PSYCHOPHYSICAL METHOD COMPARISON TO ESTIMATE PSYCHOMETRIC FUNCTIONS FOR VISUALLY PERCEIVED SIZES

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Abstract

The choice of psychophysical method to accesses the psychometric functions for visually perceived size is still controversial. To address the question, observers compared the sizes of two circles displayed on a vertical meridian of a computer screen by three procedures: method of constant stimuli, staircase procedures (1up-1down and 1up-2down) and four-point sampling method. Slopes and points of subjective equality (PSE) were estimated on normal cumulative curves. Results indicated no significant difference for calculating PSE among these methods, but significant differences among slope computations. Slope was higher for four-pointing sampling method, intermediate for constant stimuli method, and lower for the staircase. We concluded that the three methods are similar for PSE estimation, but some care should be taken into account for choosing the method to estimate the slope.

Frequently it is argued that the method of constant stimuli (MCS) is inefficient (Watson and Fitzhugh, 1990). Despite these criticism, this method is still widely used and is chosen because causes fewer errors, less variability in calculated parameters, simplicity to implement it, requires no prior assumptions about the psychometric curve shape and results can be adjusted to various functions. These advantages have been exposed by Simpson (1988), which compared through simulation adaptive methods and MCS. Nevertheless, this method allows for a full sampled psychometric function, which brings a disadvantage: many trials about stimuli levels that are not informative about the threshold.

Thus, in the adaptive psychophysical methods (e.g. staircase procedures) efficiency would be greater, because it concentrates the attempts close to the parameter to be calculated. Doing this avoid attempts that provide little useful information, reducing subject and experimenter time (Leek, 2001). On the other hand, it is likely that the estimates (e. g. PSE and slope) will be more variable.

In this sense, an alternative to reduce the time and decrease parameters variability would be the four-point sampling method (Lam et al., 2007). In this method, a psychometric function is fitted by four points, each one repeated several times, as in MCS. By this way, adaptive methods could provide information to choose the four points. From the foregoing lines it can be seen that the choice of psychophysical method to accesses the psychometric function, especially for visual size perception, is still controversial.

Method

5 students (all men) from the University of São Paulo (USP) compared the size of two black circles in the vertical meridian and in a gray background. These pair were composed by a standard stimulus (St - 100 pixels) always presented in the lower visual field and a comparison stimulus (Cs) presented always in the upper visual field. They were presented for 100 milliseconds (ms). There were three different blocks according to the method through the stimuli were presented: (1) method of constant stimuli (MCS), staircase procedures (1up-1down and 1up-2down) and four-point sampling method (Lam et al., 1997).

On MCS, Cs could take 11 different values ranging from 85% to 115% compared to St and each pair of stimulus was presented 20 times. On both staircase procedures, two interleaved staircases was used, one beginning at 88% of St and another at 112% of St. The stopping rule was 24 reversals and the first 6 was discarded to estimate the stimulus value of 50% (PSE) and of 70,7%. On four-point sampling method, was carried out adaptive methods (1up- 2down and 2up-1down) to obtain estimates of threshold (*M*) and spread (*S*), which are used to determine the four Cs stimulus levels (91 %, 97 %, 106 % and 112 % compared to St).

Slopes and points of subjective equality (PSE) were estimated on normal cumulative curves and both were submitted to repeated-measure ANOVAs with 3 (psychophysical methods) as within participants variables.

Results

The PSE mean values were less than 100 for staircase and method of constant stimuli, showing that Cs were overestimated, while in the four-point sampling method the PSE were greater than 100, indicating that the Cs were underestimated (Figure 1). The ANOVA do not revealed differences among the three psychophysical methods [F(2,8)=1,331, p=0,317]. Probably, the large variance observed in staircase procedure is responsible to do not reach significant differences.

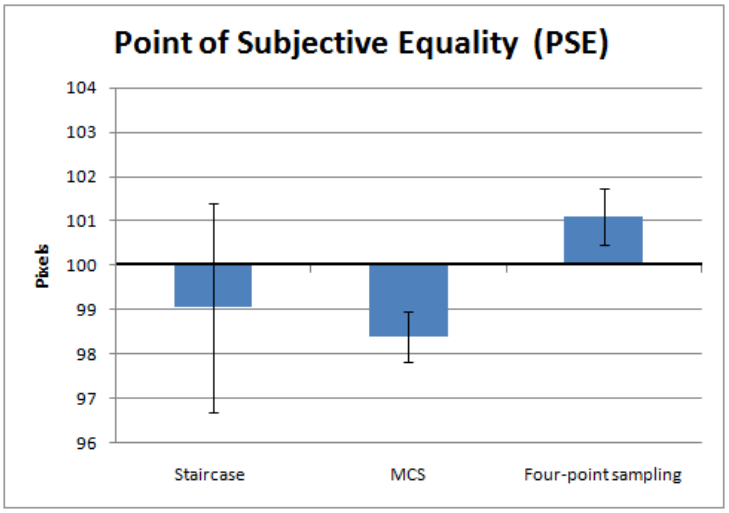

Fig. 1. Points of Subjective Equality (PSE) means for size comparisons made with three different psychophysical methods: staircase (1up-1down), method of constant stimuli (MCS) and four-point sampling method. Error bars refers to the mean standard error

Table 1. Means and standard errors (SE) of slope as a function of psychophysical methods.

Psychophysical Methods	Slope	SE
Staircase procedure – two points (50% and 70.7%)	0.0690	0.0080
Staircase procedure – three points (29.3%, 50% and 70.7%)	0.0948	0.0081
Method of Constant Stimuli (MCS)	0.1912	0.0286
Four-Point Sampling Method	0.2396	0.0322

The slope means values for the three methods, including the two calculated slope for staircase procedure (two or three points used) are showed in the Table 1. Slope was higher for four-point sampling method, intermediate for MCS and lower for the staircase procedure. The ANOVA with staircase slope (two points) showed a significant effect for psychophysical methods [$F(2,8)=23.955$, $p<0.001$] and a *post hoc* tests showed a significant difference between staircase and MCS ($p=0.038$), staircase and four-points sampling method ($p=0.023$) and MCS and four-point sampling method ($p=0.018$). Another ANOVA was carried out with staircase slope (three points) calculated in staircase procedure (Figure 2). This ANOVA revealed difference among the methods [$F(2,8)=18.216$, $p=0.001$] and through *post hoc* tests was verified that the difference between staircase and MCS ($p=0,077$) was not reached, but the difference remains between staircase and four-points sampling method ($p=0.027$) and MCS and four-point sampling method ($p=0.023$).

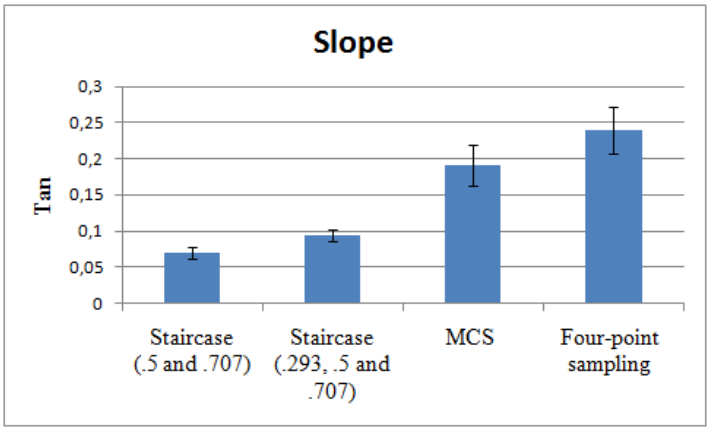

Fig. 2. Slope means of psychometric function made with three psychophysical methods: staircase (two and three points of psychometric function), method of constant stimuli (MCS) and four-point sampling method. Error bars refers to the mean standard error.

Discussion

The smaller size distortions observed could be caused for the height in the visual field, which provide cue to distance and possibly to size. Results indicated no significant difference for calculating PSE. However, staircase PSE showed a large variance. This can be reduced by using all trials and not only the reversals to calculate it (Kaernbach, 2001; Klein, 2001). We perform this change. The variance reduced around 10%, but remains too high. This effect may be explained due to a small sample size, but this great variability should be a feature inherent to staircase procedures.

Significant differences among slope computations are showed. If three points, and not two, are used to estimate slope from staircase procedures, significant difference between this method and MCS is not reached. We concluded that some care should be taken into account for choosing the method to estimate psychophysical parameters for size comparison task. The staircase procedures was the less reliable, because generates high variability in PSE estimate and shallower slopes, indicating lower sensitivity to size discrimination.

Acknowledgements

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