Self-reported vividness of tactile imagery for object properties and body regions: An exploratory study

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ABSTRACT
Mental imagery ability has been examined principally in the visual domain. Despite evidence for tactile mental representations in the absence of direct stimulation, this ability is poorly understood. We investigated tactile imagery for both active and passive tasks in a large sample (N = 118). Vividness of imagery was tested across two different tasks: somatosensory imagery (of body sensitivity) and tactile imagery (of object properties) in all participants. Evidence for vivid imagery across tactile and somatosensory dimensions was found with a positive, albeit weak, correlation in imagery strength between dimensions. Imagery ratings varied across objects and object properties in the tactile imagery task and across body sites in the somatosensory imagery task. These findings shed light on the capacity for, and characteristics of, tactile mental imagery in the general population and suggest that the ability to experience vivid tactile mental images may mediate performance across a number of perceptual tasks.

1. Introduction
Mental imagery is the ability to imagine a sensory experience in the absence of corresponding external input (Kosslyn, 1995; Nanay, 2020; Pearson, 2019). This arises via the retrieval of stored sensory representations from memory and the subsequent ‘re-construction’ of this information (Farah, 1989; Kosslyn et al., 2001; Pearson, 2019), a process that can occur automatically or through voluntary will (Pearson et al., 2015).

Given its associated phenomenology, it is perhaps unsurprising that mental imagery has been examined mostly in the visual domain (Kosslyn, 1995; Pearson, 2019). Several brain regions, including the primary visual cortex, are reported to be involved in visual imagery (Dijkstra et al., 2017; Slotnick et al., 2005; Stokes et al., 2009). Moreover, patterns of neural activity appear specific to imagery content (O’Craven & Kanwisher, 2000; Slotnick et al., 2005; Stokes et al., 2009), demonstrating a close link between imagery and perception. Nevertheless, there is evidence for mental imagery in other modalities, including for touch. For example, studies have investigated imagery for tactile patterns (Schmidt et al., 2014), object properties (Belardinelli et al., 2009; Klatzky et al., 1991; Newman et al., 2005; Uhl et al., 1994), tactile stimulation on a body site (Chivukula et al., 2021; Schmidt & Blankenburg, 2019; Yoo et al., 2003) and somatosensory sensations (Belardinelli et al., 2009; Grebot & Paty, 2005) as well as affective touch (Lucas et al., 2015; Panagiotopoulou et al., 2018).

To date, the results of a number of neuroimaging studies (fMRI, EEG) have shed light on the neural correlates of tactile imagery...
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(Chivukula et al., 2021; Fallgatter et al., 1997; Schmidt et al., 2014; Uhl et al., 1994; Yoo et al., 2003). Tactile imagery is reported to be supported by a fronto-parietal ‘co-construction’ network (Schmidt et al., 2014) including the somatosensory cortex, in which activity during tactile imagery appears topologically similar to activation during veridical tactile perception (Chivukula et al., 2021; Schmidt & Blankenburg, 2019; Schmidt et al., 2014; Yoo et al., 2003). Other studies have further implicated such regions as the posterior parietal cortex in body-based tactile imagery (Chivukula et al., 2021), the insula and amygdyla in affective tactile imagery (Lucas et al., 2015) and the lateral occipital cortex in haptic imagery (Newman et al., 2005).

Despite an increase in the number of investigations of tactile imagery, our understanding of the characteristics of tactile imagery is poor compared with other modalities, particularly vision. Typically, introspective ratings are used to quantify imagery vividness across modalities and such ratings have indicated the capacity for relatively vivid tactile imagery (e.g., Belardinelli et al., 2009; Klatzky et al., 1991). Given evidence for differences in the strength of encoding of different tactile sensations (Klatzky et al., 1987, 1993; Murdoch, 1997) and for variations in sensitivity across different body parts to tactile stimulation (Corniani & Saal, 2020; Myles & Binseel, 2007; Weinstein, 1968), it might be expected that associated imagery of tactile stimulation may vary in vividness. As such, it is important to investigate individuals’ ability to form mental tactile images in order to provide a better understanding of its potential role in other cognitive operations. A notable gap in knowledge is how an individual’s vividness of tactile mental representations for distal objects in the environment relates to imagery of somatosensory sensations that are proximal on the body. Of the existing studies of tactile imagery, few have examined haptic imagery for a range of different objects and object properties and for somatosensory imagery across multiple body sites and, to the best of our knowledge, none have examined these effects in the same study. Given the reported distinctions between active, or haptic, touch and passive tactile perception, both from behavioural (e.g., Gibson, 1962; Lederman & Taylor, 1972; Prescott et al., 2011) and neuroimaging (Simões-Franklin et al., 2011) studies, it is of interest to determine whether the ability to imagine tactile sensations generalises across both types of touch.

The present study was designed to examine the characteristics of tactile mental imagery by measuring self-reported mental imagery for touch in a large sample. Imagery in the tactile domain was tested across two different tasks: somatosensory imagery (ratings of vividness across the body) and tactile imagery (of object properties) in all participants. The present study aimed to answer the three following research questions:

1) Do tactile imagery ratings vary according to object type and object property?
2) Do somatosensory imagery ratings vary across different body sites?
3) What is the relationship between self-reported vividness for active (tactile) versus passive (somatosensory) imagined touch?

2. Material and methods

2.1. Participants

An opportune sample of participants was recruited from attendees to a public exhibition in the Science Gallery Dublin. In total, 376 participants volunteered to take part in the experiment. However, data from several participants were excluded from the final analyses due to incomplete datasets (113 participants did not complete all parts of the experiment), or reported neurological (35 participants) or tactile (3 participants) disorders. As the purpose of the present study was to investigate tactile imagery in the general population, data from 10 participants identified as having mirror-touch synaesthesia (based on a screening task in which mirror-touch sensations were quantified in response to a set of videos, see O’Dowd et al., 2019 for further details) and from a further 97 participants who self-reported having synaesthesia (grapheme-colour, music-colour, taste-colour or other) were excluded. Data from the remaining sample of 118 participants (57 male; 58 females; and 3 unknown) were included in the present analysis. Most participants were adults aged between 18 and 55 years (103 participants). An additional 3 participants reported being older than 55 years of age while the remaining 12 participants reported being younger than 18 years of age. Most participants reported being right-handed (104 participants) and all reported being fluent in English.

All participants provided informed consent (consent was provided by the legal guardians of participants younger than 18 years) and the experiment was granted ethical approval by the School of Psychology, Trinity College Dublin, and the Science Gallery Dublin Research Ethics Committee and complied with the Declaration of Helsinki. Data were collected in full compliance with EU General Data Protection Regulation (GDPR).

2.2. Stimuli and apparatus

The study comprised one of several studies which were part of a public exhibition held at the Science Gallery Dublin in spring 2018. The exhibition space was divided into separate booths, located in a quiet area of the Gallery. All tasks described in this study were conducted in a dedicated testing booth measuring 2 m by 2 m and surrounded by a black curtain that was closed during testing. The experiment was presented on a computer (Dell Optiplex 790) with a high-resolution monitor (1920 × 1080 pixel resolution, refresh rate of 60 Hz). The monitor was positioned on a table approximately 70 cm from the seated participant, and a keyboard for responding was also placed on the table in front of the participant. All experimental tasks were programmed using Psychopy (version 1.84.2, Peirce et al., 2019).

The study involved two different tasks designed to assess tactile mental imagery (TMI) and somatosensory mental imagery (SMI). All participants performed both tasks in one experimental session.

The stimuli for the TMI task consisted of the written names of five objects; bubble wrap, ice cube, sandpaper, velvet, and wet sponge
and a description of object properties. The object properties included force, surface compliance, texture and weight. A stimulus therefore consisted of an object name, which was presented at the top of the screen, and instructions to rate the object on the vividness of the imagery of each property. For example, in the case of sandpaper, the instruction for the participant was to provide separate ratings of how vividly they could imagine the amount of tactile force required to feel sandpaper, the compliance of the sandpaper surface, the texture of the sandpaper surface and the weight of the sandpaper. A Likert rating scale ranging from 1 (I cannot imagine this) to 7 (I can vividly imagine this) was used. The rating scale comprised a movable triangular marker along a scale from 1 to 7. Participants were instructed to use a mouse to move the triangle along the scale to the point corresponding to their rating. They then clicked the mouse to confirm their rating. At the beginning of each trial, the default position of the marker was always the midpoint of the scale.

For the SMI task, the stimulus set included 21 schematic, line-drawn illustrations of different parts of the body from five main regions including the foot (hallux, ball of the foot, foot underside, dorsal foot), lower body (shin, thigh), upper body (abdomen, chest, neck, upper arm, forearm), head (mouth, nose, cheek, ears, forehead) and hand (dorsal hand, palm of the hand, dorsal finger, finger underside and fingertips). In each stimulus the relevant anatomical site was highlighted (in colour). For example, a stimulus may comprise of an image of a foot, with the ball of the foot highlighted as the site of interest. Participants were instructed to imagine being stimulated by a light brushstroke on their own corresponding body site and provide a rating of their sensitivity using a Likert scale ranging from 1 (not sensitive at all) to 7 (extremely sensitive). The same scale used for the TMI task was again used here and was presented at the bottom part of the screen.

2.3. Design

All participants performed both the TMI and SMI rating tasks. Each task was conducted once only and the SMI task preceded the TMI task for all participants. Trials were randomly presented across participants for both imagery tasks. The TMI task was based on a fully-factorial within-subjects design with object type (5; bubble wrap, ice cube, sandpaper, velvet, wet sponge) and object property (4; force, surface compliance, texture and weight) as factors. The SMI task was based on a within-subjects design with the single factor of body site only. Likert scale ratings served as the dependent variable.

2.4. Procedure

Participants were invited to take part in the study as they entered the exhibition space. Each participant first provided informed, written consent and demographic information at an electronic sign-in station which was located at the entrance to the exhibition. For any individual under the age of 18, a parent or legal guardian was required to complete the consent form before the individual could participate in the study.

The participant was then directed to the testing booth to perform the TMI and SMI tasks. There they were met by the experimenter who further explained the study. Each participant conducted the tasks on their own inside the testing booth. At the start of the experiment, the participant was again provided with the task instructions on the screen. To ensure the participant understood the rating procedure, a practice trial was presented. This trial required the participant to rate the taste of a lemon (from 1 ‘very sweet’ to 7 ‘very bitter’) using the same rating scale as in the other tasks.

All participants were first presented with the TMI task. For each trial, participants were instructed to imagine feeling a specific object (one of bubble wrap, ice cube, sandpaper, velvet, wet sponge) with their eyes open. They were then required to provide a rating of the vividness of their tactile imagery per object for the following properties: force, surface compliance, texture and weight. Brief explanations were provided for these tactile properties; for example, participants were asked to imagine the force needed to pop the bubble wrap, or squeeze the wet sponge or they were asked to imagine feeling the compliance of the surface of each object (i.e., the hardness or softness). Each name stimulus in the TMI task was shown until the rating responses were recorded. All ratings were provided on a scale from 1 (I cannot imagine this) to 7 (I can vividly imagining this). There were four main trials in this task, with four ratings provided to each trial (i.e., 16 ratings in total per participant).

Following a self-timed break, the SMI rating task was then presented. For this task, participants were presented with a stimulus and asked to refer to each schematic illustration of the body shown in each trial. They were required to imagine being stimulated on their own corresponding body site by a light brushstroke. Each stimulus was displayed for 2 s, subsequent to which the participants were presented with instructions to provide a rating of their sensitivity using a Likert scale ranging from 1 (not sensitive at all) to 7 (extremely sensitive).

Trials in either task were presented once to each participant and were not repeated. The entire experiment lasted no more than 10 min per participant.

2.5. Data analysis

The analyses were performed using R (version 3.5.0; Team R, 2017) on R studio (Team R, 2015). Inter-rater reliability of imagery scores was assessed using a two-way mixed, average-measures intraclass correlation coefficient (ICC; Koo & Li, 2016; McGraw & Wong, 1996) via the ‘irr’ package (Gamer et al., 2012). Participants’ mean Likert ratings to the TMI and SMI tasks were entered into within-subjects ANOVAs for statistical analysis. The ANOVAs were conducted using the ‘ez’ package (Lawrence, 2016) with type 3 sum-of-squares to test for significant main effects and interactions. Where appropriate, the Greenhouse-Geisser correction was applied to adjust the degrees of freedom of within-subject tests to correct for violations of the sphericity assumption and, in these cases, the adjusted p-value is reported. Separate post-hoc tests were carried out for significant main effects or interactions. When multiple paired-
sample \( t \)-tests were performed, the Bonferroni correction was used to maintain a family-wise Type 1 error rate at 0.05. Interactive graphs are available at [https://psychplots.shinyapps.io/interactive_tmi_smi/].

3. Results

3.1. Tactile mental imagery (TMI) rating task

The resulting ICC for object ratings on the TMI task suggested good agreement across participants’ ratings (ICC = 0.65; 95% CIs [0.21, 0.95]; \( F(4, 372) = 4.02, p = 0.003 \)) (Cicchetti, 1994). The ICC for agreement in object property ratings was very high (ICC = 0.91; 95% CIs [0.73, 0.99]; \( F(3, 334) = 16.8, p < 0.001 \)). This indicates that vividness of imagery for tactile stimuli was rated similarly across participants. The high ICCs suggest a minimal amount of measurement error and that statistical power for analysis was not compromised.

In the TMI task, 87.3% of participants had a mean vividness rating at or above the midpoint (4) of the rating scale (see Fig. 1 for ratings distribution). Across objects, the highest vividness rating was provided in response to the wet sponge (\( M = 5.17, SD = 1.26 \)) followed by the ice cube (\( M = 4.96, SD = 1.37 \)), bubble wrap (\( M = 4.84, SD = 1.33 \)), sandpaper (\( M = 4.84, SD = 1.35 \)) and velvet (\( M = 4.80, SD = 1.12 \)). Across object properties, the highest rating was provided in response to texture (\( M = 5.58, SD = 1.19 \)) followed by surface compliance (\( M = 5.01, SD = 1.18 \)), force (\( M = 4.66, SD = 1.17 \)) and weight (\( M = 4.45, SD = 1.33 \)).

A within-subjects 4 (Object type) X 5 (property) ANOVA was performed on participants’ mean tactile imagery ratings. There was a significant main effect of Object (\( F(4, 468) = 4.59, p = 0.001, \eta^2 = 0.07 \)) and of Object property (\( F(3, 351) = 70.74, p < 0.001, \eta^2 = 0.07 \)) as shown in Fig. 2 (see Table S3 in Supplementary Material s for further information).

3.2. Somatosensory mental imagery (SMI) rating task

The ICC for agreement in the SMI task was high (ICC = 0.96; 95% CIs [0.93, 0.98]; \( F(20, 1464) = 30.90, p < 0.001 \)), suggesting a minimal amount of measurement error for somatosensory imagery ratings.

To simplify the analysis of SMI ratings, the 21 body parts (see Fig. 4a) were clustered into 5 main body regions; head (mouth, nose, cheek, ears, forehead), upper body (abdomen, chest, neck, upper arm, forearm), lower body (shin, thigh), foot (hallux, dorsal foot, foot underside, ball of foot) and hand (dorsal hand, palm of the hand, dorsal finger, finger underside, fingertip). The distribution of imagery

Fig. 1. Plots showing the density distribution of vividness in imagery ratings to a) each of the individual objects and (b) each of the object properties presented in the TMI task. In each plot, the dashed line demarcates the midpoint of the rating scale (from 1 to 7).
ratings across participants for each of these five body sites is shown in Fig. 3. In the SMI ratings task, 82.2% of participants provided a mean vividness ratings at or above the midpoint (4) of the rating scale. The highest ratings were provided in response to the head region (M = 4.88, SD = 1.08), followed by the upper body (M = 4.86, SD = 0.98), foot (M = 4.49, SD = 0.99), hand (M = 4.33, SD = 0.99) and lower body (M = 3.97, SD = 1.18).

A one-way within-subjects ANOVA with the factor Body Region was then conducted on participants’ mean ratings of imagined sensitivity to tactile stimulation. A main effect of Body Region was found (F(4, 468) = 21.67, p < 0.001, η² = 0.10), as illustrated in Fig. 4b (see Supplementary Materials for further information).

We also examined whether affective touch may be influencing the imagery ratings to body parts in the SMI task. To that end we re-
grouped the body sites according to glabrous skin sites which are not densely innervated with CT afferents (McGlone et al., 2014; such as the hallux, sole of the foot, ball of the foot, lips, palm of the hand and the tips and underside of the fingers) and non-glabrous (i.e., hairy) skin sites (in which CT afferents are mainly found, including the dorsal foot, lower leg, thigh, belly, breast, neck, nose, cheek, ears, forehead, forearm, upper arm and the dorsal surface of the hand and fingers). Overall, participants imagery ratings to imagined touch on the glabrous skin sites on the body ($M = 4.70, SD = 0.80$) were significantly more vivid than ratings to the hairy skin sites on the body ($M = 4.52, SD = 0.78; t(117) = 2.47, p = 0.15, d = 0.23$) (see Fig. 4a).

3.3. Relationship between imagery ratings across the TMI and SMI tasks

All participants took part in both ratings tasks allowing us to determine whether there was any patterns in the reported vividness of imagery across these tasks or whether the two tasks tap into independent aspects of mental imagery for touch (active touch, TMI, and passive touch, SMI). First, a paired $t$-test conducted on the mean imagery ratings across both tasks revealed significantly higher vivid imagery ratings for the TMI task ($M = 4.92, SD = 1.09$) compared to the SMI task ($M = 4.58, SD = 0.70$); $t(117) = 3.26, p = 0.001, d = 0.30$). However, this difference did not remain significant when ratings for texture, the most vivid object property, were not included ($t(117) = 1.13, p = 0.26$). Second, a Pearson’s correlation analysis on each of the participants’ ratings across the two imagery tasks was
performed. As shown in Fig. 5, this analysis revealed a significant positive correlation between the TMI and SMI ratings ($t(116) = 2.77$, $p = 0.006$, $r = 0.25$, 95% CIs [0.07, 0.41]) across individuals (and remained significant when ratings for texture were removed; $t(116) = 2.66$, $p = 0.009$, $r = 0.24$, 95% CIs [0.06, 0.40]). However, the positive correlation is weak, indicating that there is a low likelihood that somatosensory imagery ratings are related to tactile imagery ratings. Indeed, as shown in Fig. 5, the positive correlation is driven mainly by participants who are classified as having overall average or above average imagery on both the SMI ($\geq 4.58$) and TMI ($\geq 4.92$) tasks. The figure also illustrates individual variability and participants clustered by colour according to their performance above or below the sample mean rating for both tasks.

4. Discussion

The present study investigated the vividness of tactile imagery in the general population across two tasks that, together, typified the type of perceptual tasks involving the tactile system; that is imagery of objects and their properties and imagery of tactile sensations on the body. The results demonstrated that most participants are able to imagine tactile information for both forms of information, aligning well with previous findings supporting the capacity to generate tactile mental representations (e.g., Grebot & Paty, 2005; Klatzky et al., 1991; Schmidt et al., 2014; Yoo et al., 2003).

The results of the SMI task showed that passive, tactile stimulation of some body regions was more vividly imagined than of others, with greater vividness exhibited in ratings to imagined tactile stimulation of the upper body than lower body regions, particularly for the head region overall. Studies investigating tactile sensitivity of the body have shown differences in sensitivity across body parts (Corniani & Saal, 2020), although the nature of the tactile input/measurement can also have an effect (e.g., pressure, tactile localisation, two-point thresholds or vibrations; Myles & Binseel, 2007; Weinstein, 1968). Curiously, participants’ ratings to imagined stimulation on certain body parts were relatively lower than would be expected from previous findings, particularly the fingers (Myles & Binseel, 2007). Although this result might appear inconsistent, our findings may be related to the specific nature of the imagined

![Fig. 5. Plot shows significant correlation between mean TMI and SMI ratings provided by each participant. The shaded area around the regression line shows the 95% confidence intervals. The vertical dashed line represents the mean TMI rating and the horizontal dashed line represents the mean SMI rating. For illustration purposes only, participants’ ratings are colour and shape coded according to whether their rating was below or above the average imagery on both tasks yielding four different groups (see legend for this colour and shape coding).](image)

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tactile stimulation; that is, participants were asked to imagine being stroked by a paintbrush in the SMI task whereas previous studies of tactile sensitivity referred to spatial discrimination (e.g., orientation discrimination or two-point thresholds). Furthermore, it is possible that the imagined brush stroke evoked tactile imagery that was more related to a ‘ticklesensation’, which might explain why certain body regions, such as the underside of the foot, the abdomen, the ear, the neck and the palm of the hand, were associated with higher ratings of tactile imagery than other body sites (e.g., see Grebot & Paty, 2005; Murray, 1908).

The results of the SMI task also showed that participants rated glabrous skin sites on the body as more sensitive to imagined touch than hairy skin sites, suggesting that imagining a brushstroke on the body may not necessarily evoke imagery specific to affective touch which is more associated with stimulation of non-glabrous skin. Discriminative and affective touch are thought to be underpinned by separate systems (McGlone et al., 2014). More specifically, the peripheral nerve fibres from mechanoreceptors in the skin are fast-conducting and myelinated (Ab fibres) and project via the thalamus to the somatosensory cortex. In contrast, affective touch is underpinned by slow-conducting and unmyelinated fibres (CT, C-Tactile; Gordon et al., 2013; Olausson et al., 2010) which project mainly to the insula in the brain (Kirsch et al., 2020; Gordon et al., 2013). Moreover, CT afferents are reportedly found mainly in hairy as opposed to glabrous skin (McGlone et al., 2014). Similar to the SMI task in the present study, Lucas et al. (2015) asked participants to imagine gentle touch via a paintbrush to the arm (hairy site) and palm (glabrous site). They found that this task did inspire imagery for affective touch, which, on the face of it, may seem contradictory to the results reported here. One important difference, however, is that in their study the imagery blocks were preceded by experiential blocks of trials in which participants were presented with veridical tactile stimulation at an optimal velocity for CT responses. It is possible therefore that such stimulation subsequently promotes more precise and specific forms of tactile imagery.

Although most participants reported vivid tactile imagery across both the TMI and SMI tasks, the ratings were variable within the sample, suggesting individual differences in tactile mental imagery abilities, consistent with previous findings in the tactile domain (Belardinelli et al., 2009) and with research on mental imagery more broadly (Cui et al., 2007; Kosslyn et al., 1984). The weak correlation between the ratings across tasks suggests a limited generalisation of tactile imagery abilities across different active and passive tactile experiences. This finding appears somewhat compatible with evidence for a distinction between passive (somatosensation) and active (haptics) touch within the somatosensory system (Simões-Franklin et al., 2011).

While we made every effort to reduce the role of other modalities in our imagery tasks, by using stimuli and tasks that are mainly associated with touch, the potential role of motor and/or visual imagery is nevertheless important to consider (Lacey & Lawson, 2013; Nanay, 2020; Spence & Deroy, 2013). Indeed, there is evidence that visual imagery can contribute to tactile perception of familiar objects (Amedi et al., 2001; Klitzky et al., 1987, 1991; Lacey et al., 2010; Newman et al., 2005) and that the occipital cortex can also be activated during tasks involving tactile perception or imagery (e.g., Newman et al., 2005; Schmidt et al., 2014; Uhl et al., 1994). For example, Newman et al. (2005) investigated tactile imagery of material and geometric properties of familiar objects and found evidence for an involvement of the lateral occipital complex during haptic imagery. In addition, Zhang et al. (2004) found that the vividness of visual imagery, as quantified through the Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973), correlated with the degree of haptic shape-selective activity in the right lateral occipital complex. The lateral occipital complex has previously been implicated in visual as well as haptic perception of familiar objects (Amedi et al., 2001; James et al., 2002). However, the relative involvement of vision in tactile tasks may be dependent on the task itself. For example, Merabet et al. (2004) reported that repetitive transcranial magnetic stimulation (rTMS) of the somatosensory cortex disrupted performance on a tactile task involving roughness but not distance judgements while application of rTMS to the occipital cortex disrupted tactile spatial judgements only.

These studies suggest that visual imagery can be associated with tasks requiring discriminative touch, particularly for object perception. Indeed, Klitzky et al. (1991) stated that participants overtly reported using visual imagery when making judgements of geometric or material properties of objects and a visuo-motor image of a hand interacting with the objects was evoked, particularly for difficult judgements of material properties. Other studies have similarly reported that participants experience visual imagery during haptic tasks (e.g., Sathian & Zangaladze, 2001), and possibly more often than they experience haptic imagery during visual tasks (Zhang et al., 2004). This suggests a close interaction between vision and touch but also an asymmetry in some cross-modal imagery of objects (Spence & Deroy, 2013).

Our findings provide some novel insights into the phenomenology of somatosensory and tactile mental imagery in the general population and raise important questions for future research on this topic. Firstly, although participants here were explicitly instructed not to use visual information when providing their ratings on both imagery tasks, it nevertheless remains possible, particularly for the TMI task, that visual images were generated when participants imagined the tactile qualities of each stimulus. Here, we found particularly vivid sensations for texture and surface compliance. This is consistent with reports that certain object properties are particularly salient during haptic exploration and form durable representations in memory (Klatzky et al., 1987; Murdoch, 1997), presumably facilitating subsequent reconstruction. Although vision can play a role in the perception of texture and surface compliance (Klatzky & Wu, 2014; Whitaker et al., 2008), vision is thought to contribute less to tasks involving judgements of material properties, which were the focus of the present study (e.g., texture, compliance and weight), compared to judgements of a spatial or geometric nature (e.g., orientation, size and shape; Klitzky et al., 1987, 1993; Klatzky & Wu, 2014). Although activation of visual cortical regions during haptic imagery has been documented (e.g., Newman et al., 2005; Schmidt et al., 2014; Uhl et al., 1994), the precise role for visual (and motor) imagery and the extent of cross-modal contributions to both tactile object imagery and somatosensory imagery remains an open question for future studies to address. For example, to disentangle the possible contributions of vision to tactile imagery, the present work could be extended by assessing the strength of visual imagery during active and passive tactile imagery and/or by examining tactile imagery in congenitally blind individuals.

Secondly, whether the ability to form vivid imagery is related to perceptual ability in touch is uncertain. The results of several studies suggest common, topologically congruent neural underpinnings between tactile imagery and tactile perception in terms of
activation patterns within somatosensory cortex (Schmidt & Blankenburg, 2019; Schmidt et al., 2014; Yoo et al., 2003), or within posterior parietal cortex (Chivukula et al., 2021). Indeed, directly contrasting the vividness of imagined somatosensory stimulation across each of the body parts, in a manner similar to that documented for veridical stimulation (Corniani & Saal, 2020; Myles & Binseel, 2007; Weinstein, 1968), could also help elucidate the role of cortical organisation in the somatosensory system on tactile imagery. Finally, further work is required to examine whether the vividness of tactile images is associated with variations in cortical excitability within somatosensory cortex, consistent with results from visual studies (e.g., Keogh et al., 2020). If so, imagery in the tactile domain may be a novel avenue for rehabilitation of tactile function following brain trauma or disease.

5. Conclusions

In sum, the ability to mentally represent tactile information in the absence of direct stimulation appears prevalent in the general population for active (haptic) and passive somatosensory sensations. The results of our rating studies suggest evidence for variations in the vividness of tactile mental imagery for active and passive touch. That is, the imagery ratings provided to different imagined objects and their properties varied significantly across these stimuli, suggesting that some object properties are more easily imagined through touch than others. Similarly, participants reported different levels of sensitivity to imagined touch across different regions of the body, with the results suggesting stimulus-specific effects rather than tactile perception across these sites. In addition, participants’ reported vividness of images of tactile object properties and tactile stimulation of different regions of the body were correlated, albeit weakly. The results of this exploratory study, based on a relatively large sample, helps shed further light on the characteristics of tactile imagery in the general population. In particular, the variability in responses across individuals suggests an ability to imagine tactile stimulation that could be objectively measured. Furthermore, these results suggest a potential functional role for tactile imagery in task-goals, similar to that proposed for imagery in other domains, notably vision.

CRediT authorship contribution statement

A. O’Dowd: Conceptualization, Methodology, Investigation, Writing – original draft, Formal analysis. S.M. Cooney: Conceptualization, Methodology, Investigation, Writing – review & editing. F.N. Newell: Conceptualization, Methodology, Investigation, Writing – review & editing, Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Declaration of interests

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.concog.2022.103376.

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