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Recognition Rate of Grasping Force for Prosthetic Hand Feedback Using a Pneumatic Device on the Earlobe

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***Abstract*—The use of a pincer device, composed of two finger-shaped pneumatic elastomer actuators, on the ear lobe to provide feedback for a hand-grasping prosthesis was studied. The pincers apply a force to the user's earlobe that is proportional to the grasping force exerted by the prosthesis. We tested user recognition rate of the pinching force applied by the device.**

I. INTRODUCTION

When using a hand prosthesis, a feedback device that allows users to know the grasping force being exerted should be part of the device; this is necessary to prevent the user from exerting too great a force—crushing an object to be held or inflicting injury on others. We investigated the use of a device that is worn on the earlobe to give grasping-force feedback. The design of the device has been reported in a previous paper [1]. Two finger-shaped pneumatic elastomer actuators, with bellows on the convex surface to allow flexibility, are able to bend to produce a pinching motion (Fig. 1). The device pinches the earlobe of the user with a force proportional to the grasping force being exerted by the prosthesis. In this study, we investigated the recognition rate of the pinching force provided by the device via user testing.

II. METHODS

Two tests were performed, and three examinees took part in the tests. Both earlobes of each examinee were tested. The finger-like device was placed on the examinee's ear lobe, and the device pinched the earlobe 30 times in a random order with (1) three force values (stages 1–3: 2.9 N, 8.8 N, and 14.7 N) in a random order or (2) five force values (stages 1–5: 2.9 N, 5.9 N, 8.8 N, 11.8 N, and 14.7 N). The examinee selected the perceived force each time the stimulus was presented. The pinching-force recognition rates (i.e., number of correct answers out of 30) were calculated. In Fig. 1a, the device is shown before activation, being worn by a user during Test 2. In Fig. 1b, the examinee answers "stage 5," after activation. The device is soft and showed compliance, and its maximum pinching force was less than 2 kg. The possibility of causing pain or injury to the participants was thus extremely low. This study was approved by the Ethics Committee of Chiba University.

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III. RESULTS

Three examinees (all men; height, 158 to 174 cm; age, 24 to 27 years) participated in this study. In Test 1, the average recognition rate was 93.3%, with a standard deviation of 5.2%. In Test 2, the average recognition rate was 63.9%, with a standard deviation of 11.8%. None of the participants reported pain or injury.

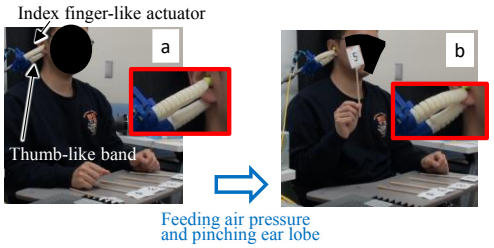

Figure 1. Examinee performing Test 2

Figure 2. Downsized actuators

IV. DISCUSSION & CONCLUSION

A high recognition rate was obtained for Test 1, but in Test 2, which had a higher degree of operational difficulty, the rate was lower (approximately 60%). The results indicate that the device is capable, to some degree, of providing discernable feedback, although recognition variability increased with difficulty. In future work, we aim to investigate this device using tests with a higher degree of operational difficulty (e.g., a 7-stage test), and more participants. Moreover, we will test downsized actuators that we developed to improve utility and portability (Fig. 2).

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