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A plasma display window?—The shifting baseline problem in a technologically mediated natural world

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Abstract

Humans will continue to adapt to an increasingly technological world. But are there costs to such adaptations in terms of human well being? Toward broaching this question, we investigated physiological effects of experiencing a HDTV quality real-time view of nature through a plasma display "window." In an office setting, 90 participants (30 per group) were exposed either to (a) a glass window that afforded a view of a nature scene, (b) a plasma window that afforded a real-time HDTV view of essentially the same scene, or (c) a blank wall. Results showed that in terms of heart rate recovery from low-level stress the glass window was more restorative than a blank wall; in turn, a plasma window was no more restorative than a blank wall. Moreover, when participants spent more time looking at the glass window, their heart rate tended to decrease more rapidly; that was not the case with the plasma window. Discussion focuses on how the purported benefits of viewing nature may be attenuated by a digital medium.

Keywords: Nature; Views; Technology; Plasma display; Physiology

1. Introduction

Digital technologies will increasingly mediate the human experience of the natural world. We know, for example, that children come of age more and more with nature represented through television, video, and the Web rather than experienced directly (Kahn & Kellert, 2002). Other technologies may well take hold. For example, there is some evidence that robotic pets (e.g., Sony's AIBO) will offer partially compelling substitutes to live animals for children (Kahn, Friedman, Perez-Granados, & Freier, 2006; Melson et al., 2005 Melson, Kahn, Beck, Friedman, Roberts, & Garrett, 2005) and the elderly (Beck, Edwards, Kahn, & Friedman, 2004). Or consider a "Telegarden": a community garden that allows users to plant and tend seeds in a remote garden by controlling a robotic arm through a web-based interface (Goldberg, 2000; Kahn, Friedman, Alexander, Freier, & Collett, 2005). And there has also been "Telehunting": one goes online and can kill a real animal remotely by controlling a rifle by means of a web-based telerobotic installation (Root, 2005). If such technological trends continue, which seems likely, then an important question needs to be answered: What are the physical and psychological effects of experiencing technologically mediated nature? This paper reports a study that investigated this question.

An empirical starting point for this study builds on the literature that supports the proposition that people benefit by experiencing many aspects of a diverse natural world (Beck & Katcher, 1996; Frumkin, 2001; Kahn, 1999; Wilson, 1984). In one canonical study, for example, Ulrich (1984) examined the potential differences in the recovery of patients after gall bladder surgery depending on whether the patients were assigned to a room with a view of a natural setting (a small stand of deciduous trees) or a view

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of a brown brick wall. Patients were paired on relevant variables that might affect recovery (e.g., age, sex, weight, tobacco use, and previous hospitalization). Results showed that "patients with the natural window view had shorter postoperative hospital stays, had far fewer negative comments in nurses' notes ('patient is upset,' 'needs much encouragement') and tended to have lower scores for minor postsurgical complications such as persistent headache or nausea requiring medication. Moreover, the wall-view patients required many more injections of potent painkillers, whereas the tree-view patients more frequently received weak oral analgesics such as acetaminophen" (Ulrich, 1993, p. 107). Other studies have shown that interactions with animals (such as a dog, cat, bird, dolphin, or even small turtle) increase the physiological health, social competence, and learning opportunities of children, the elderly, and the general population (Beck & Katcher, 1996; Myers, 1998). Contact with nature can also lead to "enjoyment, relaxation, and … increased levels of satisfaction with one's home, one's job, and with life in general" (Kaplan & Kaplan, 1989, p. 173).

If we accept that interacting with many aspects of nature can benefit people, then a question arises. There are over six billion of us on this planet, and through human activity we pollute the air (and most scientists now recognize a "greenhouse effect"), pollute the waters, deplete soil, deforest, create toxic wastes, and extinguish over 27,000 species each year (100–1000 times the background extinction rate). If contact with the diversity of nature is so good for us, then why are we destroying it? One possible answer is that the baseline for comparing what is normal continues to shift downward as environmental conditions degrade.

As a case in point, consider a study of the environmental views and values of African American children in the inner-city of Houston, Texas (Kahn & Friedman, 1995). Results showed that a significant number of the young children interviewed in that study understood about the idea of air pollution; but they did not believe that Houston had such a problem even though Houston was then (and still remains) one of the most polluted cities in the US. In interpreting these results, Kahn and Friedman (1995) suggested that these children may have lacked a comparative experiential baseline from cities with less pollution by which to recognize that Houston was itself a polluted city. Building on these results, Kahn and Friedman also proposed that people across generations experience psychologically something quite similar to the children in Houston, that people construct a conception of what is environmentally normal based on the natural world encountered in childhood. The crux is that with each ensuing generation, the amount of environmental degradation can increase, but each generation tends to take that degraded condition as the non-degraded condition, as the normal experience: a condition that Kahn (1999, 2002) has termed environmental generational amnesia, and which more broadly we refer to as "the shifting baseline problem."

This problem has been recognized in other fields, as well. Pauly (1995), for example, has written of what he calls the "shifting baseline syndrome" of fisheries:

> Essentially, this syndrome has arisen because each generation of fisheries scientists accepts as a baseline the stock size and species composition that occurred at the beginning of their careers, and uses this to evaluate changes. When the next generation starts its career, the stocks have further declined, but it is the stocks at that time that serve as a new baseline. The result obviously is a gradual shift of the baseline, a gradual accommodation of the creeping disappearance of resource species… (p. 430).

Along similar lines, Evans, Jacobs, and Frager (1982a, 1982b) showed that long-term residents in Los Angeles, compared to recent arrivals, showed a greater desensitization in their judgments of the severity of the smog problem to their health. Dubos (1980), too, has argued: "Any disease, or any kind of deficiency, that is very widespread in a given social group comes to be considered as the 'normal' state and consequently is accepted as a matter of course within that group" (pp. 250–251).

While the research literature has shown physical and psychological benefits of experiencing many aspects of nature, there are also indications that some of these benefits carry over when experiencing visual representations of nature. For example, static photographs of nature have been shown to confer health benefits in a hospital setting (Ulrich, 1993). People also tend to appreciate and feel psychologically restored by photographs of nature (Heerwagen & Orians, 1993; Kaplan & Kaplan, 1989; Orians & Heerwagen, 1992). There is also some evidence that videotapes of nature-dominated scenes (compared to artifact-dominated scenes) can confer quicker recovery from stress and greater immunization to subsequent stress (Parsons, Tassinary, Ulrich, Hebl, & Grossman-Alexander, 1998).

Building on these findings, Friedman, Freier, and Kahn (2004) created a technological installation—a "plasma window"—where they installed an HDTV camera on top of an university building on their campus, and displayed, as the default image, a real-time local nature view on 50-in plasma screens. The rationale behind this study was that if static photographs of nature were beneficial in people's lives, then why not capitalize on more cutting-edge technologies that convey more realistic portrayals of nature and investigate the effects of a real-time "streaming" nature view for people who otherwise lacked access to the outside environment. The screens were mounted on the interior walls (as "windows" to the outside) in windowless offices of seven faculty and staff within the same building. Results showed that participants reported an increase in their psychological well being, cognitive functioning, connection to the wider social community, and connection to the natural world. Thus there is some initial evidence that a plasma window with a compelling nature view can

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confer benefits to people who would otherwise be working in a windowless environment.

A critical question, however, is not just whether there are benefits of the technologically mediated form, but if there are, then how those benefits compare to the direct natural form. For if the technologically mediated form comes up short compared to the direct form but still confers a benefit, then in the years ahead we may unknowingly allow the technologically mediated form to substitute for our direct experience of nature, shifting the baseline lower for what can be considered optimal human functioning.

Thus, in the current study, we investigated the physiological effects of experiencing (a) an HDTV quality real-time view of nature (a similar installation as used by Friedman et al., 2004), (b) essentially the same view through a glass window, and (c) no window at all. Participants came into the office setting under the guise of a task performance study. While they worked on four tasks and had two specified resting periods, participants' heart rate was assessed. Prior to the start of each of the six activities (the four tasks and the two waiting periods), a researcher gave each participant instructions for the new activity. This form of social interaction typically elevated participants' heart rate, and thus functioned as a low-level stressor. A camera (time-synchronized with the physiological recording equipment) focused on participants' faces to allow coding of the frequency and duration of looking behavior out the glass window and plasma window, and at the blank wall. We sought this behavior data so as to allow us to examine whether physiological recovery might depend not only on participants being in one of the three office conditions but on their actually looking out the window.

We had two hypotheses and two open questions. First, we hypothesized that in terms of the rate of heart rate recovery from the low-level stressor the glass window would be more restorative than the blank wall; it was an open question how the plasma window would compare to the blank wall. Second, we hypothesized that when participants spent more time looking at the glass window, their heart rate would decrease more rapidly; it was an open question in terms of rate of recovery when participants spent more time looking at the plasma window.

2. Methods

2.1. Participants

Ninety participants (all undergraduate students; age 18–34; $M = 20.8$; SD $= 2.53$) were recruited through flyers posted on a university campus. All participants were recruited during the summer, prior to the return of students for the fall term, which started at the end of September. Thirty participants were assigned to each of the three office conditions, balanced by gender within condition. Each participant was compensated with $20.00. The experiment lasted approximately 1 h.

2.2. The three conditions

Each of the three conditions employed the same office on the university campus. In the glass-window condition, the south-facing view through a glass window overlooked a nature scene that included water in the foreground, as part of a public fountain area, and then extended to include stands of deciduous trees on one side, and a grassy expanse that allowed a visual ''exit'' on the other. This office view was chosen to include features that people usually find esthetically pleasing and restorative in nature (Kaplan & Kaplan, 1989; Orians & Heerwagen, 1992). The office size was approximately 13 ft by $8\frac{1}{2}$ ft, with off-white colored walls, matte finished, $10\frac{1}{2}$ foot ceilings with fluorescent ceiling lights. An office desk, $7\frac{1}{2}$ ft by 2 ft (32 in high), was placed in front of the window. A swivel chair was locked into position on the floor so as to keep constant the distance to the window.

In a second condition, the plasma window condition, a 50-in plasma screen was inserted into the office window, entirely covering it (Fig. 1). We then mounted an HDTV camera approximately 15 ft higher on top of the building and, through hard cabling, displayed on the plasma screen essentially the same glass-window view one would see from inside the office itself. The size of the glass window and plasma window were virtually identical. The desk was moved approximately 4 ft from the plasma window so as to mimic as close as possible from a viewer's perspective the experience of the same view through the glass window.

In the third condition, the blank wall condition, we first sealed off the original glass window with light-blocking material, and then covered the sealed window with drapes,

Fig. 1. Demonstrator in the plasma window condition. The plasma window covered up the same-sized window used in the glass-window condition. The camera that recorded looking behavior can be seen poking out from the drapes to the left of the plasma window. The drapes were pulled across the entire wall for the blank wall condition.

in effect turning the space into a windowless office. The desk was moved back to the position as established in the glass-window condition.

Installing the plasma window required many hours, and uninstalling it even longer, since the surrounding window area required re-plastering and repainting after removing the hardware. As a result, it was not feasible to repeatedly switch data collection efforts back and forth between the glass window and plasma window conditions, and thus it was not possible to randomly assign participants to the three conditions. We collected all of the plasma window data prior to collecting data for the glass window. That said, all of the participants came from a summer-school population. The plasma window condition was run from early July to early August, and the glass-window condition was run from mid-August to mid-September. The blank wall condition was interspersed throughout the other two conditions from early July to mid-September. Moreover, participants during the first 5 weeks of data collection were assigned to either the plasma window condition (30 participants) or the blank wall condition (15 participants), while participants during the remaining 5 weeks of data collection were assigned to either the glass-window condition (30 participants) or the blank wall condition (15 participants).

The lighting was kept congruent with the anticipated contexts of use: the glass-window condition had both natural light and fluorescent light; the plasma window condition had light from the display and fluorescent light; and the blank wall condition had fluorescent light. Because both light intensity and outside weather had the potential to differ across conditions, data on these variables were collected, and subsequent analyses were conducted to examine their potential role in heart rate recovery.

2.3. Procedure

At the start of the experiment, participants had a 5-min "waiting period" during which they could (depending on their condition) look out the glass window or plasma window, or at the blank wall, if they so chose. Then participants completed a series of four tasks: a 10-min proofreading task, a 3-min "name-a-Droodle" task that asked for clever labels for ambiguous drawings, a 7-min "invent-a-Droodle" task that asked for the creation of one's own Droodle, and a 10-min "tin can unusual uses" task that asked for different uses for a tin can. The tasks were chosen to allow for different forms of mental engagement. Following the tasks, participants had another 5-min waiting period.

2.4. Assessments

To assess heart rate, we used a Biopac MP 100 physiological system with a 2-lead configuration to collect electrocardiogram (ECG) waveform data at a rate of 200 samples per second. Cardiac interbeat interval (IBI) was determined from the ECG waveform based on the interval between R-waves, and heart rate was computed as the reciprocal of IBI.

To assess looking behavior, we recorded the face of participants during the experiment by means of a camera (visible in Fig. 1) that was time-synchronized with the physiological recording equipment. We subsequently coded on a second-by-second basis the frequency and duration of looking behavior out the glass window or plasma window, or at the blank wall.

Outside weather conditions and light intensity inside the office were recorded for each experimental session. Cloud-cover conditions for the start and end of each session were obtained from surface weather observations at the Seattle NOAA/NWS Lake Washington weather station,[1] located approximately 3 miles from the office where the experiment was conducted. These weather observations were then collapsed into one of three categories (sunny/mostly sunny, cloudy/mostly cloudy, or mixed) as a single evaluation of the general weather conditions during the session. Also, a Minolta TL-1 Illuminance meter was used to measure the light intensity on the work surface of the desk at the start of each session. When the desk surface was in direct sunlight in the glass-window condition, light intensity sometimes exceeded the meter's light measurement range of .11—21,517 lx (.01–1999 ft-c) and hence was recorded as over 21,517 lx (2000 + ft-c).

Prior to the start of each of the six activities (the two waiting periods and four tasks), a researcher gave each participant instructions for the new activity. This form of interaction typically elevated participants' heart rate, and thus functioned as a low-level stressor. To assess the rate of heart rate recovery from the resulting low-level stress, the slope of the least-squares regression line for each participant's heart rate was computed as a function of time during the first 60 s of the activity, beginning from the moment the researcher left the side of the participant (to sit behind a partition in a different part of the experimental room). These slopes were computed separately for each participant and each activity, yielding six measures of short-term heart rate recovery for each participant.

2.5. Intercoder reliability

Two individuals independently coded the looking behavior for 10 participants. Intercoder reliability, using Cohen's kappa, showed that $\kappa = .79$, which is considered excellent agreement (Fleiss, Levin, & Paik, 2003).

3. Results

Table 1 provides summary statistics for the slopes of the least-squares regression lines for heart rate as a function of

[1]Archived weather data available at http://www.atmos.washington.edu/data/old_obs.cgi.

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Table 1
Summary statistics for linear regression slopes of heart rate recovery by activity and condition (in beats per minute per minute (bpm/min))

Activity	Glass window	Plasma window	Blank wall	All conditions
Waiting period 1				
M slope	−5.10	−1.44	−3.12	−3.24
SD	13.32	15.30	9.12	12.78
Name-a-Droodle				
M slope	−5.16	−4.74	−3.30	−4.38
SD	9.42	6.60	6.60	7.62
Invent-a-Droodle				
M slope	−7.80	−4.80	−4.98	−5.88
SD	8.22	7.62	6.24	7.44
Tin can				
M slope	−7.02	−6.54	−5.52	−6.36
SD	15.06	11.28	8.22	11.76
Proofreading				
M slope	−8.88	−7.38	−6.48	−7.56
SD	9.66	8.28	8.58	8.82
Waiting period 2				
M slope	−15.18	−6.30	−8.22	−9.90
SD	11.76	17.82	11.58	14.4
Average across all activities				
M slope	−8.19	−5.19	−5.26	−6.21
SD	6.91	5.30	3.69	5.58

time during the first 60 s of each activity.[2] Visually, these data are summarized in Fig. 2. The mean slope was negative across all combinations of condition and activity, indicating that heart rate typically declined during the first minute of each activity regardless of condition.

To address our first hypothesis about heart rate recovery by condition, general linear models (GLM) were used, treating the six linear regression slopes for each participant as repeated measures of the rate of heart rate recovery. As hypothesized, there was more rapid heart rate recovery in the glass-window condition compared to the blank wall condition ($F(1,58) = 4.204$, $p = .045$, Cohen's $d = .538$). In turn, there was no difference in the heart rate recovery between the plasma window condition and the blank wall condition: ($F(1,58) = .003$, $p = .955$, $d = .015$). Thus, in terms of this measure of heart rate recovery from low-level stress, the glass window provided a significant physiological benefit over a windowless office (the blank wall condition), while there was no evidence of a similar benefit from a plasma window when compared to a windowless office.

Another way of comparing the functionality of a plasma window compared to a glass window is in terms of what participants did with their eyes. How often did they look out each window, and for how long? Our results showed that participants looked just as often at the plasma window (median 58 occurrences per participant) as at the glass window (median 52 looks per participant) (Mann–Whitney test, $U = 370$, $p = .324$, $\hat{\theta} = .425$[3]). However, the total duration of looking time was significantly greater in the glass-window condition (median = 622.0 s) than in the plasma window condition (median = 491.5 s) (Mann–Whitney test, $U = 299$, $p = .039$, $\hat{\theta} = .656$). Participants spent much less time looking at the blank wall (median = 55.5 s) than either the real window ($U = 26$, $p < .0005$, $\hat{\theta} = .029$) or the plasma window ($U = 21$, $p < .0005$, $\hat{\theta} = .024$). In other words, both windows just as frequently garnered participants' attention, and on this measure our results showed equivalent functionality between the two windows. But the glass-window view held participants' attention longer than the plasma window view.

To address our second hypothesis about heart rate recovery and looking behavior, we conducted the following analysis. For each participant in the glass window and plasma window conditions, the Pearson correlation coefficient was computed within subject between the duration of looking during the first 60 s of each activity and the heart rate slope during the same 60 s. Negative correlations indicate a tendency for more rapid heart rate recovery with more looking, while positive correlations indicate a tendency for slower recovery with more looking. Results showed the mean correlation for participants in the glass-window condition ($M = -.218$, $SD = .445$) was significantly less than 0 ($t(29) = -2.683$, $p = .012$, Cohen's $d = .498$), while the mean correlation in the plasma window condition ($M = .144$, $SD = .535$) was not significantly different from 0 ($t(29) = 1.478$, $p = .150$, $d = .274$). Thus, on tasks where participants spent more time looking at the glass window, their heart rate tended to decrease more rapidly than on tasks where they spent less time looking at the glass window. This was not the case with the plasma window, where no relationship was found between duration of looking at the plasma window and rate of heart rate recovery.

The experimental design did not directly control for light intensity and outside weather conditions. Thus we conducted additional analyses to explore differences in these variables across the three experimental conditions, and the possible impact of these variables on heart rate recovery.

In terms of outside weather conditions across the three experimental conditions, the weather was sunny or mostly

[2]There were no statistically significant differences between the two groups of 15 participants in the blank wall condition, either on demographic variables (gender, age) or on our outcome measures (heart rate slopes and duration and frequency of looking at the wall). As a result, the two groups were collapsed into a single group of 30 participants for all analyses.

[3]$\hat{\theta}$ is a probabilistic measure of effect-size obtained from the Mann–Whitney U-statistic by $\hat{\theta} = U/mn$, where m, n are the group sizes. It provides an estimate of the probability that the value of the variable for an individual in the first condition will exceed the value for a randomly selected individual from the second condition (Acion, Peterson, Temple, & Arndt, 2006).

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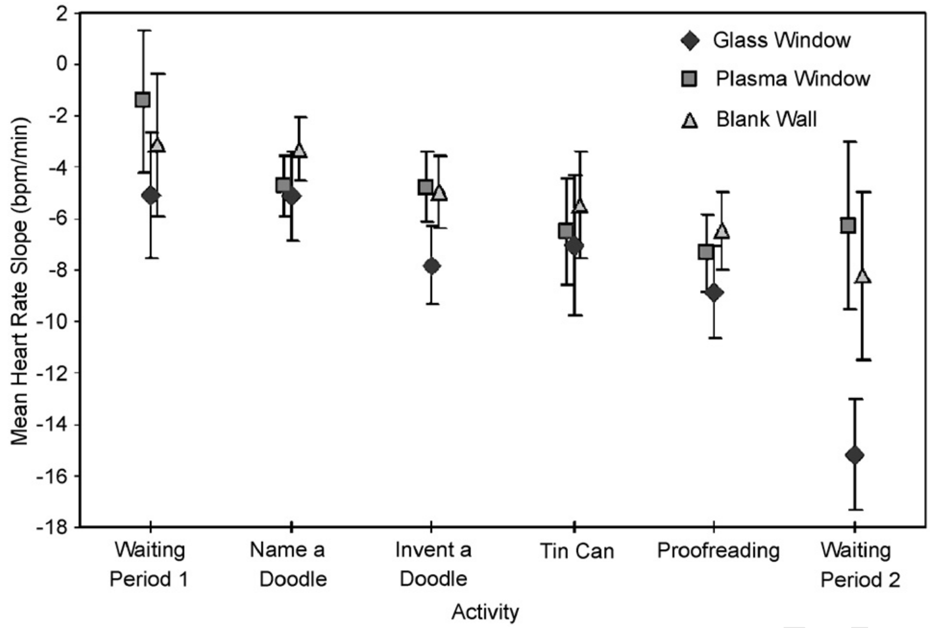

Fig. 2. Heart rate recovery from low-level stress. Values are the mean slope of heart rate (in beats per minute per minute (bpm/min)) during the first 60 s of each activity. Negative values indicate decreasing heart rate, and points lower on the graph represent more rapid decreases in heart rate. (The activities are ordered by the overall average slope across all six activities.)

sunny for 47% of the sessions with the glass window, 47% plasma window, and 50% blank wall. The weather was cloudy or mostly cloudy for 20% of the sessions with glass window, 33% plasma window, and 30% blank wall. For the remaining sessions, the weather was a mix of sun and clouds for 33% of the sessions with the glass window, 20% plasma window, and 30% blank wall. Pearson's χ^2-test ($\chi^2 = 2.541$, 4 d.f., $p = .637$, $\phi = .166$) showed no significant difference in weather conditions across the three experimental conditions. Furthermore, there was no evidence that the average of the heart rate slopes differed significantly by outside weather condition, either with all three experimental conditions combined (ANOVA, $F(2,87) = 1.469$, $p = .236$, $\eta^2 = .033$) or within each condition separately (glass window: $F(2,27) = 1.939$, $p = .163$, $\eta^2 = .125$; plasma window: $F(2,27) = .032$, $p = .969$, $\eta^2 = .036$; blank wall: $F(2,27) = .469$, $p = .631$, $\eta^2 = .125$).

Next we compared light intensity on the work surface of the desk across the three experimental conditions. Results showed that light intensity was quite similar in the blank wall condition (median = 456.4 lx, range 418.7–480.1 lx) and plasma window condition (median = 462.8 lx, range 338.0–477.9 lx) (Mann–Whitney test, $U = 357.5$, $p = .240$, $\hat{\theta} = .411$). This finding was as expected since these two conditions occurred in the same office with the same fluorescent lighting as the primary light source. However, with the addition of natural light in the glass-window condition, light intensity was much greater and more variable (median = 5010.6 lx, range 277.7 to over 21,517 lx) than with either the plasma window ($U = 29$, $p < .0005$, $\hat{\theta} = .967$) or the blank wall ($U = 30$, $p < .0005$, $\hat{\theta} = .966$).

Given the large amount of variability in light intensity in the glass-window condition, we then examined the association between light intensity and heart rate recovery within this condition. For each participant in the glass-window condition, we computed an average rate of recovery by finding the mean of the six linear regression slopes for the first 60 s of each activity. Using the non-parametric Kendall's tau-b, the correlation between light intensity and average rate of recovery was .140, which is not significantly different from zero ($p = .287$). (Descriptively, the positive correlation indicates a slight, though not statistically significant, tendency toward slower heart rate recovery with higher light intensity.) In the blank wall and plasma window conditions there was also no significant correlation between light intensity and average rate of recovery, but this is not surprising given the very limited variation in light intensity in these conditions.

4. Discussion

This study established three key findings. First, in terms of heart rate recovery from low-level stress, working in the office environment with a glass window that looked out on a nature scene was more restorative than working in the same office without the outside view (the blank wall condition). Second, in terms of this same physiological measure, the plasma window was no different from the blank wall. Third, when participants looked longer out the glass window, they had greater physiological recovery; but that was not the case with the plasma window, where increased looking time yielded no greater physiological recovery. Thus the results from this study provide a check on what might otherwise be an unbridled positive judgment about plasma windows (cf. Friedman et al., 2004),

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particularly if one has the option of building or inhabiting spaces with glass windows offering natural views.

Other research has suggested that people may accrue physiological and psychological benefits simply by experiencing daylight in otherwise inside spaces (Küller & Lindsten, 1992; Leather, Pyrgas, Beale, & Lawrence, 1998; cf. Küller & Wetterberg, 1993). Thus it could be argued that the effects of our current study could be completely explained on the basis of daylight: that the glass-window condition was the only condition of the three that had actual daylight (as opposed to digitally represented daylight through the plasma window). To partly address this potential confound, we examined the association between light intensity and heart rate recovery within the glass-window condition. We did not find a significant correlation. In other words, our data indicate that in the glass-window condition there was no tendency for heart rate recovery to be more rapid when the light intensity was greater. In contrast, when we examined the relationship between time spent looking at the window and heart rate recovery in the glass-window condition, we did find a significant association. While this result does not rule out the possibility that part of the observed difference in heart rate recovery between the blank wall condition and the glass-window condition is due to natural daylight vs. artificial light, our data do provide evidence that actually looking out the window plays a significant role in heart rate recovery.

Various theories have been advanced for why nature views may be physiologically and psychologically restorative. For example, according to attention restoration theory (Kaplan & Kaplan, 1989), nature views have properties that engage involuntary yet undemanding attention, and thus promote recovery from mental fatigue. Alternatively, according to one version of psycho-evolutionary theory (Ulrich et al., 1991 Ulrich, Simons, Losito, Fiorito, Miles, & Zelson, 1991), many aspects of nature accord in humans a quick positive affective reaction which subsequently benefits physiological and psychological processes. What is striking about our findings is that the physiological and psychological experience of nature would appear to differ depending on the medium (transparent glass or digital display) through which one views nature. Granted, the difference may be due to the lack of full fidelity in the digitized real-time display; for example, the plasma window did not afford parallax (the apparent shifting of objects when viewed at different angles), a difficult but tractable technical problem (Radikovic, Leggett, Keyser, & Ulrich, 2005). But we suspect—and it awaits further study—that the difference is due to more complex reasons, involving not only technical issues of parallax, pixilation, and 2-D as opposed to 3-D depth perception, but judgments by viewers about what it means for a view to be "real" as opposed to "represented," and how such judgments feed back into the physiological and psychological system.

This study also speaks to the problem of the shifting baseline. The problem is characterized well in the context of the human–nature relationship by Fredston (2001) who, over several decades, rowed more than 20,000 miles of some of the wildest coastlines in the arctic waters. During one of her later expeditions, she and her husband were rowing along portions of Norway. She notes that much of Norway's built environment has an esthetic that most towns in Alaska (where she lives) lack. But then she adds:

> Still, even the undeniably beautiful portions of the Norwegian coast that send visitors from more developed, congested parts of Europe into raptures seemed sterile to us…That experience frightened us to the marrow. It made us realize that, like the perpetually grazing sheep [in Norway], centuries of human habitation have nibbled away not only at the earth but at our perception of what constitutes nature. When we do not miss what is absent because we have never known it to be there, we will have lost our baseline for recognizing what is truly wild. In its domestication, nature will have become just another human fabrication (p. 217).

This problem of the shifting baseline takes on greater import when one recognizes that not only are we quickly degrading the natural world (and thus limiting our opportunities to interact with healthy and diverse ecosystems), but more and more the human experience of nature will be mediated by technological systems. Of course, humans will continue to adapt to such technologies. But it is important to address the issue of whether such adaptations are not just different but impoverished from the standpoint of human functioning and flourishing, and whether such technological systems and resulting interactions are shifting the very baseline of what we can recognize as impoverishment. The current study can be understood as an initial foray into this largely uncharted territory; and our results, even in this early stage, provide some cautionary thoughts.

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