SOME CAUSES OF ERRORS USING ANTHROPOMETRIC DATA WHEN DESIGNING PRODUCTS AND WORKSTATIONS

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When we mention anthropometry nowadays it looks a pre-historian subject. Nevertheless people complains about dimensional errors in products and workstation with problems to the user comfort and to the system safety. The data are available - a lot of research with different population -; what is the problem? In this paper the results of interviews with designers are presented as an attempt to explain the reason for the misuse of anthropometric data and the most common errors applying anthropometry to design of products and workstation.

PROBLEM

There are some errors of anthropometric application in product and workstation design. Some designers, use the measures of their own bodies when designing. Obviously this results in design errors, problems of comfort for the user and safety for the system.

Some other designers even knowing anthropometric data choose measurements based in the "average man" (50^{th} percentile).

As there are not enough researches in the anthropometric data of the Brazilian population, many designers simply do not use any kind of data. They think that international researches will not provide correct values. However, they use pre-defined measurements published in some product design books. (e.g., 75 cm for table heights and 45 cm for chair heights), ignoring the compatibility of the extreme percentiles – small woman and large man.

OBJECTIVE

Verify the procedures, strategies and references used by designers when developing layouts, shapes and dimensioning products and workstations.

Verify the errors in developing layouts, shapes and dimensioning products and workstations, caused by errors and slips in the use of ergonomic procedures during the design activity.

METHODS AND TECHNIQUES

Literature research to point out some evidences of the designers' major mistakes in applying anthropometric data, making arrangements for the project, setting products and workstations' conformation and dimensions.

Eight designers were interviewed in order to enumerate the methods, procedures, strategies and references used to set the products and workstations' conformation and dimension.

An analysis of the mistakes was pointed out by the authors in setting the products and workstations' conformation and dimensions.

RESULTS

Regarding the application of the anthropometrics data, the most frequent mistakes made by designers are: the use of the designer's own body dimensions as a parameter, and the use of the so-called "average man".

According to the designers, the lack of specific anthropometric data on the Brazilians people is the reason for inappropriate setting of dimensions in Brazilian products. However, the same mistake is observed in American, English and French products. Nevertheless, anthropometric data of those populations are available. The main question is not which data of which population the designer will use in his/her project, but the use of the "average man" (Moraes, 1994).

In the account of anthropometric data, it is worth quoting:

"The proper or improper setting of dimensions regarding Brazilian products is not related to the lack of Brazilian data. The question is how to use the existing data. The wrong utilisation of the existing data is worst than the lack of data, American or Brazilian – that influences even bigger mistakes." (Moraes, 1994).

According to Pheasant (1996), there are five fundamental fallacies on the use of anthropometric data said by designers about projecting workstations, furniture and products:

"1. This design is satisfactory for me - it will, therefore, be satisfactory for everybody else.
2. This design is satisfactory for the average person - it will, therefore, be satisfactory for everybody else.
3. The variability of human beings is so great that it cannot possibly be catered for in any design - but since people are wonderfully adaptable it doesn't matter anyway.
4. Ergonomics is expensive and since products are actually purchase on appearance and styling, ergonomic considerations may conveniently be ignored.
5. Ergonomics is an excellent idea. I always design things with ergonomics in mind - but I do it intuitively and rely on my common sense so I don't need tables of data or empirical studies."

It was possible to confirm such ideas in statements heard during the interviews with Brazilian designers of products, furniture and workstation:

1) The product "satisfies" its own designer

"(...) You have a certain piece that is an architectural element, it has to be comfortable in addition to pretty. The comfort itself gives you no prettiness and no piece at all. The beauty itself, without the comfort, gives you a sculpture. There is a need to bring together these two important components: prettiness and comfort, the functionality. My experience is all I have because I didn't study this kind of thing at College. The chairs that I've been doing are, in principle, based on my own body. A chair is meant for many people to sit on it, I don't mean a space ship or Formula 1 seat, those are made specially (...)" [author's emphasis]

2) The product "satisfies" the average person

"(...) I'm concerned with setting dimensions that I can consider as an average dimension, they'll never be ideal. Our philosophy here is to try to do things, every object, that an average person, an outsider, will look at and won't fear. We risk doing it because we immediately feel safe to do it. (...)" [author's emphasis]

THE ANALYSIS OF THE MISTAKES

It is possible to enumerate other typical mistakes done by designers while designing the products:

Inter-population versus intra-population differences

Moraes (1992) says that many designers look up the demographic census in search for the average Brazilian. It is proved by research that anthropometric data may have a bigger variability among the same population than between different populations, *i. e.*, the difference between American and Brazilian people is smaller than the difference between people of two distinct states in Brazil. Therefore it is worst to use the data on average stature from one northern state to products for populations of southern state than it is to use it from Americans to Brazilians.

"The mean stature for some 1,200 samples from Africa and Europe is 167.1 cm, and the standard deviation of the means is approximately 5.6 cm. The standard deviation stature is known for 200 of these samples. The mean standard deviation is 6.1 cm. In other words, variation in total body size between populations is, if anything, less than that within populations. Tildesley (1950) examined a number of anthropometric dimensions in a similar way for indigenous populations all over the world. (...) In almost every dimensions, the variability within populations was greater than that between populations." (Roberts apud Moraes, 1992)

Therefore, it is possible to conclude that to use data from Paraná (a Brazilian State) in setting dimensions for products to Maranhão (another Brazilian State) is a bigger mistake than to use American tables to dimension Brazilian products.

Population's selection/research

Mistakes in setting dimensions for workstations, furniture and products can be caused by the use of anthropometric data from specific population research – among College students or military subjects for example. As Roebuck (1975) observes:

"The percentile values used in Apollo Project were based in data of the Flying Personnel ... incorrect results could be expected if the percentile values had been selected from a less representative population, like a research on students or American army truck drives."

It is said that the proper way to set those dimensions would be to use research with more general data.

As Moraes (1983) says, many authors demonstrated (Chapanis, 1962; Panero & Zelnick, 1983; Pheasant, 1986) and researches proofed (Vital&Health Statistics, 1981) that the younger, wealthier and better-educated populations have bigger dimensions. Therefore, the use of data from a research with students to design products to an older, poorer or less educated population, may result in damage to smaller individuals.

Correct Variable's Selection

Another reason for mistakes in setting workstations and products dimensions, according to Moraes (1983), is the choice of the variable (or variables) which will be taken into account when projecting a product. For instance, one can frequently see the definition of the better place for visualisation on display windows be set according to stature. The proper thing to do would be to use the eye level's height and then set the limits for the vision field. Projects should use specific anthropometric variables for each dimension to be set. It is necessary to make a chair's function, for example, explicit. To design a chair for a typist is different than to design one for an auditorium.

The fallacy of the average man

One of the most common mistakes is to use data from the "average man" when designing products and workstations. The project is based on an average supposing to satisfy the majority.

Various mistakes can be lead by the selection of values from the percentile 50. Actually, as the average value is used, half of the population is damaged – at times this half is smaller than the average (it's the case of the ranges), at other times the half is larger than the average (in defining the space for the legs under a table, for example). Moraes (1992).

Cushman (1991) recommends the use of the percentile 95° to establish the products' minimal dimensions involving spaces (clearances) and the body dimensions of percentile 5° for the products' maximum when ranges are involved.

Many authors discuss the "fallacy of the average man" (Damon et alii, 1966; Moraes, 1992, 1983; Panero & Zelnik, 1979; Pheasant, 1986; Roebuck, 1975; Van Cott, 1972). Still, some designers persist on the "average man" myth.

Cushman (1991) emphasises that there is no such thing as a percentile 50^{th} individual, percentile 5^{th} or a percentile 95^{th} individual. These values represent the individual's possible average, minimum and maximum dimensions, respectively and the individual may not necessarily have them all. He/she might alternate a percentile 5^{th} dimension with a percentile 50^{th}. Quoting Cushman:

> "(...) terms such as '50^{th} percentile user', '5^{th} percentile female', and '95^{th} percentile male' usually refer to percentile rankings for only one body dimension. The variability among the percentile rankings of body dimensions for the same person is clearly shown in a study of several hand dimensions (Champney, 1977). Subject #1 had only a 1^{st} percentile hand breadth but had a 52^{nd} percentile hand thickness, for example. Subject #14 had a 96^{th} percentile hand breadth but only a 6^{th} percentile hand spread wedge."

Therefore the designer will consider the value of the percentile's maximum extreme or the value of the percentile's minimum extreme, according to the product's characteristics, the system's functions and the activities performed by the operator.

The importance of the Task Analysis

One thing to be considered is that many mistakes happen when designers, while projecting a workstation or a piece of furniture, begin using ergonomics, in fact anthropometry, without task analysis. The designer usually begins his/her ergonomic study at the stage of development instead of the stage of rising data. As a consequence, the alternative designs for the project will not consider the requirements, the parameter and the task's aim to the application of the anthropometric data.

After Porter (1995) we shall mention that "It is essential that ergonomics input to a product takes place throughout the design process but nowhere is it more important than at the concept and early development stages of design. Basic ergonomic criteria such us the adoption of comfortable and effective postures need to be satisfied very early on. If these criteria are not thoroughly assessed then there is usually only very limited scope for modifications later on as all the other design team members will have progressed too far to make major changes without considerable financial and time penalties."

Pheasant (1996) can be mentioned in relation to the importance of the task analysis:

> "A task analysis is really a formal or semi-formal attempt to define and state what the user/operator is actually going to do with the product/system/environment in question. This is stated in terms of the desired ends of the task, the physical operation the user will perform, the information-processing requirements it entails, the environmental constrains that might pertain, and so on. An effective task analysis will clarify the overall goals of the project, establish the criteria that need to be met, point out the most likely areas of mismatch, and so on."

Designers commonly make a mistake in a product's project that, in spite of being directly linked to the application of anthropometric data, the task analysis, as said before, is what gives the basic requirements for the application of the anthropometric data. It follows some pieces of the interview related to this kind of mistake:

> "(...) some times the work is done on the product's material, other times on its function, it depends on each case, but we try to create a number of ideas. Some times I promote a workshop, for example, where everybody – I've done this about a food processor – everyone from my

office get into the conceptualisation stage, I put all the designers working all day long and at the end of the day we have little models and ideas (…)"

"(…) we begin to have an idea of Design here, I mean, that there is a Brazilian consumer that will use this product, so the first thing is to understand this consumer's psychology, I mean, who is really going to use this product. Then we have to create the most logical sequence possible. Visualise commands that need no superior intelligence, I do this for a four year old child (…)"

"(…) we try to begin by making all our arrangements based merely on concepts, if it will fit the arches position and measures, whatever, the ranges inside the population that we're trying to reach (…)"

"(…) many times a project may not need an extensive task analysis. It may not even have a task, depending on the product's project. I mean, there will always be some activity, but, it may not be organised as a task (…)"

"(…) I developed a good example about the auditorium seat; I visited various movie theatres which auditoriums were in different conditions and looked them up in catalogues. I did all that trying to find out what was that seat's exact function and I basically did it by sitting on a lot of them (…)"

Wrong use of the standard measures

As stated earlier, many designers – out of unawareness or laziness - persist in using the "standard" measures or use existing measures from products even if they are not correct, not considering the task analysis, which would explain the requirements to set the product's dimensions. Such problem can be pointed out in the following interview:

"(…) if the product is going to have a sequence in relation to a previous product, then I follow the existing dimensions, or, if it's a new product, I use external data, like literature. At times I apply tests and, when possible, I raise some more extensive data in specific researches on the product. In that case I use the client's knowledge too, whatever research the client already has on the topic and the product's public. I also use, obviously, books that tell me how to adapt this kind of product."

"(…) I take for granted the chair's approximate height, a chair's medium height is 45, a table's average height is 75, some things are already standardised (…)"

"(…) if it is about an industrially produced chair, you have to use that chair's medium standard."

CONCLUSION

The designer's speeches are explicit. During the design process they do not apply ergonomic in the early stage of project development.

Moreover it is obvious the lack of task analysis as an usability tool. Some designers use task as a buzzword.

The main references are the dimensions of existent products, the colleague's opinion. They also look for data in the literature that often are specific for others human-task-machine-systems.

The designers - it is amazing - are still designing for the average man!!

Those are problems that the use of Anthropometric CAD will not solve.

Even in the post modern age designers need to be trained in how to design considering ergonomics for better product usability. Part of this implies how to use anthropometric data after ergonomic task analysis.

BIBLIOGRAPHIC REFERENCES

CHAPANIS, Alphonse. *Research Techniques in Human Engineering*. Baltimore: Johns Hopkins, 1962.

CUSHMAN, Wilian H.; ROSENBERG, Daniel. *Human Factor in Product Design*. Amsterdam: Elsevier, 1991.

DAMON, Albert; STOUDT, Howard W.; MCFARLAND, Ross A.. *The Human Body in Equipment Design*. Cambridge: Harvard University Press, 1966.

MORAES, Anamaria de. *Pesquisa Conformação da Interface Homem-Tarefa-Máquina: Arranjo Físico de Subsistemas e Dimensionamento e Desenvolvimento dos Componentes; O Uso de CADs de Antropometria*. Rio de Janeiro: ESDI/UERJ/CNPq APB, 1995-1996.

MORAES, Anamaria de. *Diagnóstico Ergonômico do Processo Comunicacional do Sistema Homem-Máquina de Transcrição de Dados: Posto de Trabalho do Digitador em Terminais Informatizados de Entrada de Dados*. Tese de Doutorado – IBICT/ECO/UFRJ – Área Maior: Ciência da Informação. Rio de Janeiro: ECO/UFRJ, 1992.

MORAES, Anamaria de. *Aplicação de Dados Antropométricos: Dimensionamento da Interface Homem-Máquina*. COPPE/UFRJ, Tese de M.Sc., Engenharia de Produção, 1983.

PANERO, Julius; ZELNIK, Martin. *Las dimensiones humanas en los espacios interiores; estándares antropométricos*. Barcelona: Gustavo Gili, 1983.

PHEASANT, Stephen. *Bodyspace: Anthropometry, Ergonomics and Design of Work*. 3. ed. London: Taylor & Francis, 1996.

PHEASANT, Stephen. *Bodyspace*. London: Taylor & Francis, 1986.

PORTER, J. M. et al. Computer aided ergonomics and workspace design. Wilson, J. R; Corlett, N. G. *Evaluation of human work; a practical ergonomics methodology*. London, Taylor & Francis, 1995. 2nd ed. 1134 p. pp 574 -620.

ROEBUCK Jr., J. A.; KROEMER, K. H. E.; THOMSON, W. G.. *Engineering anthropometry methods*. New York: John Wiley, 1975.

VAN COTT, Harold P.; KINKARE, Robert G.. *Human Engineering Guide to Equipment Design*. Washington D.C.: US Government Printing Office, 1972.

VITAL & HEALTH STATISTICS. *Height and weight of adults ages 18-74 years by socioeconomic and geographic variables*. Hyattsville(USA): U.S. Department of health and human services, 1981.