

The Grasp-span Weight Illusion

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Abstract

Charpentier (1891) showed that when objects of identical mass but different volume are lifted, subjects consistently report that the smaller object is heavier. This finding is preserved even when subjects are aware that the objects are of the same weight, and has become known as the size-weight illusion. More recently, Flanagan & Bandomir (2000) found that a similar effect is seen when subjects pick up weights with different grasp spans. In this case, weights picked up with a narrow grip are judged to be heavier than identical weights picked up with a wide grip. The experiment described here is an extension of Flanagan & Bandomir's work, which eliminates visual feedback. We find that the grasp-span weight illusion is present without the aid of vision.

Introduction

Flanagan & Bandomir (2000) examined the effect of the grasp span used to lift an object on the lifter's perception of its weight (note that throughout we refer to Flanagan & Bandomir's Experiments 1 and 2). They asked subjects to pick objects of different weights, and report whether the object was lighter or heavier than a reference object. The part of the object used to pick it up was rectangular, so the object could be grasped across the narrow axis (3cm) or across the wide axis (7cm). In addition, the subject could move such that the face of the object presented to the subject was the wider or the narrower face.

This study found that subjects perceived the weight to be lighter when lifted with a wide grip, and heavier with a narrower grip (Experiment 1). This finding holds whether the subject views the object from the front or from the side (Experiment 2).

Flanagan & Bandomir's study did not exclude the classic size-weight illusion as their subjects could see the objects that they were lifting, instead the object was rotated such that a wider or a narrower face of the object was visible to the subject. The study presented here corrects this, and tests the presence of a grasp-span weight illusion without vision.

Method

We recruited 20 able-bodied subjects, who did not report any difficulty with using their preferred hand at the time of the experiment. 15 men and 5 women were tested, between the ages of 18 and 23 years. Subjects were not rewarded for their participation.

Following Flanagan & Bandomir we used a forced-choice paradigm, in which blindfolded subjects lifted a test weight, selected in random order from weights of 80g, 94g, 101g, 108g, 115g, 123g, 130g, 137g and 151g, then lifted

a reference weight of 115g. Subjects were then asked to report whether the test weight was lighter or heavier than the reference. Each weight could be lifted using either a narrow grip or a wide grip, giving a total of four conditions.

A standard lifting platform was used for each weight, with a central, narrow grasping site (3.2cm) and an outer, wider grasp site. The size of the wide grip could be varied according to the size of the subject's hand, and was either 9.6cm or 11.35cm. We chose the grip size such that the subject was just able to pick up the lifting platform. The two groups performed statistically identically (data not shown), and will be treated as one group. The grasp sites had strips of sandpaper attached to provide a high-friction surface, and to reduce the grip force needed to lift the object (Flanagan & Wing 1997).

The subjects were instructed to lift the platform using the thumb and the ring and middle fingers. No instructions were given as to how to lift the weight, but all subjects were observed to lift the weight by about 10cm, hold it momentarily then place it down again.

Analysis

The responses for 20 subjects were pooled, and for each test weight in each condition we found the proportion of trials where the test weight is reported as being heavier than the reference weight. Each subject lifted each weight twice in each condition, so there are 40 estimates per point in each

condition. The point of subjective equality (where the two weights are judged to be identical) was found for each condition by fitting a sigmoid function to the observed data.

We performed F-tests on pairs of curves to determine whether or not the underlying populations were significantly different.

Results

We find that when both weights are lifted with the same grip width (narrow-narrow or wide-wide), the curves fitted to the response data are not significantly different to each other [$F(2, 14) = 1.16$, n.s.], and the halfway points of these curves are close to the true value of the reference weight.

However when the weights were lifted with different grip sizes (wide-narrow or narrow-wide), subjects report that the test weight is heavier when it is lifted with a narrow grip, and lighter when lifted with a wide grip. The fitted curves are significantly different [$F(2, 14) = 347.76$, $p < 0.001$], with the curve representing the narrow condition shifted to the left, and the wide condition to the right.

Figure 1 shows the proportion of subjects who reported that the test weight was heavier than the reference, for each weight in each condition. It is clear from the data and from the fitted sigmoids that the subjects were more accurate when the weights were lifted with the same grasp size than with different grasp sizes.

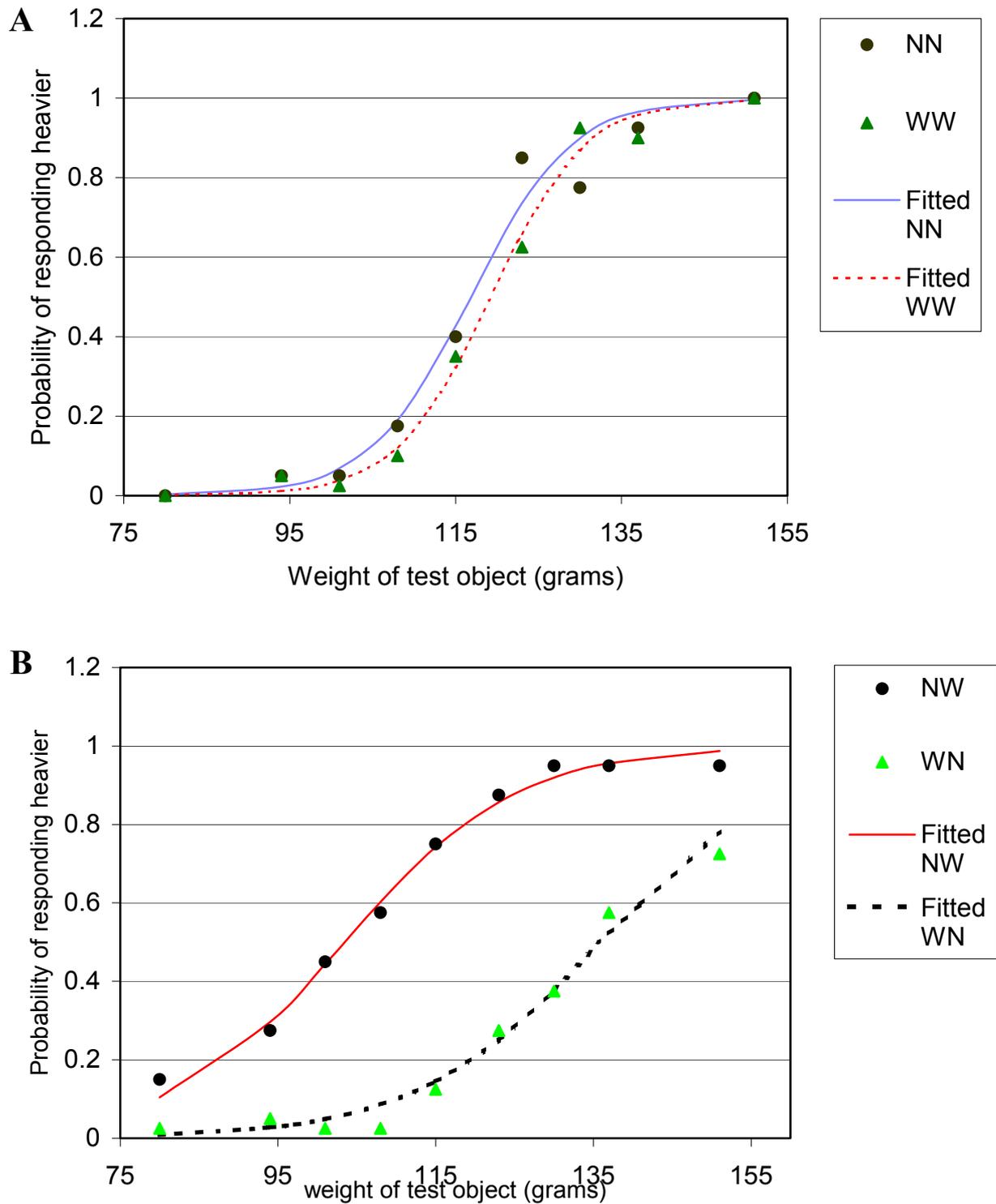


Figure 1. These figures show the proportion of subjects who reported that the test weight was heavier than the reference weight, for a given test weight. Figure 1A shows the conditions where the two weights were lifted with the same grasp span (W = wide, N = narrow), with the fitted sigmoid shown. 1B shows the conditions where the grasp spans were different (NW = test weight narrow grasp, reference weight wide; WN = test weight wide, reference weight narrow).

The midpoints of the fitted sigmoids away from the true value of the reference weight give the points of subjective equality for the different conditions. In the condition where the test weight was lifted with a narrow grip and the reference weight with a wide grip (narrow-wide condition), the midpoint is shifted to the left by 11.5g, suggesting that for a given weight, the perceived weight was 11.5g heavier than the true weight. For the wide-narrow condition it is shifted to the right by 20.9g, suggesting that it is perceived as being that amount lighter.

Discussion

The experiment described here demonstrates that the grasp-span weight illusion has a purely haptic or kinaesthetic cause, since we eliminated the ability of subjects to use vision to pre-judge the properties of the object to be lifted.

Since the only parameter of the experiment that is being manipulated between conditions is the grasp span, the illusion must arise either from perception of the grasp size, or from the perception of the work required from the hand muscles.

Van Doren (1998) found that as grasp span increases, the amount of work required of the hand muscles

decreases, for a given grip force. Our grip spans were larger than those that Van Doren measured (up to 8cm). We believe that the trend should hold for larger grip spans, however this study did not measure muscle activity during the task. We suggest that this differential pattern of muscle activity is the best candidate for the substrate of the grasp-span weight illusion.

References

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