Short and Sweet

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Two Left Hands, Ten Interlaced Fingers: A New Rubber Hand Illusion

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Abstract
A variation on the rubber hand paradigm elicits an illusion in which the participant's sense of body ownership can switch back and forth between two viewed prosthetic hands. The interlaced fingers paradigm involves three prosthetic left hands: Two are positioned in full view of the participant, with their fingers interlaced, and the fingers of a third prosthetic hand are interlaced with the fingers of the participant's left hand, which is hidden from view. The examiner alternates brushstrokes to the two viewed prosthetic hands, while administering synchronous brushstrokes to the participant's hidden hand. Most participants experience ownership for the prosthetic hand that is being stroked at a given moment.

Keywords
Body representation, interlaced fingers, rubber hand illusion, visual capture

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The rubber hand illusion (RHI; Botvinick & Cohen, 1998) had its humble beginnings at a Halloween party attended by Matthew Botvinick. He noticed that one of the party decorations was a rubber hand, and he seized the opportunity to run an impromptu experiment, thus providing a striking demonstration of the malleability of body representation. A simple procedure is used to elicit the RHI. A prosthetic left hand[1] is positioned in full view of the participant, and the participant's left hand is hidden from view. When the examiner administers synchronous touch to the two hands, it may seem to the participant that the prosthetic hand is the participant's hand (illusion of ownership), and that he or she is feeling touch at the location of the prosthetic hand (visual capture of touch).

During a tutorial on experimental methods and design, we serendipitously discovered an exciting variation on the RHI. Our objective was to elicit an illusion in which the participant assumed ownership of a single, 10-fingered hand. Lacking a 10-fingered prosthetic hand, we improvized by interlacing the fingers two prosthetic left hands. The resulting illusion took us by surprise!

We piloted our procedure with 10 participants (6 females, 4 males; 19–33 years). The participant viewed two prosthetic left hands, which were positioned on a table at the participant's body midline, palms facing upward and fingers interlaced. Sitting 30 cm to the left, and hidden from view by a vertical divider, was the participant's left hand, which was also positioned with the palm facing upward and fingers interlaced with a prosthetic left hand (Figure 1). The experiment spanned 180 s. For the first 60 s, the examiner administered synchronous paintbrush strokes to the fingers of *one* of the viewed prosthetic hands and the corresponding fingers of the participant's hidden hand. For the remaining 120 s, the examiner alternated strokes to the fingers of *each* of the viewed prosthetic hands, while synchronously stroking the corresponding fingers of the participant's hidden hand. Stimulation was pseudorandom. Strokes were administered at a rate of approximately 1/s, and consecutive strokes were administered to neighboring digits. Thus, an example sequence comprised three consecutive strokes to (a) the index finger of prosthetic hand A and the participant's index finger, (b) the middle finger of prosthetic hand B and the participant's middle finger, and (c) the ring finger of prosthetic hand A and the participant's ring finger.

The participant was invited to verbalize his or her experience *during* the experiment. One participant did not experience an illusion. During the first 60 s, the remaining nine participants reported the regular RHI: ownership of one prosthetic hand and visual capture of touch. With the introduction of alternating strokes to the viewed prosthetic hands, these participants rapidly transitioned to experiencing a new illusion. All nine experienced ownership of *one* prosthetic left hand; seven reporting ownership for *whichever* prosthetic hand was being stroked in a given moment, and two reporting ownership for a large hand with 10 fingers. All nine participants experienced visual capture of touch. This was particularly disconcerting for the seven participants who experienced the switching hands illusion. The participant would assume ownership of one prosthetic hand, feeling touch in its location, and "not expect to feel touch" on the other prosthetic hand. Yet when the examiner stroked the other hand, the participant's sense of self was rapidly updated and they would immediately feel touch on this hand. Participants commonly exclaimed: "that's my hand . . . no wait, that's my hand! I feel touch there . . . no there!" The illusion was disrupted by asynchronous stimulation, occurring, for example, when the examiner accidentally stroked a finger of the hidden prosthetic hand, rather than the participant's hidden hand.[2]

How are we to explain the dominant illusion that ownership can switch between two viewed prosthetic hands? We approach this question in two stages. First, why does the participant experience ownership of any prosthetic hand? This may be explained by

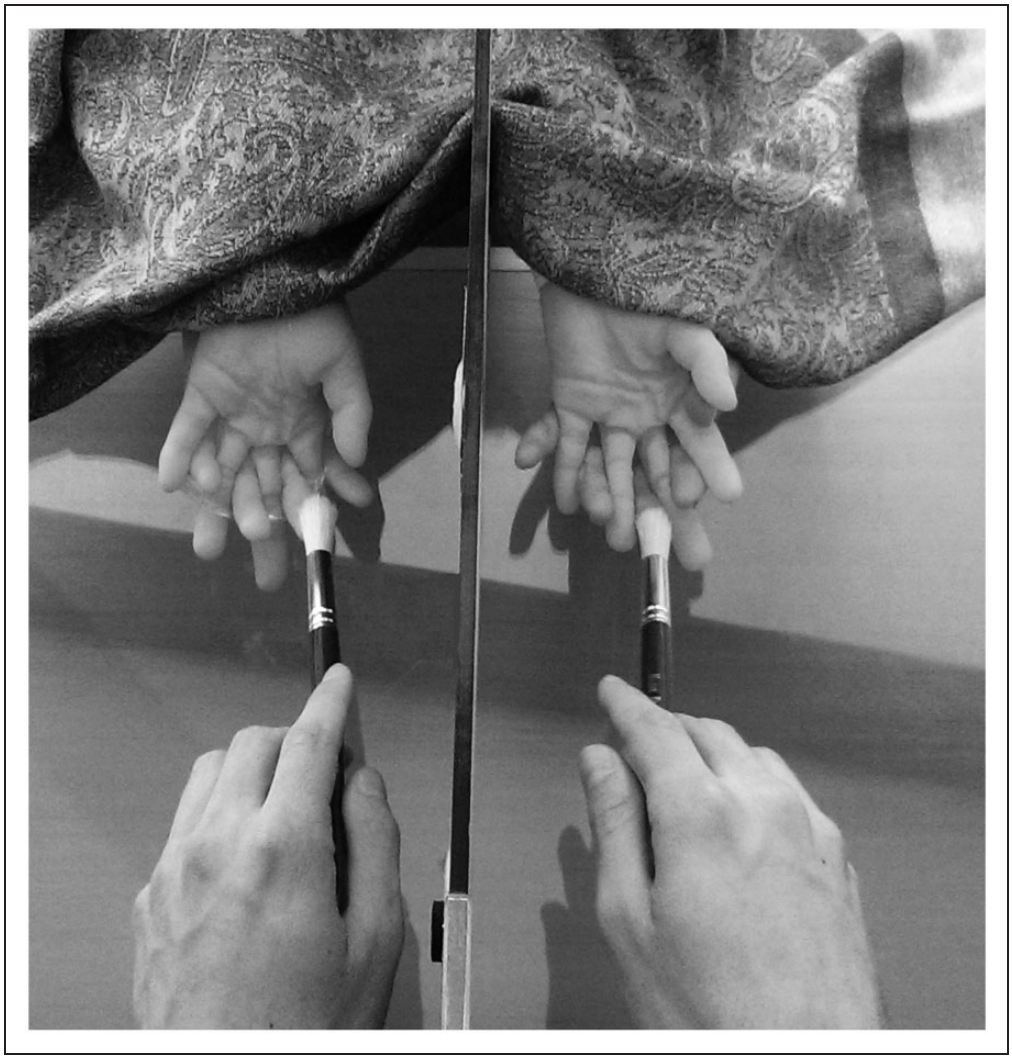

Figure 1. The left side of the image depicts the viewed prosthetic hands receiving strokes from a paintbrush in the examiner's left hand. The right side of the image depicts the hidden hands—the participant's left hand interlaced with a prosthetic left hand—receiving strokes from a paintbrush in the examiner's right hand. Note that of the two hidden hands, it is *only* the participant's left hand that is stroked.

temporal correspondences between what the participant sees (touch on a hand) and what the participant feels (touch on her hand), which lead to the interpretation: "I am looking at my own hand being touched." Second, why does ownership switch between the two hands? We believe that the participant takes ownership of the prosthetic hand that is statistically more likely to be her own, at a given point in time. The prosthetic hand that is being touched fulfils this criterion.

Previously, Ehrsson (2009) demonstrated concurrent ownership of two prosthetic right hands, when both were in full view and receiving touch that was synchronous with touch to the participant's hidden right hand. Subsequently, Guterstam, Petkova, and Ehrsson (2011) demonstrated concurrent ownership of a prosthetic right hand and the participant's right

hand, when both were in full view and receiving synchronous touch. In these experiments, the participant experienced the illusion of having more than one right hand, testament to the malleability of body representation. In our experiment, only one of two viewed prosthetic hands was touched at any given moment. Participants reported ownership of one hand, and this ownership flipped *between* the two viewed prosthetic hands. This finding speaks to both the malleability and the fragility of body ownership.

Declaration of Conflicting Interests

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Notes

1. Note that the procedure can be adapted to a right hand, but for the sake of simplicity, we describe the methods as they apply to a left prosthetic hand and the participant's left hand.
2. The reader may question whether we could have avoided this asynchrony by positioning the participant's hidden hand on its own; that is, not interlacing the fingers with those of a prosthetic hand. In preliminary testing, we experimented with precisely this version of the paradigm. The visual input of two interlaced hands was incongruent with the participant's tactile feedback, because the participant's hand was not in contact with another hand. This barrier to a compelling illusion was easily overcome by interlacing the fingers of the participant's hidden hand with a prosthetic hand.

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