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## MANUAL DISCRIMINATION OF FORCE

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Optimal design of human-machine interfaces for teleoperators and virtual-environment systems which involve the tactual and kinesthetic modalities requires knowledge of the human's resolving power in these modalities. The resolution of the interface should be appropriately matched to that of the human operator. We report some preliminary results on the ability of the human hand to distinguish small differences in force under a variety of conditions. Experiments were conducted on force discrimination with the thumb pushing an interface that exerts a constant force over the pushing distance and the index finger pressing against a fixed support. The dependence of the sensitivity index  $d'$  on force increment can be fit by a straight line through the origin and the just-noticeable difference (JND) in force can thus be described by the inverse of the slope of this line. The receiver-operating-characteristic (ROC) was measured by varying the *a priori* probabilities of the two alternatives, reference force and reference force plus an increment, in one-interval, two-alternative, forced-choice experiments. When plotted on normal deviate coordinates, the ROCs were roughly straight lines of unit slope, thus supporting the assumption of equal-variance normal distributions and the use of the conventional  $d'$  measure. The JND was roughly 6-8% for reference force ranging from 2.5 to 10 newtons, pushing distance from 5 to 30 mm, and initial finger-span from 45 to 125 mm. Also, the JND remained the same when the subjects were instructed to change the average speed of pushing from 23 to 153 mm/sec. The pushing was terminated by reaching either a wall or a well, and the JNDs were essentially the same in both cases.