

Beyond Five: How the Experience of a Supernumerary Sixth Finger Alters Action Perception

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When interacting with the world, one's bodily features are estimated in relation to the objects we handle. Perceived changes to one's hand size and shape alter the perception of the actions that can be performed with that hand. Here, we investigated whether experiencing the illusion of a sixth finger on the hand alters individuals' perception of their action abilities and movement boundaries. After inducing the sensation of having a sixth finger, healthy adult participants estimated the smallest aperture their hand could fit through and the largest object they felt capable of grasping. Our results show that the illusion of a sixth finger expanded both the smallest aperture that participants believed their hand could pass through and the largest object they felt capable of grasping. Importantly, these effects occurred even in participants who did not explicitly report feeling a sixth finger, indicating that the representation of the extra digit operates at both implicit and explicit levels. These findings demonstrate that hand representation and the perceived action capabilities and boundaries it defines can be rapidly and flexibly updated in response to the illusion of an additional finger, highlighting the plasticity of the human body schema.

Public Significance Statement

This study shows that people can instantly update their sense of what their hands can do when experiencing the illusion of having a sixth finger. Even without real movement, the brain incorporates an illusory and invisible extra digit into action judgments, altering the perceived abilities of what the hand can grasp or pass through. This flexibility has direct implications for the design of prosthetics and augmentation robotics and broadens our understanding in cognitive science and psychology of how perceiving extra body parts alters action perception.

Keywords: body perception, body representation, action perception, body augmentation, supernumerary body parts

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Our capacity to act in the world relies not only on the properties of surrounding objects but also on the dynamic representation of our own bodies. Gibson (1979) introduced the concept of *affordances* to describe how the interaction between environmental and bodily properties determines the actions we can perform. In everyday life, we rely on our perception of affordances to effortlessly estimate what our bodies can achieve in relation to our surroundings. This perception is continuously updated when we encounter action boundaries, such as objects that are too large to grasp, providing insight into our body's limitations and capabilities (Proffitt & Linkenauger, 2013). We use our body as a reference to measure our environment (Linkenauger et al., 2013) and to define the boundaries of near space (Longo & Lourenco, 2007). In the present study, we investigated whether the illusory experience of having a supernumerary sixth finger on the hand could dynamically update individuals' perception of affordances.

Humans have an impressive ability to perceive their action boundaries, seamlessly estimating whether they can pass through spaces or manipulate objects. For instance, we estimate we can fit through a door if its width is more than about 1.3 times the size of our width, from shoulder to shoulder (Warren & Whang, 1987). Importantly, these judgments are highly accurate and body-scaled, such that the critical ratio is consistent when expressed relative to participants' physical size, with values of approximately 1.31 for smaller participants and 1.28 for larger participants, and remains stable across walking speeds. Safety margins are small, typically only a few centimeters per shoulder. Together, this study shows that humans can reliably estimate action limits relative to their own bodies. This suggests that the perception of affordances maintains a safety margin: If a door is not 1.3 times larger than our width, we rotate our body to pass through it. Moreover, participants accurately estimate the largest object they can grasp (Linkenauger et al., 2009), and the smallest size opening that the hand can reach through (Ishak et al., 2014). Regarding the perception of aperture passing capabilities, adults' perceptions appear less erroneous than those of young children when deciding on the smallest aperture their hand can reach through. Specifically, adults can successfully fit their hand through an aperture that is 0.4 cm smaller than the aperture they chose as the smallest possible, in contrast with 1 cm in young children (Ishak et al., 2014), showing this perception is attuned throughout development.

Even though adults have a consistent model to estimate action boundaries, estimations can be easily reshaped by sensory inputs. Viewing their hand enlarged through a monitor resulted in participants using a smaller grip aperture to grasp an object (Marino et al., 2010). When participants wore a prosthetic that increased the width of their hand by 1 cm (Ishak et al., 2008), they chose a larger aperture to fit their hand through. An element of flexibility in action and affordances perception is necessary to adapt to changes both in our developing bodies and in our surroundings, in the same way as our own-body perception also requires flexibility to allow an accurate representation of our bodies as they grow (Gottwald et al., 2021). If we experience rapid changes to the perception of our bodies, then we need to update the perception of what our bodies can do. Yet this flexibility is not restricted to bodily changes: Tool use extends perceived reach (Witt et al., 2005), alters action kinematics after brief or imagined use (Baccharini et al., 2014), reshapes body and space representations (Canzoneri et al., 2013; Martel et al., 2016), and allows us to

localize touch on the tool as if it were part of the body (Miller et al., 2017, 2018).

This raises a compelling question: Does experiencing an extra finger reshape our perception of the body's capabilities, or do affordance representations remain anchored to the actual anatomical structure? A striking illusion developed by Newport et al. (2016) induces the sensation of having a sixth finger, through carefully timed visual-tactile stimulation. Building on this, we extended the illusion's duration by modifying the stimulation pattern to a "double back and forth" and producing a continuous and enduring experience of a sixth finger (Cadete & Longo, 2020). In our setup, the participant watches the reflection of their right hand in the mirror, whereas their left hand is hidden from view, and the experimenter strokes both fingers synchronously, thumb with thumb, index with index and so forth, up to the little finger. In the last stroke, the outer lateral side of the hidden little finger is stroked at the same time as empty space next to the right hand, reflected in the mirror. This creates the illusion of having a sixth finger, an additional digit that feels vividly present. Importantly, this multisensory illusion creates a representation of an extra finger without distorting the perception of the real ones, allowing participants to simultaneously experience both their actual hand and an illusory supernumerary digit. Recent studies demonstrate that the illusory sixth finger can be experienced with properties that do not mirror those of the real hand, including distinct perceived sizes (Cadete & Longo, 2022), orientations (Ambron & Medina, 2023; Cadete et al., 2026), and shapes (Ambron & Medina, 2023; Cadete, Alsmith, & Longo, 2022). Strikingly, this occurs while the actual little finger is still perceived with its normal size, shape, and orientation, highlighting the mental flexibility for supernumerary body parts (Cadete, Alsmith, & Longo, 2022; Cadete et al., 2026; Cadete & Longo, 2022), denoting the independence of the supernumerary finger from the real fingers. Finally, although the illusion is highly robust, embodiment weakens when the extra finger is positioned further from the hand, especially for biologically implausible shapes (Folger & Medina, 2025).

Supernumerary fingers can be embodied with shapes, sizes, and orientations independent of the actual fingers. Yet it remains unclear whether such experiences alter the perception of the hand as a whole, particularly its overall size, which would require the illusory finger to be integrated into the body representation. It is also unknown whether feeling a sixth finger modifies our perception of action abilities and boundaries. Here, we investigated whether perceiving a sixth finger reshapes the representation of one's hand and the perceived actions that the hand can perform. We tested whether perceiving an illusory supernumerary finger alters the hand's perceived affordances by measuring participants' aperture passing ability, namely the smallest gap they felt their hand could fit through, before and after inducing the six-finger illusion, using our established paradigm (Cadete, Alsmith, & Longo, 2022; Cadete & Longo, 2020, 2022). If we embody a sixth finger, our hand should be perceived as wider and with enhanced action abilities, hence adjusting the action boundaries estimations to a six-fingered hand that can pass a specific aperture. As such, we predicted that participants would overestimate the minimum size opening they could pass their hand through in the illusion trials, choosing a larger opening after the illusion, than in the control trials. Moreover, we assessed participants' estimates of their grasping ability (the maximum object they can grasp), both before and after inducing the

six-finger illusion. If it is the case that we embody a sixth finger, our flexibility for feeling a sixth finger on our hand may translate into a flexibility in ability and affordances perception, with a gain in object-size grasping ability, and extended degrees of freedom in the perceived action abilities of one's hand. We predicted that participants would overestimate more their ability to grasp an object after being induced the six-finger illusion, than in the control condition. All procedures, including design, sample size, methods, materials, hypotheses, and analysis plans, were preregistered on the Open Science Framework (Cadete, Readman, et al., 2022).

Method

The study design, hypotheses, and primary analyses were preregistered on the Open Science Framework (Cadete, Readman, et al., 2022).

Participants

Fifty people, $M(SD) = 31.4(11.3)$ years; 32 females, participated after giving written informed consent. The study was performed in accordance with the Declaration of Helsinki and was approved by the School of Psychological Sciences Ethics Committee at Birkbeck (Protocol Number 2223017, approved February 10, 2023). All but one participant were right-handed, as assessed by the Edinburgh Handedness Inventory (Oldfield, 1971), $M = 80.2$, range from -30 to 100 . All participants underwent the illusion with the left hand, regardless of handedness, as in previous studies

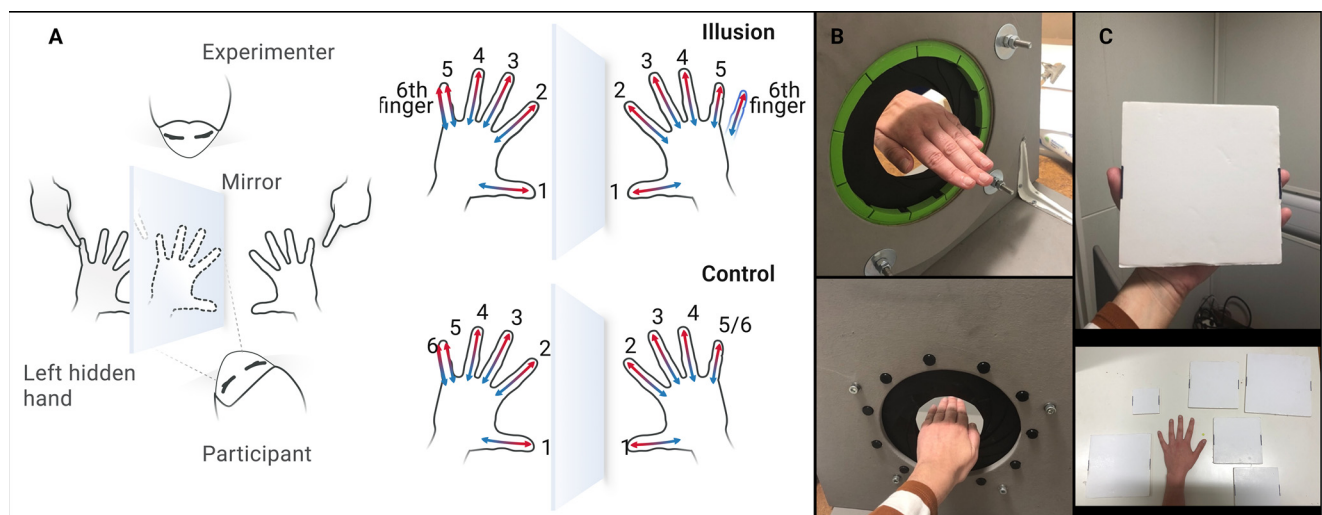
investigating this illusion. As power in a within-subjects design depends on the correlation between conditions, we assumed a correlation between conditions of .75. This is somewhat lower than the actual correlation between conditions reported by Ishak et al. (2008), who found correlations of .97 and .86 in their Experiments 1 and 2, respectively. Thus, our estimated correlation is likely to be conservative. We aimed to have good power to detect an effect size of Cohen's $d_z = 0.4$. A power analysis using G*Power 3.1 (Faul et al., 2007), with a 2-tailed alpha of .05 and 95% power, indicated that 43 participants were required. Because of uncertainty in the estimates used to perform this calculation, and to be able to have sensitivity to potentially provide support for the null hypothesis using Bayesian analyses, we chose to round the sample size up to 50 participants.

Design and Procedure

The Sixth-Finger Illusion

We followed the experimental procedure and paradigm of Newport et al.'s (2016) sixth-finger illusion, using the pattern of stimulation version we developed in our previous study, which allows the illusion to be felt for a long duration (Cadete & Longo, 2020). The participant sat at a table with a mirror positioned on the table aligned with their body midline. They placed their left hand behind the mirror and their right hand in front of it. The mirror's reflection of their right hand thus appeared to be a direct view of their occluded left hand, as shown in Figure 1A, an effect known as the

Figure 1
Setup, Procedure, and Action-Ability Tasks



Note. Panel A: Setup and procedure for inducing a sixth finger (Cadete & Longo, 2020; Newport et al., 2016). The participant sat with one hand on each side of a mirror aligned with their body midline and viewed the reflection of their right hand as if it were their left. Synchronous stroking was applied to the corresponding fingers. In the illusion condition, we stroked the inner lateral and then the outer lateral side of the hidden little finger, paired with strokes on the top of the visible little finger and the adjacent empty space. In the control condition, the outer stroke was applied again to the little finger instead of empty space. Panel B: Aperture passing task. Participants used the method of adjustment to indicate the smallest aperture they feel that they could fit their left hand through, without spaces between their fingers and without touching the edges. Panel C: Grasping-ability task. Participants estimated whether they would be able to grasp with their left hand, the block placed on the table, using visual information only. This was executed for all 16 objects. The black lines on the parallel edges of the objects indicated the imagined grasping location, if the participant were to extend their hand from and to when estimating grasping ability. The lines were also used to indicate the grasping location when deducing actual grasping ability. See the online article for the color version of this figure.

mirror box illusion (Ramachandran & Rogers-Ramachandran, 1996). The participant placed the tip of their index finger on a marked position for both hands, at 24 cm from the edge of the table and 17 cm from the mirror. The participant was asked to look at the hand reflected in the mirror throughout each trial.

The pattern of stimulation was the same as the continuous sixth-finger illusion (Cadete & Longo, 2020). Each finger was stroked synchronously back and forth twice (thumb with thumb, index with index, and so forth), the lateral side of the hidden finger was then touched at the same time as the seen little finger, followed by 20 strokes on the outer lateral side of the hidden little finger at the same time as the space next to the reflected little finger, that is, the perceived location of the sixth finger. We used the same control condition of previous studies (Cadete & Longo, 2020, 2022; Newport et al., 2016), which consists of the same pattern of stimuli of the illusion up to the little finger, applying the last 20 strokes on the little finger, instead of empty space; that is, the sixth set of strokes are applied to both little fingers, not inducing the illusion.

The illusion and the control stimuli were induced for 1 min, before the apertures task and again before the grasping task. In both tasks, the experimenter did a top-up of the illusion or the control stimuli every two estimation responses. Illusion and control blocks were counterbalanced in ABBA style. Also, if the first participant had ABBA, the second had BAAB. Each block included an apertures task and a grasping task, and within each task, there were four trials. Each condition had a total of eight estimations. The order of the starting size of the task was alternated: If the first trial started with the widest aperture or with the biggest object, the second started with the smallest aperture or smallest object.

Estimating the Perception of Aperture Passing

We assessed aperture perception using the same procedure as in previous studies (Linkenauger et al., 2012; Readman et al., 2021). The task employed the apparatus developed by Readman et al. (2021), consisting of 3D-printed black triangles mounted on a gray wooden frame that open and close like a camera lens shutter. Aperture size was adjusted continuously by moving a handle to the right (increasing size) or to the left (decreasing size), producing openings from 2.7 to 18 cm. The full device measured 47 cm in height, 48 cm in width, and 2 cm in depth. The experimenter induced the illusion or the control condition stimuli, after which the participant's hand was covered with a box with an opening for their arm to fit through. The participant's hand was covered during the tasks to prevent them from using visual inspection of their hands during their estimations, while maintaining their arms and hands in the same position throughout the experiment. Every two trials, the experimenter uncovered the participant's hands and topped up the sixth-finger illusion or the control stimuli, which consisted of one sequence of stimulation. To prevent the participant from moving their hands and gain proprioceptive information that could decrease the illusion, they kept their hands placed in the same position throughout the experiment, and the apertures apparatus was placed diagonally on a table next to the mirror table, which the participant was able to see in direct view by slightly rotating their head or torso.

We used the method of adjustment, in which participants were instructed to estimate the point at which they could just fit their left hand through the aperture without touching the black inner

triangles. The experimenter moved the apparatus slowly, and the participant asked to stop or adjust until it matched the estimated fitting size. Participants were asked to imagine performing the aperture passing movement with their left hand, with their fingers closed. At the point at which the participant indicated they could just fit their hand through the hole, the experimenter registered the measure displayed on a ruler only seen by the experimenter.

There were four trials of this task per block, resulting in a total of eight estimations of aperture passing after the illusion and another eight estimations after the control stimuli. In *descending* trials, participants were presented with the largest size aperture, and the experimenter gradually made the aperture smaller. In *ascending* trials, the participant was presented with the smallest aperture, and the experimenter gradually made the aperture bigger. Descending and ascending trials were alternated, with the order of the first trial counterbalanced across participants.

At the end of the experiment, we obtained a measure of the smallest aperture size that the participant could actually fit their hand through. To obtain this, participants placed their hand in the hole, and the experimenter gradually reduced the size of the aperture to the point at which the hand just fitted in the aperture without coming into contact with the black triangles.

Estimating the Perception of Grasping Ability

We employed the same procedure and materials previously used to assess grasping-ability perception (Linkenauger et al., 2012; Readman et al., 2021). A set of 16 1 cm thick foam board square objects were used as the grasping stimuli. The width of these square objects ranged from 4 to 25 cm and increased in 1.4 cm increments. Each object has two parallel black lines (3 cm) long drawn in the center of opposing sides, to indicate where the participant would imagine placing their finger and thumb when grasping the object.

Participants were instructed to estimate whether they could grasp each object with their left hand. Grasping was defined as the ability to place their thumb on the black line on one edge of the object and extend their hand over the surface of the object so that one of their fingers is placed on the black line on the parallel edge of the object. We used an occluding board to block the participant's view while the experimenter placed one of the 16 objects on the table, to prevent them from gaining visual information regarding the experimenter's ability to grasp the objects and subsequently use this information to guide their grasping-ability estimations. Once the object was placed, the experimenter removed the occluding board and the participant was instructed to use visual inspection to indicate whether they would be able to grasp the object with their left hand. This procedure occurred for all 16 objects.

There were four trials of this task per block, resulting in a total of eight estimations of grasping ability after the illusion and another eight estimations after the control stimuli. In *descending* trials, participants were presented with the largest object, and the experimenter placed the next smaller object until the participant felt they would be able to grasp it. In *ascending* trials, the participant was presented with the smallest object, and the experimenter presented the next wider object, one at a time, up to the largest object they estimated they would be able to grasp. Descending and ascending trials alternated, with the order of the first trial counterbalanced across participants.

At the end of the experiment, we measured actual grasping ability. This was obtained by asking participants to overtly grasp the largest object they could with their left hand, comfortably, without straining the fingers and without bending the object. The participant was instructed to grab the square by the black lines, placed on both lateral sides of the square. Participants were encouraged to try the next size up to ensure that a true measure of maximal grasping ability is obtained.

Sixth-Finger Illusion Questionnaire

At the end of each block, participants reported how strongly they experienced specific aspects of the illusion using an 11-point scale (0 = *strongly disagree*, 10 = *strongly agree*), based on the questionnaire from Newport and colleagues' study and our prior studies using the sixth-finger paradigm (Cadete & Longo, 2020, 2022; Newport et al., 2016). We added one question to the questionnaire, as we have observed in previous studies that a smaller subset of participants experience a larger little finger rather than a sixth finger (Cadete, Alsmith, & Longo, 2022). Participants reported the embodiment of a sixth finger and its properties using an 11-point scale, in which 0 corresponds to *strongly disagree*, and 10 to *strongly agree*. Before the questionnaire, the experimenter did a top-up of either the illusion or the control stimuli.

The questionnaire items used were as follows:

- A. It felt like I had six fingers on my left hand
- B. It felt like I had two little fingers on my left hand
- C. I felt a touch where I do not normally feel a touch
- D. I felt a touch that was not on my body
- E. It felt like I had an extra hand
- F. It felt like I had a larger little finger on my left hand

Transparency and Openness

We report how we determined our sample size, all data exclusions (there were none), all manipulations, and all measures in the study. The study design and primary analyses were preregistered on the Open Science Framework (Cadete, Linkenauger, et al., 2022). Any analyses not specified in the preregistration are clearly identified as exploratory in the article. Raw data and analysis are available on the Open Science Framework (Cadete, Readman, et al., 2022). Data were collected in 2023.

Results

Embodiment

All preregistered analyses were conducted as specified in the preregistration document and are available on the Open Science Framework (Cadete, Linkenauger, et al., 2022). No preregistered analyses were omitted. Additional post hoc analyses, not specified in the preregistration, are clearly identified as exploratory. This study aimed to explore whether embodying an illusory sixth finger leads participants to update one's action and abilities perception, by perceiving that the smallest aperture to fit the hand through as larger, and perceiving an ability to grasp wider squares after the illusion.

First, we validated whether participants experienced the feeling of having a sixth finger by running a paired *t* test between illusion and condition scores for each questionnaire item. These results are shown in Figure 2. Participants reported significantly higher ratings of having six fingers ($M = 4.36$, $SE = 0.53$), compared with the control condition ($M = 1.13$, $SE = 0.29$), $t(49) = 6.94$, $p < .001$, $d_z = 0.98$. Participants similarly showed significantly higher ratings of having two little fingers in the illusion condition ($M = 3.96$, $SE = 0.52$), compared with the control condition ($M = 1.24$, $SE = 0.30$), $t(49) = 6.14$, $p < .001$, $d_z = 0.87$. Ratings were also significantly higher for feeling a touch where it is not normally felt in the illusion condition ($M = 4.92$, $SE = 0.51$), compared with the control condition ($M = 1.86$, $SE = 0.38$), $t(49) = 5.98$, $p < .001$, $d_z = 0.85$, and for feeling a touch off their body in the illusion condition ($M = 3.55$, $SE = 0.51$), compared with control, ($M = 0.93$, $SE = 0.27$), $t(49) = 5.20$, $p < .001$, $d_z = 0.74$. As expected, there was no significant difference for the control item, about feeling an extra hand, between illusion ($M = 1.35$, $SE = 0.31$), and control conditions ($M = 1.1$, $SE = 0.27$), $t(49) = 1.08$, $p = .28$, $d_z = 0.15$. Finally, participants reported significantly higher ratings of having a larger little finger in the illusion condition ($M = 3.06$, $SE = .45$) compared with the control condition ($M = 1.8$, $SE = 0.34$), $t(49) = 3.11$, $p = .003$, $d_z = 0.44$. Overall, the embodiment results are similar to previous studies using this illusion and validate that the six-finger illusion was successfully induced.

Action Abilities Tasks

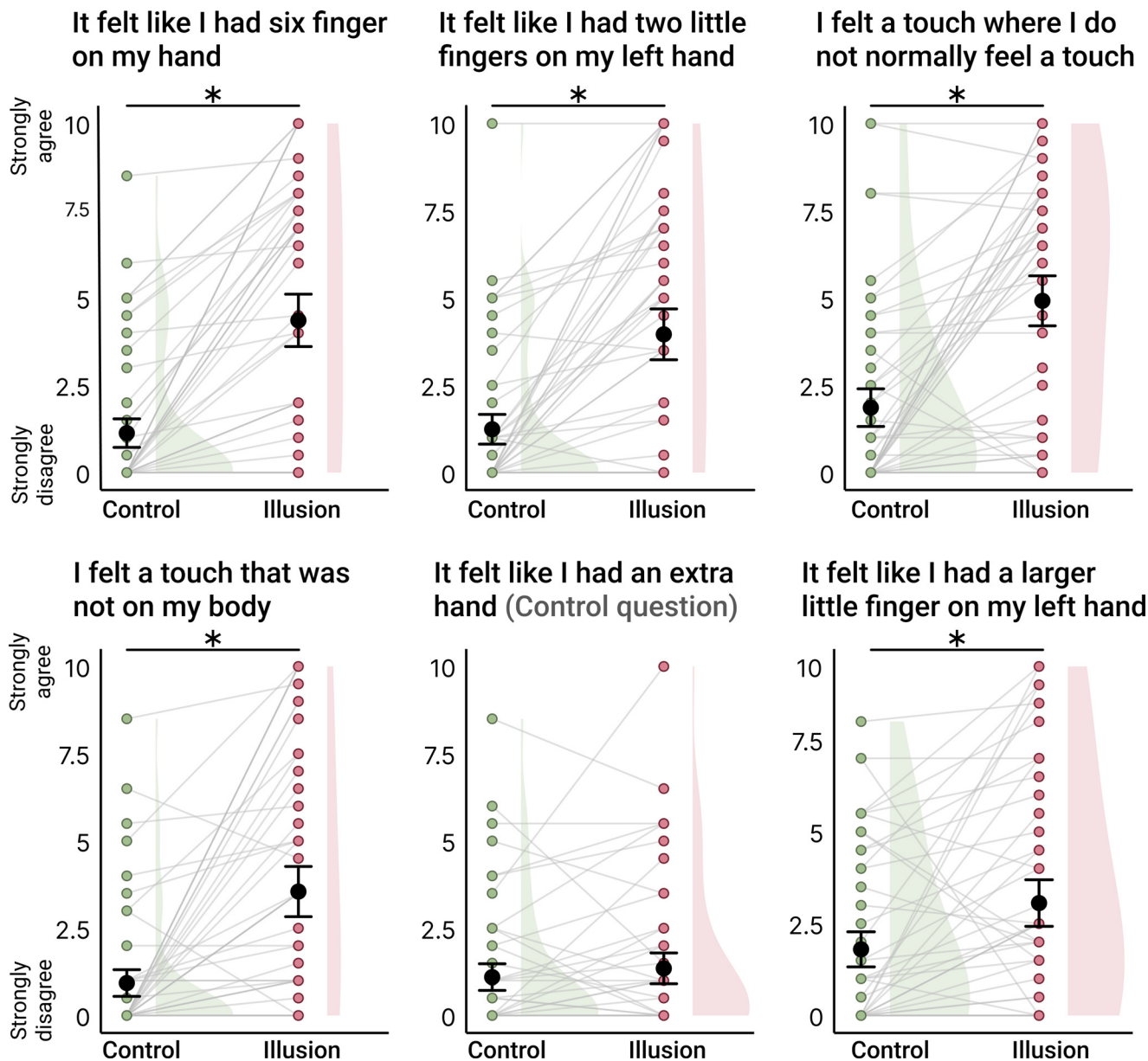
To test the hypothesis that feeling a sixth finger increases the perceived ability of participants in an apertures and in a grasping task, we calculated the ratio of the estimated ability, to the actual ability. A value of more than 1 indicates that the participant overestimates their ability and less than 1 indicates they underestimate it (Readman et al., 2021). These results are shown in Figure 3.

Participants' perceptions of the smallest aperture they could fit their hand through were larger following the sixth-finger illusion ($M = 0.97$, $SE = 0.02$) than in the control condition ($M = 0.92$, $SE = 0.02$), $t(49) = 5.67$, $p < .001$, $d_z = 0.80$. That is, they chose a larger aperture to fit their hand through after being induced the illusion of having a sixth finger on their hand. Participants' perceptions of the largest block they could grasp were larger following the sixth-finger illusion ($M = 1.01$, $SE = 0.02$) compared with the control condition ($M = 0.98$, $SE = 0.02$), $t(49) = 2.34$, $p = .02$, $d_z = 0.33$. This means they felt they could grasp a bigger block when the sixth-finger illusion was induced. Bayesian analyses, including sensitivity analyses varying the prior width, supported both action-ability effects and are reported in the exploratory Bayesian analyses section later.

Correlation Between Embodiment and Action Overestimation

As specified in the preregistration, to explore whether the degree of reported embodiment of the sixth finger correlated with perception of one's action capabilities, we calculated the ratio of the change in accuracy between illusion and control conditions' scores, and ran a correlation analysis between these ratios and the

Figure 2
Embodiment Ratings in the Sixth-Finger Illusion and Control Conditions



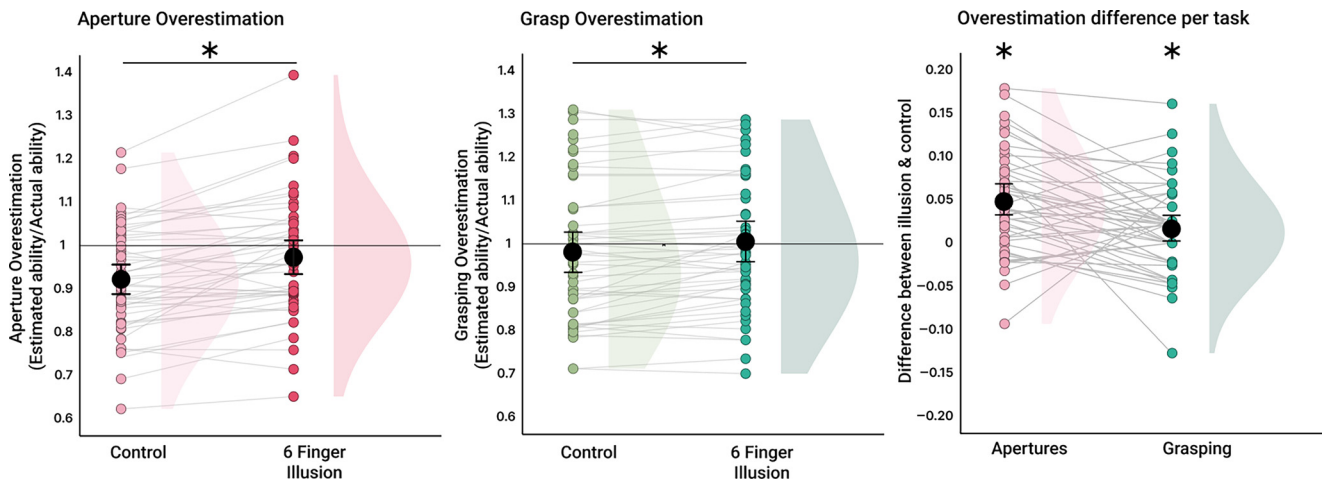
Note. Participants reported feeling a sixth finger on their hand, in the illusion condition. The asterisk indicates a significant difference between the sixth finger and the control conditions, where all items were significantly different except from the control question, that is, feeling an extra hand. The raincloud plots show the distribution of the data (Allen et al., 2021), with dots representing individual participants and the clouds showing the probability density of responses in each condition. The bars represent 95% confidence intervals, and the central dot marks each condition's mean. See the online article for the color version of this figure.

questionnaire embodiment scores. To run these analyses, we used questionnaire item A, which has been shown to have the highest scores (Cadete, Alsmith, & Longo, 2022; Cadete & Longo, 2020, 2022; Newport et al., 2016). We had predicted that higher embodiment scores would positively correlate with higher overestimation in the illusion trials for both tasks. However, there was no significant correlation between apertures overestimation and reporting feeling a sixth finger, $r(49) = -.07, p = .62$, nor between the aperture's overestimation difference (illusion-control) and feeling a

sixth finger, $r(49) = .21, p = .14$. The grasping overestimation also did not significantly correlate with reporting feeling a sixth finger, $r(49) = -.08, p = .60$. The grasping overestimation difference between illusion and control also did not correlate with the scores for feeling a sixth finger, $r(49) = .08, p = .59$.

We also ran correlations between the action abilities overestimations and the last questionnaire item scores. For feeling a larger little finger, we found the same pattern of nonsignificant correlations with aperture overestimation, $r(49) = .00, p = .98$,

Figure 3
Apertures Passing and Grasping Estimations



Note. Overestimation of action ability for the apertures task and the grasping task. Left panel: Participants showed an increase in the smallest aperture they felt they could fit their hand through in the illusion condition than in the control condition, $p < .001$. They chose a bigger aperture to put their hand through when the sixth-finger illusion was induced. Center panel: Participants also showed an increase in the biggest block they felt they could grasp in the illusion compared with the control condition, $p = .02$. Right panel: The difference between the illusion and control conditions for each task. The raincloud plots show the distribution of the data (Allen et al., 2021). Dots represent individual data scores, and the clouds show the probability density of responses in each condition. The bars represent 95% confidence intervals, and the central dot marks each condition's mean. Asterisks indicate significant differences between the illusion and control conditions (aperture: $p < .001$; grasping: $p = .02$). See the online article for the color version of this figure.

and aperture overestimation difference between illusion and control, $r(49) = -.10$, $p = .51$. There was also no significant correlation with grasping overestimation, $r(49) = -.00$, $p = .98$, and grasping overestimation difference between illusion and control, $r(49) = -.03$, $p = .80$.

Action Abilities Tasks by Six-Finger Embodiment Agreement

Sixth-Finger Embodiment Groups

We also conducted exploratory analyses that were not included in the preregistration plan, to further analyze the dissociation between reporting feeling a sixth finger and the estimation of passing an aperture and grasping a block in the illusion and control conditions. To do that, we split the participants into two groups: Those who scored 3 or more for feeling like they had a sixth finger in their hand were placed in the group that felt a sixth finger, and those who scored lower were placed in the group that did not feel a sixth finger. These results are shown in Figure 4.

We based this cut-off value on a previous study using the same 11-point scale (Cadete et al., 2026), in which participants showed a score of .6 for the control condition and 2.5 for feeling an extra hand, which was the control question. The 28 participants that reported feeling a sixth finger ($N = 28$, scores ranging from 4 to 10), chose significantly larger apertures to fit their hand through (underestimated less) in the illusion condition ($M = 0.97$, $SE = 0.03$), than in the control condition ($M = 0.90$, $SE = 0.02$), $t(27) = 5.42$, $p < .001$, $d_z = 1.02$. The same occurred for the group that reported not feeling a sixth finger ($N = 22$, scores ranging

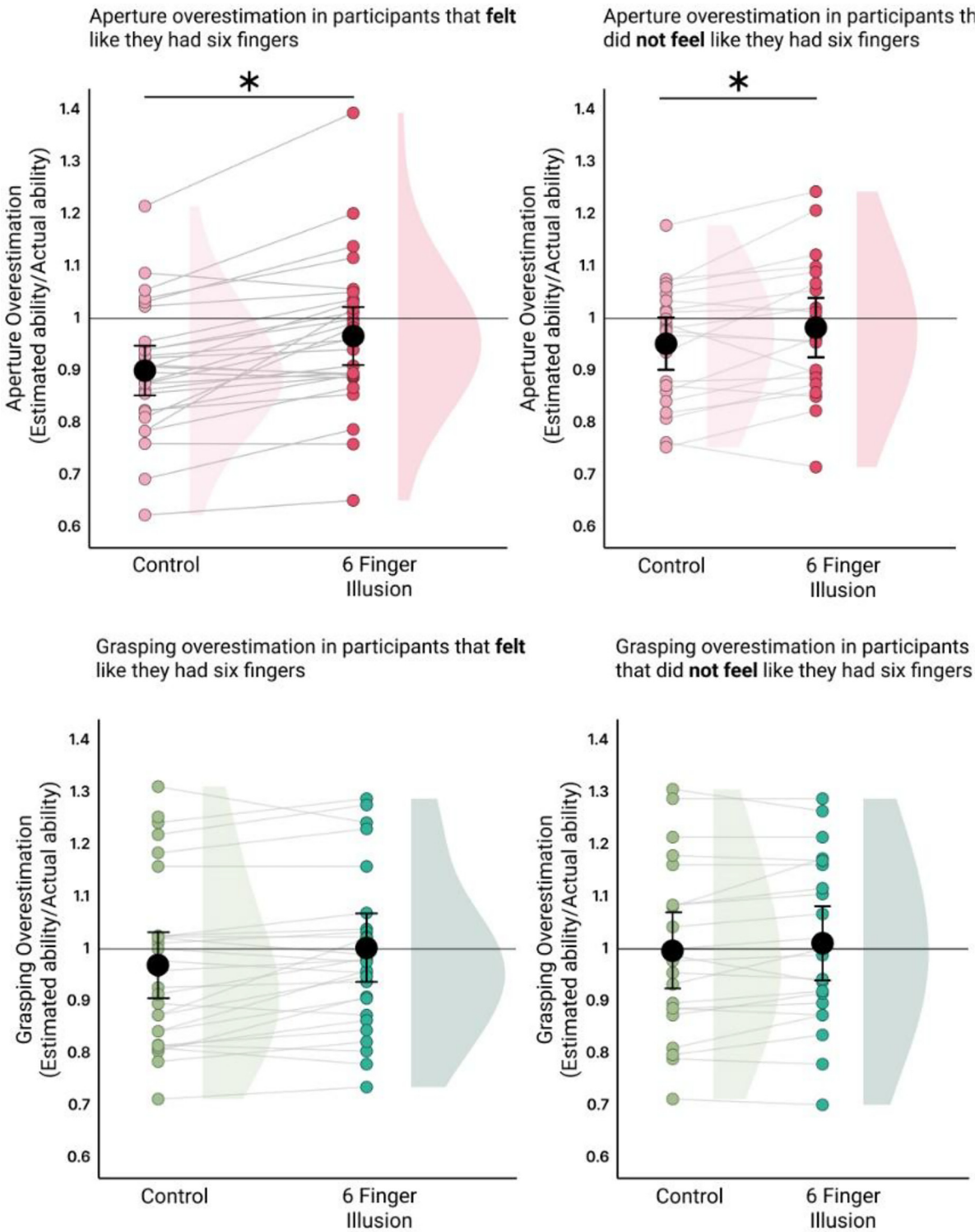
from 0 to 2), having chosen significantly larger apertures (underestimated less) to fit their hand through in the illusion condition ($M = 0.98$, $SE = 0.03$), than in the control condition ($M = 0.95$, $SE = 0.02$), $t(21) = 2.57$, $p = .02$, $d_z = 0.55$.

In the grasping task, there was no significant difference between the control and illusion conditions in either group. Those who reported feeling a sixth finger accurately estimated the biggest block they could grasp ($M = 1.00$, $SE = 0.03$), and slightly underestimated it in the control condition ($M = 0.97$, $SE = 0.03$), yet this difference did not reach statistical significance, $t(27) = 1.94$, $p = .06$, $d_z = 0.37$. Those who reported not feeling a sixth finger also did not show a significant difference between the illusion condition ($M = 1.01$, $SE = 0.03$) and the control condition ($M = 1.00$, $SE = 0.04$), $t(21) = 1.36$, $p = .19$, $d_z = 0.29$.

To test whether experiencing the illusion increased the overestimation effect, we compared the illusion-control aperture difference between participants who reported experiencing the illusion and those who did not. Participants who reported experiencing the illusion ($M = 0.07$, $SD = 0.07$) showed a larger illusion-control aperture difference than those who did not ($M = 0.03$, $SD = 0.06$), Welch's $t(47.47) = 2.07$, $p = .044$, $g = 0.57$. Participants who reported experiencing the illusion ($M = 0.02$, $SD = 0.06$) did not differ from those who did not ($M = 0.01$, $SD = 0.04$) in the illusion-control grasping difference, Welch's $t(44.12) = 0.90$, $p = .373$, $g = 0.24$. This shows that experiencing the illusion was associated with a larger overestimation effect in aperture estimation, but not in grasping.

Our results show that participants chose a wider aperture to fit their hand through when a sixth finger was induced, regardless of reporting feeling it or not. For the grasping task, the difference

Figure 4
Apertures Passing and Grasping Estimations Split by the Sixth Finger Embodiment Report



Note. Aperture and grasping overestimation between the control and sixth-finger illusion, split between participants who felt a sixth finger in their hand (score of ≥ 3 in the Likert scale to the first questionnaire item; $N = 28$), and those who did not ($N = 22$). Both groups exhibit the same trend in the aperture and grasping estimations, with less underestimation when a sixth finger was induced, regardless of reporting feeling it. Asterisks indicate significant differences between the illusion and control conditions for aperture estimations (participants who felt a sixth finger: $p < .001$; participants who did not feel a sixth finger: $p = .02$). See the online article for the color version of this figure.

between conditions lost its significance when splitting into groups, with both groups showing a nonsignificant difference between conditions. Together with the nonsignificant correlations between ability estimations and reported embodiment of a sixth finger, these results suggest a dissociation between explicit reports of the illusion and action-ability judgments.

Additional Exploratory and Descriptive Analyses

The following post hoc analyses were not preregistered. They were exploratory and assessed the observed pattern of results in more detail, particularly the dissociation between explicit reports of the illusion and ability judgments.

Descriptive Pattern of Illusion Reports. We first report how many participants showed weak or absent explicit reports of the illusion. Out of 50 participants, 12 participants never exceeded the illusion threshold (ratings > 3) across any questionnaire item or condition. Among these, six participants consistently reported ratings of 0, indicating a complete absence of illusory experience. When considering the illusion condition alone, 13 participants remained below the illusion threshold across all questionnaire items, with six consistently reporting zero.

Bayesian Analyses of the Main Action-Ability Effects. We conducted a Bayesian paired *t* test, using the default parameters in JASP 0.16.4 (Wetzels et al., 2012) and found very strong evidence in favor of our hypothesis that the sixth-finger illusion increases the aperture size estimations in the apertures task, $BF_{10} = 21,752.40$. Nonpreregistered sensitivity analyses varying the Cauchy prior width on the effect size ($r = .5$ – 1.0) yielded Bayes factors that remained decisively in favor of the alternative hypothesis ($BF_{10} > 20,000$ across priors), indicating that the result was robust to reasonable prior specifications. For grasping ability, the Bayesian paired *t* test provided strong evidence for the hypothesis that the sixth-finger illusion increased estimations of the biggest block participants felt they could grasp, $BF_{10} = 38.30$. Nonpreregistered sensitivity analyses varying the Cauchy prior width on the effect size ($r = .5$ – 1.0) yielded Bayes factors that remained strongly in favor of the alternative hypothesis ($BF_{10} = 32.36$ – 41.56), indicating that the conclusion was robust to reasonable changes in prior specification.

Descriptive Pattern of Underestimation and Overestimation. We also conducted additional analyses, not specified in the preregistration, to determine how many participants underestimated versus overestimated their action abilities across tasks and conditions. These analyses are reported for descriptive purposes. For aperture passing, underestimation was common overall, but the sixth-finger illusion shifted responses toward increased estimates. In the illusion condition, 29 participants (58%) underestimated aperture size and 21 (42%) overestimated it, whereas in the control condition 36 participants (72%) underestimated and 14 (28%) overestimated aperture size. A similar pattern was observed for grasping ability. In the illusion condition, 28 participants (56%) underestimated the largest block they could grasp and 21 (42%) overestimated it, with accurate estimates being rare (one participant, 2%). In the control condition, 28 participants (56%) underestimated and 20 (40%) overestimated grasping size (two participants, 4% accurate). Thus, although underestimation predominated in both tasks, the sixth-finger illusion was associated

with reduced underestimation and an increased proportion of overestimation for both aperture passing and grasping, consistent with an expansion of perceived action capabilities.

Bayesian Analyses of the Relationship Between Explicit Reports and Ability Judgments. We conducted Bayesian analyses using JASP's default Bayesian correlation framework with a stretched beta prior on the correlation coefficient, centered on zero, to assess whether the absence of significant correlations between explicit reports of the illusion and action-ability judgments was supported by evidence for the null hypothesis. A Bayesian analysis provided moderate evidence for the null hypothesis for the correlation between apertures overestimation and reported sixth-finger embodiment ($BF_{10} = 0.20$). Sensitivity analyses varying the stretched beta prior width (0.5–1.5) yielded Bayes factors ranging from 0.16 to 0.29, consistently favoring the null hypothesis. For the correlation between apertures overestimation difference (illusion-control) and reporting feeling a sixth finger, the Bayes factor provided anecdotal evidence for the null ($BF_{10} = 0.49$). Sensitivity analyses varying the stretched beta prior width (0.5–1.5) yielded the same qualitative pattern of evidence, with Bayes factors ranging from 0.39 to 0.70, consistently favoring the null hypothesis. Together, these results indicate that embodiment ratings were not meaningfully associated with aperture overestimation or with the overestimation difference between illusion and control conditions.

A Bayesian analysis provided moderate evidence for the null hypothesis for the correlation between grasping overestimation in the illusion condition and reported sixth-finger embodiment ($BF_{10} = 0.20$). Sensitivity analyses varying the stretched beta prior width (.5–1.5) yielded Bayes factors ranging from 0.16 to 0.30, consistently favoring the null hypothesis. For the grasping overestimation difference (illusion-control), the Bayesian analysis likewise provided evidence in favor of the null hypothesis ($BF_{10} = 0.20$). Sensitivity analyses varying the stretched beta prior width (.5–1.5) yielded aligned Bayes factors ranging from 0.16 to 0.30, consistently favoring the null hypothesis. Overall, these results suggest that reporting feeling a sixth finger was not meaningfully related to grasping overestimation nor to the overestimation difference between illusion and control conditions.

For the correlation between aperture overestimation in the illusion condition and ratings of feeling a larger little finger, the Bayes factor indicated moderate evidence for the null hypothesis ($BF_{10} = 0.18$). Sensitivity analyses varying the stretched beta prior width (.5–1.5) yielded Bayes factors ranging from .14 to .26, consistently favoring the null hypothesis. For the correlation between the aperture overestimation difference (illusion-control) and ratings of feeling a larger little finger, the Bayes factor provided anecdotal evidence for the null hypothesis ($BF_{10} = 0.51$). Sensitivity analyses varying the stretched beta prior width (.5–1.5) yielded Bayes factors ranging from 0.40 to 0.72, consistently favoring the null hypothesis.

For the correlation between grasping overestimation in the illusion condition and ratings of feeling a larger little finger, the Bayes factor indicated moderate evidence for the null hypothesis ($BF_{10} = 0.18$). Likewise, for the correlation between the grasping overestimation difference (illusion-control) and ratings of feeling a larger little finger, the Bayes factor again supported the null hypothesis ($BF_{10} = 0.18$). Sensitivity analyses varying the stretched beta prior width (.5–1.5) yielded Bayes factors ranging from 0.14 to 0.26 across both analyses, consistently favoring the null hypothesis.

Relationship Between Aperture and Grasping Effects. A correlation showed no association between aperture overestimation and grasping overestimation, $r = .048$, $p = .74$. Bayesian correlation analyses provided evidence in favor of the null hypothesis, with Bayes factors consistently below 1 across priors: $BF_{10} = 0.19$ (prior width = 1), $BF_{10} = 0.27$ (prior width = 0.5), and $BF_{10} = 0.15$ (prior width = 1.5). Grasping difference and aperture difference were positively correlated, $r = .413$, $p = .003$. Bayesian correlation analyses provided strong evidence for this relationship, with Bayes factors consistently favoring the alternative hypothesis across prior widths: $BF_{10} = 13.17$ (prior width = 1), $BF_{10} = 10.84$ (prior width = 1.5), and $BF_{10} = 16.48$ (prior width = 0.5). This indicates that participants who showed a greater difference between the illusion and control conditions in aperture perception also exhibited a larger illusion-control difference, in the same direction, in grasping, whereas absolute levels of overestimation were unrelated across tasks.

Co-Occurrence of Subjective Illusion Reports. Finally, we examined the co-occurrence of different subjective reports of the illusion in the illusion condition. A total of 15 participants reported both experiencing a sixth finger and experiencing a touch that was not localized on the body, whereas 13 participants reported experiencing a sixth finger without reporting disembodied touch. Only four participants reported disembodied touch without reporting a sixth finger, and 18 participants reported neither experience. A similar pattern was observed for reports of a larger little finger. Fifteen participants reported both experiencing a sixth finger and experiencing a larger little finger, whereas 13 participants reported experiencing a sixth finger without reporting a larger little finger. Only three participants reported a larger little finger without reporting a sixth finger, and 19 participants reported neither experience. In addition, only a small number of participants reported other illusion-related experiences in the absence of perceiving a sixth finger, with zero participants reporting two little fingers, and six participants reporting illusory touch in an unusual location, without reporting a sixth finger. Overall, although multiple subjective experiences were reported, experiences of disembodied touch or a larger little finger most often co-occurred with reports of a sixth finger, and only a small minority of participants reported these experiences in the absence of perceiving a sixth finger.

Discussion

When we interact with objects in our environment, we must compute the size and shape of both our body and the objects (Jeanerod et al., 1995). These computations are not independent; estimating the properties of the body influences how we estimate the properties of objects, and vice versa, forming a reciprocal relationship (Linkenauger et al., 2011, 2013). In this study, we show that participants update their perceptions of one's action capabilities following the illusion of having a sixth finger on one's hand. After experiencing the illusory sixth finger, participants judged both the smallest aperture they could fit their hand through and the largest object they could grasp as larger than with their normal five-fingered hand. Remarkably, this effect occurred regardless of whether participants reported feeling the sixth finger. This shows that instantly perceiving an invisible illusory finger updated the action perception of what would be possible to do with that hand. Even participants who did not report experiencing a sixth finger on

the questionnaire still selected significantly wider apertures and objects to grasp, as confirmed by significant differences between illusion and control conditions when participants were split by subjective experience. This finding suggests that the sixth-finger illusion can change hand representation and its action abilities, even when the explicit experience of having an extra finger is weak or absent. This interpretation is consistent with previous work on the rubber hand illusion, where explicit ownership reports and indirect measures of body representation can dissociate. One key example is proprioceptive drift, which refers to a shift in the perceived location of the hidden real hand toward the seen rubber hand. Proprioceptive drift is often used as an indirect measure of changes in hand position sense, but it does not always correlate with explicit reports of ownership. For example, Rohde et al. (2011) showed that proprioceptive drift can occur without a corresponding feeling of ownership, whereas Abdulkarim and Ehrsson (2016) also showed that experimentally changing perceived hand position did not change the strength of the rubber hand illusion. Similarly, Radziun and Ehrsson (2018) found that short-term visual deprivation increased proprioceptive drift without increasing subjective ownership ratings, a pattern also observed by Gallagher et al. (2021) in the somatic rubber hand illusion after increasing stimulation duration. These studies show that changes in perceived hand position (proprioceptive drift) and the feeling of ownership rely on partly distinct processes. Similarly, in the present study, action abilities' judgments changed even when explicit reports of having a sixth finger were weak or absent, and ratings of the sixth-finger experience did not correlate with aperture or grasping estimates. The sixth-finger illusion changed the hand representation used to estimate action capabilities, even when participants did not explicitly report the conscious experience of having a sixth finger. This suggests that explicit reports and implicit action abilities' judgments are not capturing the same underlying process, but partly different aspects of the illusion.

After the sixth-finger illusion, participants overestimated the biggest block they would be able to grasp and the smallest aperture they could fit their hand through, as if they had indeed a six-fingered hand. Feeling a six-fingered hand altered perception of action abilities, in the same way as when using a prosthetic that increases the actual width of the hand (Ishak et al., 2008). This suggests that the illusion changed the hand's representation and updated the perceived ability and control of their hand. Our findings show that the illusory sixth finger is perceived as part of the hand, and not part of a third hand or more extreme scenarios like a finger detached from the body or linked to another body part. It could be that participants felt the illusory finger, but did not include it in the representation of the hand, or that it was misperceived as an existing finger. Such an outcome would not be surprising, as Kammers et al. (2009) showed that local embodiment of a single finger on the rubber hand illusion, did not alter the overall hand representation. They found that the proprioceptive drift was specific to the finger being stimulated; it cannot transfer to other fingers (Kammers et al., 2009; Tsakiris & Haggard, 2005), and it does not generalize to the whole hand. If the drift had generalized to the whole hand, participants' hands would have been perceived as wider or narrower due to changes in the felt location of the index and little fingers. However, they showed that the perceived shape of their hand remained stable. Instead, our results reveal the opposite when perceiving a supernumerary

finger: The illusion reshapes the entire hand representation to accommodate an extra finger, demonstrating the unique role of supernumerary fingers in the updating of perceived hand size, shape and spatial boundaries.

Recent studies have investigated the embodiment of extra body parts, including extra hands (Ehrsson, 2009; Guterstam et al., 2011) and extra fingers (Ambron & Medina, 2023; Cadete & Longo, 2020; Hoyet et al., 2016; Newport et al., 2016). However, it has been unclear whether this extra body part is felt to belong to one's body, and in what way it would be connected to it. When one perceives two right hands, the extra hand might be represented as a part of the same arm or an extra arm, or even not connected to the body at all. These findings raise the question of how supernumerary body parts relate to the representation of the biological body, and under what conditions they become functionally integrated. Our results suggest that the supernumerary finger is represented as a part of one's hand, hence updating the hand's overall size and action abilities. In light of previous research with supernumerary effectors being integrated into body representation, this finding is not unexpected.

Supernumerary robotic effectors have been shown to integrate into the body representation, as shown by the pioneering work of Makin et al. (Kieliba et al., 2021; Makin et al., 2023) showing that an additional robotic finger can be incorporated into coordinated action, leading to changes in motor behavior, task performance, and even driving changes in the neural representation of fingers (Kieliba et al., 2021). Such changes occur specifically under conditions involving active control of the extra robotic finger, compared with control groups that wore a static version of the thumb. Recent research has also demonstrated remarkable functional integration of artificial finger augmentations. Radziun et al. (2026) showed that using wearable finger extensions stretched the user's finger representation, with perceived size and location flexibly changing as the device length increased. In the first stage, there was a perceived compression of the biological finger, in the second stage, a stretching of perceived finger position/size for both the biological and artificial finger during training, and a persistent stretching of the user's finger representation after the device was removed. This research provides compelling evidence that extensions of existing body parts can be incorporated into body representations through active sensorimotor interaction. In such work, however, motor representations and active control are a conspicuous and integral component. The present findings address a complementary question, namely whether the body representation can also incorporate an additional finger, even when it is physically absent and lacks any form of motor control. To our knowledge, this is the first evidence that an illusory supernumerary body part can be functionally integrated with the representation of the actual body, updating the perceived action abilities. Our results show that an illusory supernumerary finger can nonetheless be represented as part of the hand, leading to systematic changes in perceived hand size and action abilities, even in the absence of any motor feedback.

It has been shown that humans consistently overestimate their grasping and aperture passing abilities (Ishak et al., 2008; Linke-nauger et al., 2009; Readman et al., 2021), and we expected to replicate that result in the control condition. However, we observed an underestimation instead, in both control conditions and in the sixth-finger condition for the apertures task. Due to the nature of the illusion in the present study, the participant sees their "hands"

in the mirror in both conditions during the procedure, as the hands were only covered during the task. This contrasts with previous studies using the apertures task in which the hand has been blocked from view. The visual information about the hand may be driving the underestimation of action abilities. For instance, perceived touch on the hand shrinks when seeing the hand (Longo & Sadibolova, 2013). Still, the direction of the predicted effect was confirmed when comparing the illusion and control conditions, with higher estimations when feeling six fingers.

This study reinforces the sixth-finger illusion as a paradigm that elicits the embodiment of a supernumerary finger, providing additional evidence from two implicit and indirect tasks. Supernumerary body illusions provide us a way to study the embodiment of extra body parts and in what way they are represented differently from actual body parts. For instance, previous studies have shown that the supernumerary finger is represented flexibly and independently from the existing fingers, having a different size (Cadete & Longo, 2022), shape (Cadete, Alsmith, & Longo, 2022), and orientation (Cadete et al., 2026) from the actual finger, at the same time. Its radical independence from what a finger looks like and what it can do (such as rotating up to 180° up or to the side of the hand), could mean that it is also independent from the hand representation, and could even cast doubt on its categorization as a body part. Yet this study suggests that the sixth finger is mapped onto the actual hand representation, as a part of it. It also shows that the illusion led to a shift in perceived affordance boundaries consistent with an updated hand representation, despite the lack of a dedicated cortical representation of the supernumerary body part.

The ability to instantly incorporate an extra body part into one's perceived action capabilities may reflect an evolutionarily adaptive feature of how we represent our bodies. Given that morphology can shift across the lifespan and evolutionary history, a flexible representation may allow the system to adjust perceived action boundaries to accommodate bodily changes and additions. Our findings suggest that this flexibility extends beyond anatomical changes or tool use, and it can instantly be updated with invisible illusory body parts that lack any feedback of action control. That an entirely passive and unseen sixth finger can still reshape affordance judgments underscores the nervous system's readiness to shift perceived action abilities and boundaries based on somatosensory signals alone, even in the absence of any motor control feedback.

Although the illusion elicited a range of subjective experiences, with the experience of a sixth finger emerging as the most frequently and strongly reported outcome, the present data do not allow us to conclude that explicitly feeling a sixth finger was the sole driver of the observed changes in perceived action abilities. As shown by the overlap analyses, some participants exhibited shifts in perceived aperture and grasping limits despite not reporting perceiving a sixth finger. This raises the possibility that the changes in perceived action boundaries reflect broader effects of the illusion procedure that are not fully captured by explicit questionnaire reports of the illusion experience. In this sense, although the perception of six fingers is the dominant subjective experience, with at most six out of 50 participants reporting other questionnaire experiences in the absence of feeling six fingers, the present findings indicate that changes in perceived action abilities cannot be straightforwardly attributed to the conscious experience of an additional finger alone. Nevertheless, regardless of the specific perceptual experience elicited by the illusion, it altered perceived

hand boundaries and action capabilities, indicating that touch mapped onto nearby empty space can be attributed to one's own hand and, in turn, shape perceived affordances. This limitation highlights the need for future work to address (a) a more comprehensive exploration of the perceptual experiences arising from the illusion, and (b) the relationship between the illusion and changes to motor imagery, motor intention and motor execution.

A related limitation of the present study concerns the fact that participants estimated action affordances by imagining performing actions with their hand, rather than executing or intending actual movements. In our study, participants estimated affordances by imagining performing actions with their hand after being induced the illusion of having a sixth finger. It could be that actually performing the task would have distinct results from just imagining. Indeed, neurological dissociations such as optic ataxia and action blindsight illustrate that conscious perception and action control can be supported by distinct neural systems (Longo, 2025, p. 81; Milner & Goodale, 2006). For instance, optic ataxia impairs the online control of reaching and grasping, particularly for unfamiliar objects (Perenin & Vighetto, 1988). However, patients may still retain knowledge of how to grasp familiar objects when grasping or reaching from memory, with their eyes closed (Milner & Goodale, 2006). Similarly, patients with action blindsight can reach toward objects in their blind visual field, even when they cannot report seeing them (Weiskrantz et al., 1974). These dissociations suggest a potential difference between imagined action capabilities and actual sensorimotor representations, and our results are interpreted as evidence for changes in perceived action capabilities, rather than actual motor control.

In conclusion, our results demonstrate that affordance perception is immediately updated after being exposed to the illusion of having six fingers. Not only can we feel an extra finger or a touch on empty space near the hand, but this also instantly alters perceived action abilities and boundaries of the hand. Importantly, participants did not need to control the sixth finger; somatosensory feedback alone was sufficient to update hand representation and perceived capabilities. This finding highlights the brain's flexibility in incorporating extra body parts to extend action possibilities. Our results indicate that perceiving an illusory sixth finger for just 1 min, instantly updates the hand's action abilities and boundaries, protecting the hand with a just-acquired sixth finger, while also making the best use of the extra finger by including it when imagining grasping an object with that hand.

Constraints on Generality

The present findings are intended to generalize to healthy adult participants with typical hand anatomy and intact multisensory processing. Because the illusion relies on visuotactile integration under controlled laboratory conditions and on judgments of imagined action, generalization to clinical populations, individuals with atypical sensory processing, or contexts involving active motor control should be made with caution.

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