(*Plectropomus* spp.), are specialized predators of fishes. The evidence that any exploited fishes are significant predators of *A. planci* is circumstantial or anecdotal. Fishing commonly removes large predators and has led to trophic cascades involving multiple trophic levels in other marine systems (for example [9]). A study comparing near-shore fish communities in no-take and in fished areas on the GBR [10] found that numbers of coral trout were higher in no-take areas, while a majority of likely prey species were less abundant, including the common benthic-feeding wrasse, *Thalassoma lunare*. A plausible positive link between commercially exploited fishes and predation on *A. planci* could involve higher numbers of large piscivores in no-take areas reducing densities of benthic carnivorous fishes such as wrasses, so causing ecological release of invertebrates that prey on very small *A. planci*. *A. planci* juveniles live hidden in rubble for 16–19 months after settlement [1] and have very high disappearance rates that are not due to emigration [11]. This implies that the invertebrate faunas in the rubble habitat of juvenile *A. planci* should also differ predictably between no-take and fished reefs.

The GBRMP was re-zoned in mid-2004, increasing the no-take zones from 4.5% to 33% of the area of the park [7]. Whatever the underlying mechanism, this study suggests that this increase should reduce the overall impact of future waves of *A. planci* outbreaks. That effect may be amplified if fewer reefs with starfish outbreaks mean less effective propagation of outbreaks from reef to reef through the central GBR. More generally, the geographic range of *A. planci* includes the most biodiverse [12] as well as some of the most threatened reefs [13] on earth; this study provides an additional argument for establishment of effective MPAs across the range [14], as refuges from exploitation and other threats and as sources for recolonisation of damaged reefs to increase ecological resilience.

Supplemental data
Supplemental data are available at http://www.current-biology.com/cgi/content/full/18/14/R598/DC1

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Visual coding for action violates fundamental psychophysical principles

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According to Weber's law, a basic perceptual principle of psychological science, sensitivity to changes along a given physical dimension decreases when stimulus intensity increases [1]. In other words, the 'just noticeable difference' (JND) for weaker stimuli is smaller — hence resolution power is greater — than that for stronger stimuli on the same sensory continuum. Although Weber's law characterizes human perception for virtually all sensory dimensions, including visual length [2,3], there have been no attempts to test its validity for visually guided action. For this purpose, we asked participants to either grasp or make perceptual size estimations for real objects varying in length. A striking dissociation was found between grasping and perceptual estimations: in the perceptual conditions, JND increased with physical size in accord with Weber's law; but in the grasping condition, JND was unaffected by the same variation in size of the referent objects. Therefore, Weber's law was violated for visually guided action, but not for perceptual estimations. These findings document a fundamental difference in the way that object size is computed for action and for perception and suggest that the visual coding for action is based on absolute metrics even at a very basic level of processing.

According to Weber's law, people's sensitivity to changes in a given physical continuum is relative rather than absolute when measured in physical units [1]. The minimum detectable increment in stimulus magnitude (JND) is therefore proportional to stimulus magnitude. Weber's law is the first and still the most widely tested (and confirmed) formal principle in modern psychological science [2]. It has been found to account

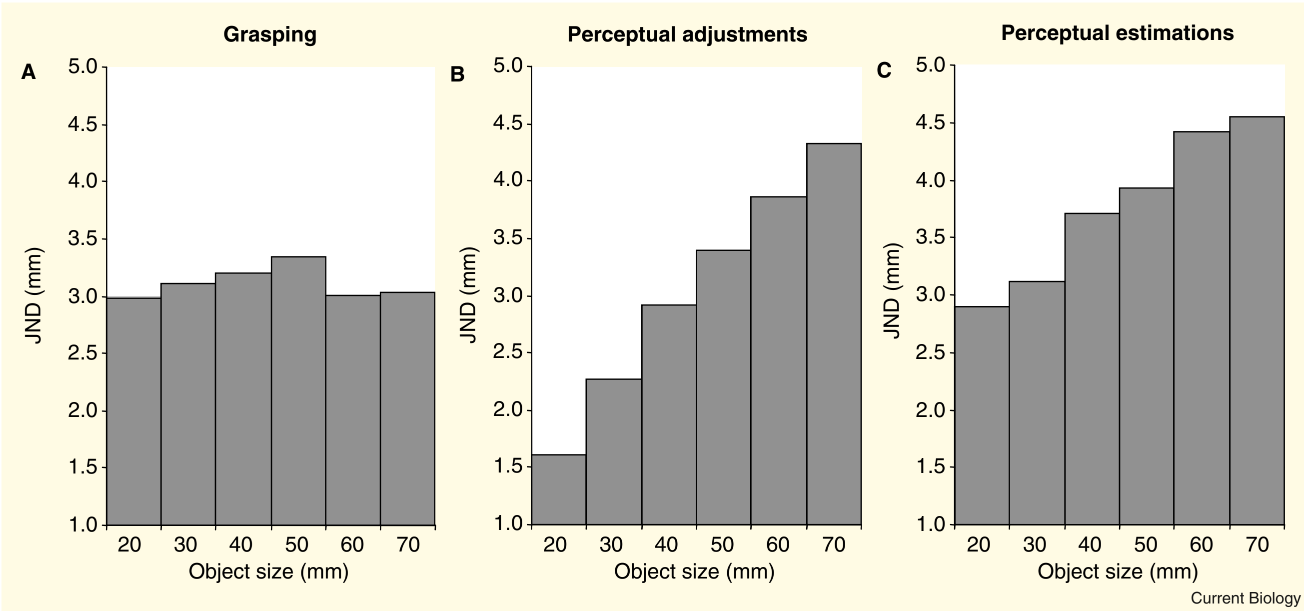

Figure 1. Effects of object length on visual resolution for grasping and for perceptual judgments.

The JNDs, which represent visual resolution, are shown for: (A) the grasping experiment; (B) the perceptual adjustment experiment; and C) the perceptual estimation experiment. JND increased linearly with length for the two perceptual conditions but was unaffected by length for grasping. The interactions between experiment (i.e., perception versus grasping) and object size were both significant (grasping and adjustments, $F(11,85) = 11.2$, $p < 0.01$; grasping and estimations, $F(5,110) = 7.3$, $p < 0.01$). The linear component accounted for 99% of the variance for adjustments and for 98% of the variance for estimations, but only for 0.2% of the variance for grasping.

for human perception in scores of dimensions, including object size [3], but its validity has not been directly tested when visually guided action is involved. The logarithmic relationship between perceived and physical size that Fechner derived on the basis of Weber's law probably reflects the evolutionary cost of the brain's need to compress a large range of physical information to a restricted range of subjective perception [2]. But this asymmetry does not necessarily characterize visually guided action, which usually applies to a narrower range of physical stimuli.

We carried out a series of psychophysical and visuomotor experiments to compare sensitivity for changes in object size for visually guided action and for perception. The participants were asked to either grasp or to make perceptual estimations of the length of rectangular objects varying in length (see the Supplemental data available on-line with this issue). To measure the JND, we used the classic psychophysical method of adjustment in which observers reproduce the standard stimulus such that the reproduction matches the standard in length.

In the grasping experiment, the anticipatory opening between the thumb and index finger (maximum grip aperture, MGA) was used as the main dependent measure [4–6]. Two perceptual experiments were run; a standard adjustment experiment in which observers determined the length of a comparison line presented on the computer screen to match the size of the target stimulus, and a perceptual estimation experiment in which observers were asked to make size estimations by opening their finger and thumb to match the length of the target object. Note that although fingers are involved, this is a standard perception experiment — used as a control in studies of visually guided action [4,6] — in which the observer consciously indicates the perceived length. The JND for a given length is determined in the method of adjustment by the variance or the standard deviation of the reproductions. This variance gauges the 'area of uncertainty' for which the observer is unable to tell the difference between the size of the comparison and the target object.

A main effect of stimulus size was found for the responses in all three experiments (perceptual adjustments, $F(1.5,7.4) = 570.3$, $p < 0.001$, $n = 6$; perceptual estimations, $F(1.2,12.4) = 200.7$, $p < 0.001$, $n = 11$; MGAs during grasping, $F(5,60) = 287.2$, $p < 0.001$, $n = 13$). The effect confirmed that all three measures were sensitive to changes in object size. Notably, an analysis of the variance (ANOVA) revealed that for perception the JND increased with object length in a linear fashion in accordance with Weber's law (Figure 1B,C: adjustments, $F(5,25) = 10.9$, $p < 0.001$; estimations, $F(5,50) = 10.3$, $p < 0.01$). In sharp contrast, the JND remained invariant across the same stimulus values for grasping ($F(5,60) < 1$, Figure 1A). These findings provide the first evidence that, unlike in perception, the JNDs for grasping are not affected by object size.

We conducted an additional control experiment to rule out potential ceiling effects for MGAs (which are, by definition, larger than actual object size). Action and perception were compared for the same participants under the same experimental conditions using MGA as the dependent measure. Real-time grasping in one condition was contrasted with delayed,

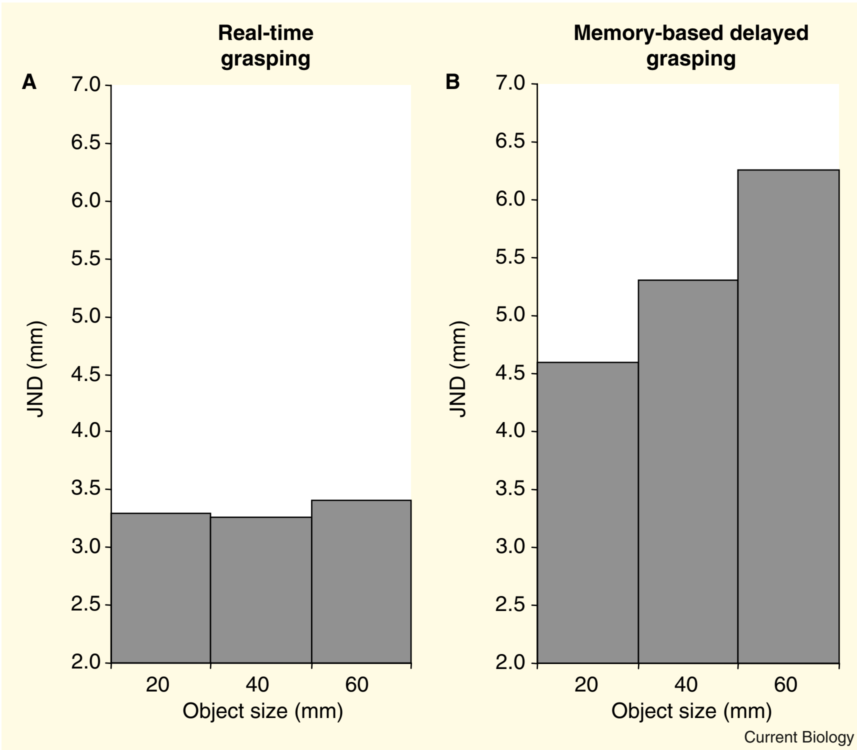

Figure 2. Effects of object length on visual resolution during real-time and memory-based grasping.

The effects are shown for the within-subject control experiment during: (A) real-time grasping; and (B) memory-based, delayed grasping. The significant interaction between real-time grasping and memory-based grasping ($F(2,34) = 6.3$, $p<0.01$) showed that size had differential effects on responding in the two experimental conditions. As in the previous experiments, JNDs were unaffected by size for real-time grasping. In contrast, memory-based grasping performance, which is known to rely on perceptual representations, showed a linear increase in JND with object length ($F(1,17) = 14.4$, $p < 0.001$).

memory-based grasping in the other condition. In the latter condition, following the initial presentation of the object, vision was occluded for five seconds. Such memory-based grasping in the dark is a standard perceptual condition in which performance has been shown to be driven by perceptual representations and which can be fully dissociated from real-time grasping [7]. The results are shown in Figure 2. MGAs during memory-based grasping were larger overall than the MGAs during real-time grasping [7] ($F(1,17) = 46.2$, $p < 0.001$). Most important, JNDs increased with object size for memory-based grasping ($F(2,34) = 9.2$, $p < 0.001$), but were again unaffected by size for real-time grasping ($F(2,34) < 1$).

We note that Fitts' law, a tradeoff between movement time and precision, entails a logarithmic relationship, which can be compatible with Weber's law [8]. However, dissociations of various aspects of human motion have been documented previously [9], so that the present one is by no means unusual. What we have discovered is that one important feature of human action is coded based on absolute object size and hence is inconsistent with Weber's law.

Our findings are consistent with previous neuropsychological [10] and behavioral data [6] showing qualitative differences between visuomotor control and visual perception. However, the present findings probably provide the most direct evidence to date that the coding of object size during action can be free of many of the nonlinear transforms that govern perception. Previous studies provided evidence that action can be directed to a stimulus independently of that stimulus' neighbors, thereby removing well-known visual illusions from action [4–6]. Other studies showed that action can be directed towards a single dimension of an object while ignoring other dimensions of the object [4,11]. Our findings show that action can even be directed to a single dimension of an object in a manner independent of changes in relative magnitude along that same dimension.

Supplemental data

Supplemental data are available at http://www.current-biology.com/cgi/content/full/18/14/R599/DC1

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