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We conducted a classification analysis to identify factors associated with sitting comfort and discomfort. The objective was to investigate the possible multidimensional nature of comfort and discomfort. Descriptors of feelings of comfort and discomfort were solicited from office workers and validated in a questionnaire study. From this study, 43 descriptors emerged. The 42 participants rated the similarity of all 903 pairs of descriptors, and we subjected the resulting similarity matrix to multidimensional scaling, factor analysis, and cluster analysis. Two main factors emerged, which were interpreted as comfort and discomfort. Based on these findings, we postulate a hypothetical model for perception of comfort and discomfort. Comfort and discomfort need to be treated as different and complementary entities in ergonomic investigations.

INTRODUCTION

Comfort and discomfort in sitting are major concerns of office workers (Kleeman, 1991; Lueder, 1983) and are commonly assessed in ergonomic evaluations of office environments (e.g., Helander, Czaja, Drury, Cary, & Burri, 1987; Shackel, Chidsey, & Shipley, 1969). However, such evaluations are tenuous, given that sitting comfort and discomfort have not been well defined.

In common parlance, *comfort* may refer to both comfort and discomfort. Likewise, many researchers and practitioners assume that comfort and discomfort are two opposites on a continuous scale, ranging from extreme comfort through a neutral state to extreme discomfort (e.g., Shackel et al., 1969). Formal definitions of comfort provide a different picture. *Webster's Third International Dictionary of the English Language* (1981, unabridged) defines comfort as a "state or feeling of having relief, encouragement, and enjoyment." Slater (1985) attempted a more scientific definition: "a pleasant state of physiological, psychological, and physical harmony between a human being and the environment" (p. 4). These definitions stress that comfort is a multifaceted construct influenced by several factors and that it is not merely the opposite of discomfort.

Several researchers have questioned the unidimensional, continuous nature of comfort/discomfort. Hertzberg (1972) referred to comfort as "absence of discomfort, . . . a state of no awareness at all of a feeling" (p. 41), and Branton (1969) concurred that comfort "does not necessarily entail a positive affect" (p. 205). By these definitions comfort is conceptualized as a neutral feeling, and only two discrete stages are

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possible: comfort present or comfort absent. A logical conclusion is that there cannot be a graded scale to measure comfort, and the use of a Likert scale would hence rest on erroneous assumptions of the properties of comfort.

Several studies, however, have used graded Likert scales to measure comfort/discomfort in sitting (e.g., Gross, Goonetilleke, Menon, Banaag, & Nair, 1992; Habsburg & Middendorf, 1977; Kamijo, Tsujimura, Obara, & Katsumata, 1982). These were "successful" in that the measures produced significant differences among chairs. Therefore, there is indirect evidence to favor a unidimensional scale for comfort/discomfort.

We argue in this paper that comfort and discomfort are different entities. Many research studies indicate that discomfort is primarily associated with physiological and biomechanical factors and that comfort is primarily associated with aesthetics. These findings are summarized in the following paragraphs.

A kyphotic spinal curvature, typical for sitting, causes increased disk pressure (Nachemson & Morris, 1964), stretched posterior ligaments (Adams & Hutton, 1980), and a hampered supply of nutrients to the nerves (Kraemer, Kolditz, & Gowin, 1985; Park & Watanabe, 1985). This eventually leads to low-back pain and discomfort.

Discomfort can also be attributable to seat pressure distribution (Habsburg & Middendorf, 1977; Kamijo et al., 1982), and peaks in pressure may cause tissue distortion over and posterior to the ischial tuberosities (Floyd & Ward, 1967; Hertzberg, 1972). After a long period of sitting, this may lead to pain and numbness.

Long periods of static sitting cause blood pooling and discomfort in the lower extremities (Pottier, Dubrevil, & Monod, 1969; Winkel, 1986). Seat temperature and humidity have also been shown to increase discomfort (Brattgard & Severinsson, 1978).

A prolonged static sitting posture, such as that imposed by a computer task, may cause discomfort of the neck, shoulders, and back (Cantoni et al., 1984; Grandjean, 1984; Hunting, Laubli, & Grandjean, 1984; Ong, 1984).

Typical for all of these effects is that they increase with time on task; reported discomfort is typically low at the beginning of a workday and considerably higher after a full day of work (see also Michel & Helander, 1994).

Comfort seems to be related to other aspects, such as "aesthetics" and a "neutral feeling" (Shackel et al., 1969). Kleeman (1983) observed that if a chair is appealing in style and/or well built, people think of it as comfortable. Helander et al. (1987) likewise demonstrated positive correlations between the appearance of chairs and comfort ratings. Grant found that two identical chairs would elicit different ratings of comfort, depending on the aesthetics of the cloth material used to cover the chairs (C. L. Grant, personal communication, November 10, 1991). Furniture manufacturers have recognized the emotional effect of an appealing and pleasant design in achieving an impression of greater comfort (Weale, Croake, & Weale, 1982).

From the literature it seems that comfort and discomfort may be associated with different factors. There is evidence to link discomfort with biomechanical factors and fatigue, but there is less information as to which factors are related to comfort. No theory or model has been published that can satisfactorily explain any differences between the two.

Objective

The main purpose of this research was to identify whether different factors are indeed associated with comfort and discomfort in sitting and, if possible, to pose a unified model for perception of comfort/discomfort.

In order not to bias experimental participants in their assessments and to validate our findings, we performed three studies in which the concepts of comfort/discomfort were gradually introduced: a questionnaire study, a validation study, and a classification study. The questionnaire study was composed of three parts and was used to (a) solicit opinions and impressions about office workplaces, (b) solicit descriptors of comfort and discomfort, and (c) evaluate

descriptors of comfort and discomfort. The validation study was used to validate the 73 descriptors that emerged from the questionnaire study. The classification study consisted of two parts: (a) pairwise comparisons of 43 descriptors to produce a similarity matrix, and (b) multidimensional scaling, factor analysis, and cluster analysis to analyze the similarity matrix.

QUESTIONNAIRE SURVEY STUDY

Questionnaire Design

The objectives of the questionnaire survey were to investigate the importance of sitting comfort/discomfort to office workers and to collect descriptors of feelings of comfort and discomfort from seated office workers.

To collect descriptors of comfort and discomfort, we used two questionnaires. Questionnaire A was designed to collect descriptors of comfort, whereas Questionnaire B asked about discomfort. By using two different questionnaires with two different groups of respondents, we avoided the problem of respondents describing comfort and discomfort as mere opposites of each other. The main advantage of using two questionnaires was thus the avoidance of response bias.

The questionnaires were designed in three sequential sections on different pages covering (a) general assessment of factors that are important in the workplace, (b) respondent-generated descriptors of comfort or discomfort, and (c) evaluations of experimenter-generated descriptions of comfort or discomfort.

In Section 1 of the questionnaire, respondents were asked to give their opinions and impressions about the workstation they were using and to rank order these opinions in terms of importance for workstation design. This was a deliberately vague question, and neither comfort nor discomfort was mentioned. The objective was to identify which features are generally considered important in workplace design. We later analyzed these data in order to understand the extent to which comfort/discomfort may play a role.

It may be difficult for people to produce formal definitions of comfort and discomfort. We assumed that related feelings are easier to describe (Pearson, 1957). Therefore, in Section 2 respondents were asked to describe feelings associated with comfort (Questionnaire A) or discomfort (Questionnaire B) in a seated workplace.

Section 3 contained a list of descriptors of comfort and discomfort collected from the Feeling Tone Checklist (Pearson, 1957), the Stress Arousal Checklist (Mackey, Cox, Burrows, & Lazzerini, 1978), the McGill Pain Questionnaire (Melzack, 1975), the General Comfort Scale (Shackel et al., 1969), *Webster's Third International Dictionary of the English Language* (1981, unabridged), and *Roget's Thesaurus*. The purpose was to expose the respondents to as many related terms as possible in order not to miss any potential dimensions in the analysis. Respondents were asked to rate these descriptors with respect to either comfort (Questionnaire A) or discomfort (Questionnaire B).

Survey

We distributed 700 questionnaires to office workers employed at the State University of New York at Buffalo (SUNY Buffalo). Of the 106 that were returned, 85% were from women and 15% from men, whose ages ranged between 20 and 60 years (mean = 35.7, SD = 10.9 years). Because of inappropriate responses, two questionnaires could not be used, resulting in 104 responses (Questionnaire A = 63; Questionnaire B = 41).

Results and Discussion

Choice of participants. Clerical workers, administrators, students, and professors are all office workers. To solicit descriptors of comfort and discomfort and for preliminary evaluation, we sought experienced, mostly female clerical workers in the administration offices at SUNY Buffalo. The gender of participants was not a concern, given that we had no indication from

the literature that gender would affect comfort, discomfort, or outcomes of ratings.

The ages of the respondent population were typical for office workers at SUNY Buffalo and did not present a source of bias. The return rate of the questionnaire was about 15%. To our knowledge those who responded to the questionnaire were representative of the population of office workers. The low rate of return was not of great concern. At this first stage of the study, our main purpose was to solicit descriptors, all of which were later validated by random populations in the validation study and in the classification study.

Opinions and impressions about workstations. For Section 1 of the questionnaire there were 392 responses, which were classified into three categories: comfort/discomfort, convenience, and social-organizational (see Table 1). Of the 392 responses, 85% related to comfort/discomfort, 9% to convenience, and 4% to social organizational issues. For comfort/discomfort the three main issues were environment, posture, and aesthetics, each with about 22% of the responses. Aesthetics was included in this category because of the research findings quoted previously. Chair comfort was mentioned in 12% of the responses. This was the largest single category, which indicates that sitting comfort is, indeed, important in the office work environment.

Solicitation of descriptors of comfort or discomfort. In Section 2 respondents described their feelings related to comfort and discomfort. The results are summarized in Tables 2 (Questionnaire A, comfort) and 3 (Questionnaire B, discomfort). For Questionnaire A there were 78 responses, which were classified into 29 distinct response types or descriptors. The descriptors were further grouped into six main categories, of which the first three (relaxation, neutral feeling, and well-being) accounted for 75% of the total number of responses.

TABLE 1

Classification of 392 Responses Regarding Important Features in Office Workplace Design

Category	Examples	Percentage of Reponses	Percentage Subtotal
1. Comfort/discomfort			
a. Environment			
Temperature	Ventilation, natural air, warm/cool	11.0	
Lighting	Natural lights	10.2	
Noise/music	Phone, equipment, noise, music	3.1	24.2
b. Posture			
Chair	Supporting, cushioning, height, size	12.0	
Equipment	Height, location, twist to reach	6.6	
Table	Height, adjustability, surface angle	4.3	22.9
c. Aesthetics			
Appearance	Color, decoration, cleanliness	11.7	
View	View of outside, facing the wall	8.9	20.6
d. Space			
Crowdedness		10.7	
Private office		4.8	15.8
e. Overall comfort			2.3
2. Convenience			
Equipment available	Share equipment, location	6.6	
Equipment design	Old, too small	2.8	9.4
3. Social-organizational			
	Interpersonal, job, supervision, isolation		4.1
4. Other			
	Safety, smoking		0.8
TOTAL			99.8

TABLE 2

Summary of Responses in Section 2, Questionnaire A: Feelings Associated with Comfort (63 questionnaires with 78 responses were summarized into 29 descriptors)

1. Relaxation		
Relaxation	24	(relaxed 15, less stressful 7, at ease 1, relief 1)
Being supported	4	(being supported 4)
2. Neutral feeling	19	(not think of workplace, able to concentrate on job)
3. Well-being		
Contentment	8	(content 3, happy 2, calm 1, cheerful 1, pleased 1)
Pleasantness	4	(luxurious 1, spacious 1, cozy 1, pleasant 1)
4. Energy	8	(alert 5, crisp 1, less exhausted 2)
5. Environmental	2	(quiet 1, warm 1)
6. Social/psychological	9	(satisfying 2, motivated 1, accepted 1, competent 1, in control 1, success 1, confident 1, secure 1)
Total	78	

Relaxation. This was the largest category, with 28 responses and five descriptors. The results suggest that to be comfortable, one must have a sense of relaxation. We grouped "supporting features" with this category. These referred primarily to postural support.

Neutral feeling. This category consisted of 19 responses, with two descriptors. Many individuals thought of comfort as a state when one does "not think of the workplace" and when one is "being able to concentrate on the job." The implication of this category is that comfort is defined as the absence of distracting discomfort (Corlett, 1973), and it is surprising that so many individuals thought of this subtle and abstract aspect.

Well-being. There were 12 responses, which were further divided into two subgroups: contentment and pleasantness. The former represents positive feelings, whereas the latter is related to impressions (e.g., aesthetics) of the workplace. This category produced nine descriptors.

Energy. This category contained eight responses and three descriptors related to the respondents' state of alertness.

Environmental. For this category there were two descriptors relating to auditory and thermal comfort.

Social/psychological. This category contained eight descriptors related to job satisfaction. Although this may be relevant to overall comfort, it was not considered important to seating comfort, and these descriptors were excluded from further analysis. As a result we submitted a total of 21 descriptors from the previous five

TABLE 3

Summary of Responses in Section 2, Questionnaire B: Feelings Associated with Discomfort (41 questionnaires with 118 responses were summarized into 34 descriptors)

1. Pain	44	(pain and ache 26, hurting 1, prickly 1, smarting 1, stinging 1, dull ache 1, cramped 2, pressing 1)
2. Soreness and numbness	31	(sore 7, numbness 6, circulation to legs cut off 3, fidgety 2, tingling [pins and needles] 1, heavy leg 1, stiff 10, swollen ankle 1)
3. Fatigue	16	(tired/exhausted 9, sleepy 1, drowsy 1, sluggish 2, ill at ease 1, unsupported 2)
4. Environmental	13	(cold/hot 11, noisy 2)
5. Anxiety	14	(nervous 1, edgy [impatient] 1, uneasy 1, stressful 3, anxious 2, anger 2, upset 1, tense 1, frustrated 1, disturbed 1)
Total	118	

categories to a validation procedure (see next section).

Table 3 summarizes 34 descriptors from 118 responses obtained for Questionnaire B related to discomfort. As with Questionnaire A, the responses were broken down into several categories.

Pain. This was the most frequent category, with 44 responses broken down using eight descriptors.

Soreness and numbness. Somewhat similar to pain, this category had 31 responses, which were summarized in eight descriptors.

Fatigue. There were 16 responses resulting in six descriptors.

Environmental. Thirteen responses were summarized using two descriptors.

Anxiety. In this category there were 14 responses resulting in 10 descriptors. They were excluded from this study because they were infrequently cited and not of primary interest to this study. Thus 24 descriptors remained from Questionnaire B.

Evaluating Descriptors from Previous Research

The last section of the questionnaire asked respondents to rate 111 descriptors of comfort/discomfort found in the literature. Participants evaluated these items with respect either to comfort (in Questionnaire A) or to discomfort (in Questionnaire B). A three-point classification was used: related (either positively or negatively), not related, and not sure. We computed the frequencies for each classification and retained descriptors for further evaluation if more than two-thirds of the respondents considered them to be related to comfort or discomfort. The terms selected from this procedure and those in Tables 2 and 3 formed a preliminary list of 73 descriptors, which are presented in Table 4.

VALIDATION OF DESCRIPTORS

In the questionnaire survey we generated a variety of descriptors of comfort/discomfort in seated workplaces using several methods. The reason was that we did not want to miss any possible dimensions. In this part of the study, the purpose was to validate and reduce the number of descriptors.

Participants. The 34 participants were all full-time employees at SUNY Buffalo, were selected randomly among office workers, and worked at various clerical and secretarial tasks. To avoid response bias, these participants were different from those who participated in the questionnaire survey. The current group consisted of 90% women and 10% men whose ages ranged from 20 to 60 years (mean 42.9 years, SD = 9.8).

Descriptor selection. We divided the 73 descriptors into two groups: comfort related or discomfort related. Participants were asked to rate the descriptors in terms of sitting comfort and sitting discomfort. A five-point scale was used (1 = *very closely related,* 2 = *closely related,* 3 = *slightly related,* 4 = *not related at all,* and 5 = *don't know*). The terms that were rated 1 and 2 by at least 70% of the participants were retained for further study. After this rating 43 descriptors remained, which are listed in Table 5.

CLASSIFICATION STUDY

To identify the factors of sitting comfort/discomfort, we classified the 43 retained descriptors into groups using factor analysis, cluster analysis, and multidimensional scaling. To perform these analyses we generated a similarity matrix of the descriptors using pairwise comparisons of all possible pairs of descriptors. This process, though time-consuming, produces highly reliable data (Guilford, 1954).

Similarity Matrix Generation

Forty-two participants (11 women and 31 men) rated the similarity of all possible 903 pairs of the 43 descriptors using pairwise comparison. Participants were recruited from among students on the SUNY Buffalo campus. This task took about 3 h and involved the use of scales for comparison of word pairs. This task was conceptual in nature and required familiarity in the use of scales. We therefore considered students to be more appropriate to perform the task than

TABLE 4

The 73 Descriptors

21 descriptors related to sitting comfort		
agreeable	not think about workplace	restful
at ease	pleasant	safe
calm	pleased	softer
content	plush	spacious
cozy	refreshed	supported
happy	relaxed	warm
luxurious	relief	well-being
22 descriptors related to sitting discomfort		
ache	ill-at-ease	stiff
circulation to legs cut off	numbness	strained
cramped	pain	swollen ankle
dull ache	pressing	tingling
fatigue	restless	tired
fidgety	sleeping	unsupported
heavy legs	smarting	
hurting	sore	
30 descriptors that were excluded		
alert	exhausted	prickly
binding	happy	quiet
biting	itchy	ready to drop
cheerful	less exhausted	sluggish
crisp	less stressful	stale
cold/hot	noisy	stinging
delightful	peaceful	tender
distress	peppy	tense
drowsy	petered out	uneasy
energetic	pooped	weariness

regular office workers. Participants' ages ranged from 20 to 40 years (average = 24 years, SD = 4). They were paid $5 per hour for their participation.

The task was generated using a computer program specially written for this purpose. Pairs of descriptors were displayed in random order on the screen one pair at a time. A seven-point scale was also displayed (1 = *totally different*, 7 = *almost the same*), and participants were instructed to rate each pair of descriptors in terms of similarity. After a rating had been entered on the keyboard, the next pair was automatically displayed. This task continued until all pairs of descriptors had been rated, taking approximately 3½ h for each participant. The outcome of the rating process was a 43 × 43 similarity matrix, which was the average of the 42 matrices of individual participants.

Classification Analyses

The similarity matrix was submitted to computer programs for multidimensional scaling, factor analysis, and cluster analysis. These three methods analyze data somewhat differently, as is illustrated in the following discussion of results.

Multidimensional scaling (MDS). This was calculated using the SAS ALSCAL procedure with Euclidean distance option. The results are plotted in Figure 1. The items in the two-dimensional plane are clearly divided into two areas. On the right side are two major groups and a few single items that can be identified with comfort. The upper group contains most of the descriptors related to feeling relaxed. In this group one may distinguish two categories, the first consisting of "relaxed," "relief," "restful,"

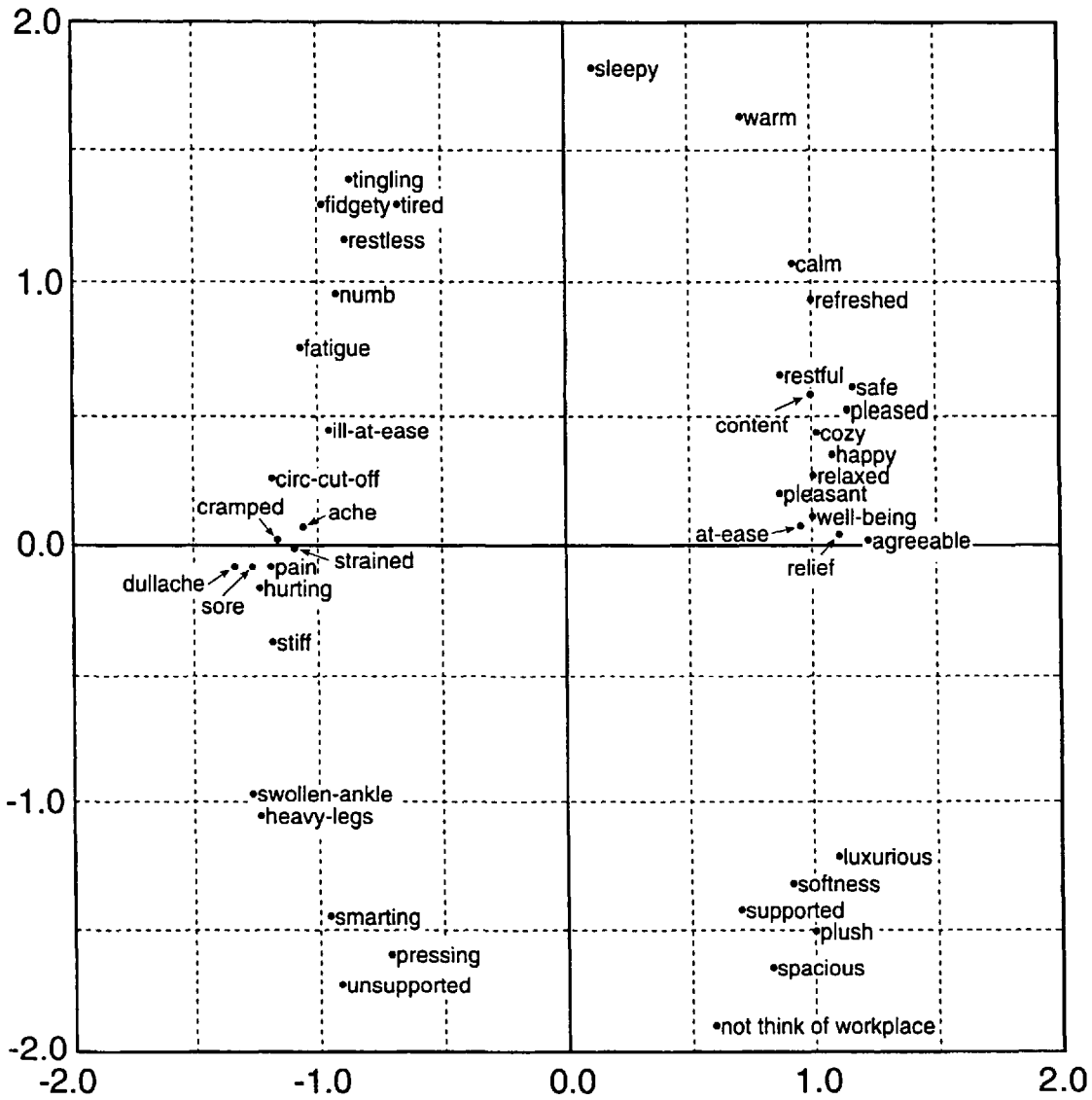

Figure 1. Plot of 43 descriptors of comfort and discomfort, multidimensional scaling approach (SAS, ALSCAL procedure, INDSCALE option).

and "refreshed" and the second consisting of "pleasant," "well-being," and "at ease."

The second group, in the bottom right corner, contains descriptors related to *impressions* ("plush," "luxurious," "spacious," "soft") and to neutral feelings ("supported," "not thinking of workplace").

The items on the left side were relatively scattered but can be divided into three groups. The six items at the top relate to *fatigue/energy*, such as "tired," "fatigue," and "restless." The items in the middle section are related to discomfort caused by biomechanical factors in sitting, such as "pain" and "circulation cutoff." This group may be labeled *pain-biomechanics*. The items in the lower left corner also belong to the pain-biomechanics group (e.g., "heavy legs," "pressing").

In addition, there are two single items: "sleepy" and "warm." These descriptors may

have been difficult for participants to interpret, given that each has both positive and negative aspects. For example, "sleepy" may be associated with "restful" (to the right) but also with "fatigue" (to the left).

Factor analysis. Because similarity rating also indicates correlation of the descriptors, the averaged matrix (across 42 participants) was submitted to factor analysis with the SAS factor procedure. The principal component method was selected for factor extraction, and the varimax method was chosen for rotation. The factor loadings of the variables in each factor are listed in Table 5.

Five factors were found. The first two factors explain approximately 50% of the total variance, or 75% of the total commonality. The first factor contains descriptors related to comfort, and the second factor consists mostly of items related to feelings of discomfort attributable to biomechanics. This factor corresponds to the pain-biomechanics cluster in the MDS analysis.

The remaining three factors explain an additional 17% of the variance and are somewhat less important. The third factor has three main items. "Restless" and "fidgety" have the highest factor loadings, and this factor was named *restlessness*. The third item, "pressing," has a lower factor loading and is equally related to the second factor because it may be interpreted as arising from physical pressure.

The fourth factor is the impression factor, and it contains four impression factors with high loadings (0.6 to 0.7) on Factor 4 and fairly high loadings on Factor 1 (0.4 to 0.5). The last factor, fatigue, contains two energy-related items, "sleepy" and "tired." The former has a moderate loading in the first factor, whereas the latter has a large portion of its loading in Factor 2. This bridging effect can also be seen in the MDS analysis in Figure 1.

Most of the findings are consistent with those in the MDS, but there are a few differences. Factor 1 items are found in the comfort cluster in MDS, Factor 2 items correspond to the pain-biomechanics group in MDS, Factor 3 items correspond to the energy-fatigue group of MDS, and Factor 4—impression—is also distinctly located in Figure 1. However, the items in Factor 5 ("sleepy" and "tired") are not associated in MDS.

Cluster analysis. The averaged similarity matrix was subjected to a cluster analysis using BMDP 1M procedure with the averaged linkage option. The results are displayed in Figure 2.

According to Romesberg (1984), the cluster tree could be decomposed at the level at which the number of branches has remained the same for a longer range. Therefore the structure was decomposed at a level of the similarity index of about .5. Three descriptors ("not thinking about workplace," "unsupported," and "warm") joined the tree at a late stage (<.5). This indicates that they are fairly dissimilar to other items, and hence they were not included in the plot.

There are two main clusters, of which the upper was named *discomfort* and the lower *comfort*. Within the discomfort cluster are three subclusters, or branches. The top branch consists of three items that correspond to Factor 5, fatigue, in the factor analysis. The second branch contains three items: "ill at ease," "fidgety," and "restless," corresponding to Factor 3 in the factor analysis. The last branch, containing 12 descriptors, corresponds to Factor 2 of the factor analysis and the pain-biomechanics group in the MDS approach. This branch can be decomposed into three low-level root clusters. The first cluster has six items describing the feelings of pain. The second cluster consists of three descriptors: "stiff," "strained," and "cramped." These describe feelings resulting from a constrained work posture. The third cluster contains descriptors related to circulation cutoff at the legs.

The comfort branch can be decomposed into two major branches. The first branch consists of four descriptors related to aesthetic impressions. The second branch contains all remaining descriptors, corresponding to Factor 1 in the factor analysis. This branch can be further decomposed into three low-level root clusters (relief, well-being, and relaxation), as indicated in Figure 2.

TABLE 5

Factor Loadings after Varimax Rotation

	Factor 1 (Comfort)	Factor 2 (Discomfort)	Factor 3 (Restlessness)	Factor 4 (Impression)	Factor 5 (Sleepy)
relaxed	0.824	0.150	0.059	0.142	0.252
at ease	0.818	0.158	0.085	0.156	0.162
happy	0.813	0.147	0.111	0.075	−0.032
content	0.807	0.150	0.131	0.024	0.056
pleased	0.806	0.150	0.101	0.061	0.018
pleasant	0.785	0.183	0.745	0.245	0.073
well being	0.762	0.176	0.153	0.140	−0.037
restful	0.760	0.167	0.025	0.119	0.323
safe	0.732	0.119	0.137	0.048	−0.021
calm	0.729	0.124	0.038	0.037	0.323
relief	0.706	0.194	0.043	0.196	0.096
agreeable	0.702	0.143	0.089	0.252	−0.027
refreshed	0.700	0.182	0.056	0.141	0.116
cozy	0.691	0.145	0.096	0.300	0.190
supported	0.585	0.209	0.174	0.125	−0.085
warm	0.535	0.221	0.054	0.208	0.105
not think of workplace	0.492	0.174	0.233	0.081	0.069
sore	0.161	0.811	0.138	0.060	0.067
pain	0.164	0.811	0.212	0.055	−0.032
ache	0.162	0.806	0.161	0.054	0.094
circulation to legs cut off	0.109	0.791	0.123	0.047	0.143
hurting	0.180	0.790	0.220	0.054	−0.045
dull ache	0.151	0.784	0.137	0.061	0.085
swollen ankle	0.141	0.755	0.078	0.073	−0.036
numb	0.200	0.708	−0.008	0.063	0.273
stiff	0.171	0.708	0.166	0.125	0.170
heavy legs	0.140	0.684	0.062	0.062	0.227
smarting	0.216	0.629	0.154	0.072	−0.090
tingling	0.264	0.627	0.076	0.024	0.196
cramped	0.132	0.625	0.431	0.143	0.123
strained	0.178	0.583	0.506	0.074	0.162
ill at ease	0.218	0.561	0.531	0.064	0.031
fatigue	0.149	0.557	0.327	0.081	0.550
unsupported	0.167	0.435	0.376	0.125	0.086
restless	0.191	0.370	0.746	0.049	0.220
fidgety	0.177	0.387	0.691	0.042	0.139
pressing	0.215	0.424	0.488	0.074	−0.003
plush	0.431	0.133	0.055	0.752	0.051
luxurious	0.507	0.098	0.096	0.715	0.027
softness	0.416	0.193	−0.033	0.615	0.217
spacious	0.430	0.105	0.202	0.585	−0.036
sleepy	0.375	0.225	0.147	0.123	0.783
tired	0.223	0.448	0.335	0.030	0.658
Variance explained	10.606	9.469	2.876	2.357	2.157

DISCUSSION

Summary of Classification Analyses

The overall pattern from all three analyses is of two major groupings of descriptors, each with similar internal structure and a small number of outliers or less related descriptors. The major patterns can be named *comfort* (sense of well-being; plushness of the chair) and *discomfort* (poor biomechanics; fatigue and restlessness). The term "plushness" is used to describe aspects

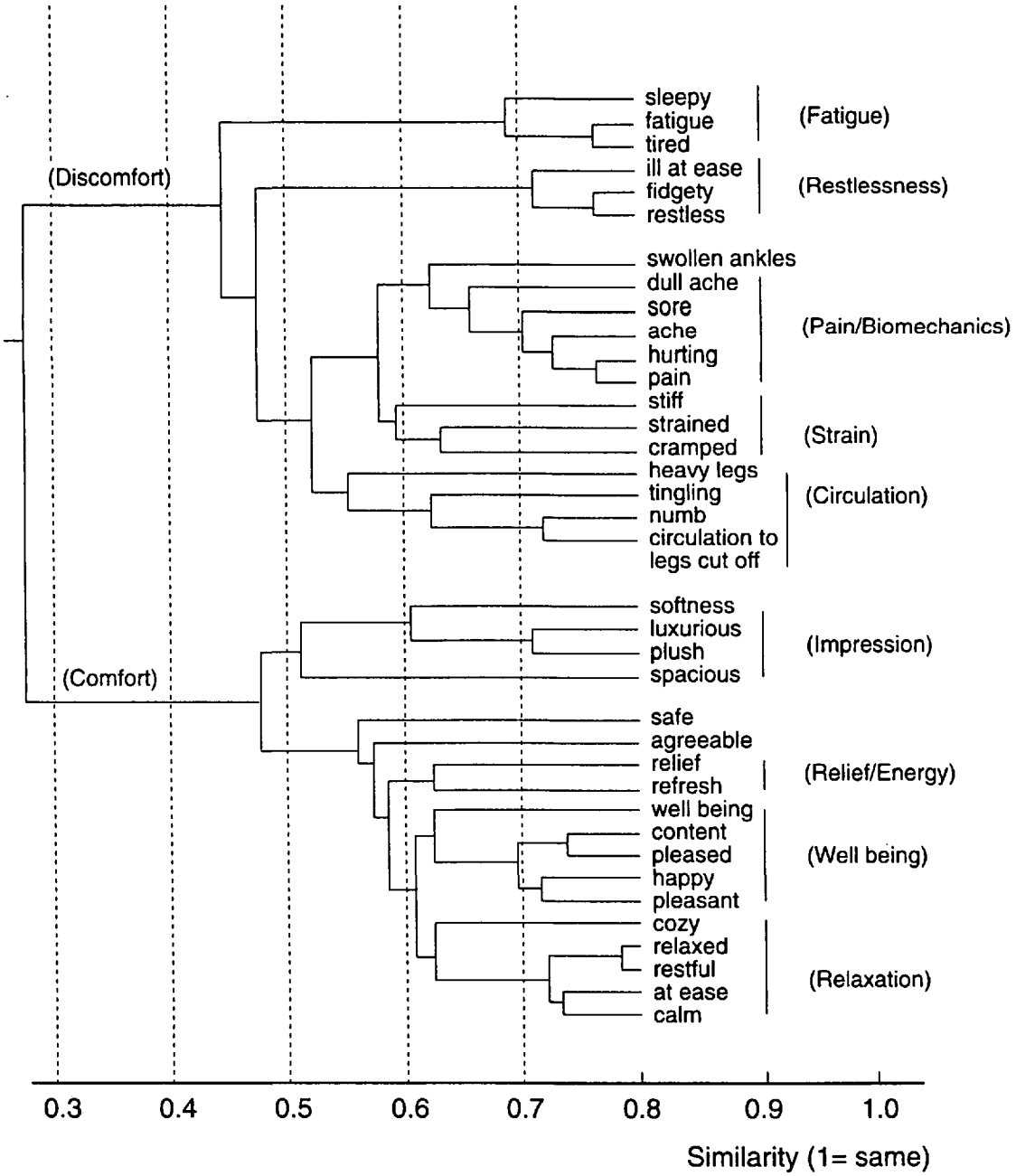

Figure 2. Simplified structure of cluster analysis.

of the chair related to impression, aesthetics, softness, and spaciousness.

For each of the two major groupings there are many descriptors with the same classification by each analysis method. These should logically form the basis for future research. Other descriptors show less consistency, such as "supported/unsupported," "warm," "smarting,"

"tingling," "pressing," "ill at ease," "fatigue" and "sleepy." As the cluster analysis in Figure 3 illustrates, these terms joined into main branches of clusters at a rather late stage, indicating the weak association of these terms with other comfort/discomfort descriptors. These descriptors are less valid and may be excluded in further study.

A Conceptual Model of Sitting Comfort and Discomfort

Based on the findings, we propose a model for perception of discomfort/comfort. Discomfort is associated with biomechanical factors (joint angles, muscle contractions, pressure distribution) that produce feelings of pain, soreness, numbness, stiffness, and so on. As we noted in the introduction, feelings of discomfort increase with time on task and fatigue. (The effect of fatigue was not addressed in our study.) Discomfort can be reduced by eliminating physical constraints, but this does not necessarily produce comfort.

Comfort is associated with feelings of relaxation and well-being. In agreement with Helander et al. (1987), the sensation of comfort may be amplified by an aesthetic design of the chair or office. The absence of these feelings will not lead to discomfort because adverse biomechanical conditions are necessary for this. Figure 3 illustrates the interaction of the two variables.

Transitions from discomfort to comfort and vice versa are possible in the intersection of the axes in Figure 3. Thus if discomfort is reduced, comfort may be perceived. If discomfort is increased, such as with increased time on task and fatigue, comfort will decrease. The presence of adverse physical factors will hence break the physical harmony and direct attention to discomfort. Although good biomechanics will not increase the level of comfort, it is likely that poor biomechanics may turn comfort into discomfort. As defined by Slater (1985), comfort is a "pleasant state of physiological, psychological and physical harmony between a human being and the environment" (p. 4).

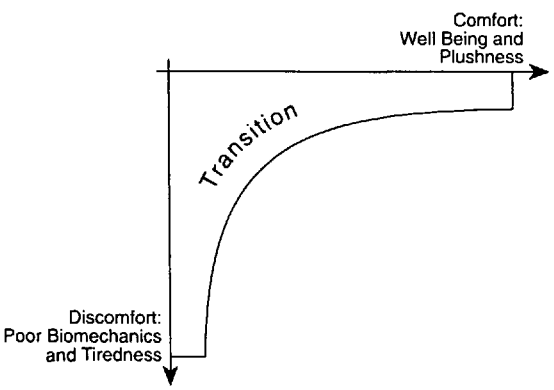

Figure 3. Hypothetical model of discomfort and comfort.

In passing, we note that our findings have similarities to theories of job satisfaction. In Table 2 we deliberately excluded social/psychological descriptors because they were not considered relevant to comfort. Nevertheless, similar descriptors reemerged and form the basis for the comfort assessment (e.g., "relaxed," "content," "well-being"). The association between comfort and job satisfaction needs to be assessed in future research. We note here the similarities between Maslow's (1970) model of human needs, in which physical needs are categorized as different from social/psychological needs. Likewise, the two-factor theory proposed by Hertzberg, Mausner, and Snyderman (1959) distinguishes between "poor hygiene factors," which may lead to job dissatisfaction, and "good motivating factors," which bring about job satisfaction. Perhaps comfort is merely another aspect of the tenuous concept of job satisfaction.

It is now necessary to test this model in the field. Although participants in this study were office workers sitting in chairs, two important aspects should be addressed in future research: the effect of different chairs with different discomfort/comfort and the effect of time of day on ratings of comfort and discomfort.

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