Supplementary Materials:

Electrode Pairs Selection

Electrode pair exploration was performed by randomly selecting pairs from the 2×8 grid using a current level between 3 and 4 mA. The subjects were asked to report any discomfort or sensation perceived along their hand during this process. If the stimulation amplitude was found to cause discomfort or produce finger motion, the amplitude was decreased to a value that would alleviate the issue. If the sensation was found to be faint or light in intensity, the amplitude was increased to ensure clear tactile sensation was present. Sensations at particular fingers were reported by the subjects, and were recorded. Five subjects were randomly selected to have pairs that elicited sensation in the median and ulnar region of the hand, while the other five subjects had sensations along the index and middle fingers. This allowed for a direct comparison with prior work, while allowing for a comparison across the two groups. Information pertaining to the pair selected for each subject is reported in Table S1. The arrangement of the electrodes along the grid and the selection process for the sensory and motor threshold is explained in the Methods section. The subject's elbow position was not constrained, allowing them to move freely within the limits of the setup, without causing changes to the location of sensation. However, a more systematic evaluation of the potential effects of varying the elbow's position is necessary in future studies.

Familiarization Phase

Prior to the start of each experimental block, we delivered a stimulation trace to the subjects that was repeated 3-5 times. The stimulation trace included examples of a possible stimulation pattern in a given trial. For example, in the shape recognition task, the stimulation trace would elicit a stimulation pattern for the cube followed by the sphere. During this time, they were given the order of the elicited sensations to allow them to make associations based on the encoding methods. After this familiarization phase, the experimental trials began. No further training was provided that allowed them to test their ability to discriminate the sensations. Examples of the pre-recorded force traces is shown in Fig. S2.

Stimulation Scheme

Stimulation intensity was modulated based on the readings from sensors located on the prosthetic hand. Stimulation intensity was selected, instead of stimulation frequency, due to its higher number of distinguishable sensation levels and lower adaptation effects as has been shown in Valle et al [10]. However, stimulation intensity modulation is sensitive to changes in electrode-skin impedance, especially in the longer term. Specifically, skin-electrode contact or skin sweat could potentially impact the sensation elicited or lead to discomfort. Although we did not observe a change of the sensation during the period of the experiment, evaluating the effect on the evoked sensation should be investigated in the future. Sensation intensity variability can be prevented by modulating stimulation parameters in response to large changes in impedance as in Akhtar et al [15]. Additionally, modulating stimulation paradigms with more biomimetic and intuitive sensory encoding strategies could potentially alleviate this issue and provide users with more information about object interactions. Studies have shown that by modulating the stimulation frequency and amplitude simultaneously, sensations can become more natural and in turn allow individuals to interpret interactions more intuitively [8]. Additionally, sensory adaptation was not accounted for in this study. The individual trials did not exceed 10 seconds and a 10-second of rest time was provided between trials, which may have reduced the extent of sensory adaptation.

Comparison Across Selected Pairs

Subjects were assigned electrode pairs that elicited sensations either in the median and ulnar region (not matched with the prosthesis fingers) of the hand of the subjects or in the index and middle fingers (matched with the prosthesis fingers) as shown in Table S1. The two groups performed well in the shape and surface topology recognition task with recognition accuracies that were all significantly greater than chance ($p<0.005$). When comparing the recognition accuracies across the two groups (Fig. S3), no statistical difference was found for any of the closing speeds ($p>0.05$).

TABLE SI
ELECTRODE PAIRS AND SENSATIONS ELICITED FOR INDIVIDUAL SUBJECTS

Subject #	Median & Ulnar or Index & Middle	Prosthetic Finger	Electrode Pair	Elicited Sensation Region	Sensory Threshold (mA)	Motor Threshold (mA)
Subject 1	Index & Middle	Index	4-14	Index	2.9	3.8
		Middle	11-13	Middle	3.2	4.6
Subject 2	Median & Ulnar	Index	5-16	Index & Middle	4	5.5
		Middle	13-15	Ring & Pinky	3	5
Subject 3	Median & Ulnar	Index	2-14	Index	4.5	5.2
		Middle	11-15	Pinky	4.3	5.2
Subject 4	Index & Middle	Index	5-14	Index	2.6	3.9
		Middle	6-16	Middle & Ring	2.3	2.9
Subject 5	Index & Middle	Index	3-5	Index	3.6	4.6
		Middle	4-7	Middle	3.1	4.2
Subject 6	Index & Middle	Index	6-12	Index	2.7	3.7
		Middle	4-15	Middle	2.1	3
Subject 7	Median & Ulnar	Index	6-8	Index & Middle	5	5.8
		Middle	3-5	Ring & Pinky	4	5.5
Subject 8	Median & Ulnar	Index	3-5	Middle	3	3.9
		Middle	7-9	Ring & Pinky	4	4.9
Subject 9	Median & Ulnar	Index	6-12	Middle	3.3	3.7
		Middle	9-13	Ring & Pinky	3.6	5
Subject 10	Index & Middle	Index	6-12	Index	2.1	3.3
		Middle	7-14	Middle	2.2	2.7

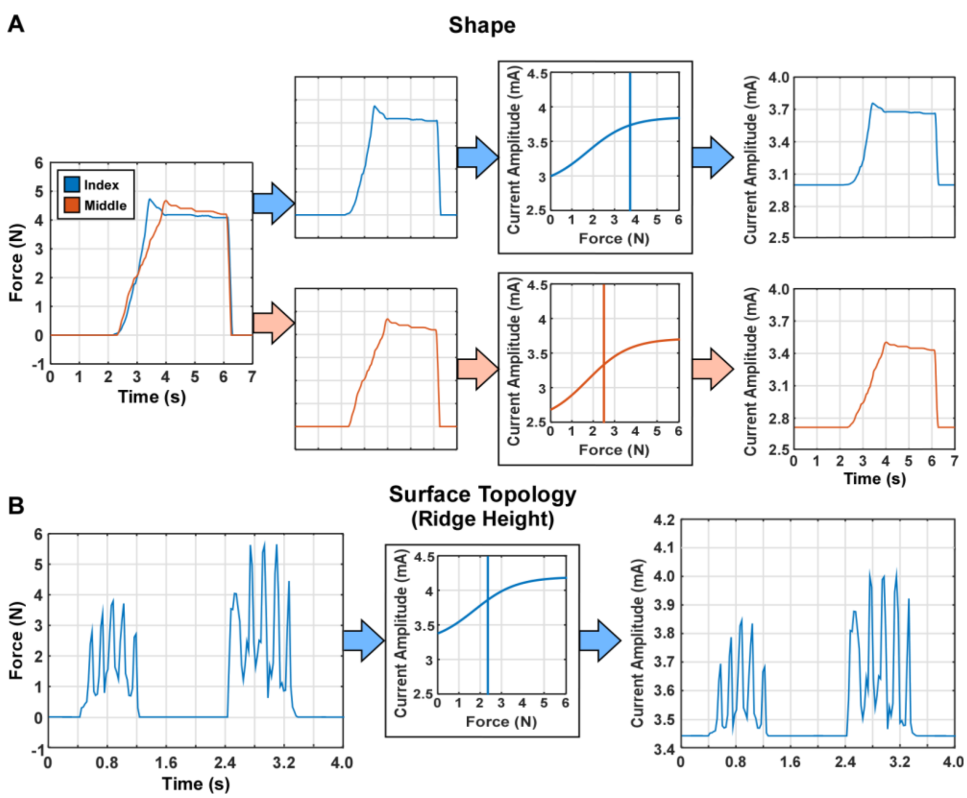

Fig. S1. Representative force-current transformation process using traces from the shape (A) and ridge height (B) recognition tasks. A cube with a hand closing speed of 40 deg/s is depicted for the shape transformation process, where the index and middle fingers have distinct sigmoid function resulting in independent stimulation patterns. For the ridge height trial, the stimulation trace shows the pair of stimulation patterns resembling two surfaces with different ridge heights.

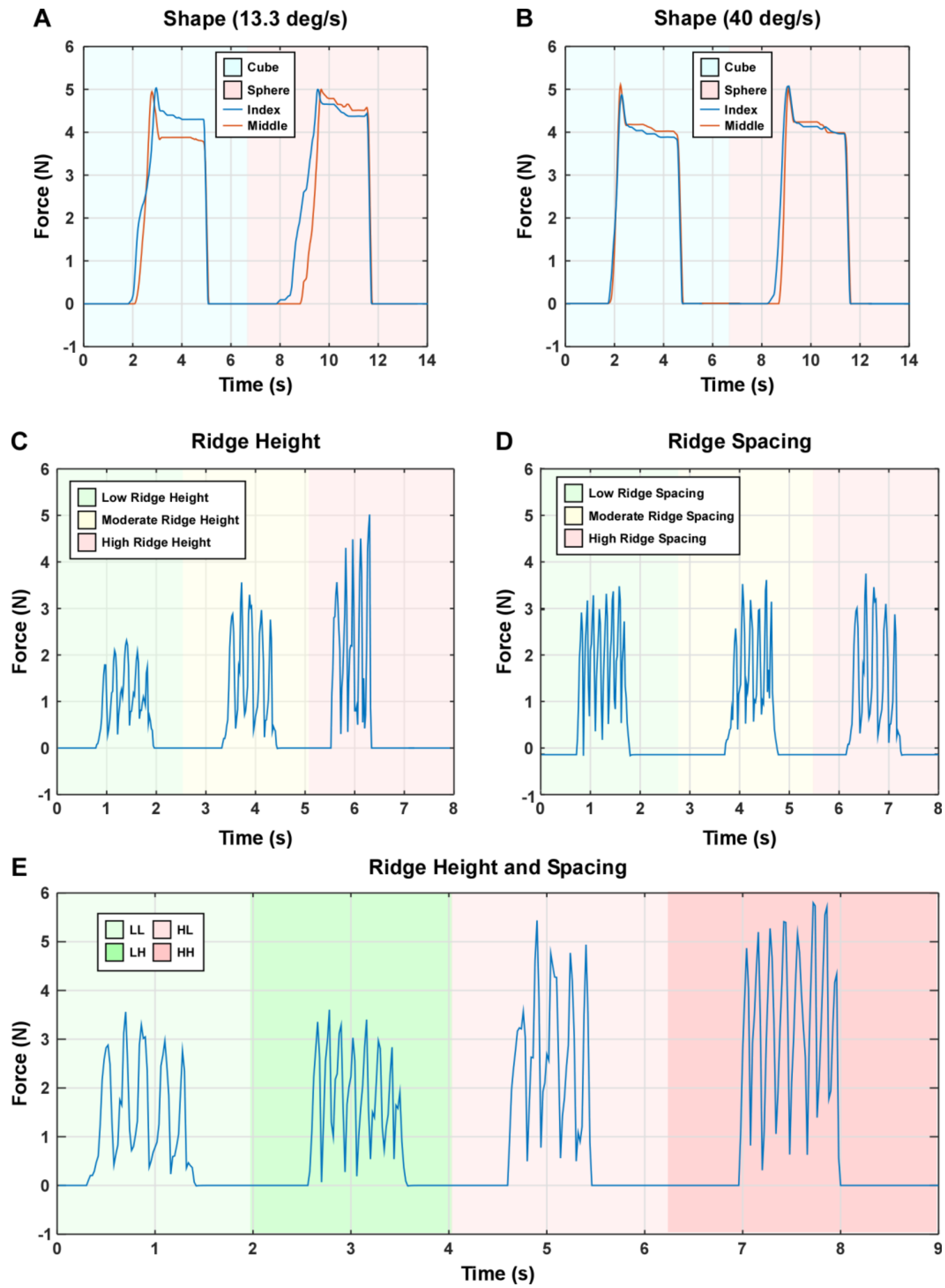

Fig. S2. Representative stimulation patterns delivered in order to familiarize the subjects with the stimulation trial. Familiarization for each of the speed was performed using speed-specific examples. Force traces for 13.3 deg/s (A) and 40 deg/s (B) are shown, along with those for ridge height recognition (C), ridge spacing recognition (D), and combined ridge height and spacing recognition (E).

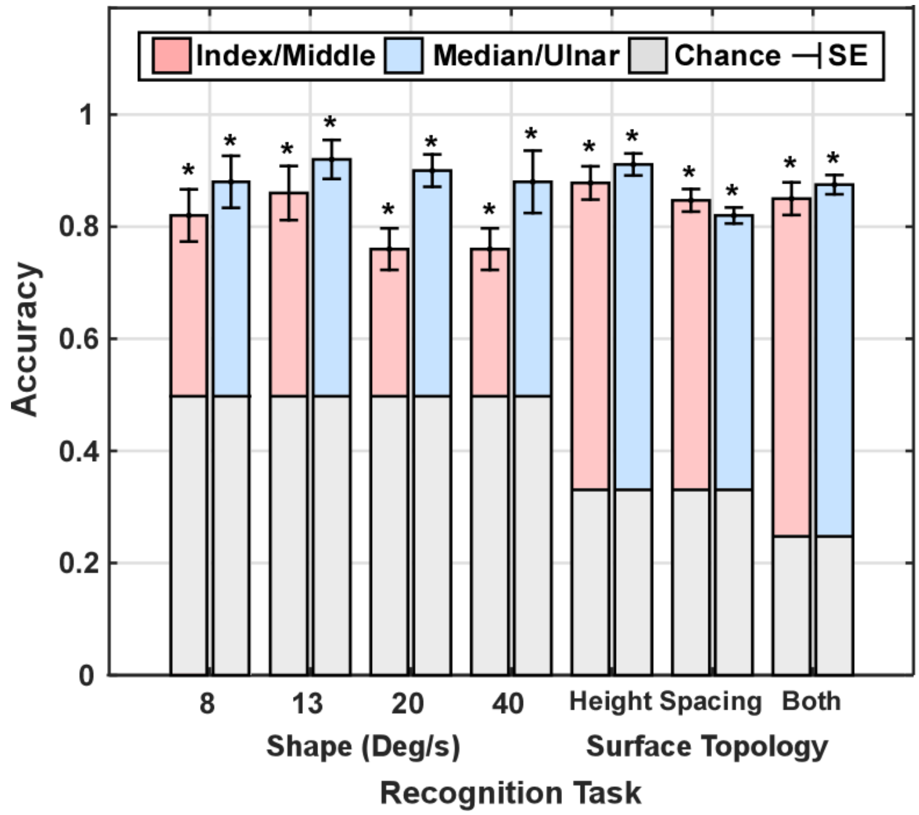

Fig. S3. Average recognition accuracy and standard error for the subjects with index & middle sensations (red) and median & ulnar sensation (blue). The asterisk indicates if the group was significantly different from the chance value ($p<0.05$). Using a paired t-test and logit transformation, statistical analysis indicated that the groups (red vs. blue) were not significantly different ($p<0.05$).