ASSESSING BELIEFS ABOUT LIGHTING EFFECTS ON HEALTH, PERFORMANCE, MOOD, AND SOCIAL BEHAVIOR

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ABSTRACT: Energy conservation through the adoption of new, energy-efficient technologies will succeed only to the extent that the new technologies are not themselves perceived as risk sources. Previous research has found that beliefs about the health effects of fluorescent lighting predict compact fluorescent lamp use in homes. This paper describes the development and validation of a questionnaire to assess beliefs about the effects of common types of interior lighting on human health, work performance, mood, and social behavior. Principal components analysis of the 32-item Lighting Beliefs Questionnaire revealed 6 interpretable components: Lighting Importance, Brightness, Major Health Effects: Fluorescent Lighting, Minor Health Effects: Fluorescent Lighting, Social Setting, and Daylighting. The questionnaire may be used to explore responses to interior lighting and to discover what beliefs are held by end users. This information will assist in allaying unwarranted fears and concerns about new lighting technologies.

Environmental issues have two aspects: the effects of human activity on ecological stability and the effects of the environment on human health and well-being. The latter fall into the domain of

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risk perception, in that individuals judge themselves to be endangered by some environmental exposures, but not by others. The former are seen in the awareness of the serious changes wreaked on the planet by human behavior, past and current.

The two domains sometimes collide in public policy debates because any attempt to prevent environmental damage can succeed only if it is not itself perceived as a new risk. Efforts to encourage energy conservation are a large part of efforts to halt environmental degradation. However, these campaigns will succeed only if people believe that the means to achieve energy efficiency will not diminish their quality of life, their health, or their well-being.

Social psychology has well-developed models of beliefs, attitudes, and behaviors that apply to this situation (e.g., Fishbein & Ajzen, 1975). Beliefs underlie and direct attitudes and behavioral intentions, and these in turn guide behaviors. Ajzen and Fishbein (1977) asserted that general attitudes do not predict specific behaviors. For instance, general attitudes about global environmental issues are poor predictors of environmentally concerned behavior in general (Axelrod & Lehman, 1993) and of energy conservation behavior specifically (Samuelson & Biek, 1991). This implies that education campaigns for energy efficiency in specific domains will succeed only to the extent that they target the appropriate domain-specific beliefs.

Stern (1992) has argued that the most effective targets for energy conservation are not individual energy-use behaviors but technology choices. Rather than requiring the reinforcement of a daily behavior, such as carpooling, this approach requires the reinforcement of infrequent decisions, such as the choice of a high-efficiency furnace or a low-flow shower head. Energy conservation research over 20 years has produced models of resource use (e.g., Costanzo, Archer, Aronson, & Pettigrew, 1986; Stern & Oskamp, 1987) that explain environmental choices in terms of structural or positional factors (e.g., financial circumstances, availability of an energy-efficient alternative) and psychological factors such as knowledge, attitudes, and beliefs.

Risk perception research also emphasizes the role of individual differences, attitudes, and beliefs. There are differences between expert perceptions of risk and lay persons' judgments (e.g., Bostrom, Fischoff, & Morgan, 1992; Maharik & Fischoff, 1993); furthermore, individual and cultural differences also explain responses to environmental risks (Vaughan, 1993). Vaughan discussed three classes of policy-related uses for information about the social, psychological, and economic context of risk perceptions involving specific hazards: design of risk management programs, understanding and predicting risk responses, and risk communication. Wandersman and Hallman (1993) concurred that specific understanding of the psychological processes in the perception of specific risks provides necessary information to policy makers.

Thus, from both the perspective of encouraging energy-efficient choices and to understand risk perception of new, energy-efficient technologies, there is a need to examine the beliefs and attitudes that will influence these choices. We chose to focus on lighting as an obvious choice for energy conservation. Electric lighting consumes 30-40% of the electricity consumed in commercial buildings (I. Pasini, personal communication, 6 June 1994), and 6% in homes (Stern & Gardner, 1981). Additionally, lighting is important to people. Respondents in a 1979 Louis Harris poll of office workers ("Office lighting," 1980) cited "good lighting" as a feature that makes a comfortable office more often than any other feature (85%, versus 73% for the second-ranked feature, "comfortable chair"). Veitch, Hine, and Gifford (1993) surveyed undergraduate students and found strong agreement that lighting is important to studying effectiveness, mood, and well-being.

New technologies allow substantial energy savings for lighting homes and offices. The best known of these is the compact fluorescent family of lamps that has been promoted vigorously by utility companies. Utility company rebate programs emphasize financial incentives for changing from one lighting system to another by lowering the initial cost of the product. These strategies have limited success. For example, Howard, Delgado, Miller, and Gubbins (1993) offered residents three levels of incentive in this order: They took compact fluorescent lamps to the consumer; they offered a week's free home use of the lamp; and they offered a 20% discount off the regular retail price of the lamp. Across all three incentive types, the total number of lamps purchased by 120 households was 28, by 24 households (20%). Howard et al. had previously determined that the median number of incandescent lamps per home in their community was 51.

Where monetary incentives have not led to the adoption of energy-efficient lighting, beliefs about lighting effects might explain why. Beckstead and Boyce (1992) studied beliefs and attitudes toward fluorescent lighting and usage of compact fluorescent lighting in the home. Beliefs about lighting predicted compact fluorescent lighting usage; moreover, the LISREL analysis revealed that usage depended on beliefs about the effects of fluorescent lighting on people and not on beliefs about cost, efficiency, or operation of fluorescent lamps. That is, people who perceived that there could be health risks associated with the choice did not choose the energy-efficient compact fluorescent lamp.

The present study tested a new measure of beliefs about lighting effects, examining its structure and the relationships of lighting beliefs to beliefs about the physical environment in general, technical knowledge about lighting, and to other personality measures. To the extent that lighting beliefs relate to other constructs in predicted ways, the construct validity of the measure would be established (compare Ghiselli, Campbell, & Zedeck, 1981).

We predicted that the Lighting Beliefs Questionnaire (LBQ) scores would correlate with beliefs about other effects of physical environmental features, as assessed by the Person-Surroundings Scale (PSS) (Gifford, 1992a). We also predicted that both LBQ scores and scores on a test of lighting knowledge would correlate with a measure of the desire for control over the physical environment, but not with the actual control provided, in their current school or workplace environments, both measured using the Survey of Personal Influence in Common Environments (Gifford & Eso, 1988). These predictions were based on a reading of the literature on control in environmental and social psychology, as well as on limited evidence in the lighting domain specifically.

Repeated experience with choices in the physical environment has been said to be the source of both expectations regarding consequences and the perception of being able to control outcomes (Barnes, 1981). Barnes noted that perceived control in this sense is associated with a desire for certainty, to be able to predict accurately the outcome of a particular choice. When one can anticipate the likely outcome of a particular choice, it becomes more likely that one will obtain the desired outcome. Barnes theorized that perceived control is desirable because it allows the individual to know whether it will be possible to manipulate the environment to fulfill one's needs; it leads to satisfaction with the environment.

The respondents to Beckstead and Boyce's (1992) survey of home lighting choices chose lighting that was consistent with their existing beliefs about the consequences of the choice. This is consistent with the predictions of the Theory of Planned Action (Ajzen & Madden, 1986), an extension of the theory of reasoned action (Fishbein & Ajzen, 1975) to acts that are not entirely volitional—that is, acts for which success is not guaranteed. Ajzen and Madden (1986) found that *perceived behavioral control* contributed significantly to the prediction of behavioral intentions (to obtain an "A" in a course) and to goal attainment. The measures of perceived behavioral control (over attending class) correlated highly with beliefs about the consequences of attending class (r = .54 or better) but also predicted both intentions and behavior directly.

Butler and Biner (1987) studied preferred light levels for tasks within settings and found that when participants believed the lighting conditions to be important to a situation, they wanted to be able to control the lighting. Similarly, we predicted that beliefs about the effects of lighting would correlate with the desire to control physical features, including lighting.

This prediction was further supported by previous research (Veitch et al., 1993). In general, the respondents in that survey believed that lighting is important to the achievement of a healthy, productive life and expressed a preference for lighting types that they believed would help them to achieve desirable outcomes. In the present study, therefore, we predicted that individuals who endorse statements about the effects of light on performance, mood, and health would prefer to have control over their physical surroundings as a means of ensuring that they would obtain beneficial outcomes.

Technical knowledge about lighting was expected to correlate with desired control to the extent that such knowledge contributes to the ability to predict the outcomes of lighting choices (compare Barnes, 1981). Ratings of actual control, which depend on the resources available in settings currently occupied, were not expected to correlate with the more general lighting beliefs built over many past experiences.

The present study also included the Rotter Internal-External Locus of Control (LoC) Scale (Rotter, 1966), which is a measure of generalized expectancies concerning reinforcement. Internals are more likely to believe that their own actions determine whether one receives rewards; externals believe that chance or powerful others govern reward contingencies. We predicted that there would be no relationship between lighting beliefs and LoC because the general outcomes referenced in the LBQ are not consequences (rewards or punishment) of specific actions (compare Rotter, 1975). Similarly, endorsement of statements about lighting beliefs was not expected to relate to beliefs in free will or determinism (compare Sappington, 1990); LoC and determinism may be related (Stroessner & Green, 1990).

METHOD

PARTICIPANTS

Participants in this study were sampled from three populations: 31 female and 65 male employees of a Canadian government research laboratory; 33 female and 8 male undergraduate students at a small Eastern Canadian university; and 111 female and 70 male undergraduate students at a medium-sized Western Canadian university. The participants ranged in age from 18 to 65 and varied in their level of education from high school graduates to doctoral graduates. The research laboratory employees were older and better educated than the university student samples, but there were no statistically significant differences between the LBQ scores for the three samples. Therefore the samples were pooled to form a data set of 318 cases (175 women and 143 men).

MEASURES

The participants voluntarily completed a questionnaire package in their classrooms or offices. The package varied slightly in length for the various samples according to the time available for the participants to complete the package. The complete package included the LBQ, the Lighting Knowledge Test, the PSS (Gifford, 1992a), the school/workplace portion of the Survey of Personal Influence in Common Environments (Gifford & Eso, 1988), the Free Will-Determinism Scale (Gifford, 1992b), and the LoC Scale (Rotter, 1966). Copies of all the questionnaires are available upon request.

The LBQ consists of 32 statements about lighting and its effects on people (see Appendix). Respondents rated their agreement with each item on a 5-point Likert scale or used a "don't know" option. The statements were based on beliefs, commonly reported in the popular press, the lighting design literature, and the *Lighting Handbook* published by the Illuminating Engineering Society of North America (IESNA, 1987), about lighting effects on people. Pilot testing eliminated some confusing statements and refined the phrasing of the retained items, and the resulting questionnaire was reviewed by two lighting researchers.

The Lighting Knowledge Test was a revised form of the original test by Veitch et al. (1993); items that had proven confusing or unreliable were rewritten. It consists of 10 true/false items about technical aspects of common light sources. For example, "Fluorescent lights produce less heat than incandescent lights" (true). The development data, based on 1,059 university undergraduates, had an internal consistency reliability of .70 for the best 7 of 10 items (Veitch et al., 1993).

The PSS (Gifford, 1992a) is a 22-item instrument (18 valid items and 4 fillers) on which respondents indicate, using a 7-point Likert scale, their agreement or disagreement with statements about the effects of the physical environment on people. Examples of the items are: "Rain changes my mood" and "The way a room is decorated affects the way I act in it." It was included because of its logical connection to the LBQ, although its internal consistency is not high: alpha = .61, based on 140 respondents.

The Survey of Personal Influence in Common Environments (Gifford & Eso, 1988) is an instrument that assesses the degree of influence that the respondent currently experiences over features in specific settings (actual control) and the importance to the individual of having influence over the same features (desired control). In both cases, the rating is on a 5-point Likert scale. The instrument includes ratings for indoors and outdoors at home, work/school, and public spaces. This study used the Work/School Indoors subscale; respondents rated actual and desired control for 21 features (e.g., brightness of the lighting, furniture arrangement, and so on) in their most common work or school setting and for that setting overall. In the development study, data from 198 respondents produced alpha estimates of .95 for actual control and .92 for desired control on the Work/School Indoors subscale.

The Free Will-Determinism Scale (Gifford, 1992b) is a 14-item scale of statements such as "Our entire lives are predetermined" (reverse-scored) and "Only a few unimportant incidents in our lives are determined," which respondents rate on a 5-point agree/disagree Likert scale. Three items are fillers. Determinism, here, is the belief that for every event that could ever occur in one's life, there are conditions that dictate that the event is the only possible outcome. Free will is the belief that individuals have the power to direct a particular outcome. The scale is bipolar, with higher scores indicating a belief in free will and lower scores a belief in determinism. The scale was developed using data from a separate sample of 144 undergraduate psychology students and has good internal consistency reliability (Cronbach's alpha = .80).

The Rotter LoC Scale (Rotter, 1966) is a 29-item forced-choice questionnaire assessing the belief that reinforcement for one's behavior comes from internal (self) or external (chance or powerful others) sources. Six items are fillers. Development and validation data from many sources attest to its reliability and validity (Rotter, 1966).

RESULTS

DESCRIPTIVE STATISTICS

Descriptive statistics for the full scales are presented in Table 1.

Lighting Beliefs Questionnaire. The items on the LBQ were rated on a Likert scale from 0 to 4. Half of the items are negatively worded; scores on these items were recoded so that higher scores invariably reflect the belief that lighting causes a particular effect. The questionnaire provided for a "don't know" option that was used extensively by the research laboratory sample but infrequently by the student samples. Interviews with randomly-selected respondents in that sample revealed that they had used "don't know" when they did not feel strongly that they agreed or disagreed with the statement. Therefore, "don't know" scores were recoded to 2 (neutral) for all cases to maximize the number of cases for analysis. The scale score was calculated as the mean of the nonmissing items for each participant. The overall mean of 2.26 (SD = 0.33) on the scale from 0 to 4 indicates that lighting beliefs in general are moderately strong.

The frequency data for each item are shown in the Appendix. Some statements rated high agreement: 65% of the respondents reported that the quality of light is important to their well-being. A large majority (80.5%) agreed or strongly agreed

TABLE 1
Descriptive Statistics: Full Scales

Scale	*Limits*	M	SD	N	*items*	*alpha*
LBQ	0—4	2.26	0.33	302	32	.79
Lighting Knowledge Test	0—10	6.10	3.07	318	10	.83
Actual Control	0—4	2.97	0.71	175	21	.91
Desired Control	0—4	1.86	0.69	178	21	.91
PSS	0—6	3.58	0.62	312	18	.63
Free Will-Determinism	0—4	2.66	0.61	222	11	.77
LoC	0—23	12.30	4.51	88	23	.79

NOTE: PSS = Person-Surroundings Scale; LBQ = Lighting Beliefs Questionnaire; LoC = Locus of Control. For LBQ and PSS, higher values indicate stronger beliefs in physical environmental effects on people. Higher Lighting Knowledge Test scores indicate greater knowledge. Higher scores on Actual Control Scale, Desired Control Scale, and LoC Scale reflect control external to the individual. Higher Free Will-Determinism Scale scores indicate greater belief in free will.

that natural daylight indoors improves their mood. Seventy percent reported that the type of lighting in a room makes a difference to them.

Some of the more interesting findings are those that imply contradictions. For instance, 32.7% of respondents agreed or strongly agreed that "Bright lights are stimulating; they make me feel energetic." However, only 14.8% agreed or strongly agreed that they accomplish more work under bright light. Forty percent reported that bright light can make them feel tense.

When asked to rate the statement, "Fluorescent lighting is bad for your health," only 14.8% reported any degree of agreement. Almost twice that number agreed or strongly agreed that fluorescent light can give them headaches. Forty-one percent agreed that working under fluorescent lights can give them eyestrain.

Lighting Knowledge Test. Each item answered correctly scored 1, and correctly scored items were summed to form the scale score out of 10. The mean score was 6.1 ($SD = 3.1$), and the median was 7.

Survey of Personal Influence in Common Environments. The Desired Control and Actual Control scales were rated on Likert scales from 0 to 4, where higher numbers reflected control vested outside the respondent (either the individual lacked control over the feature in question or preferred not to have control over that feature). The scale scores are means of the nonmissing component items. They therefore reflect actual and desired control over all features in the respondent's primary work or school setting. The overall mean for actual control was 2.97 ($SD = 0.71$) and for desired control, $M = 1.86$ ($SD = 0.69$). The respondents perceived that others control their physical settings at work/school, but desired more control.

Person-Surroundings Scale. The items were rated on a scale from 0 to 6, with higher values indicating that the respondent believes that the physical surroundings have an effect on mood or behavior (for example, "Bright colors make me happy" and "Stuffy air does not affect me much"). Negatively worded items were reverse-coded for consistency. The scale score is the mean of the nonmissing items for each participant. The overall mean, 3.58 ($SD = 0.62$), indicates moderate endorsement of beliefs about the effects of the physical surroundings.

Free Will-Determinism Scale. This measure used a 5-point Likert scale from 0 to 4. Negatively worded items were reverse-coded, and the scale score is the mean on nonmissing items for each participant. Higher values reflect stronger beliefs in free will; lower scores indicate a deterministic viewpoint. The overall mean of 2.66 ($SD = 0.61$) indicates beliefs more in favor of free will than determinism.

Locus of Control Scale. This measure was scored according to the Rotter's (1966) instructions. Items were scored so that the External response rated 1 and the Internal response rated 0. The scale score can range from 0 to 23, and higher values reflect greater control vested in chance or powerful others. The overall mean was 12.30 ($SD = 4.48$).

RELIABILITY ANALYSES

Internal consistency reliability of the seven dependent measures was assessed using Cronbach's alpha. The results, with the exception of the PSS, ranged from acceptable (above .70) to good (above .90). In these analyses and all others, the number of participants providing data on each scale varied widely because of differences in the number of dependent measures administered at the various sites and because of missing data.

For the LBQ, with 32 items and 302 participants, alpha was .79. The internal consistency of the Lighting Knowledge Test was somewhat higher, with alpha = .83 (10 items, 318 participants).

The PSS assesses beliefs about the effects of the physical environment on behavior and mood but over a wider variety of physical conditions than the LBQ. The PSS covers more than one domain, whereas the LBQ is focused on lighting. Not surprisingly, PSS had a lower internal consistency (alpha = .63, 18 items, $N = 312$).

The Actual Control Scale and Desired Control Scale from the Survey of Personal Influence in Common Environments both showed good internal consistency. For both scales, alpha = .91. Each scale consisted of 21 items; Actual Control had 175 participants, and Desired Control had 178.

The Free Will-Determinism Scale, with its 11 items, had acceptable internal consistency (alpha = .77, $N = 222$). The alpha value (.79) for the Rotter LoC Scale (23 items, $N = 88$) is consistent with previous reports (compare Rotter, 1966).

PRINCIPAL COMPONENTS ANALYSIS: LIGHTING BELIEFS QUESTIONNAIRE

Principal components analysis was employed to investigate interrelationships between the 32 items on the LBQ. Based on a scree plot, six components were retained. Varimax rotation of these components produced a simple structure that explained 42.84% of the variance. For interpretation, variables with component loadings greater than 0.400 were retained. No items had loadings greater than 0.400 on more than one component; eight items did not load on any of the six components. The scales were labelled Lighting Importance, Brightness, Major Health Effects: Fluorescent Lighting, Minor Health Effects: Fluorescent Lighting, Social Setting, and Daylighting.

Table 2 displays the component loadings and questionnaire items. Subscale scores (mean of nonmissing values) were

TABLE 2
Lighting Belief Questionnaire Component Loadings and Subscale Descriptive Statistics

	Loading	*Subscale* M	*Subscale* SD	*Subscale alpha*
Component 1 Lighting Importance				
Total Variance Explained: 7.91%				
16. It makes no difference to me what kind of lighting is in a room. (R)	0.692			
13. The quality of light in my workplace is irrelevant to my job satisfaction. (R)	0.689			
7. I learn equally well in a room with any kind of lights. (R)	0.601			
1. The quality of light wherever I am is important to my well-being.	0.544			
Subscale Statistics		2.53	0.67	.63
Component 2 Brightness				
Total Variance Explained: 7.84%				
4. Bright lights are stimulating; they make me feel energetic.	0.785			
9. The brighter the light, the more work I accomplish.	0.725			
8. Bright light at work does not improve my morale. (R)	0.628			
32. Bright lights rarely make me feel excited and full of anticipation. (R)	0.602			
Subscale Statistics		1.85	0.69	.70
Component 3 Major Health Effects: Fluorescent Lighting				
Total Variance Explained: 6.38%				
18. Pregnant women should avoid exposure to fluorescent lighting.	0.802			
23. Fluorescent lights are bad for your health.	0.744			
2. You cannot get skin cancer from working under fluorescent lights. (R)	0.637			
Subscale Statistics		1.82	0.61	.64
Component 4 Minor Health Effects: Fluorescent Lighting				
Total Variance Explained: 7.52%				
26. Fluorescent light seldom gives me a headache. (R)	0.643			
5. I get eyestrain from working under fluorescent lights.	0.629			
19. My vision never becomes blurred when the lights are very bright. (R)	0.560			

TABLE 2: Continued

	Loading	*Subscale* M	*Subscale* SD	*Subscale alpha*
Component 4 Minor Health Effects: Fluorescent Lighting				
20. Glaring lights give me headaches.	0.551			
Subscale Statistics (without Item 19)		2.32	0.83	.73
Component 5 Social Setting				
Total Variance Explained: 5.84%				
29. Incandescent lighting in a room helps me to pay attention to the speaker.	0.598			
27. If a restaurant is very brightly lit, I will leave soon after I've finished eating.	0.581			
17. Soft, diffuse light is soothing.	0.575			
24. If I want to create an intimate setting, I dim the lights.	0.573			
25. Bright light makes people talk louder.	0.419			
Subscale Statistics		2.55	0.55	.54
Component 6 Daylighting				
Total Variance Explained: 7.33%				
30. I do my best work in places that are lit using natural daylight.	0.703			
14. Natural daylight indoors improves my mood.	0.622			
28. Lack of sunlight in winter does not bother me. (R)	0.535			
3. Sunny days make me happy.	0.459			
Subscale Statistics		2.94	0.67	.64

NOTE: All scales rated between 0 (strongly disagree) and 4 (strongly agree). (R) indicates reverse-scoring. Total variance explained = 42.85%.

calculated for the items loading highly on each component, and their descriptive statistics are also shown in Table 2.

BETWEEN-SCALES CORRELATIONAL ANALYSES

The correlation matrix was computed using pairwise deletion of missing values to maximize sample size and Bonferroni probability correction to control familywise error over all 78 correlations in the full matrix. The full matrix included the full-scale LBQ, its six subscales, the PSS, the Actual Control Scale, Desired Control Scale, the Lighting Knowledge Test, the Free Will/Determinism Scale, and the LoC Scale.

TABLE 3
Pearson Correlations Between Whole Scales

	Actual Control	*Desired Control*	*PSS*	*Lighting Knowledge Test*	*LBQ*	*Free Will-Determinism*
Desired Control	0.18					
PSS	0.08	–0.19				
Lighting Knowledge Test	–0.16	–0.36*	0.01			
LBQ	0.11	–0.12	0.51*	–0.06		
Free Will-Determinism Scale	0.11	–0.14	–0.03	0.05	–0.02	
LoC	0.16	–0.201	0.11	0.13	0.15	–0.45

NOTE: *Bonferroni-adjusted probability <.05. Correlations were calculated using pairwise deletion of missing cases. Error rate adjustment was applied to the full matrix of 78 correlations. PSS = Person-Surroundings Scale; LBQ = Lighting Beliefs Questionnaire; LoC = Locus of Control.

Table 3 contains the correlations between the full scales. As predicted, LBQ scores correlated highly with PSS scores (r = .51). LBQ scores did not correlate with either Desired or Actual Control, although a relationship to Desired Control had been predicted. LBQ did not correlate with either LoC or Free Will-Determinism, which is consistent with our predictions. Scores on the Lighting Knowledge Test correlated with Desired Control as predicted (r = –.36, with more knowledgeable people desiring more control over workplace features).

Table 4 shows the correlations between subscales of the LBQ and the full scales. This table reveals differences between the subscales. For example, Importance scores (beliefs about the importance of lighting) correlated significantly with Desired Control (r = –.33), with people who believe that lighting is important to health and well-being also desiring more control over workplace physical features. Other LBQ subscales did not correlate with Desired Control. Two subscales (Brightness and Major Health Effects) did not have statistically significant correlations with the PSS; the significant relationships varied in size from .19 to .44.

Table 5 displays the intercorrelations between the various LBQ subscales. Although some of the intercorrelations were

TABLE 4
Pearson Correlations Between Lighting Beliefs Questionnaire Subscales and Whole Scales

	Actual Control	*Desired Control*	*PSS*	*Lighting Knowledge Test*	*LBQ*	*Free Will-Determinism*	*LoC*
Importance	–0.04	–0.33*	0.44*	0.15	0.62*	0.03	0.04
Bright	0.06	0.06	0.17	–0.09	0.40*	0.01	–0.02
MajHlth	0.15	0.09	0.14	–0.13	0.39*	–0.13	0.07
MinHlth	0.09	0.03	0.19*	–0.12	0.60*	–0.10	0.09
Social Setting	0.12	–0.11	0.27*	0.03	0.55*	0.05	0.14
Daylight	–0.01	–0.02	0.40*	–0.02	0.65*	0.04	0.14

NOTE: *Bonferroni-adjusted probability <.05. Correlations were calculated using pairwise deletion of missing cases. The Bonferroni adjustment was applied to the full matrix of 78 correlations (Tables 3, 4, and 5). PSS = Person-Surroundings Scale; LBQ = Lighting Beliefs Questionnaire; LoC = Locus of Control; MajHlth = Major Health Effects; MinHlth = Minor Health Effects.

TABLE 5
Correlations Between Lighting Beliefs Questionnaire Subscales

	Importance	*Bright*	*MajHlth*	*MinHlth*	*Social Setting*
Bright	0.17				
MajHlth	0.07	0.13			
MinHlth	0.19	–0.04	0.26		
Social Setting	0.28*	0.09	0.10	0.24*	
Daylight	0.32*	0.23*	0.12	0.32*	0.34*

NOTE: *Bonferroni-adjusted probability <.05. Correlations were calculated using pairwise deletion of missing cases. The Bonferroni adjustment was applied to the full matrix of 78 correlations (Tables 3 and 4, Appendix). MajHlth = Major Health Effects; MinHlth = Minor Health Effects.

statistically significant, all are smaller than the internal consistency reliability (average of item intercorrelations) of each subscale (Table 2). The fact that the intercorrelations between items in each subscale are stronger than the relations between the subscales is further evidence that the subscales measure distinct components of lighting beliefs.

DISCUSSION

The development of the LBQ and the identification of distinct dimensions of lighting beliefs is a first step toward understanding how these beliefs influence overt behaviors. The LBQ demonstrated adequate internal consistency and some of the predicted relationships to other constructs. The results partially replicate other work and provide pointers for further research and for design applications.

THE STRUCTURE OF LIGHTING BELIEFS

Although the LBQ demonstrated an adequate overall internal consistency, the principal components analysis revealed that the scale can be deconstructed into six interpretable components. Four of these components are similar to the interpretable constructs identified by Veitch et al. (1993): beliefs about the importance of lighting, about health effects of lighting, about the superiority of daylight, and about bright light. The subscales themselves had acceptable internal consistency reliability for the number of items.

The relationships between the subscales were consistent with the previous research. Using canonical correlation analysis, Veitch et al. (1993) demonstrated that people who endorse beliefs about lighting effects on health also endorse beliefs about the superiority of natural light over other types. Similarly, the present study showed that people who hold beliefs about the benefits of daylight also hold beliefs about the minor effects of lighting on health. In this study, the existence of correlations between beliefs about daylight and other subscales demonstrates that beliefs about daylight co-occur with many other beliefs about the effects of lighting and about the physical environment.

CONSTRUCT VALIDITY

Although the overall scale did not perform precisely as predicted, the LBQ demonstrated adequate construct validity when subscale relationships were taken into account. LBQ scale scores showed the expected strong relationship to general beliefs about the physical environment's effects on people. The overall LBQ score did not show the predicted relationship to Desired Control; however, the Importance subscale did show a strong relationship to the desire for control over physical features. This outcome replicated previous research (Butler & Biner, 1987; Veitch et al., 1993). Lighting Knowledge Test scores did correlate with Desired Control at a statistically significant level, as predicted. There were, as predicted, no significant relationships of any lighting beliefs to the actual control available to the respondents in their work or school settings.

The Importance scores did not correlate significantly with Lighting Knowledge ($r = .15$), although this may be an artifact of the very conservative Bonferroni probability procedure (the unadjusted probability associated with this correlation is $p < .01$, $N = 318$). The Importance-Knowledge relationship is of the same magnitude as a significant correlation reported by Veitch et al. (1993).

LBQ scores, both overall and subscales, were unrelated to both LoC and Free Will-Determinism scores, which had been expected. The LoC and Free Will-Determinism scores, despite an $r = -.45$ (External LoC associated with beliefs in determinism), did not show a statistically significant relationship. This was the result of two factors: the very conservative Bonferroni procedure and the smaller sample size ($n = 92$) than for most of the pairs in the matrix. The strength of the relationship, however, warrants attention in future research. The magnitude of this relationship is similar to previously reported results (Stroessner & Green, 1990).

APPLICATIONS

The results suggest certain specific applications to lighting design and facilities management. For example, the present study supports the hypothesis that people with greater knowledge about lighting would prefer to control their lighting. This finding suggests that providing individual controls to individuals who have little understanding of lighting might not be appropriate; or, that instruction should be provided when individual controls are installed.

The components of the LBQ provide direction for communication between designers and end users, and identify the broad themes that are important to people when they think about lighting. Designers can use this awareness to improve their understanding of their clients' needs, beliefs, and expectations, thereby increasing the likelihood that the lighting design will be satisfying.

This study confirms the findings of previous research (Veitch et al., 1993) in finding that some people suspect fluorescent lighting to be the cause of certain transient health problems, such as headaches and eyestrain (although fewer of these respondents endorsed the more general statement "Fluorescent lighting is bad for your health"). Empirical research has been unable to demonstrate that these problems are caused by lighting. Marketing attempts to encourage the use of compact fluorescent lighting should take heed of this discrepant belief.

FUTURE RESEARCH

This study demonstrates that people hold identifiable beliefs about the effects of lighting on their behavior, mood, and health. Furthermore, it appears that specific subsets of those beliefs may predict specific behaviors; the various subscales did not show identical patterns of correlation with the other dependent measures. Future research should explore the possibility that certain subscales may be more important than others in explaining lighting choices. Various educational campaigns that emphasize different themes, as identified by the subscales, could be tested for their effectiveness in encouraging the selection of energy-efficient lighting systems or products.

The Daylight subscale deserves special attention. Its mean was highest of all the subscales, reflecting a strong belief in the beneficial effects of daylight over artificial light. In this respect also the present study replicated earlier work (Veitch et al., 1993). Future research should investigate the possibility that these beliefs also relate to a reluctance to trust or to accept new lighting technologies. Although increasing use of natural daylight is one way to increase energy efficiency, artificial lighting is a necessity of modern life, particularly at northern latitudes.

CONCLUSION

Beckstead and Boyce (1992) found that in homes, beliefs about lighting predicted the use of one type of energy-efficient lighting. In homes, the person who makes the lighting decision also uses the lighting system, but in commercial and institutional settings the lighting decision maker is not always the end user. Evidence suggests that in some cases, decision makers avoid choosing innovative, energy-efficient products to avoid problems with end user acceptance of a new lighting system (Conway & Leslie, 1992). In the absence of empirical evidence about what people believe about lighting, the institutional decision maker can rely only on informal heuristics to predict end user response. Cognitive psychology has demonstrated that such heuristics can produce biased decisions and overestimates of risk (Tversky & Kahneman, 1974).

This study demonstrates that there are reliably held beliefs about lighting in the general population. Improving our understanding of those beliefs and their relationship to other attitudes and behaviors will allow us to improve the means we choose to encourage energy conservation through lighting choices, both in homes and in workplaces.

APPENDIX
Response Frequencies for Lighting Beliefs Questionnaire Items

	Response Frequency (%)						
Item	*0*	*1*	*2*	*3*	*4*	M	(SD)
1. The quality of light wherever I am is important to my well-being.	1.26	4.40	29.25	46.86	18.24	2.76	(0.84)
2. You cannot get skin cancer from working under fluorescent lights. (R)	11.36	23.03	55.84	6.94	2.84	1.67	(0.87)
3. Sunny days make me happy.	1.60	2.56	13.1	39.62	43.13	3.21	(0.89)
4. Bright lights are stimulating; they make me feel energetic.	5.70	22.15	39.24	25.63	7.28	2.07	(1.00)
5. I get eyestrain from working under fluorescent lights.	3.15	23.66	31.23	29.97	11.99	2.24	(1.04)
6. Incandescent lights are relaxing.	1.27	10.13	62.66	21.52	4.43	2.18	(0.72)
7. I learn equally well in a room with any kind of lights. (R)	4.42	20.19	32.49	32.81	10.09	2.24	(1.03)
8. Bright light at work does not improve my morale. (R)	6.94	25.24	42.59	22.08	3.15	1.89	(0.93)
9. The brighter the light, the more work I accomplish.	8.23	36.39	40.51	11.39	3.48	1.66	(0.91)
10. Glittery, dazzling lights rarely make me dizzy. (R)	9.46	29.34	29.34	25.55	6.31	1.90	(1.08)

APPENDIX: Continued

	Response Frequency (%)						
Item	*0*	*1*	*2*	*3*	*4*	M	(SD)
11. It is easier for me to work under full-spectrum fluorescent light than regular fluorescent light.	3.15	4.10	82.65	8.52	1.58	2.01	(0.56)
12. Bright, harsh fluorescent lighting can make me feel tense.	1.58	9.78	48.26	29.97	10.41	2.38	(0.86)
13. The quality of light in my workplace is irrelevant to my job satisfaction. (R)	3.15	19.24	22.40	43.22	11.99	2.42	(1.03)
14. Natural daylight indoors improves my mood.	.63	3.15	15.46	40.69	40.06	3.16	(0.85)
15. Bright lights in grocery and drug stores don't make me buy more. (R)	19.87	35.96	36.59	6.94	.63	1.33	(0.89)
16. It makes no difference to me what kind of lighting is in a room. (R)	4.10	10.09	14.51	54.57	16.72	2.70	(1.00)
17. Soft, diffuse light is soothing.	.63	1.90	25.32	55.38	16.77	2.86	(0.73)
18. Pregnant women should avoid exposure to fluorescent lighting.	5.36	11.36	77.60	3.79	1.89	1.86	(0.65)
19. My vision never becomes blurred when the lights are very bright. (R)	6.62	18.61	32.18	32.81	9.78	2.21	(1.06)
20. Glaring lights give me headaches.	1.27	8.89	22.86	41.90	25.08	2.81	(0.96)
21. I rarely use warm-coloured lighting to help me relax. (R)	16.77	36.71	26.27	16.46	3.80	1.54	(1.07)
22. Reading under dim light doesn't damage your vision. (R)	2.84	10.09	19.87	33.75	33.44	2.85	(1.08)
23. Fluorescent lights are bad for your health.	6.05	15.29	63.69	9.55	5.41	1.93	(0.84)
24. If I want to create an intimate setting, I dim the lights.	2.22	7.28	11.08	44.94	34.49	3.02	(0.97)
25. Bright light makes people talk louder.	2.22	12.03	62.34	17.72	5.70	2.13	(0.77)
26. Fluorescent light seldom gives me a headache. (R)	8.23	29.11	33.86	20.89	7.91	1.91	(1.07)
27. If a restaurant is very brightly lit, I will leave soon after I've finished eating.	2.85	18.04	38.92	29.75	10.44	2.27	(0.97)

(continued)

APPENDIX: Continued

Item	Response Frequency (%) *0*	*1*	*2*	*3*	*4*	M	(SD)
28. Lack of sunlight in winter does not bother me. (R)	3.17	13.02	13.97	41.59	28.25	2.79	(1.09)
29. Incandescent lighting in a room helps me to pay attention to the speaker.	1.59	9.24	76.75	9.24	3.18	2.03	(0.62)
30. I do my best work in places that are lit using natural daylight.	1.58	11.08	35.13	28.48	23.73	2.62	(1.02)
31. Humming noise from fluorescent lights usually does not distract me. (R)	6.01	35.13	15.82	27.85	15.19	2.11	(1.21)
32. Bright lights rarely make me feel excited and full of anticipation. (R)	7.91	30.38	41.14	18.99	1.58	1.76	(0.91)

NOTE: All items are scored in the positive direction; high scores indicate endorsement of the effect. (R) indicates reverse-scoring. "Don't know" responses were recoded to "neutral" (2). Total *N* = 318. The response percentages are valid percentages, excluding missing data on a few items.

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