Surprise, arousal, and pleasantness in movement between spaces

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Abstract

In one theory as perceived surprise increases, arousal increases and pleasantness increase up to a point, after which it levels off or decreases. However, studies indicate that for environmental response, arousal and pleasantness are independent of one another. Those studies did not examine movement through spaces. We sought to study response to surprise as experienced in moving between pairs of offices. We created three simulated offices (A, B, and C) and nine virtual walks between each possible pair, such that some walks had no physical differences (AA, BB, and CC), some had moderate physical differences (AB, BA, BC, CB), and some had larger physical differences (AC, CA). A test confirmed that the manipulations worked as planned. To measure arousal and pleasantness, we created two three-item scales (each in English and Italian). We assigned participants in the US (121 adults, 47 men, 84 men) and Italy (67 adults, 34 men, 33 women) at random to either a within-group condition or one of the three between-group conditions (Low Surprise, Medium Surprise, or High Surprise). We used the within group to test the Confirmatory factor Analysis model (CFA), and we used the between group conditions to test the effects of surprise. The CFA found the two three-item scales fit the multi-level model well. We combined the items into two three-item scales for the analysis of effects of surprise. Both arousal and pleasantness increased from low to moderate surprise, but decreased from moderate to high surprise. The results suggest value in studying dynamic environmental experience.

Key words: Aesthetics; dynamic perception; environmental preference; sequential experience; affective response.

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Physical properties of places or perceptions of them affect pleasantness (Kaplan & Kaplan, 1989; Nasar, 1994), but designers and researchers agree that some perceptions and pleasantness arise from movement between environments (Lozano, 1974; Berlyne, 1971; Heft & Nasar, 2010). Designers may use contrast between spaces (in such elements as size, lighting, texture, or shapes) to create interest. For example, Tadao Ando's Church in Water has people enter a large windowed nave facing nature through a narrow dimly lit, long corridor; and Frank Lloyd Wright's Falling Water has people enter a large well-lit library through a confined dark corridor. For researchers, these differences may evoke surprise, which they define as a mismatch between what one experiences in a place and what one anticipated for it (Berlyne, 1971). An environment can set up an expectation for the next. As the perceived discrepancy between two increases, surprise increases, and that surprise affects arousal and pleasantness (Berlyne, 1971; Huron, 2006).

Two theories, one more perceptual and the other more perceptual-cognitive, predict similar effects of surprise on uncertainty, and arousal, but a different effect on pleasantness for high arousal. The perceptual theory predicts a decrease in pleasure for high arousal, while the perceptual-cognitive theory predicts a continued increase (in a safe condition).

In both theories, the stimulus conflict of surprise evokes uncertainty and has arousal potential that motivates the observer to try to reduce the uncertainty and make sense of the environment (Berlyne, 1972; Wohlwill, 1976). Theories of intrinsic motivation agree that surprise evokes uncertainty, arousal, and curiosity, that motivate exploratory or avoidance behavior (Deci & Ryan, 1985). Berlyne's (1972) more perceptual-based theory predicts that pleasantness increases with surprise up to a point (an optimal level) after which it levels out and decreases (Figure 1).

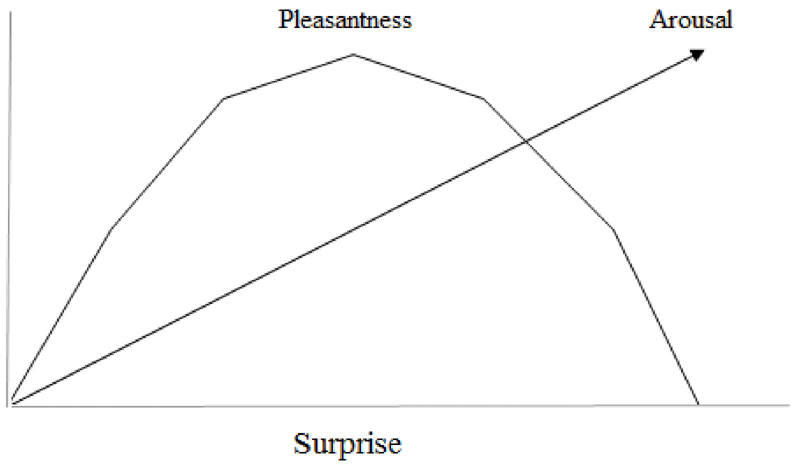

Figure 1. Theoretical relation of arousal and pleasantness to surprise (Berlyne, 1972; Wohlwill, 1976).

This occurs because a primary reward system generates positive affect as arousal potential starts to increase. However, a secondary system activates at a higher level of arousal, and it generates negative affect as arousal potential increases. In theory, the two systems together produce an increase in hedonic tone (pleasantness) from neutral to positive as surprise increases, but a leveling off and shift from positive to negative as surprise continues to increase beyond an optimal level. Studies of responses to the built environment support the theory (Akalin, Yildirim, Wilson, & Kilicoglu, 2009; Nasar, 1987; Wohlwill, 1968), but some studies have found a linear (Heath, Smith, & Lim, 2000) or U-shaped relation of pleasantness to arousal (Martindale, Moore, & Borkum, 1990), although the Martindale et al. (1990) study examined responses only to polygons and art.

According to the perceptual-cognitive theory, evolution has favored the ability of humans to anticipate future information. However, because humans cannot know what will happen next, uncertainty accompanies anticipation. In this theory, surprise results from a failure to anticipate the future, and that failure creates a rapid reaction of uncertainty, arousal, and fear. That rapid reaction arouses a slower cognitive appraisal to make sense of the potential danger (Huron, 2006). Up to this point, the theory agrees with the perceptual theory. However, it then posits that the slower appraisal can replace the rapid negative reaction with a neutral or positive one. If it finds the fear unwarranted, it sends a signal to the brain to stop the fear response. That subsequent appraisal relates both to the perceived harm or benefit of the outcome and to the contrast between the quick and slower reaction (Gaver & Mandler, 1987; Solomon, 1980). Pleasurable surprise mixes the initial fear of the unexpected features of the environment with the slower appraisal that the environment is safe. As the rapid uncertainty, arousal and fear increases, the contrast between the rapid reaction and the slower appraisal of the situation as non-threatening should increase, and with it, pleasantness should increase.

Humans have three kinds of responses to surprise, danger, and fear: *fight*, *flight*, or *freeze,* each of which can lead to a specific physically-based pleasurable response: *laughter*, *awe*, or *frisson* (Huron, 2006). A *fight* reaction occurs in response to a threat from another animal or something entailing a large expenditure of physical energy, such as a loud sound or an abrupt change. For example, the reaction includes *piloerection* (or goosebumps, like when the hair on the back of your arms goes up). If the slow appraisal judges the animal, sound or change as safe, the piloerection becomes the pleasurable chill of frisson. *Flight* and *laughter* (a kind of panting) occurs in response to a momentary fear, such as tripping but not falling. *Freeze* occurs in response to a sustained or fixed danger, such as encountering a cliff. If the danger appears manageable, the freeze (gasp) becomes *awe*. Regardless of the type of fear and response, as the surprise and rapid fear increases relative to the slower cognitive appraisal of safety, pleasure increases. In contrast to Berlyne's (1972) theory, pleasantness continues to increase for high arousal.

Of the three kinds of response, we believe the flight/laughter response may best fit responses to the physical environment. In movements through typical neighborhoods, homes, offices, commercial centers, or places of worship, if one encounters a surprise, the rapid fear reaction is small and short-lived, because the subsequent appraisal quickly recognizes the new environment as non-threatening.

The research and theory suggest three questions, one about the relationship between pleasantness and arousal, one about the relationship of arousal to environmental surprise, and one about the relationship of pleasantness to environmental surprise. For preference and arousal, the theories differ in their predictions. While Huron (2006) and Berlyne (1971) suggest a relation between pleasantness and arousal, Russell found them as independent of one another (Russell, 1980; Russell, Lewicka, & Nitt, 1989; Russell & Pratt, 1980). For arousal and surprise, both Berlyne (1971) and Huron (2006) suggest that arousal would increase linearly with surprise. Finally, for pleasantness and surprise, Huron (2006) predicts that pleasantness increases linearly with increases in surprise, but Berlyne (1971) predicts that pleasantness has an inverted U-shaped relation to increases in surprise, increasing up to a point, and then leveling off or decreasing.

Similarities and Differences in Response

Research has shown strong consistency in people's evaluations of the environment. A meta-analysis of responses to more than 3,200 scenes by almost 20,000 respondents found high correlations in response across cultures, genders, age, special interest groups, between students and others (Stamps, 1999). Van den Berg, Vlek, & Coeterier (1998) refer to the assumption that similarities in response outweigh differences across individuals, groups, and cultures as the "consensus assumption." Indeed, studies suggest differences across cultures or cultural groups in response to some kinds of environments (Hunziker, Felber, Gehring, Buchecker, Bauer, & Kienast, 2008; Herzog, Herbert, Kaplan, & Crooks, 2000). Through experience and socialization, people may develop similarities in attitudes, values and behaviors within a culture or subculture, and differences across them (Berry, Poortinga, Breugelmans, et al., 2011). Cultures may differ in their social representation of an environment such that judgments of pleasantness are socially mediated (Graumann & Kruse, 1990). Such cultural differences, however, need not conflict with an evolutionary or biological explanation of environmental preferences (Lyons, 1983; Van den Berg et al, 1998). Instead, they may reflect an effect of a shared mediating variable such as typicality or familiarity. Because both biological and cultural factors affect human responses to the environment (Bourassa, 1990; Hartig, 1993), it makes sense to consider the degree to which different groups have commonalities and differences in response.

Multi-Level Models

The social-ecological approach offers a complex but realistic perspective on the influence of the environment on humans (King, Stokols, Talen, Brassington, & Killingsworth, 2002). Among other things, it notes the importance of environmental and sociocultural variables. In discussing the consensus assumption, Van den Berg et al. (1998) acknowledge the importance of establishing the relative importance of biological and cultural factors in aesthetic response. For research to go beyond determination of the degree of consensus, and to find information on determinants of individual or socio-cultural differences in the characteristics of the environment, one can use multi-level models. These can estimate the effect of environmental variables while taking into account individual or group variations in the relationships, and they allow the estimation of cross-level interactions between the characteristics of the environment and the individuals responding to it. Thus, the present study used multi-level models to study group similarities or differences in response to the dynamic experience of surprise in the environment.

Taking into account the need to explore the relation among surprise, arousal, and pleasantness for dynamic experience, also in a cross cultural perspective, the present study used movements between simulated spaces to test the effects of environmental surprise on arousal and pleasantness. It did this across two groups, adults in the US and in Italy. We manipulated physical properties of spaces that would likely affect the perceived differences between the spaces, and thus might affect surprise. We did so with simulated movement through spaces. One test of environmental surprise, found that although pleasantness increased with surprise (Nasar & Cubukcu, 2011), it did not level off for high surprise. We wondered if the high surprise and related arousal did not get high enough to reduce pleasantness, but also realized that most everyday environments would not reach such a high level of surprise. Nevertheless, the present research, centering on movement through three spaces, sought to create higher levels of surprise and test effects of surprise on arousal and pleasantness across two countries (U.S. and Italy). It had three research questions:

R1. Does perceived arousal increase with the level of the surprise experienced between pairs of spaces (Berlyne, 1971; Huron, 2006)?

R2a. If arousal does increase with surprise, does surprise affect pleasantness in an inverted U-shaped function (Berlyne, 1972), or in a linear way (Huron, 2006)?

R2b: If arousal does not increase with surprise, does pleasantness still relate to surprise?

METHOD

Preliminary steps

Before the main study, we did two steps to set up the study. First, we created and tested an environmental manipulation to generate different levels of surprise. Second, we tested the goodness of a measurement model for arousal and pleasantness. In the main study, as the manipulation and measurement model worked as expected, we conducted an experiment that examined arousal and pleasantness in response to different levels of surprise.

Procedure and Data Analysis

We used 3D Max plug-in to create nine dynamic color desk-top virtual reality (VR) walks. The simulations paused in a start office (A, B, or C) and then walked the observer through it, turned right at a door, and walked into an end office (A, B, or C), where it stopped. We used a turn to the person would not see the end office until entering it. Table 1 shows the characteristics of each office, and Figures 2, 3, and 4, show the three offices.

Before creating the simulations, we tested surprise and preference in relation to features of a space that studies have found related to its perceived spaciousness and preference (Flynn, 1988; Kaplan, Kaplan, & Brown, 1989; Kaye & Murray, 1982; Im, 1984; Ozdemir, 2010): size, lighting, window size, amount of furniture, wall picture (natural or urban), or wall texture (vertical or horizontal). Using the dynamic color desk-top virtual reality, we moved two groups of respondents from a start-space to a destination space, and had them rate the destination space on scales from 0 to 10. One group of 30 (17 men, 13 women) rated surprise. Another group of 30 (16 men, 14 women) rated preferences. For surprise, the instructions stated that if the destination space has no difference from the start space it has no surprise, and if it has a huge difference from the start space, it has a big surprise. Participants rated the surprise on the following scale:

0	1	2	3	4	5	6	7	8	9	10
Very Small		Small			Not Small or Large		Large			Very Large

For preference participants rated each of the three bipolar items (order varied across respondents) shown below:

0	1	2	3	4	5	6	7	8	9	10
Very Small		Small			Not Small or Large		Large			Very Large

0	1	2	3	4	5	6	7	8	9	10
Very Unappealing		Unappealing			Not Unappealing or Appealing		Appealing			Very Appealing

0	1	2	3	4	5	6	7	8	9	10
Very Unattractive		Unattractive			Not Unattractive or Attractive		Attractive			Very Attractive

As the three items had high Cronbach alpha reliability, we combined them into a preference scale.

Based on the results of the two tests, we assigned properties to each office to make it more likely that offices would differ from one another at the desired level of surprise, but would elicit similar levels of preference. For surprise, the analyses found statistically significant differences between the start-and destination spaces for each of the six manipulations. For preference, the analyses found that participants preferred the larger size, brighter lighting, larger window, natural wall picture, and horizontal texture at a statistically significant level and the larger amount of furniture at a marginally significant level. Previous studies (Kaplan & Kaplan, 1989) repeatedly show higher preferences for nature (the natural view, natural picture, or the plant). Thus, office A had the largest size, the dimmest lighting, the least amount of furniture, urban views, urban skylines and no plant. It had a larger window because its size required that. In contrast, office C had the smallest size, the brightest lighting, the most furniture, views of nature, a picture of nature, and a plant. The B office had a mix of the attributes rated favorably and unfavorably. Note also, that we chose attributes to create the largest contrast between the A and C office.

Attribute*	**Office**		
	A	**B**	**C**
Size	Smallest	Medium	Largest
Lighting	Brightest	Moderately bright	Dimmest
Window Size	Small	Medium	Largest
Amount of Furniture	Most	Moderate (hard)	Least
Wall Texture	Vertical	Grid (vertical & horizon-tal)	Horizontal
View	Nature	Nature	Urban
Wall Picture	Natural scene	Urban skyline	Urban skyline
Plant	Plant	None	None

Table 1. Characteristics of the Three Offices
*We kept all other attributes, such as entrance location into the second office, floor surface, and walking speed (4.99 kph) constant.

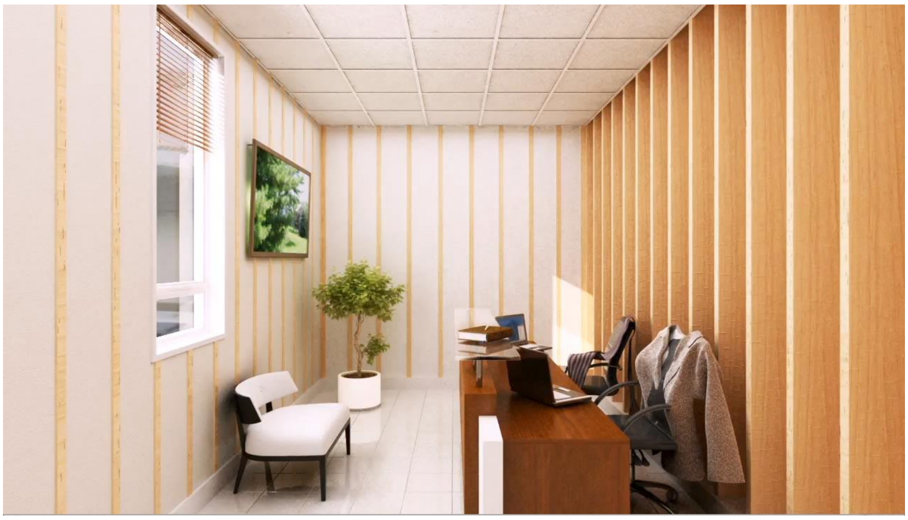

Figure 2. Office A.

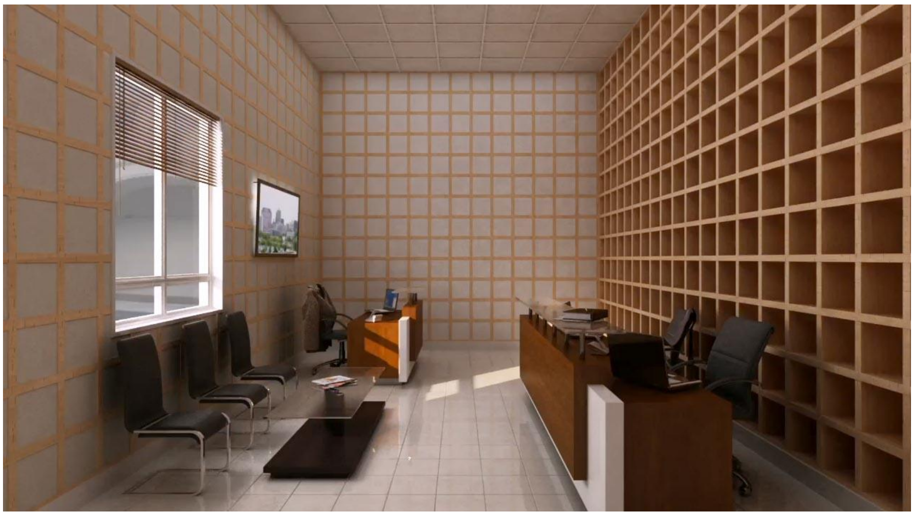

Figure 3. Office B.

Figure 4. Office C.

We tested whether the perceived difference varied as we intended through the manipulation. For this, we had 46 adults in the U.S. (18 men, 26 women) judge each walk for degree of difference between the spaces (from 0 = No Difference to 10 = Completely Different). As planned, the low surprise walks (A-A, B-B, C-C) evoked the smallest judged difference (M=2.42, SD=2.27), the high surprise walks (A-C, C-A) evoked the largest judged difference (M=8.25, SD=1.97), and the medium surprise walks (A-B, B-A, B-C, C-B) was in between (M=7.21, SD=1.76). The effect of the type of walk achieved statistically significant ($F(2,86)=143.66$, $p<.000$), and it represented a large effect ($\eta_p^2=0.77$). Post-hoc pairwise comparisons with Bonferroni adjustments found significant differences in the expected direction between each pair (Low vs. Medium, $t(44)= -11.79$, $p<.001$; Low vs. High, $t(44)= -13.73$, $p<.001$; Medium vs. High, $t(44)= -5.29$, $p<.001$).

Measures

To test the effect of surprise, we developed and tested two three-item scales, one for arousal and one for pleasantness. We drew these items from studies on environmental descriptors and on emotional appraisals of the environment (Kasmar, 1972; Russell, 1980; Russell, Lewicka, & Nitt, 1989; Russell & Pratt, 1980).

For both the instrument check and main study, we used an on-line survey with one VR walk per page. Participants rated each destination office after the virtual walk on the six items in English or Italian from 0=Not at all (in Italian: per niente) to 10 = Very much (moltissimo).

For arousal, the study used three up to four items of the arousal dimension of the Mehrabian and Russell (1974) PAD (Pleasure, Arousal, and Dominance) scale:

arousing, stimulating, and activating ("attivante, stimolante, dinamizzante" for the Italian sample).

For pleasantness, the survey uses three items that Kasmar (1970) found valid for assessing interior spaces, and used in the pilot study to identify spaces that differed physically but elicited similar pleasantness scores: inviting, attractive, and pleasant ("invitante, attraente, piacevole" in the Italian version).

In the instrument check, we used responses from 120 participants (54 from US and 66 from Italy) to test the psychometric properties of the two measures. These participants took some virtual walks going to a first office to a second one. Each virtual walk took around 10 seconds. At the end of each walk, the on-line survey had the participants rate the end space using arousal and pleasantness scales. After participants finished the ratings, the survey advanced to a new page with a new video. To lessen order effects, the survey randomized the order of walks across the participants.

We used Mplus version 6.11 (Muthén & Muthén, 1998–2011) to run multilevel confirmatory factor analyses (MCFA) and measurement invariance analyses (MI), controlling for a clustering effect of individual in the data.

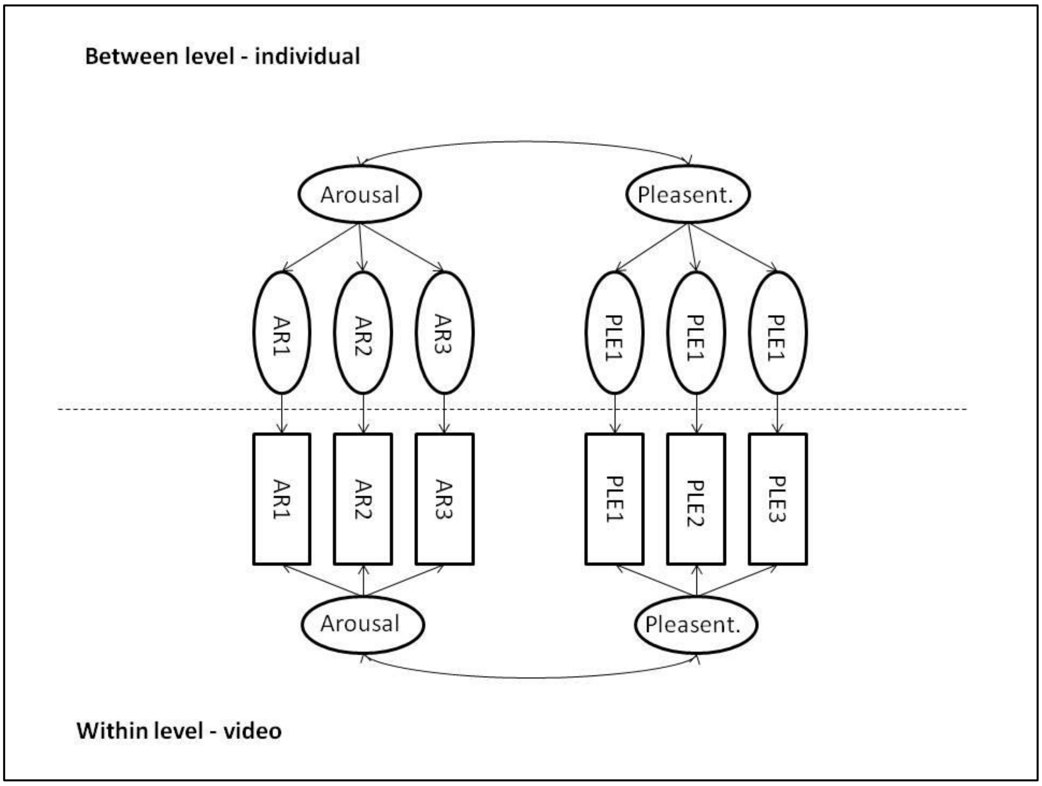

Figure 5. The Multilevel Model tested with Multilevel Confirmatory Factor Analysis

Note: Estimator: maximum likelihood estimation with robust standard errors; Fit indexes: Chi-square degree of freedom ratio ($\chi 2/df \leq 2$), comparative fit index (CFI ≥ .900), root- mean- square error of approximation (RMSEA ≤ .080), the standardized root mean square residual at within and between level ($SRMR_w$, $SRMR_b \leq .080$). Some preliminary assumptions were verified, before running the analyses; results are reported in note[1]. Descriptive statistics were reported in Table 2.

[1] We checked the missing distribution on our database. Analyzing the distribution of missing values, the maximum value of missing data for item was below 2%. However, we conducted the Little's test to check whether the missing data were 'missing completely at random' (MCAR) and the results confirmed this hypothesis ($\chi 2(5) = 1.686$, $p = .891$). Then for each item, means and standard deviations were computed, and items were also checked for normal distribution, computing skewness and kurtosis separately by country. The Skewness ranged from -.01 to .19 for the Italian sample and from -.01 to .16 for the US sample. The Kurtosis ranged from -.85 to -.59 for the Italian sample and from -.97 to -.59 for the US sample, confirming the normal distribution of the items.

		US		Italy	
Surprise	Start to End	Arousal *M (SD)*	Pleasantness *M (SD)*	Arousal *M (SD)*	Pleasantness *M (SD)*
Low	A to A	3.54 (2.26)	4.27(2.37)	4.47 (1.98)	4.73 (1.96)
	B to B	4.47 (2.56)	4.76 (2.68)	5.04 (2.07)	5.43 (1.82)
	C to C	4.38 (2.49)	4.50 (2.57)	5.33 (2.31)	5.63 (2.38)
Medium	A to B	4.47 (2.22)	4.40 (2.27)	6.41 (2.13)	6.56 (2.53)
	B to A	5.38 (1.80)	6.06 (1.94)	6.62 (2.10)	6.74 (2.09)
	B to C	4.50 (2.50)	5.09 (2.52)	5.08 (1.96)	5.18 (2.06)
	C to B	2.35 (1.84)	3.23 (1.78)	5.85 (2.50)	6.02 (2.58)
High	A to C	3.91 (2.00)	4.75 (2.13)	5.18 (2.36)	4.93 (2.29)
	C to A	4.59 (2.22)	6.20 (2.56)	5.35 (2.15)	5.43 (1.95)

Table 2. Means (Standard Deviations) for Each Scale in Each Country

In the next step we run two Multilevel Confirmatory Factor Analyses to separately test the goodness of the scales for the Italian and the US sample. To have the possibility to assess the measurement model of Arousal and Pleasantness scales composed by three items each one we decided to test a model which considered the two scales together taking in account of the covariation between the two latent factors Arousal and Pleasantness (see Figure 5). The MCFA were conducted separately on the Italian and the US sample. The models showed excellent fit indexes (see Table 3). Then we tested the measurement invariance across countries and different level of surprise[2]. The results of the sequence of gradually more restrictive tests of measurement invariance (MI) supported for both the analyses configural, metric, and scalar invariance, but not uniqueness invariance (see Table 3).

For the main study, we averaged the three pleasantness items to create composite pleasantness scores, and we averaged the three arousing items to create composite arousing scores.

Because office B appeared only for two levels (Small and Medium), we could not compare it with the other two offices. Thus, we analysed only responses to destinations (offices A and C). We ran two mixed ANOVA with two between subject factors (Surprise with three levels, Low, Medium, or High; and Country with two levels, US, Italy, one for Arousal and one for Pleasantness).

Participants

Participants in the US (121 adults, 47 men, 74 women) and Italy (67 adults, 34 men, 33 women) were randomly assigned to the within-group condition (for the CFA model test) or one of the three between-group conditions: Low Surprise, Medium Surprise, or High Surprise. Surprise is defined as the perceived mismatch between what one experiences in a place and what one anticipated for it (Berlyne, 1971). As the perceived discrepancy increases, surprise increases. We accomplished this through virtual walks through environments. The main study analyzed the data from the between group conditions.

[2] To test Measurement Invariance (MI) we considered four steps: configural invariance, allowing all the parameters to be freely estimated; (2) metric invariance, requiring invariant factor loadings; (3) scalar invariance, requiring also invariant intercepts; and (4) uniqueness invariance, requiring invariant item uniqueness. Comparisons among models were based on differences in CFI and RMSEA, sample size independent: Support for no changes in goodness of fit indexes requires a change in CFI and RMSEA less or equal than .010 and .015, respectively (Chen, 2007).

Groups	Model	$\chi2/df$	CFI	RMSEA	$SRMR_w$	$SRMR_b$	Δ CFI	Δ RMSEA
Country	Italy (n = 66)	5.59	.951	.088			–	–
	US (n =54)	1.15	.998	.018			–	–
	Configural invariance	10.20	.982	.092			–	–
	Metric invariance	8.98	.980	.086			-.002	-.006
	Scalar invariance	7.87	.978	.080			-.002	-.006
	Residual invariance	14.44	.942	.112			.112	.032
Surprise	Low surprise	6.97	.924	.168	.032	.027	-	-
	Medium surprise	4.71	.959	.094	.025	.007	-	-
	High surprise	9,85	.921	.159	.041	.013	-	-
	Configural invariance	9.445	.976	.000			-	
	Metric invariance	7.39	.976	.000			.000	.000
	Scalar invariance	5.59	.976	.001			.000	.001
	Residual invariance	13.65	.908	.000			.000	-.068

Table 3. Results of Multilevel Confirmatory Factor Analysis and Measurement Invariance Analyses for the Model of Arousal and Pleasantness across Country (Italian, US) and Surprise (Low, Medium, High).
Note. Δ CFI = change in comparative fit index; Δ RSMEA = change in root-mean-square error of approximation.

RESULTS

Arousal

Because we found no statistically significant interactive effects for country, we combined the US and Italian scores. Destination arousal increased from the low to medium surprise conditions but decreased from the medium to high surprise conditions (Figure 5). The effect of surprise (differences from start to end space) achieved statistical significance ($F(2,185)=18.14$, $p<.001$) and a medium-sized effect ($\eta^2_p=.09$). The differences arose primarily from difference between low and medium surprise conditions. Post-hoc comparisons (with Bonferroni corrections) found medium surprise as more arousing ($d=-1.01$) than low surprise, but no difference in arousal between low and high surprise or between medium and high surprise. The only statistically significant difference was for medium versus low surprise ($t(125)=2.77$, $p=.02$).

Pleasantness

Because we found no statistically significant interactive effect of country, we combined the US and Italian pleasantness scores. As with arousal, pleasantness was lowest for low surprise, highest for medium surprise, and in between for high surprise (Figure 6). The effect of surprise (difference between start and end space) achieved statistical significance ($F(2,182)=4.34$, $p<.05$). It was a small effect ($\eta^2_p=.05$). The difference primarily reflects differences from medium surprise. Post-hoc comparisons (with Bonferroni correction) found higher pleasantness for medium than for low surprise ($d=1.38$) and for medium than for high surprise ($d=0.36$), but no difference between low and high surprise. The medium versus low achieved statistical significance ($t(120)=3.38$, $p=.02$), the medium versus high surprise achieved marginal significance ($t(120)=0.89$, $p=.060$), but the low versus high surprise did not achieve statistical significance

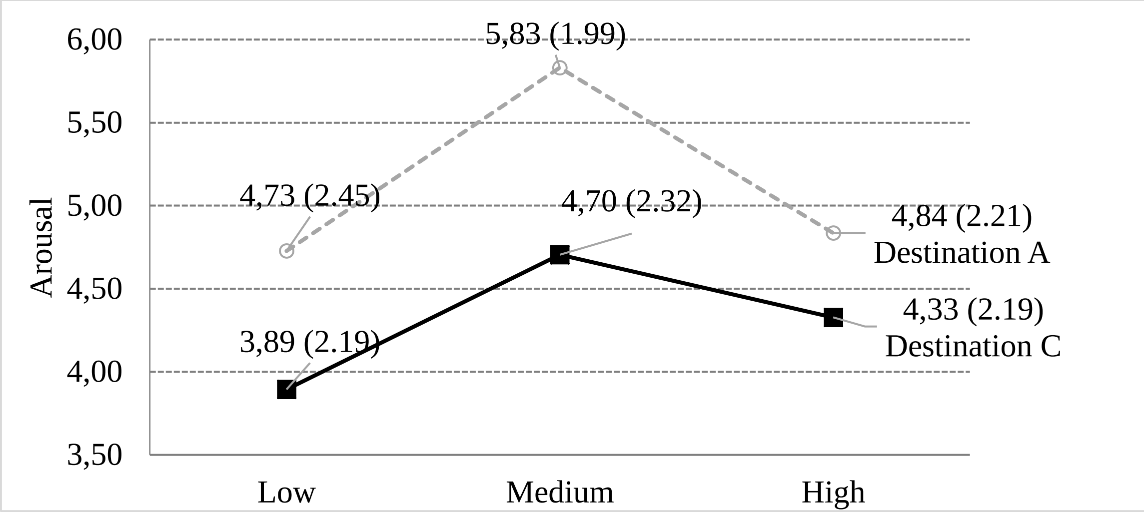

Figure 5. Arousal (from 0=not aroused at all to 10=very aroused) in destination offices A and C for low, medium and high surprise.

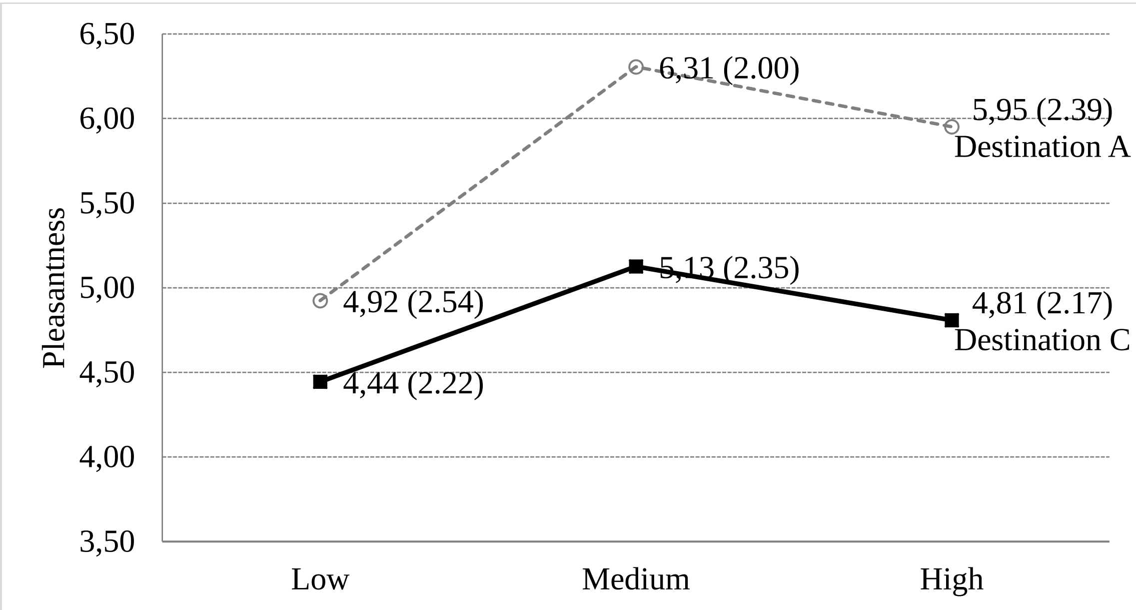

Figure 6. Pleasantness (from 0=not pleasant at all to 10=very pleasant) in destination offices A and C for low, medium and high surprise.

CONCLUSIONS

Every day, people move from place to place, indoors, outdoors, and between the two. The present study confirmed that such dynamic experience of movement between places affects people's perception and evaluation of places (Heft & Nasar, 2010). In particular, the surprise experienced from movement between spaces affected appraisals of arousal and pleasantness.

The study found consistency in response across respondents from the U.S. and Italy. These findings agree with both the finding of strong consistencies in response to environments across people (Stamp, 1999) and the consensus assumption (Van den Berg, Vlek, & Coeterier, 1998). Even though experience and socialization may create differences in attitudes and evaluations of environments across groups (Berry, Poortinga, Breugelmans et al., 2011; Graumann & Cruse, 1990), the similarities in response to surprise outweighed the differences. Adults from the U.S. and from Italy had similar appraisals of arousal and pleasantness. In addition, most respondents in each country had similar appraisals to one another.

For measurement, the three items for arousal emerged as reliable measures of arousal, and the three items for pleasantness emerged as reliable measures of pleasantness. In addition, the finding of no main or interactive effects for group means that each scale worked the same way for the U.S. and Italian respondents. Research might explore the generalizability of the scales to respondents from non-western or less developed countries.

Contrary to studies finding pleasantness and arousal orthogonal to one another in response to environmental stimuli (Posner, Russell, & Peterson, 2005; Russell, 1980; Russell, Lewicka, & Nitt, 1989; Russell & Pratt, 1980), the present study found them correlated with each other. Perhaps, the difference in results stems from a difference in response to static stimuli (such as slides and photos) and dynamic stimuli, such as the ones tested here. This suggests a need for additional research on the dimensions of affective response to the dynamic experience of places.

Regarding effects of surprise, some effects fit theory, and others did not. As predicted by theory (Berlyne, 1971; Huron, 2006), arousal increased from low to moderate surprise, but contrary to theory, it did not continue to increase with surprise. It levelled off for the high surprise condition. As predicted by Berlyne (1972), pleasantness had the inverted U-shaped function in relation to surprise, but contrary to that theory, the drop in pleasantness for high surprise did not relate to higher arousal. These findings study may not necessarily explain the relationship between pleasantness, arousal, and surprise.

The study used between-group comparisons, in which each respondent evaluated only one of the nine walks, but across all respondents all nine walks were assessed. This makes it unlikely that reactivity biased the ratings of any walk. Because each participant saw only one walk, he or she did not see the other manipulations and thus would have no basis for guessing the experimental manipulations or changing responses accordingly. Also, their response to their one walk would not be affected by their responses to other walks or multiple walks. Finally, our test of the manipulation for surprise found that that it worked as we intended. However, other aspects of the study may account for the unexpected similarity between pleasantness and arousal and for the levelling off of arousal for high surprise.

For the levelling off of arousal, perhaps participants experiencing one walk differed from those experiencing other walks in ways that affected their ratings. Such differences appear unlikely for three reasons. First, participants in each country were assigned at random to each of the nine walks. Second, participants in each country had the same pattern of response to each level of surprise. Third, research suggests commonalities in response across people (Stamps, 1999), such that differences in groups across the walks should not have biased their responses. Within group data would eliminate the threat of group differences across the conditions, because each person's responses would be compared across the walks. However, within group data would contaminate the independent variable, surprise. In a within-group design, people would see a destination space for high surprise up to five times before rating it, and that repeated experience might well lessen its surprise. This leaves the second possibility. The study had each participant rate both arousal and pleasantness. We did this, because if arousal affected pleasantness, we needed to have each person's arousal level, not some average of arousal for a walk. However, the ratings on each scale could have affected the ratings on the other. Perhaps a study which either measured arousal through psychophysiological measures or obtained independent ratings of arousal and pleasantness would find the linear relationship of arousal to surprise and a decrease in pleasantness for the high surprise and arousal condition.

The present study used simulated walks between one environmental category (offices) and it did so for one set of modern-looking offices and a one set of manipulations to create surprise. Research could test environmental surprise for different kinds of spaces, both indoors and outdoors. It could test different manipulations to create surprise. To better approximate the real environmental experience of walking through spaces, it could do so with full-scale virtual reality walk-throughs. It could also test different populations, such as children, older people, or people from other cultures.

If the findings hold, they would suggest that arousal and pleasantness increase from low to moderate surprise, and that designers seeking such arousal or pleasantness might include such moderate arousal in their designs. If people see moderate surprise as pleasant, such surprise might make places attractive for them to walk. Many environmental design firms use virtual reality simulations to create walk-through experiences of their designs. We have developed and tested reliable measures that they and others can use to gauge the arousal and pleasantness in such dynamic simulations. Through understanding likely effects of such dynamic experience before implementing a design, designers can create places that have the desired effect on humans.

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