Water-induced finger wrinkles improve handling of wet objects

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Upon continued submersion in water, the glabrous skin on human hands and feet forms wrinkles. The formation of these wrinkles is known to be an active process, controlled by the autonomic nervous system. Such an active control suggests that these wrinkles may have an important function, but this function has not been clear. In this study, we show that submerged objects are handled more quickly with wrinkled fingers than with unwrinkled fingers, whereas wrinkles make no difference to manipulating dry objects. These findings support the hypothesis that water-induced finger wrinkles improve handling submerged objects and suggest that they may be an adaptation for handling objects in wet conditions.
time to transfer submerged objects ($F_{1,16} = 35.80, p < 0.001$). With wrinkled fingers, transfer of submerged objects happened in 12 per cent ($±2.3\%$ s.e.m.) less time than with unwrinkled fingers. There was no difference in the time it took to transfer dry objects with or without wrinkles on the fingers (interaction: $F_{1,16} = 44.10, p < 0.001$; figure 1). This finding shows a clear advantage of having wrinkled fingers when manipulating submerged objects, but not dry objects.

4. Discussion
Our results are clear experimental evidence for the hypothesis that water-induced wrinkles improve the handling of submerged or wet objects. It does not, however, show how this is accomplished. One possibility is that the wrinkles channel the evacuation of water from between the finger pad and the object, as suggested by the rain tread hypothesis [11]. Another possibility is that there are changes in skin properties, such as flexibility, adhesion or an increase in the friction coefficient, which all could improve performance under submerged conditions. Whatever the mechanism, it is not effective in dry conditions, as shown by the current experiment. Future studies should be able to differentiate among the different possible mechanisms.

Our finding raises the question why finger pads are not constantly wrinkled. The most likely explanation is that there must be a cost to wrinkled fingers that outweighs its benefits under dry conditions. This is unlikely to be a cost in terms of handling objects, because there was no detrimental effect of wrinkling on the handling of dry objects in our experiment. More likely, the cost may be in terms of a loss of somatosensory sensitivity in the fingertips or increased vulnerability to damage by catching on objects. Both hypotheses remain to be tested.

Wrinkled toes may serve a similar function to wrinkled fingers, providing better footing in wet conditions. The lack of wrinkles on toes under dry conditions could again be explained by an increased vulnerability to damage. Loss of somatosensory sensation seems a less likely explanation in this case. It is unclear at present whether the wrinkling of wet glabrous skin evolved in our ancestors to support walking in wet conditions, manipulation of objects or both. Further experiments, combined with a comparative study to investigate which other species share this feature with humans, will provide deeper insights into how long ago it may have evolved, and for which primary function.

The study was approved by the Faculty of Medical Sciences Ethics Committee at Newcastle University (no. 00519/2012).

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3. Results
It took participants anywhere between 72 s (fastest person) and 198 s (slowest person) to transfer all the items. All participants transferred dry objects more quickly than submerged objects, taking on average 17 per cent ($±2.3\%$ s.e.m.) more

soapy water, drying them and then waiting for the wrinkles to disappear, which took 10–20 min.

The task was inspired by the Tynside Pegboard Test (AP Basu 2012, personal communication). We measured the time it took to transfer a total of 45 objects (39 glass marbles of different diameters: 30 of 16 mm, three of 24 mm, three of 35 mm, two of 42 mm and one of 50 mm diameter; and six lead fishing weights: two of 227 g, two of 340 g and two of 454 g) from one container to another, by taking the objects between thumb and index finger, passing them through a 5 × 5 cm hole from the right to the left hand and putting them into a 5 × 5 cm hole in the lid of a target box (figure 1). Objects dropped along the way were put back in the starting container and transferred again while the timer continued. The only difference between the conditions was that in the submerged condition, the objects were taken out of 20 cm of water.

To reduce effects of water refraction on reaching for the object in the submerged condition, participants were asked to stand at a predetermined position that minimized the refraction effects. They stood in this position for all conditions. The raw data are available as electronic supplementary materials.

References
5. Wilder-Smith EP, Chow A. 2003 Water-immersion wrinkling is due to

Figure 1. Transfer time (standardized to the time taken to transfer dry objects with unwrinkled fingers) is shortest for dry objects, independent of wrinkling, but faster for submerged objects with wrinkled (red bar) fingers than with unwrinkled (black bar) fingers (**p < 0.001). Items are picked up with thumb and index finger of the right hand, passed through a hole to the left hand, and put into a box with a hole in the lid.


