Forget About Aesthetics in Chair Design: Ergonomics Should Provide the Basis for Comfort

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Abstract. Helander and deLooze have proposed a model of seated comfort in which *comfort* and *discomfort* are conceptually separate. They argue that ergonomic chairs tend to be overdesigned with insufficient attention paid to aesthetics. This argument is critiqued on both methodological and conceptual grounds. The methodological critique is based on psychometric criteria. The conceptual critique is based on the need for an integrated (ecological) approach in which work context and user characteristics are explicitly considered. An alternative model for an ecological ergonomics is presented.

Keywords: seated comfort, ecological ergonomics.

1 The deLooze/Helander Model of Seated Comfort

Based on his own survey of the literature, and with particular reliance on the work of Helander et al. [11], deLooze [6] has proposed a model of seated comfort. The deLooze model identifies *discomfort* and *comfort* as conceptually separate entities. While *discomfort* and *comfort* are both psychological states, feelings of *discomfort* are assumed to be causally determined by "objective" biomechanical factors traditionally associated with risk factor models of musculoskeletal disorders (i.e., physical exposure, dose, response). On the other hand, feelings of *comfort* have a more complex set of determinants. The social and emotional context of the user, including factors such as job satisfaction and social support, are superimposed on the physical and task components associated with *discomfort*. In addition, deLooze differentiates between *physical* and *aesthetic design* attributes of the chair and argues that the latter uniquely impacts feelings of *comfort.* The core of Helander et al's argument is that ergonomic chairs are over-designed in terms of the amount of adjustability since users in their study were unable to differentiate ergonomic chairs with different ergonomic features on the basis of reduction in discomfort. On the other hand, the same chairs could be differentiated on the basis of satisfaction and comfort. Thus, Helander[11] concludes: "Discomfort is based on poor biomechanics and fatigue. Comfort is based on aesthetics and plushiness of chair design and a sense of relaxation and relief" [p. 1315].

M.J. Dainoff (Ed.): Ergonomics and Health Aspects, HCII 2007, LNCS 4566, pp. 19–25, 2007.

1.1 Methodological Critique

DeLooze's argument for independence of comfort and discomfort rests on a psychometric approach in which the user is asked to assess multiple attributes (chair features) of multiple stimuli (chairs) on multiple dimensions (comfort and discomfort indices). The psychometric adequacy of this model remains to be demonstrated. However, even if an approach similar to multi-trait multi-method reliability and validity could be established, the context in which the chair is used is still missing. A chair is not an isolated object, but needs to be considered as an integrated component in a complex work environment. At the very least, the user's body scale (anthropometry), biodynamic capabilities, and understanding of how the chair functions needs to be included in the model.

We have a fundamental concern with the psychometric adequacy (i.e., reliability and validity) of the subjective measures utilized in these studies and most studies of seated comfort. See, for example, Kolich[12] The users in these studies must compare several different chairs along several different dimensions. We have seen no published data on reliabilities of these scales, or on convergent or divergent validities[3]. If a serious theoretical argument about the nature of comfort and discomfort is going to be based on the psychometric differences between clusters of comfort and discomfort ratings, these methodological issues will be need to be addressed.

However, even if we take the obtained results[6],[11]at face value, there are legitimate concerns about the efficacy of the overall approach. The methodology utilized in these studies is essentially that of consumer research. Users were given a selection of chairs and a series of ratings scales on a questionnaire. There is no indication that they received the kind of training which is essential for successful ergonomic intervention. See Amick, et al[1]. Users were expected to intuit, for themselves, the functional relationships between chair controls and resulting postures, as well as the rationale for alternative seated postures. Hence, it is not surprising that preference ratings would be more highly loaded on aspects of the seat cushion rather than the control mechanisms. The resulting outcome, while perhaps important for marketing, is hardly a basis for a scientific discussion of design of ergonomic seating.

1.2 Conceptual Critique

A major problem with the DeLooze model[6] rests on the epistemological confusion inherent in the categorical linkages between biomechanics and discomfort on the one hand and aesthetics and comfort on the other. The problems with these linkages are readily apparent to any serious tennis players who have searched for the "sweet spot" on their racquets, or a carpenter who has appreciated the "feel" of his/her favorite hammer. This type of problem requires a systematic approach, such as offered by Wagman and Carello[16], Dainoff and Wagman[4]or Wagman[15].

If our goal is the scientific study of seated comfort, it is unclear why the conceptual separation of "aesthetic" and "physical" design features is useful. Helander's concept of "plushiness" as a prime example of an aesthetic factor is hardly non-physical. Instead, the term "plushiness" can be a surrogate for a combination of physical attributes including foam density and seat cover geometry. It is then an empirical question as to how variations in such attributes will interact with other chair design attributes to afford seated postures appropriate to accomplishing demands of the task for which the chair is intended to support. (A chair that is too plushy may actually impair performance.) The flaw in the deLooze/Helander approach is to associate biomechanical design features with what is essentially a *medical* goal, i.e. the avoidance of pain and discomfort.

However, traditional ergonomics is much broader. Van Wely[13] defined the field in terms of the relationship among efficiency, comfort and health. Thus, as in the example of plushiness, what deLooze calls aesthetic factors, can, at one level of analysis, be considered higher-order biomechanical factors, which must be taken into account when assessing effective user performance. Such performance can be assessed with a combination of carefully designed objective and subjective measures. One such subjective measure might be the emotions associated with ease and lack of effort entailed in using the chair.

Some sense of how this might be approached can be found in a recent proposal for "hedonomic design" (designing for user pleasure) by Hancock et al.[10]. They suggest a principle of *seamless interaction"* which: "…..enables the user to interact optimally with the tool at hand. This in turn facilitates the transparency of the tool, enabling the user to focus effort of task completion and not on the tool itself." (p.12) However, Hancock et al caution that it is, at present, premature to include design criteria for pleasure. In particular, we lack a reliable and valid measure of pleasure. Therefore, design criteria of safety, functionality and usability must take precedence. (We must also point out that as of this date, we do not yet have a valid and reliable measure of seated comfort or discomfort.)

The deLooze/Helender concept of *comfort* is conceptually similar to Hancock et al's approach to hedonomic design. For this approach to be taken seriously, a body of theory relating the psychology of emotion to aesthetic design principles needs to be developed. Such a body of theory does not now exist in a form sufficient to applied to design concepts. Consequently, it is premature to explicitly include higher-order aesthetic concepts as such in a model of seated comfort.

Instead of diverting our professional and scientific attention to a completely new arena of "aesthetics", we need to engage in a program which maps out the functional capabilities required for seated posture under various work constraints. If we can accomplish this goal, while not neglecting issues of ease of use (seamlessness), the aesthetics should come "for free."

2 Ecological Approach as a General Solution to Incorporating Ergonomics in Design

We argue that the ecological approach to ergonomics provides a broad conceptual and rigorous framework that will allow systematic scientific research to be translated into practical design concepts. Ergonomics has been described by Dainoff and Dainoff [5] as the fit between people and the elements of the physical environment with which they interact. As such, ergonomics is inherently relationship-oriented in that absolute dimensions and physical characteristics of objects in the work environment must be defined with respect to the relevant anthropometric, biomechanical and perceptual-cognitive characteristics of the user. The ecological perspective based on the work of James Gibson[9] provides a principled approach for conceptualizing such relationships.

Core concepts in the ecological approach are *affordances, effectivities, and perception-action cycles*. *Affordances* refer to the *characteristics of the physical environment* measured with respect to the individual or "actor." Affordances thus represent, in physical terms, the possibilities for action for a particular individual supported by the environment. Accordingly, any seat design factor (e.g., seatpan height) can be an affordance for comfortable seating for some group of people.

Effectivities are complementary in that they refer to action capabilities of individuals measured with respect to the physical environment. Effectivities thus represent human variability (body scale, biodynamic capabilities) relevant to the seating environment. Thus, whether a particular seatpan height is, in fact, an affordance for comfortable seating depends on certain effectivities, e.g., lower leg length. A two year old child cannot sit comfortably in an adult chair, nor can an adult sit in a child's car seat.

Affordances and effectivities are coordinated through *perception-action cycles*. Any integrated behavior pattern (task) can be decomposed into a series of steps in which information about the possibility of action is detected and followed by the action itself; this action, in turn, reveals new information about other potential actions. For our purpose, a particularly important set of perception-action cycles are the actions carried out when a user sits down in an adjustable seat and carries out the adjustments necessary for comfort.

Affordances and effectivities can be considered instances of what Vicente [14] described as *behavior shaping constraints*. That is, from an ecological perspective, it is important to consider the overall landscape within which any goal-directed behavior is possible. Behavior shaping constraints define the boundaries and shape of this landscape. We call this landscape the *work domain*. It is convenient to define four classes of such constraints: *task, environmental, organizational, individual*. *Task constraints* are those components of the work domain that are directly in service of goal-directed activity. For a knowledge worker, these would include the physical components of the work domain used to organize information, such as the computer keyboard, display screen, input device, telecommunication devices, and associated paper documents, as well as the information itself –either in electronic or print form. *Enviromental constraints* include those components of the work domain surrounding or supporting the user as she/he engages in a goal-directed activity. This includes chairs, worksurfaces, lighting ambient temperature, air quality, etc. *Organizational constraints* include those psychosocial attributes of the organization which have the potential to affect goal-directed activities. These include specific constraints such as time pressures, interruption by colleagues, or more general influences from management and coworkers. *Individual constraints (effectivities)* include both physical components (anthropometry, physical status (health, strength, disability) and psychological components (knowledge, motivation).

Ongoing goal-directed activity consists of perception–action cycles in which the actor extracts information about the affordances embedded in the array of constraints and then acts upon that information. The outcome of action will then reveal new information which in turn serves to regulate new actions. Thus, this perception-action cycle becomes the informational and behavioral context within which seated posture takes place and within which the operational effectiveness of a chair must be assessed. Task and organizational constraints define the landscape in which the primary task (e.g., writing a document) takes place. Environmental and individual constraints allow us to understand the working postures required to carry out the primary task. For example, if the task requires entering data and text collated from several different documents located on the horizontal work surface adjacent to the computer, visual demands of the task will constrain the head and trunk upright while requiring sideways reaching actions to bring different documents into the field of view.

The critical question then, as a strategy for scientifically based design, to identify chair characteristics which can support this particular working posture. That is, can the seat dynamics allow a range of users, with a variety of anthropometric attributes, to maintain working postures that minimize biomechanical loading? Because biomechanical loading is the presumed mechanism underlying fatigue/discomfort, and such fatigue/discomfort are known to develop over time, we argue that the most effective way to investigate comfort/discomfort is to utilize a reliable and valid scale of comfort over a period of time sufficient for fatigue to develop. By framing the question in this way, we identify this particular configuration of constraints as one of a limited number of exemplars that can be used to explore the range of work domain for a subject at hand.

This framework also lets us view the user-chair interaction within exactly the same framework as the user-task interaction. That is, the relationship between the user and an ergonomic chair is one of adaptive tool use. To the extent that the user understands the functional actions of the chair controls and their effect on posture, she/he can, upon detecting somatic information (discomfort), interrupt on-going task-directed perception-action cycles in order to adjust the chair in a way that minimizes that discomfort. It follows that certain chair affordances are going to be better than others in terms of (a) physical characteristics that reduce biomechanical loading/minimization of discomfort and (b) perceptual characteristics that make it more likely that the users will actually perceive the relevant chair affordances and be able to execute the perception-action sequences intended by the chair designers. This should be the focus of scientific research in support of chair design.

For example, one set of task constraints may involve only keyboard and display screen interaction, such as searching the web. In this case, a “plushy” chair which affords a backwards leaning posture would be effective in the sense that the user could maintain this work posture for relative long periods of time without discomfort. However, a different set of task constraints—working with an array of paper documents—requires a more complex set of seating affordances. Understanding the reach requirements [14] necessitates understanding the relationships between the geometric layout of the worksurface as well the task demands (number of documents and frequency of use). Reach actions determine certain postural changes, in particular, the relationship of the trunk to the backrest. That is, some reach requirements entail the trunk moving away from the backrest. Hence, the trunk support affordances built into the backrest can not be utilized. Therefore, it becomes important to design of affordances that have a dynamic character in the sense of providing support while allowing changes of posture. See, for example, Bush et al, Faiks and Reinecke [2], [7], [8]. Chairs with these characteristics have been shown by Amick et al. [1] to reduce discomfort and increase productivity.

Finally, this approach can be generalized to (almost) any product category intended to be used by humans. In the above example, let us assume the operator interrupted the task again because she needed to create a multi-level numbered outline in her document. In this case the affordances include the relevant entries in the help menu. A different perception-action cycle now is executed, but the effectiveness can be assessed in a similar fashion.

3 A General Ecological Framework for Comfort

A hallmark of Gibson's ecological theory is that it insists on the complementarity between attributes of the external environment specified in terms of the individual organism (affordances), and attributes of the individual specified in terms of the external environment (effectivities). At the same time, ergonomics can be conceptualized in terms of person-environment fit. Accordingly, theory and methods derived from ecological psychology provides a natural foundation for a scientifically based ergonomics.

Within this framework, comfort can be regarded as the product of the fit between the worker's capabilities (anthropometric, biomechanical and cognitive), the actions supported by the environment and the task demands of the work. Specifically, we can define comfort as the subjective expression of a generalized physiological state of optimization in which discomfort/pain are absent. Comfort, therefore, is necessarily a product of the entire worker-environment-work system.

Optimization can, in turn, be approached in terms of asking whether an appropriate set of affordances which match the effectivities of the user are available. Thus, we can define comfort as the *fit* of the user to the environment in the context of the work to be done. Within the ecological approach, we can clearly state that when the affordances for the work to be done are present, we get a fit of the worker to his/her environment.

There are clear implications for strategies for scientific research and the translation of that research to design principles. Contextual variables must be systematically incorporated into research design. (See, for example, the above discussion regarding the interaction of use of documents, reach, and dynamics of the chair support surface.) This adds to complexity (and difficulty) of conducting ecologically-oriented research. However, findings from such context-relevant investigations ought to be more easily and directly translated to design principles. This is the ultimate goal of ergonomic research.

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