A PSYCHOPHYSICAL STUDY ON WEIGHT SENSITIVITY BY THE FOOT AND HAND

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The weight of shoes may serve as a determining factor of perceived comfort and feel to the consumer in their purchase and repurchase decisions of footwear. People, however, seem to have trouble in accurately judging the feeling of weight of shoes on their feet. This paper made a psychophysical study of subjects' sensitivity to weight on their feet and in their hands. The experiment consisted of 3 tests according to the motions people make when they evaluate the feel of shoes: 1) vertical lifting of a shoe on the foot ("hefting" it on the foot); 2) swing the shod foot back and forth; 3) holding and lifting a shoe by hand ("hefting it in the hand). The method of constant stimuli and magnitude estimation were used for the experiment with 20 subjects. Weber's ratios and the power law exponents obtained for each of the three tests were 0.156 and 0.713, 0.108 and 0.970, and 0.065 and 1.249, respectively in the same order of the previously listed tests.

Key Words: Psychophysics, weight sensitivity, JND, Weber's ratio, power law

1. Introduction

The weight of shoes may serve as a determining factor for comfort and good feel that can be expected to influence purchase decisions and satisfaction with the product. People generally prefer a lighter shoe to a heavier one. Their perception of "a lighter shoe," however, might depend on whether they judge the weight of a shoe by hand or by foot. The author hypothesized that the perception of the weight of shoes by the foot would be less accurate than the sensitivity by the hand. It was also believed that the perception of weight by the foot might depend on the activity performed, such as lifting the foot vertically compared to swinging it back and forth. Comparisons of hand/foot and "heft"/swing perceptions are important, because people may first make judgments with the shoe in their hands before they ever put it on their feet and possibly perform only one movement with the shoe on their feet.

Therefore, a set of psychophysical experiments were designed to achieve the

following purposes:

1) Determination of JND's (Just Noticeable Difference) and Weber's ratios to learn how sensitive people are to weight change with their feet and hands.
2) To obtain the exponents of the Power Law in order to observe how people actually perceive the weight change with the foot and hand
3) To compare the JND's and the exponents obtained for the foot with the values for the hand

The methods of constant stimuli and of magnitude estimation were used for the experiment to estimate the JND and the exponent of the Power Law, respectively.

2. Method

Subjects

Twenty subjects (ten of each gender), who were normal for psychophysical tests, volunteered for the experiment. Their ages ranged from 22 to 45 years old and their average age was 31 years old.

Apparatus

A customized size 9 pair of basketball shoes, each shoe of which weighed 415g, was specially made for this study as shown in Figure 1. The test shoes had a reinforced midsole. Two slots, one in the front and the other in the rear, were cut out from the lateral side of each shoe to allow for adjustments of insertable test weights. The dimensions of each slot were 66mm X 70mm X 10mm(width X depth X height).

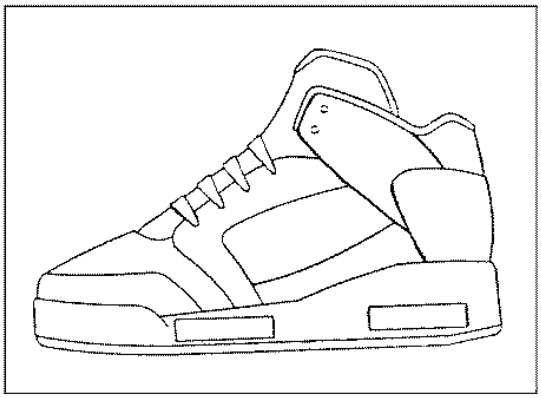

Figure 1. Test Basketball Shoe

Each weight-insert, shown in Figure 2, consisted of a piece of foamcore (65mm X 80mm X 5mm) sandwiched between two pieces of plastic (65mm X 80mm X 1.5mm). A portion of the middle part of the foamcore block was removed and replaced by a chunk of lead to secure the different weights for the experiment. The minimum and maximum weights of each weight-insert attainable within its physical constraints were 25g and 175g, respectively. For each weight comparison two weight-inserts were used per shoe. Therefore, seven total shoe weights, increasing by 50g increments, were used for the test; 465g, 515g, 565g, 615g (reference weight), 665g, 715g, and 765g.

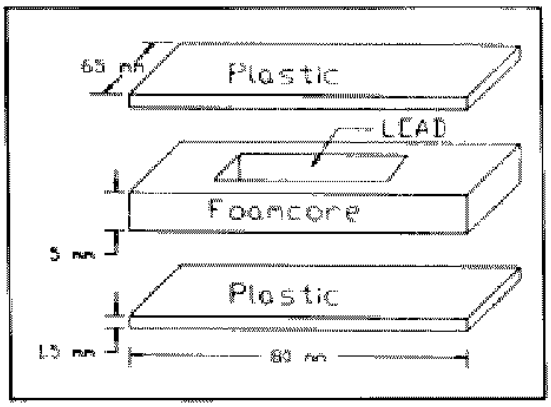

Figure 2. Weight-Insert

3. Procedure

Each subject completed the experiment that consisted of the following three sessions in randomized order:

Session 1: Vertical lifting of a shoe on the foot
Session 2: Swinging a shod foot back and forth
Session 3: Holding and lifting the shoe by hand

Before starting each session, the subjects were given practice trials followed by feedback on the actual weight. Subjects had a 10 to 15 minute rest period after each session. Figure 3 demonstrates the required motion for each session. The demanded motion for session 1 was to lift the whole leg, including thigh, shank, and foot while in a seated position. Session 2 required the seated subject to swing the lower leg and foot. The subject was asked to hold and/or lift the shoe in the hand for session 3.

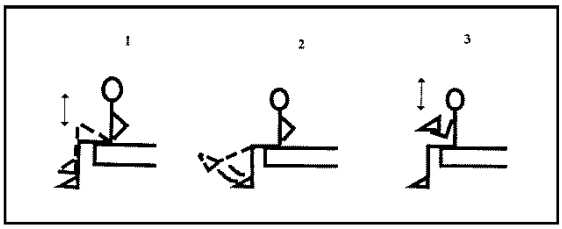

Figure 3. The required motion for each session

Each subject was asked to answer two questions per trial from the following instructions:

"Now for a series of pairs of weights… Yow will be asked to compare the weights of the shoes on your feet… Then, you are to answer by saying 'yes' or 'no' to the question: 'Is your left side (foot or hand) heavier than the right?' And then: 'If the weight you feel on your left side is considered as '10', What number would you like to assign to the weight on your right?' You can use any number you'd like. You may start the motion on either side."

Each pair of stimuli consisted of the reference stimulus (615g) and one of the seven comparison stimuli presented in a randomized order. Subjects compared the reference weight with each of the comparison weights 5 times per session for a total 105 comparisons for the entire experiment. Each subject's response was recorded on a data sheet. It took approximately 3 hours for a subject to finish the whole test.

4. Results

The method of constant stimuli - JND

Figure 4 presents the percentage of responses in which the comparison stimulus was judged to be heavier than the reference weight.

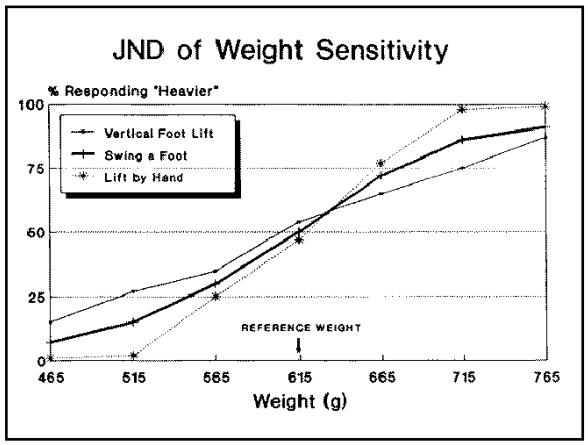

Figure 4. Percentage of subjects responded "heavier" to the comparison weight

The method of LSE (Least Square Estimator) with transformed Z-value from the percentage values in Figure 4 was used to calculate PSE's (Point of Subjective Equality), JND's, and Weber's ratios.

As indicated by the numbers in rows labeled "JND" and "Weber's Ratio" in Table 1, people were most sensitive in detecting a weight change when lifting by hand, less sensitive by swinging the lower leg, and least sensitive by lifting their whole leg vertically.

Table 1. The summary of JND

	Vertical Lifting by Foot	Swing Back and Forth by Foot	Holding and Lifting by Hand
Reference Weight (g)	615.0	615.0	615.0
PSE (g)	609.9	617.0	615.1
JND (g)	96.0	66.3	40.0
Weber's Ratio	0.156	0.108	0.065

* Weber's Ratio = JND/Reference Weight

* Weber's Law: Weber's Ratio = Constant ---- (1)

The method of magnitude estimation - exponents

The relation between the actual weight (W) and perceived heaviness (H) is expressed by the following equation:

$$\log H = n (\log W) + \text{Constant} \quad \text{---------- (2)}$$

Table 2 shows the exponents for the power law obtained through the method suggested by King and Riggs (1954).

Table 2. The summary of the exponents

	Vertical Lifting by Foot	Swing Back and Forth by Foot	Holding and Lifting by Hand
n (exponent)	0.7130	0.970	1.249
Constant	-1.008	-1.714	-2.484

Figure 5, which is converted into exponential from equation (2), graphically demonstrated how the curve is concave upward or downward, depending on whether the exponent is greater or less than 1.0. The power function for "swing a foot" is almost straight, because the exponent is close to 1.0.

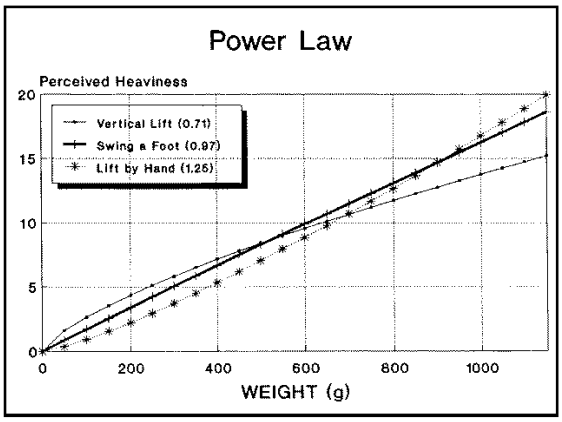

Figure 5. The power law of weight sensitivity by foot and hand

5. Discussion

The method of constant stimuli – JND

Generally Weber's law, as defined in equation (1), holds well within a sense modality for moderate stimulus values. However, Weber's ratio increases greatly when the reference weight approaches the subject's absolute threshold (Kling and Riggs, 1954). Table 3, which shows the Weber's ratios of "lifted weight by hand" from different sources, does not support Weber's law. This indicates that "lifted weight by hand" might not be a sense modality that obeys Weber's law.

The PSE (Point of Subjective Equality) is defined as the average value of the comparison stimulus that is judged equal to the reference stimulus. As in Table 1, the subjects' PSE's are

quite close (exactly within 8.3%) to the reference weight.

Table 3. Weber's ratio from different studies

Source	Ref. Weight (g)	Weber's Ratio
Boring, et al.	300	0.020
This Study	615	0.065
WADC	1000	0.065

The magnitude estimation experiment

The exponents for weight perception by foot were less than 1.0 while those by hand were greater than 1.0. For example, the exponent for "vertical lift by foot" is 0.713. This means that when the weight change of weight is perceived to be doubled, the actual weight change is more than doubled (exactly 2.64 times).

The exponent for "holding and lifting by hand" was 1.25, which is close to that found by Stevens as 1.45 (Stevens, 1986). In this case, the change of weight is perceived to be doubled when the actual weight change is less (exactly 1.74 times).

Other exponents on weight sensitivity by foot were not available for comparison.

6. Conclusion

This study concluded that the perception of the weight difference of a shoe on the foot is somewhat keener when swinging the shoe than simply "hefting" it. Further, the foot is less sensitive than the hand in detecting weight change. Therefore, a given increase in the weight of a shoe would be perceived to be less than the actual change on the foot but to be heavier than the actual change in the hand.

Even though the shoe will be worn on the foot, initial perception of the shoe weight may be based on "hefting" the shoe in the hand. Therefore, the footwear industry needs to be aware of the weight sensitivity of both the hand and the foot.

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