptual approach. The physical-perceptual approach examines relationships between physical characteristics of the environment and judgments of preference for landscapes (Im, 1984; Shafer, Hamilton, & Schmidt, 1969; Vining, Daniel, & Schroeder, 1984). For example, (the presence of) water or vegetation are physical landscape characteristics that may predict positive evaluations of environments (Bell, Greene, Fisher, & Baum, 2001). An advantage of the physical-perceptual approach compared to the ART is that it does identify objective characteristics of the environment that positively affect esthetic judgments. However, an understanding of *why* people prefer certain physical characteristics is lacking. We propose that by combining both approaches, we can study to what extent different environmental features affect perceived restoration, experienced

pleasure and preference for the environment, and understand why they do so. Therefore, the aim of the study is to combine both approaches and examine the relationship between specific physical features, positive outcomes of person–environment interactions (i.e., preference, pleasure, and restoration), and the restorative characteristics described in the ART.

Based on the ART, we would expect physical features to influence positive outcomes of person–environment interactions (i.e., preference, pleasure and restoration) *via* restorative characteristics. After all, restorative characteristics are based on the interaction between the observer and the environment. Therefore physical characteristics of the environment may influence the perceived restorative characteristics of the environment, in turn influencing preference, pleasure, and restoration. There is some initial evidence that restorative characteristics (i.e. being away and fascination) mediate the relationship between physical components and restoration likelihood. Nordh, Hartig, Hagerhall, and Fry (2009) found that certain *natural* components in small parks (such as lower ground vegetation, bushes, grass, water and trees) increased the restoration likelihood, and these effects were (partially or fully) mediated by the restorative characteristics being away and fascination. Fascination appeared to be associated with the presence of water and the size of the park, whereas being away appeared to be associated with the presence of grass, bushes, trees, and with the size of the park (Nordh et al., 2009). Nordh et al. (2009), however, did not systematically manipulate the physical components of the parks. Therefore the individual influence of each (physical) component on restoration and other variables such as preference and pleasure, remains unclear.

In the current study we are interested in the effect of physical characteristics on restorative characteristics and pleasure, preference, and restoration. As a first step we will focus on (perceived) coherence, one key restorative characteristic of the ART with a strong physical component. Previous research showed that coherence is a significant predictor of preference for the environment (Herzog, 1989; Strumse, 1994). We are interested to find out whether this preference for natural environments and the two other positive outcome variables pleasure and restoration, are *caused* by (or influenced *via*) perceived coherence. We are interested to see what happens to experienced pleasure, preference and restoration if perceived coherence of natural settings is disrupted when unnatural elements are introduced.

Laumann et al. (2001) found that natural scenes (i.e. a forest, a sea area, and mountain scene), where only natural elements are visible, were perceived as more coherent compared to an urban setting. Although it has not been tested empirically, one may argue that the natural scenes are more coherent, *because* all natural elements (trees, plants, grass, mountains, water) go well together. If this is indeed the case, it would be advisable to design environments where only natural elements are visible and let existing natural settings as they are. However, in many instances planners also want to meet the needs and wishes of people visiting natural areas, often leading to the placement of human-made objects such as park benches and garbage bins. It is quite imaginable that the introduction of these human made objects may have a negative impact on the perceived coherence of the setting, leading to a decrease of its restorative potential. But what if the objects (for example the benches in the park) are designed in a way to harmonize optimally with the environment? Will this preserve the perceived coherence of the environment, and pleasure, preference and restoration?

The first aim of the current study is to manipulate perceived coherence of a natural setting and examine its effect on restoration, pleasure and preference, by introducing two different designs of street furniture. The second aim is to examine the mediating role of

perceived coherence on the effect of these human-made objects on restoration, experienced pleasure and preference for natural environments. This will provide us with a first indication of whether physical features indeed affect perceived restoration, experienced pleasure and preference for environments *via* restorative characteristics.

To examine causal relationships between physical features, restorative characteristics, and perceived restoration, experienced pleasure and preference for the environment, ideally, researchers have to systematically manipulate aspects of the environment, while keeping the environment and all other factors constant. We argue that Virtual Reality is a very useful tool to conduct these kinds of experiments for restorative environments research. Virtual Reality (VR) is an artificial environment generated by computer software, presented in such a way that the user is able to interact with the environment similar as with a real environment. VR has two major advantages. First, researchers can exert more control in VR than in real settings. Second, it allows researchers to systematically manipulate some features of environments while keeping all other factors constant. Moreover, due to recent technological developments, VR can simulate highly realistic environments, so experiences in virtual environments can be generalized to real environments. Indeed, previous research showed that VR is a valid tool for restorative environments research, as it elicits similar effects on perceived restorative characteristics, self-reported restoration, preference, and pleasure as comparable real environments (Bishop & Rohrmann, 2003; De Kort, 2003; Pals, 2011).

In the current study we will use virtual reality to examine how the presence and the design of street furniture (fences, benches, and garbage bins) in a natural setting influences perceived coherence of this environment and preference, restoration and pleasure. We will compare three (virtual) environments: a natural environment with furniture that disharmonizes with the environment (metal furniture), a natural environment with furniture that harmonizes with the environment (wooden furniture), and a natural environment without furniture. We expected that perceived coherence, and in turn restoration, preference and pleasure are highest in the natural environment without furniture, lowest in the environment with metal furniture, and expect that the natural environment with wooden furniture will take a midpoint position (hypothesis 1). Additionally, we expect that the effect of the physical features we manipulated in the environments (i.e. the

street furniture) on restoration, preference, and pleasure will be mediated by perceived coherence (hypothesis 2).

2. Method

2.1. Participants and design

A total of 131 students participated in this study (48 men, 83 women; mean age 21.06; range 18–29 years) in exchange for course credits. The experiment had a within-subjects design with three virtual environmental conditions: an environment with metal furniture, a natural environment with wooden furniture, and a natural environment without furniture. We counterbalanced the order in which participants were exposed to the environments, in a way that each environment was once presented first, once second, and once last. In this way there were three order conditions: Wood – Metal – Control, Metal – Control – Wood, and Control – Wood – Metal. Participants were randomly assigned to the order conditions.

2.2. Virtual environment

We conducted this study in a Virtual Reality Theatre. A virtual natural environment was used as a starting point for this study (see Fig. 1). The environment contained grass, plants, bushes, trees, and water. A soil path circled through the area. To make the environment more dynamic, we included some (moving) virtual animals visible (e.g. butterflies) and bird sounds were audible. The objects in the virtual environment (e.g. trees, bushes) were modeled in a 3D computer program (3dmax). The textures of the virtual objects were based on pictures of real objects. The natural environment was based on a design of a (yet to be built) park in the Netherlands.

Three-dimensional images of the virtual environments were projected onto a wide cylindrical screen. The transparent screen was approximately ten meters wide and 2.80 m high, and surrounded participants with a 135° field-of-view. *Shutter glasses* created a three-dimensional life-like experience of the virtual environments.

2.3. Manipulation of physical features: Furniture

We expected that introducing unnatural elements in a natural environment is likely to disturb the perceived coherence and

Fig. 1. The virtual natural environment without furniture.

Fig. 2. The virtual natural environment with wooden furniture.

thereby perceived restoration, experienced pleasure and preference for the environment. However, perceived coherence and perceived restoration, experienced pleasure and preference for the environment might be preserved when the objects that are introduced are of a design that harmonizes with the environment. To test this three (virtual) environments were created: one natural environment without furniture, and two experimental environments in which we introduced different types of furniture: 1) wooden furniture that harmonized with the environment and 2) metal furniture that did not harmonize with the environment. We argued that furniture that is perceived as unnatural is more likely to be disharmonious with a natural setting, and furniture that is perceived as natural is more likely to harmonize with a natural setting. We used three types of furniture in each condition: benches, fences, and garbage cans. We manipulated the naturalness of the shape and the naturalness of the texture of the furniture. For the unnatural furniture we used shiny metal textures, smooth surfaces, and regular shapes (see Fig. 2). For the natural furniture we used raw wooden textures, uneven surfaces, and irregular shapes (see Fig. 3).

2.4. Procedure

Upon arrival participants filled out an informed consent form. Participants were seated on a 3-row stage in front of the screen. Participants were taken on a (passive) 12 min virtual tour in each environment, covering a distance of approximately 600 virtual meters. After each tour participants filled out questions about perceived coherence, restoration, preference, and pleasure. Finally participants filled out the manipulation check items and some items on demographics (i.e. age, gender).

2.5. Measures

2.5.1. Perceived coherence

We used three items from the Perceived Restorative Characteristics Questionnaire (PRCQ; Pals et al., 2009) to measure perceived coherence of the environments. The items were adapted slightly so they referred directly to the virtual environments. Participants rated on a Likert scale, ranging from 1 (totally disagree) to 7 (totally agree), their level of agreement with the following items:

Fig. 3. The virtual natural environment with metal furniture.

“Everything I saw in the virtual environment went well together”, “Everything I saw in the virtual environment fits there”, and “Everything I saw in the virtual environment belonged there”.

2.5.2. Preference, pleasure, and restoration

We have used an attitude scale to measure people's preference towards the environments. An attitude is considered to be “a person's degree of favorableness or unfavorableness with respect to a psychological object” (Ajzen & Fishbein, 2000). In this case the evaluated psychological object is the environment. Preference for the environments was measured using three seven-point semantic differentials: (I find the virtual environment) unattractive – attractive, negative – positive, and not enjoyable – enjoyable. The preference scale was reliable for all three environments ($\alpha > .85$, see Table 1).

Pleasure is operationalized as an affective response to the environment. Participants indicated on four seven-point semantic differential items to what extent they experienced pleasure when they saw the virtual environment: sad – happy, annoyed – pleased, dissatisfied – satisfied, bored – content. This scale was based on a two-dimensional model of affect by Mehrabian and Russell (1974). The pleasure scale was reliable for all three environments ($\alpha > .83$, see Table 1).

Restoration was measured using a self-report measure, based on work by Staats and colleagues (Staats et al., 2003). Participants rated on a seven-point Likert scale their level of agreement with the following five items: “In the virtual environment I was able to concentrate well”, “In the virtual environment I was able to focus on myself”, “In the virtual environment I was able to release all tension”, “In the virtual environment I was able to relax”, and “In the virtual environment my energy level got renewed”. The restoration scale was reliable for all three environments ($\alpha > .77$, see Table 1). The correlations among pleasure, preference and restoration are high ($.49 < r < .54$, $p < .01$; see Table 2).

2.6. Manipulation checks

At the end of the experiment participants evaluated the naturalness of the furniture, and how well the furniture harmonizes with the virtual environment (both on a single item seven-point Likert scale). Participants evaluated the wooden and metal furniture (the benches, the garbage bins, and the fences) separately. We calculated mean scores for naturalness and harmonizing for the wooden furniture by taking together the scores for the wooden benches, the wooden garbage bins, and the wooden fences. In the same way we computed mean scores for naturalness and

Table 1

Mean, standard deviation and Cronbach's alpha scores for perceived coherence and preference, pleasure and restoration for the environments with wooden furniture, metal furniture, and no furniture ($N = 131$).

	N items	Environmental conditions								
		Wooden furniture			Metal furniture			No furniture		
		M	SD	α	M	SD	α	M	SD	α
Coherence	3	4.73	1.31	.88	3.98	1.54	.90	5.20	1.22	.89
Preference	3	5.20	1.22	.85	4.75	1.38	.89	5.23	1.22	.87
Pleasure	4	4.57	1.15	.84	4.23	1.15	.85	4.45	1.12	.83
Restoration	5	4.36	1.03	.79	4.21	1.05	.79	4.41	1.03	.77

harmonizing of the metal furniture. Both scales were reliable for both types of furniture ($\alpha > .79$). The wooden furniture was indeed perceived as more natural ($M = 5.53$) compared to the metal furniture ($M = 2.38$, $F(1, 129) = 378.38$, $p < .001$), and participants stated that the wooden furniture harmonized better with the virtual natural environment ($M = 5.66$) than the metal furniture ($M = 2.28$, $F(1, 129) = 469.65$, $p < .001$), suggesting that our manipulation was successful.

2.7. Statistical analyses

Repeated measures analyses were conducted in SPSS to examine the main effects of furniture on perceived coherence and pleasure, preference, and restoration. We conducted multilevel analyses in MLwin to examine these effects in more detail. For each of the three contrast effects (wood – control, metal – control, and wood – metal), we tested whether coherence mediated the effect of furniture on pleasure, preference, and restoration. Following Baron and Kenny (1986), we first tested whether the three assumptions for conducting mediation analyses were met: a) there has to be an effect of furniture on the mediator variable, b) there has to be an effect of furniture on the dependent variable, and c) there has to be an effect of the mediator variable (i.e. coherence) on the dependent variable (i.e. preference, pleasure, or restoration). When these preconditions were met, we tested whether coherence indeed mediated the influence of furniture on pleasure, preference, and restoration. We will only report those cases that meet all three assumptions. We first tested Model 1 in which we examined the influence of furniture on coherence and the three dependent variables: preference, pleasure, and restoration, respectively. To test for mediation, in Model 2 we added *coherence* to Model 1 for those cases for which mediation could be established, as explained above.

Fig. 4. The interaction effects of order and environment on perceived coherence.

Table 2

Correlations between coherence and three dependent variables: Pleasure, preference, and restoration.

	Pleasure	Preference	Restoration
Pleasure	—	.49 ^a	.47 ^a
Preference		—	.54 ^a
Restoration			—

^a Correlation is significant at $p < .01$.

We repeated this step for all three dependent variables: pleasure, preference, and restoration. To test the significance of the mediation effects we inspected the test outcomes in two steps: (A) is the difference in the model fit (represented by the deviance scores) significant? These differences in model fit follow a chi-square distribution. (B) In the case of differences in model fit, is the reduction of the effects of the three contrasts from Model 1 (without the mediating variable Coherence) to Model 2 (including the mediating variable Coherence) on the three dependent variables (pleasure, preference, and restoration) substantial?

3. Results

3.1. Order effects

We included order as a variable in our model to test for order effects. We found significant main effects for order, and significant interaction effects between order and environment. As can be seen in Fig. 4 the first environment that was evaluated by the participants scored higher on perceived coherence compared to the second or third environment. We interpreted this as a “wow” effect, as most participants never saw a virtual environment before. If we look more closely into the interaction effect between order and environment we see that perceived coherence of the environment with wooden furniture and the environment with metal furniture depended on the order in which the environments were presented (see Fig. 4). Perceived coherence for the environment with metal furniture was lower when this environment was evaluated after the environment with wooden furniture. This was the case in the following two order conditions: Wood – Metal – Control and Control – Wood – Metal. When the environment with metal furniture was presented first, there were hardly any differences in perceived coherence between the three environmental conditions. Furthermore, perceived coherence of the control condition seemed consistent over all order condition.

For pleasure, preference, and restoration we found similar patterns of results. Importantly, despite these order effects, we still found main effects for environment, suggesting that the effect of furniture on coherence is strong enough to overrule these order effects. We will not describe these interaction effects in detail and focus on the main effects.

3.2. Perceived coherence

Repeated measures analysis showed that there was a difference in perceived coherence between the three conditions ($F(2, 127) = 50.19, p < .001$). The multilevel analysis showed that all contrasts (wood – control, metal – control, and metal – wood) were significant (see Table 3). These results confirmed our first hypothesis. The environment with wooden furniture scored significantly lower on perceived coherence than the environment without furniture (control condition). Also, perceived coherence was significantly lower in the environment with metal furniture

Table 3

Multilevel models of the effects of furniture type on coherence and pleasure, preference and restoration (Model 1), and the effects of furniture on pleasure, preference and restoration with coherence as mediator variable (Model 2).

	Model 1			Model 2			χ^2 ($df = 2$)
	<i>B</i>	<i>SE</i>	<i>t</i>	<i>B</i>	<i>SE</i>	<i>t</i>	
Coherence							
Wood – Control	–0.45	0.14	–3.27*				
Metal – Control	–1.78	0.14	–12.99*				
Metal – Wood	–0.073	0.14	–5.33*				
Deviance	1296.87						
Preference							
Wood – Control	–0.06	0.10	–0.59	0.13	0.08	1.65	
Metal – Control	–0.51	0.10	–5.38*	–0.06	0.09	–0.72	
Metal – Wood	–0.46	0.10	–4.79*	–0.20	0.08	–2.39*	
Coherence				0.38	0.04	9.85*	
Deviance	1124.66			1013.57			111.10*
Pleasure							
Wood – Control	0.12	0.09	1.33	0.20	0.09	2.28*	
Metal – Control	–0.22	0.09	–2.49*	–0.01	0.10	–0.05	
Metal – Wood	–0.34	0.09	–3.82*	–0.20	0.09	–2.27*	
Coherence				0.18	0.04	5.17*	
Deviance	1071.15			1045.60			84.08*
Restoration							
Wood – Control	–0.05	0.08	–0.56	0.08	0.07	1.15	
Metal – Control	–0.21	0.08	–2.44*	0.14	0.08	1.70	
Metal – Wood	–0.16	0.08	–1.87	0.05	0.08	0.68	
Coherence				0.28	0.04	8.11*	
Deviance	1010.38			926.31			25.55*

Note: *Significant at $p < .05, N = 131$.

compared to the control condition and compared to the environment with wooden furniture.

3.3. Preference, pleasure, and restoration

Repeated measures analyses revealed that there were significant differences in preference ($F(2, 128) = 23.38, p < .001$), pleasure ($F(2, 127) = 7.14, p < .001$), and restoration ($F(2, 128) = 4.86, p < .01$) between the three environments. As can be seen in Table 3, we did not find statistically significant differences in preference, pleasure, and restoration between the environment with wooden furniture, compared to the environment without furniture. Participants evaluated the environment with metal furniture significantly lower on preference, pleasure, and restoration than the environment without furniture. The environment with metal furniture was also significantly less preferred and evaluated as less pleasurable than the environment to wooden furniture. We did not find statistically significant differences in restoration between the environment with metal furniture and the environment with wooden furniture.

3.4. Perceived coherence as a mediator

As explained above, we found an effect of furniture on coherence, which means that the first assumption to establish mediation is met. Furthermore, we found that, compared to the condition without furniture, metal furniture influenced preference, pleasure, and restoration, which means that the second assumption is met for all three dependent variables. As a next step we added coherence to the model to check if the third assumption is met, and tested whether coherence mediated the effect of metal furniture on pleasure, preference and restoration. As can be seen in Table 3, Model 2 shows a significant effect of coherence on preference, pleasure, and restoration, which means that the third assumption is

met as well. As all three assumptions are met, we can now look whether coherence mediates the effects of furniture on preference, pleasure and restoration. We will look at those contrasts that are significant in Model 1. If an effect that appears significant in Model 1 is no longer significant when coherence is added (Model 2) we conclude that coherence mediates the effect of metal furniture on pleasure, preference and restoration.

We first looked at the contrast between the environment with metal furniture and the control condition (no furniture). We found that when coherence was added to the model, the negative effects of metal furniture (compared with the condition without furniture) on all three dependent variables (preference, pleasure, and restoration) were no longer significant. This implies that coherence fully mediated the negative effect of metal furniture (compared with the condition without furniture) on preference, pleasure, and restoration.

The contrast effects between the environment with metal furniture and the environment with wooden furniture on preference and pleasure are still significant in Model 2 (when coherence is controlled for) but the effects are less profound. This suggests that coherence partially mediates these contrast effects of metal versus wooden furniture on preference and pleasure.

4. Discussion

The aim of this study was to get a better understanding of how specific physical features influence restorative characteristics as described in the ART (Kaplan & Kaplan, 1989), and three positive outcomes of person–environment interactions: pleasure, preference, and restoration. Most studies on restorative environments compared urban environments with natural environments. These environments differ on a great number of aspects, which makes it hard to conclude which environmental features cause differences in restoration. In the current study we used a new way to examine positive outcomes of person–environment interactions, as reflected in pleasure, preference and perceived restoration. We used one (virtual) environment as a starting point and systematically manipulated features of the very same environment. This makes it possible to draw conclusions about causality and identify what specific features influence pleasure, preference and restoration.

As a first step in examining the relationship between physical characteristics, restorative characteristics, and pleasure, preference and restoration, we focussed on perceived coherence, one of the key restorative characteristics described in the ART (Kaplan & Kaplan, 1989). We examined whether the perceived coherence and pleasure, preference and restoration in a natural environment were influenced when we introduced two styles of furniture, reflecting a natural and unnatural design. We argued that introducing elements that disharmonize with the natural setting might weaken the perceived coherence of the setting, while introducing elements that harmonize with the natural setting might preserve the perceived coherence of the setting. We expected that the diminished perceived coherence would, in turn, diminish pleasure, preference and restoration. The second aim of the study was to examine the *mediating* role of coherence on the relationship between physical features and pleasure, preference and restoration. We argued that physical features of environments influence pleasure, preference and restoration *via* restorative characteristics, in this case perceived coherence. More specifically, the presence of unnatural or disharmonizing elements in a natural setting may negatively influence coherence and thereby diminish the occurrence of pleasure, preference and restoration.

The results of the study confirmed our hypotheses. We found that placing furniture (either wooden or metal) in a natural environment diminishes the perceived coherence of the environment.

In addition, metal furniture in a natural environment negatively influenced self-reported restoration, experienced pleasure, and preference evaluations compared to a natural environment without or with wooden furniture. When furniture of a natural design (i.e. wooden furniture) was introduced in a natural setting, perceived coherence was significantly higher than a natural environment with metal furniture, but significantly lower than a natural environment without furniture. An explanation for this finding could be that man-made objects (i.e. the furniture) may be perceived as unnatural because it is still a man-made and thus less harmonizing with a natural setting compared to a setting without man-made objects. Yet, the wooden furniture may be perceived as more natural compared to the metal furniture, due to the naturalness of the material and shape. We did not find support that self-reported restoration, experienced pleasure, and preference evaluations of the environment with the natural design furniture (i.e. wooden furniture) differed significantly from the environment without furniture. Thus, from this study we can conclude that placing unnatural (metal) furniture in a natural environment negatively influences perceived coherence and pleasure, preference and restoration. Placing natural (wooden) furniture does influence perceived coherence but preserves self-reported restoration, experienced pleasure, and preference evaluations of the environment.

We also found initial support for the mediating role of perceived coherence on the effect of metal furniture on pleasure, preference, and restoration. Therefore it is likely that the introduction of unnatural elements in a natural setting negatively affects preference, pleasure, and restoration *via* perceived coherence. In this study we only examined the mediating role of coherence in natural settings. So we cannot (yet) conclude that *coherence* also mediates the restorative experiences in other settings. Future studies could also examine the mediating role of coherence in relevant other settings, such as attractive built settings. This could also shed more light on the role of *naturalness* and the interplay between perceived naturalness and perceived coherence in environments.

We have focused on three positive outcomes of person–environment interactions: preference, pleasure and restoration. These three variables reflect a cognitive response (preference), an affective response (pleasure), and a (self-reported) restorative response elicited by the interaction with a restorative environment. As expected, placing metal furniture in a natural setting negatively influenced all three variables. Additionally, similar to other studies (Korpela & Hartig, 1996; Purcell et al., 2001; Staats et al., 2003; Van den Berg et al., 2003), the data showed that the three types of outcomes of person–environment interactions are related.

Future research is needed to further test our model, and study to what extent other variables may mediate the effect of physical features on pleasure, preference and restoration as well. In this study we have manipulated the naturalness of furniture in a natural environment and found that this influenced perceived coherence of the environment. The aesthetics of the furniture may also have played a role here. Research shows that people have a strong preference for natural environments over urban environments (Laumann et al., 2001; Pals et al., 2009; Purcell et al., 2001), thus it is likely that people will also have a preference for natural objects over unnatural objects. The esthetic quality of the furniture may have had an additional effect on preference, pleasure and restoration. However, it is unlikely that the esthetic quality of the furniture provides an alternative explanation for our findings, as otherwise we would not have found effects of the furniture on coherence and support for the mediating role of coherence.

In the current study we manipulated both the shape and the texture of the furniture. Therefore it remains unclear whether the effect of the furniture on perceived coherence and pleasure,

preference and restoration was caused by the material or the shape, or the combination of both. A study by Bar and Neta (2006) showed that people have a preference for curved visual objects. It is possible that people preferred the setting with the metal furniture less, because the shape of this furniture is less curved compared to the wooden furniture. The curved shapes of the furniture might harmonize better with the shapes of the other (natural) elements in the environment which may increase perceived coherence. Future research could be aimed at examining the effect of textures and shape of furniture on perceived coherence and pleasure, preference and restoration of the environment separately. Additionally, future research should attempt to examine how other physical characteristics might influence perceived coherence and pleasure, preference and perceived restoration.

In this study we have used self-report measures of pleasure, preference and restoration. Future studies need to replicate our findings using additional measurements, such as physiological measures of restoration or implicit measures of pleasure, preference, and restoration.

This study has important theoretical and practical implications. We have shed some light on the causal relationship between specific physical features, restorative characteristics, and pleasure, preference and restoration, and thereby contributed to the theoretical development regarding restorative environments. The current study provides initial support for our proposition that the presence of unnatural objects in a natural setting diminishes perceived coherence, and thereby negatively influencing pleasure, preference, and restoration. We have focused on one restorative characteristic: perceived coherence. To further develop the Attention Restoration Theory and understand how physical features relate to restorative characteristics and positive outcomes of person–environment interactions, the influence of other restorative characteristics should be examined as well. Nordh et al. (2009) found some initial evidence that fascination and being away mediated the effect of physical components on restoration likelihood, however, they did not systematically manipulate physical components. So it is not clear which physical component caused effects on restoration likelihood. This is an important topic for future research.

We found that the presence of unnatural elements (i.e. furniture) in a natural setting can *diminish* perceived coherence and thus pleasure, preference, and restoration. This is an important finding, because it can help us understand how we can protect or design restorative environments. It is also interesting to explore how the pleasure, preference, and restoration can be *enhanced* in a particular environment. For example, previous research shows that urban settings are less restorative, elicit less positive affect and are less preferred than natural settings. Nowadays, the majority of people live in cities, so it is important to find out how positive outcomes of person–environment interactions of peoples most immediate settings can be enhanced. To find out how this can be accomplished, future research could focus on urban settings and other types of environments, and attempt to examine how systematically manipulating physical elements affect positive outcomes of person–environment interactions in these environments.

In this study we found that introducing unnatural elements in a natural setting negatively influences perceived coherence and pleasure, preference, and restoration. This however, does not imply that the opposite is true for urban settings. Hernandez and Hidalgo (2005) found that the presence of natural elements in urban environments positively influenced perceived restorativeness. Hernandez and Hidalgo (2005) did not report the scores on each separate (perceived) restorative characteristic, but they reported an overall score which they called “general” restorativeness. So it remains unclear how for example the natural elements influenced

perceived coherence of the urban settings. It could be that introducing natural elements in an urban setting negatively influences coherence, but positively influences other restorative characteristics, for example escape and fascination, which in turn could enhance pleasure, preference and restoration in that environment. Future research could examine whether this is indeed the case. For example, it might be interesting to test whether introducing wooden furniture in an urban virtual environment affects indicators of positive outcomes of person–environment interactions.

Practical implications of this study are that practitioners involved in designing environments should pay special attention to factors that influence perceived coherence and different indicators of positive outcomes of person–environment interactions. Although some landscape architects or urban planners may already (intuitively) consider these factors in their design, we have found initial empirical evidence that pleasure, preference and restoration in an environment can deteriorate when elements that disharmonize with the environment are introduced. An obvious implication is that landscape architects or urban planners should especially be aware of the diminishing effect of placing elements in a surrounding where they become disharmonious (e.g. unnatural design furniture in parks), but the current findings may also be relevant for interior designers, as perceived coherence and other restorative characteristics are likely to play an important role in indoor places as well.

In this study we took a first step in systematically examining how physical features are related to positive outcomes of person–environment interactions (i.e., pleasure, preference, and restoration). Knowledge about what and how specific features of environments positively influence restorative experiences is very valuable as it can be used to design healthy environments.

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