

Non-commitment in mental imagery

Eric J. Bigelow^a, John P. McCoy^{b,*},¹ Tomer D. Ullman^{a,1}

^a Department of Psychology, Harvard University, United States

^b The Wharton School, University of Pennsylvania, United States

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ABSTRACT

We examine non-commitment in the imagination. Across 5 studies ($N > 1,800$), we find that most people are non-committal about basic aspects of their mental images, including features that would be readily apparent in real images. While previous work on the imagination has discussed the possibility of non-commitment, this paper is the first, to our knowledge, to examine this systematically and empirically. We find that people do not commit to basic properties of specified mental scenes (Studies 1 and 2), and that people report non-commitment rather than uncertainty or forgetfulness (Study 3). Such non-commitment is present even for people with generally vivid imaginations, and those who report imagining the specified scene very vividly (Studies 4a, 4b). People readily confabulate properties of their mental images when non-commitment is not offered as an explicit option (Study 5). Taken together, these results establish non-commitment as a pervasive component of mental imagery.

1. Introduction

Please imagine the following scene, as vividly as you can:

A person walks into a room, and knocks a ball off a table.

Once you've imagined it, read on.

Consider the scene that you imagined. Did you imagine the color of the ball? What about the ball's size? Did you imagine the color of the person's hair, or the pattern of their clothes? Can you trace with your finger the trajectory that the ball took?

If you're like most people, you imagined some of these properties, but not others.

Perhaps you can confidently say the ball was red, and moved from left to right, but did not imagine the person's hair color, or clothes, or gender. You could fill in such details if needed, but they were not there to begin with.

In this paper, we study non-commitment in mental imagery. That is, we investigate the possibility that people do not represent basic properties of an imagined scene.

Non-commitment in the imagination has been discussed in philosophy of mind, and has played a theoretical role in debates about mental imagery, but there has been little empirical study of this topic.

Mental images have been a topic of intense study and debate in philosophy, neuroscience, cognitive science, and beyond. Researchers

have debated their format, cognitive development, neural underpinnings, and phenomenology. Mental images and the imagination also play a practical role, and recent research in marketing has studied their use in product design (Dahl, Chattopadhyay, & Gorn, 1999; DeRosia & Elder, 2019), and their affect on consumer choice (Jiang, Adaval, Steinhart, & Wyer Jr, 2014; Lee & Qiu, 2009).

In philosophy, Descartes suggested that mental images are similar to rough engravings (Cottingham, Stoothoff, Murdoch, Kenny, et al., 1985), in that they directly capture some aspects of an actual scene, but leave out crucial details. More recently, philosophers have discussed non-commitment, using a zoo of thought experiments that examined non-commitment to different properties in mental images, from speckled hens (Ayer, 1940) to bald men (Shorter, 1952), striped tigers (Dennett, 1986), and purple cows (Dennett, 1993). Such examples have also been used in discussion of the inexactness of perception, but that is not our focus here.

The notion of non-commitment in mental imagery has also played a small role in the ongoing debate over the format of mental images (the 'Imagery Debate'), although the phenomenon of non-commitment was not itself empirically established and studied.

Researchers on one side of the imagery debate have argued that mental images are propositional in nature, and that the subjective phenomenon of seeing images in the mind is epiphenomenal (Pylyshyn, 1973, 1978, 2002, 2003). On the other side, researchers have argued

* Corresponding author at: University of Pennsylvania, Philadelphia, PA, United States.

E-mail address: jpmccoy@wharton.upenn.edu (J.P. McCoy).

¹ Indicates equal senior authors.

that mental images have a depictive, picture-like format (Kosslyn, Pinker, Smith, & Schwartz, 1979; Kosslyn, Thompson, & Ganis, 2006; Pearson, 2019; Pearson & Kosslyn, 2015). Non-commitment has been used to argue against the pictorial-depictive view (Pylyshyn, 1978, 2002). Defenders of the pictorial view, however, have countered that the possibility of non-commitment need not rule out a depictive format for mental images. For example, Kosslyn et al., 2006 has claimed that supposed non-commitment is due to inattention or other cognitive limitations when reporting on mental images (which are themselves highly detailed), just as perceptual and cognitive limitations may prevent you from accurately counting the numbers of dots in a Styrofoam ceiling. Block, 1983 has argued that mental images are more like sketches than photographs, in which various details can be left unspecified. Outside of the mental imagery debate, it has recently been suggested that the default values of properties in imagined scenes explain why people fall prey to ‘stumpers’ (Bar-Hillel, Noah, & Shane, 2018), riddles whose solution falls outside the dominant construal of the scene set up by the riddle.

Regardless of the format of mental images, people vary in the self-reported vividness of their imagery, and various measures have been developed to study these individual differences (e.g. Andrade, May, Deeproose, Baugh, & Ganis, 2014; Hall, Pongrac, & Buckholz, 1985; McKelvie, 1995; Reisberg, Pearson, & Kosslyn, 2003; Sheehan, 1967). Here, we are concerned with non-commitment to the properties of a mental scene that should be readily apparent in a perceptual image depicting that scene, although we also examine the relationship between non-commitment and the self-reported vividness of a mental image.

But beyond reports of very low vividness, some people report that they lack a subjective experience of visual imagery entirely. This condition is known as ‘aphantasia’ (Dance, Ipser, & Simner, 2022; Galton, 1880; Keogh & Pearson, 2018; Zeman et al., 2020; Zeman, Dewar, & Della Sala, 2015). Non-commitment in mental imagery is different to aphantasia: in principle, a person may experience a visual mental scene of a ball rolling off a table without being committed to the color of the ball, while another person may know the ball is red, without the subjective experience of a mental image.

To empirically examine non-commitment, we conducted a series of studies similar in structure to the opening example of this paper. That is, people imagined a described scene, and were then asked whether specified properties were part of their mental image.

Throughout, we rely on people’s subjective reports, as has much of previous research on imagination and mental imagery (see, e.g. Kosslyn et al., 1979, 2006; Markman, Klein, & Suhr, 2012; Pylyshyn, 2002; Shepard & Metzler, 1971), but we are also excited by the potential of methods that do not rely on self-reports (e.g. Morales & Firestone, 2023).

Our first study establishes the basic phenomenon of non-commitment, using a single scene and set of properties. People report that their imagined scenes lack basic details and properties, ones that would be readily available in real images. Our second study replicates and extends the first study with four additional scenes. Our third study examines the possibility that people’s apparent non-commitment may instead reflect forgetfulness, uncertainty, or some other factor. Our fourth study examines the relationship between individual variation in non-commitment and individual differences in vividness. Our final study finds that when they are not given the explicit option of reporting non-commitment, people confabulate details of their imagined scenes.

2. Overall procedures and methods

In each study, participants were asked to imagine a specified scene, and were then queried, in various ways, about whether particular

properties were part of their mental image. The procedures for the five studies are summarized in Fig. 1. All studies, including experimental procedures, number of participants, exclusion criteria, and analyses, were pre-registered.² All data is available at the following OSF repository: https://osf.io/mzg42/?view_only=d0d4df289e42758825a77a4e63b2e9.

In the *visualize* phase of the studies, participants saw the instructions: “Please pause, and take a moment to imagine the following scene. Visualize it in your mind’s eye, as vividly as you can”, followed by a one-sentence scene description. Next, in the *probe* phase, participants saw, for studies 1 through 4, the prompt (on a separate page): “When you imagined the scene on the previous page, was the following part of your mental image?” followed by nine properties in random order. The probe in Study 5 was phrased differently.

All of the scenes involved a person taking a simple action (e.g., “puts”), the primary object of the action (e.g., “a piece of fruit”), and a secondary object (e.g., “bag”). The nine questions for each scene were chosen such that three questions asked about the person, three asked about the primary object, and three asked about the secondary object. The properties probed for each scene are shown in Fig. 1.

Participants for all studies were recruited online via Prolific, with the following qualifications: live in the United States, speak fluent English, and have completed at least ten studies with an acceptance rate of at least 98%.

At the end of each study, participants were asked, “Please describe, in a few words, what you were asked to do in this experiment?” As pre-registered, we excluded participants who did not answer with any variant of “imagine a scene and answer questions about it”, which included the exclusion of participants who gave responses such as “I don’t know”, “do an experiment”, or “give input”. If participants were excluded from analysis, we recruited additional participants so as to obtain the pre-registered sample size.

3. Study 1: do people report not imagining basic scene properties?

Our first study used a simple scene to demonstrate the phenomenon of interest: after being asked to vividly imagine a specified scene, many people report not having imagined properties of the scene that would be easily distinguishable in a real image.

3.1. Participants and methods

In Study 1, we recruited 200 participants. The average age of participants was 34.

Of the participants, 129 participants identified as female, 70 identified as male, and one did not identify a gender. No participants were excluded.

Participants were asked to visualize the following scene as vividly as they could: “A person walks into a room and knocks a ball off a table.” Next, on a separate page, participants were asked to consider the scene that they had imagined. For each of nine properties, participants selected either “Yes, it was part of my mental image”, or “No, it was not part of my mental image”. For example, participants were asked whether the color of the ball, the shape of the table, the trajectory of the ball, the hair color of the person, and so on were part of their mental image (see Fig. 1 for the list of nine properties).

3.2. Results

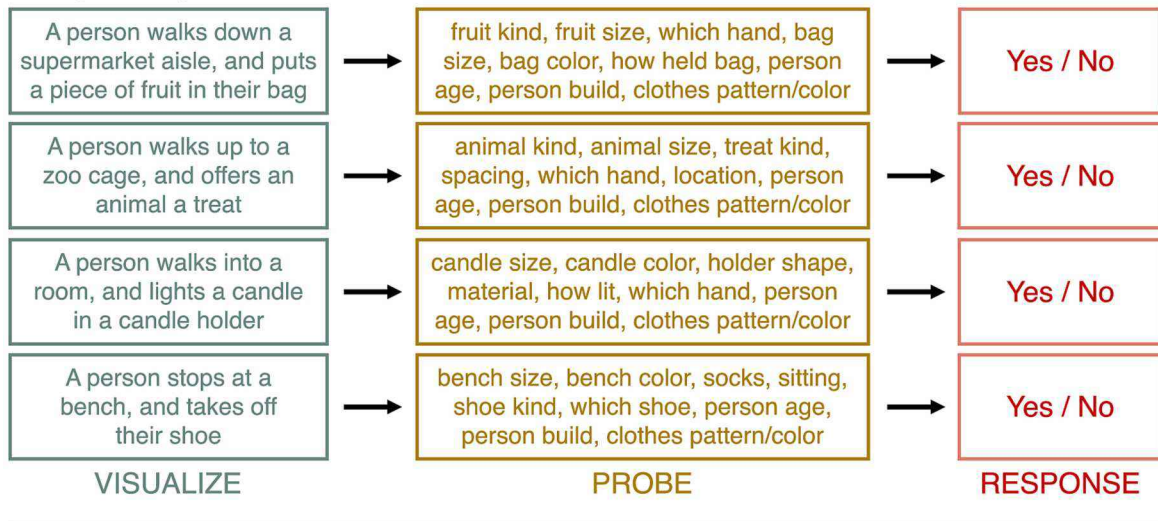
Fig. 2 shows the proportion of participants who reported that each property was not part of their mental image. For every property, the proportion of participants who reported that it was not part of their

² AsPredicted registration numbers: 78265, 84,737, 89,932, 93,941, 93,942, and 96,082

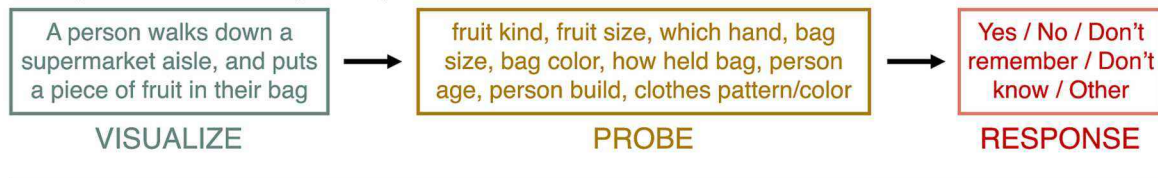
Study 1: Do people report not imagining basic properties?



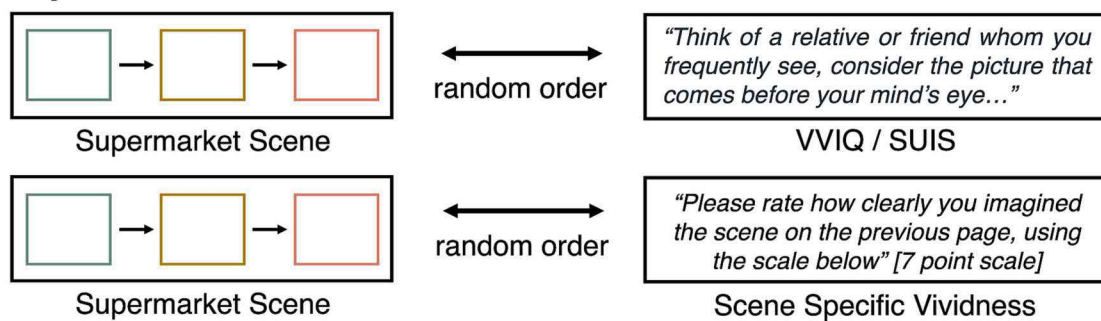
Study 2: Replication with Additional Scenes



Study 3: Non-Binary Responses



Study 4: Individual Differences



Study 5: Open-ended Responses



Fig. 1. Experiment flow for all studies. Participants visualized a scene, then probed about various items/properties and whether they were part of the mental image.

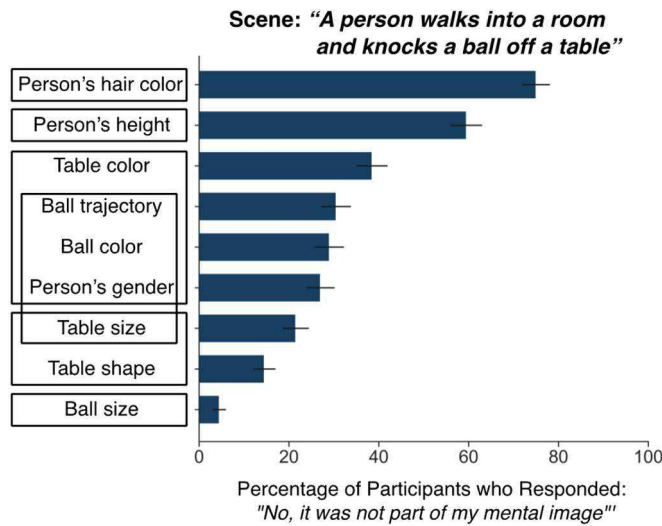


Fig. 2. Results of Study 1. Participants imagined the scene: “A person walks into a room and knocks a ball off a table”, then reported whether various properties were part of their mental image. Bars show the proportion of people who answered “No, it was not part of my mental image”. Error bars show standard errors. Properties for which the proportions are not significantly different are grouped together.

mental image was significantly different from 0.0 by a one-sided z-test of proportions (all $p < 0.001$, except for ball size, $p = 0.0011$). In Fig. 2, we group together properties that do not have a significantly different proportion of participants answering ‘No’ (using a McNemar test with $\alpha = 0.05$). For all z-tests of proportion and all McNemar tests, we correct for multiple comparisons with the Holm-Bonferroni method, as pre-registered.

For several of the properties, the proportion of participants who reported that the property was not included in their mental image was considerable. For example, only one in four participants reported that the person’s hair color was part of their mental image. For all studies, the Supplemental Material reports the proportion of participants who report not imagining each property, the standard error, and the p -value when comparing each proportion to 0.

As Fig. 3 shows, most participants answered ‘No’ to at least some properties. Specifically, 78% of participants answered ‘No’ for at least two properties. Moreover, the variation within participants suggests that

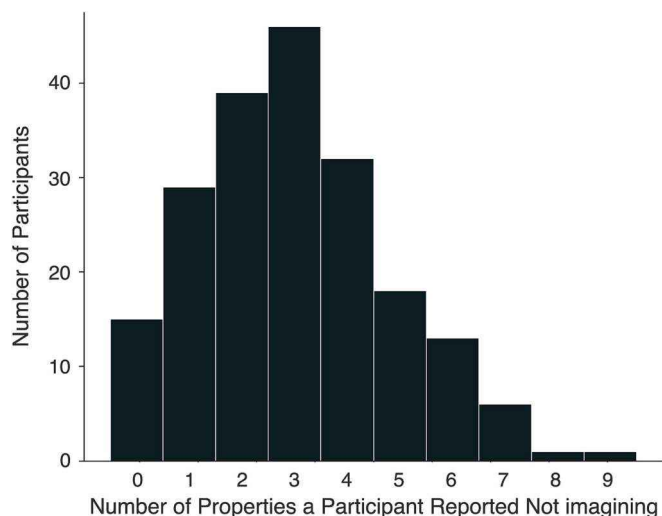


Fig. 3. The number of “No, it was not part of my mental image” responses across participants in Study 1.

they are not simply answering, with little effort or thought, ‘Yes’ or ‘No’ to all properties. Only one participant responded ‘No’ to all nine properties, and only one participant responded ‘No’ to eight properties.

There was no effect of the order in which properties were asked about on whether a participant reported that a property was not part of their mental image ($\beta = 0.01 [-0.03, 0.05]$, $p = 0.50$). We will return to this result in our discussion of the possible impact of memory on non-commitment.

4. Study 2: replication with additional scenes

To confirm our hypothesis that people do not imagine basic properties of their mental images, we replicated Study 1, using four additional scenes.

4.1. Participants and methods

We recruited 800 participants, each one randomly assigned to one of four scenes (zoo scene: $N = 201$, candle scene: $N = 201$, supermarket scene: $N = 198$, bench scene: $N = 200$). Two participants were excluded for failing the attention check. The average age of participants was 34. Of the participants, 531 identified as female, 262 identified as male, and 7 preferred not to indicate a gender.

Our second study used the same paradigm as Study 1, with each participant imagining one of four new scenes (see Fig. 1). The scenes were: (i) “A person walks up to a zoo cage, and offers an animal a treat”, (ii) “A person walks down a supermarket aisle, and puts a piece of fruit in their bag”, (iii) “A person walks into a room, and lights a candle in a candle holder”, and (iv) “A person stops at a bench, and takes off their shoe”. For each scene, participants were asked about nine simple properties.

4.2. Results

As shown in Fig. 4, participants reported not imagining basic properties in all four scenes. The proportion of ‘No’ answers was significantly different from 0.0 for every property in all four scenes, by a one-sided z-test of proportions (all $p < 0.001$). In Fig. 4, we group together properties that do not have a significantly different proportion of participants answering ‘No’ (using a McNemar test with $\alpha = 0.05$). Across all scenes and properties, 37% of responses were ‘No’. There was no effect of question order on whether a participant reported that a property was not part of their mental image ($\beta = -0.01 [-0.03, 0.004]$, $p = 0.12$). As in Study 1, most participants answered ‘No’ to at least some properties, and participants did not simply answer ‘No’ to all of the properties.

5. Study 3: probing for uncertainty and forgetfulness

In Studies 1 and 2, participants reported that they did not imagine basic properties of different scenes. However, it may be that when given a binary choice, participants opted for the “No, it was not part of my mental image” response, when they actually meant something else. Feelings of uncertainty, vagueness, and so on may lead participants to favor the ‘No’ response. In our third study, we gave participants multiple response options, to examine whether they selected the ‘No’ response due to the lack of adequate alternatives.

5.1. Participants and methods

We recruited 200 participants. Two participants were excluded due to failing an attention check. The average age of participants was 34. Of the participants, 137 identified as female, and 63 identified as male.

Study 3 used the supermarket scene and properties from Study 2. In contrast to the previous studies, participants were given multiple possible response option for each property: (“Yes, it was part of my mental image”, “No, it was not part of my mental image”, “I don’t know

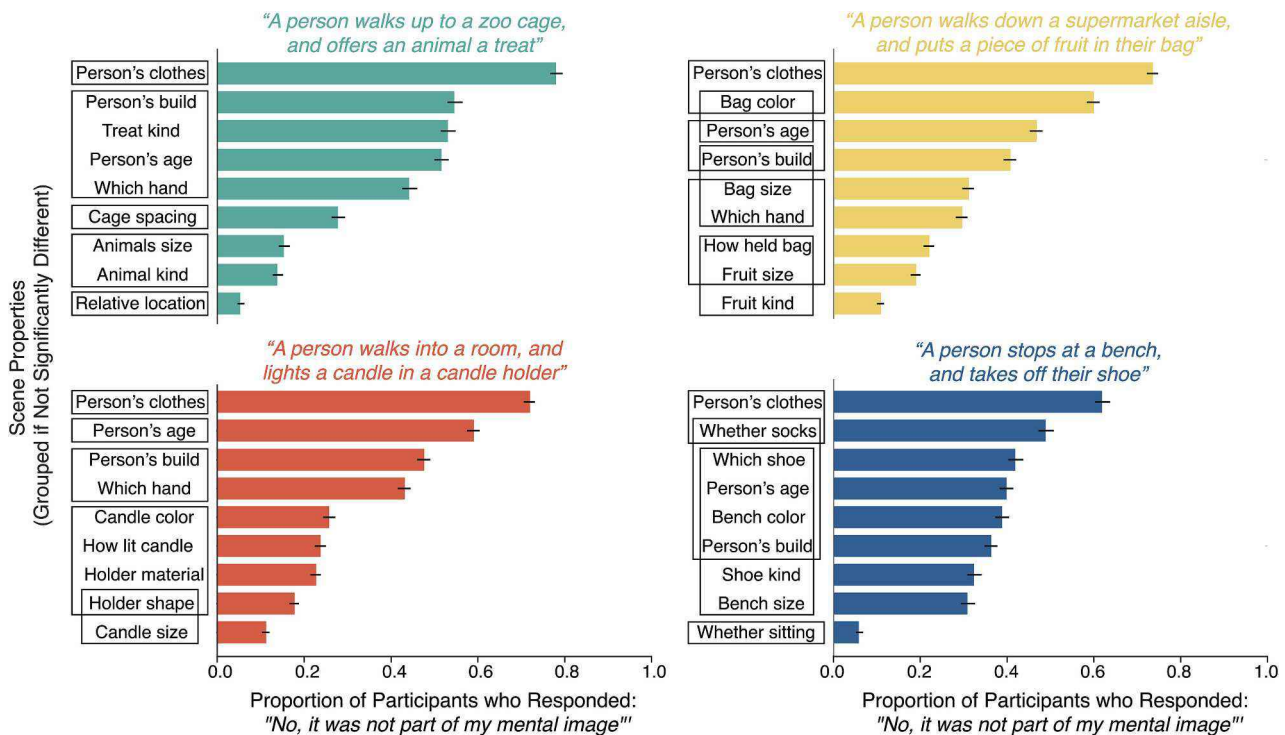


Fig. 4. Results of Study 2. Participants imagined one of four scenes, and reported whether various properties were part of their mental image. Bars show the proportion of people who answered ‘No, it was not part of my mental image’. Error bars show standard errors. Properties are grouped together if the proportions of participants answering ‘No’ are not significantly different.

whether it was part of my mental image”, “I don’t remember whether it was part of my mental image”, and “Other”.

5.2. Results

Even when given multiple options (including a blanket “Other” option), participant responses were similar to those in Study 2: 34% of the responses were “No”, and 62% were “Yes”. Participants made little use of the additional options: “I don’t know” accounted for only 3% of responses, “I don’t remember” for 1%, and “Other” for 0.1%.

At the property level, participant responses were also similar to those in Study 2 (see Supplemental Materials). For all properties, the proportion of participants who answered ‘No’ was significantly different than 0.0 (all $p < 0.001$). There was again no effect of question order on whether a participant reported that a property was not part of their mental image ($\beta = -0.02 [-0.06, 0.02]$, $p = 0.31$).

6. Study 4: non-commitment and existing mental imagery metrics

We next study the relationship between how vividly people report imagining mental scenes, and the extent to which people do not commit to properties of their mental scenes. In particular, we examine whether even people who report most vividly imagining mental scenes also report non-commitment. We used both established measures of individual differences in overall vividness for mental imagery (Study 4a), and a direct measure of self-assessed scene clarity for the specific scene people imagined (Study 4b).

6.1. Participants and methods

Studies 4a and 4b again used the supermarket scene and properties from Study 2.

In addition, participants answered questions either about the vividness of their imagination in general (Study 4a), or the clarity of the

supermarket scene in particular (Study 4b). Since Study 3 demonstrated that participants seldom chose options other than ‘Yes’ and ‘No’, we used only binary response options.

For Study 4a, we recruited 300 participants. Two participants were excluded for failing an attention check. The average age of participants was 36. Of the participants, 194 identified as female, and 106 identified as male. For Study 4b, we recruited 201 participants. One participant was excluded for failing an attention check, and data for an extra participant was collected due to an error. The average age of participants was 34. Of the participants, 139 identified as female, and 62 identified as male.

In Study 4a, participants answered the Visual Vividness in Imagery Questionnaire (VVIQ) (Marks, 1973), and the Spontaneous Use of Imagery Scale (SUIS) (Reisberg et al., 2003). The order of VVIQ and SUIS was randomized, as was whether participants first answered the individual difference measures, or first imagined the scene and answered questions about its properties. The standard VVIQ scale consists of 16 questions on a 5-point vividness scale to give a minimum of 16 and a maximum of 80. Scores below 25 are sometimes taken to indicate aphantasia, and scores above 75 to indicate hyperphantasia (A. Zeman et al., 2020). The SUIS scale consists of 12 questions (each on a 5-point scale) about the frequency of imagery experiences in everyday life, for a minimum of 12 and a maximum of 60.

In Study 4b, after being asked to imagine the supermarket scene as vividly as they could, participants were asked “Please rate how clearly you imagined the scene on the previous page, using the scale below”, and responded on a 7-point scale, from “Not clearly at all” to “Very clearly”. Participants were asked this question on a separate page before being asked about properties of their imagined scene.

6.2. Results

Fig. 5 shows the relationship between the number of properties a participant reported that they did not imagine, and their SUIS and VVIQ scores (SUIS: $\rho(298) = -0.25$, $p < 0.001$; VVIQ: $\rho(298) = -0.32$, $p <$

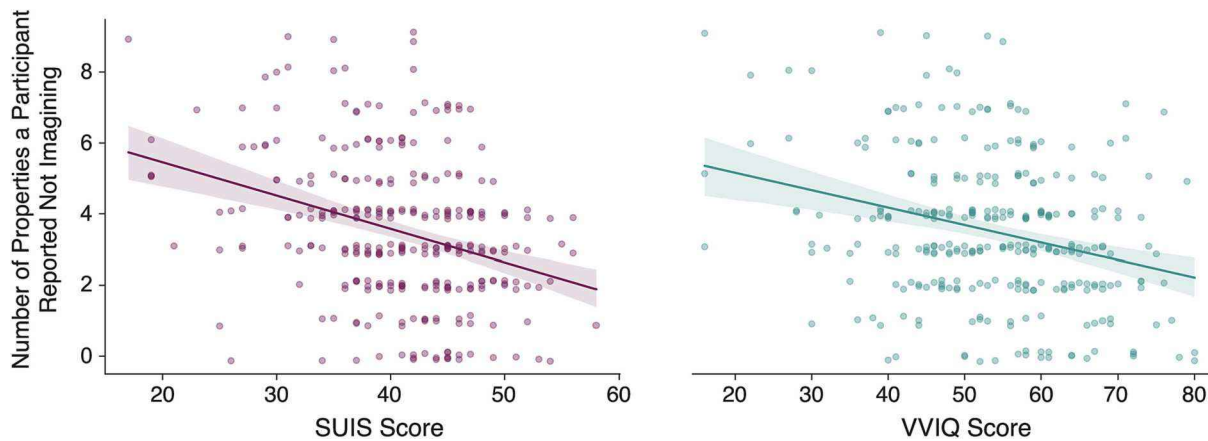


Fig. 5. Study 4a Results. The relationship between the number of properties a participant reported not imagining in a scene, and their SUIS score (left), or VVIQ score (right). Lines show best linear fits.

0.001). There was a low correlation between the number of ‘No’ responses and the scene-specific clarity rating ($\rho(298) = 0.18, p = 0.01$).

We analyzed whether participants with high scores on one of the individual difference measures reported not imagining properties of the scene. As pre-registered, we examined participants in the top quartile of SUIS scores ($SUIS \geq 46$, 75 participants) and those in the top quartile of VVIQ scores ($VVIQ \geq 61$, 81 participants) in Study 4a. We also examined participants who rated the scene clarity as a 6 or 7 (142 participants) in Study 4b. As Fig. 6 shows, even such participants report not imagining properties of the scene: the number of their ‘No’ responses was significantly different from 0.0 across all nine questions ($p < 0.001$) by a one-sided z-test of proportions.

For both Study 4a and Study 4b, there was again no effect of property order on whether a participant reported that a property was not part of their mental image (Study 4a: $\beta = 0.01 [-0.02, 0.04], p = 0.35$, Study 4b: $\beta = 0.01 [-0.02, 0.05], p = 0.50$). In Study 4a, VVIQ scores were lower when the VVIQ questionnaire was presented after participants imagined the supermarket scene ($t(298) = -3.2, p = 0.002$). No order effect was found for SUIS scores ($t(298) = -0.13, p = 0.9$), or the number of ‘No’ responses ($t(298) = 0.76, p = 0.45$).

7. Study 5: open-ended responses

In all the studies so far, many participants reported non-commitment

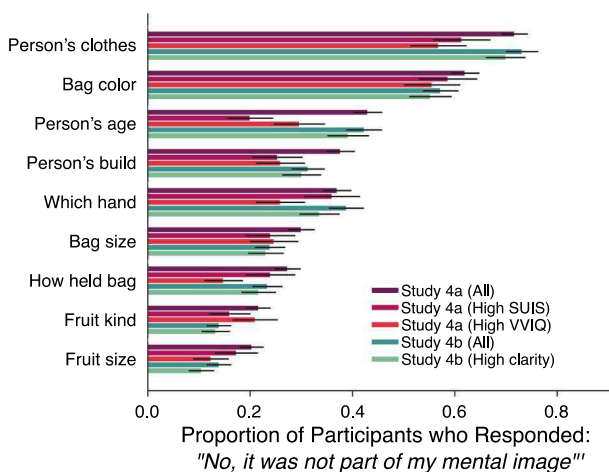


Fig. 6. Results of Studies 4a and 4b. The proportion of ‘No’ responses for each property from all participants in each experiment, as well as from the top SUIS quartile, top VVIQ quartile, and those with high self-reported scene clarity. Error bars show standard errors.

when explicitly given the option to do so. This is in contrast to the intuition that people can often report rich details of their mental scenes. To probe this contrast, we asked people to describe aspects of an imagined scene in an open-ended way. In principle, people may use this open-ended format to report non-commitment. But, the pragmatics of being asked to describe a given property may lead people to confabulate many of the details of a scene.

7.1. Participants and methods

We recruited 150 participants, and excluded one due to missing data. The average age of participants was 34. Of the participants, 98 identified as female, and 52 as male.

Study 5 again used the supermarket scene and properties from Study 2.

Participants were asked to visualize the scene as vividly as they could. On a separate page, participants were instructed, “When you imagined the scene on the previous page, please describe the following aspects of your mental image”. Participants responded using open text boxes for each of the nine properties.

We coded participant responses by whether or not they gave a specific description of the property. Answers such as “none”, “I don’t know”, “I can’t remember”, “N/A”, “I didn’t think about it”, and so on were coded as non-specific.

7.2. Results

As Fig. 7 shows, participants overwhelmingly gave specific descriptions of the scene properties. For the person’s clothes, 144 of the 150 participants described a specific color, pattern, or article of clothing. For five of the properties, 149 of the participants gave a specific answer, and for the remaining three properties all 150 participants gave a specific answer.

8. Discussion

After being asked to imagine scenes such as a person knocking a ball off a table, or a person putting fruit into a bag, participants were asked whether they had imagined various basic properties of the scenes, such as the color of the table, or the shopper’s clothes. The questions were about simple scenes, and properties that would be easily perceivable in real images. Many participants reported that, in fact, such properties were not part of their mental images. We suggest that this non-commitment is pervasive (unlike aphantasia, which is present in only approximately 4% of the population, Dance et al., 2022). Giving participants options beyond a “Yes/No” response for whether a property

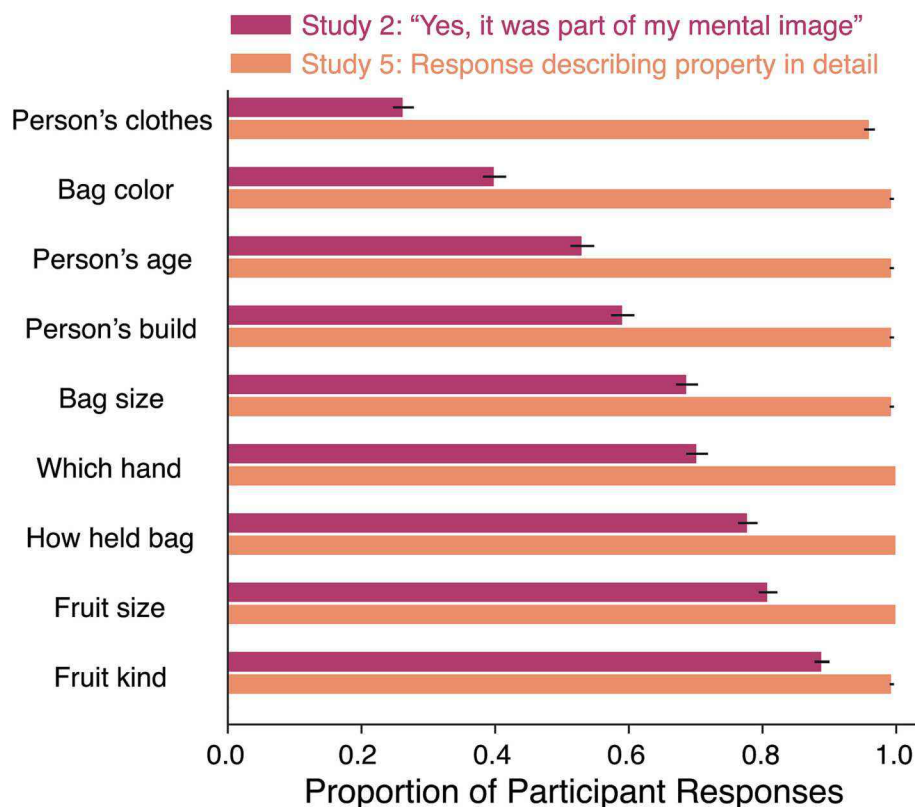


Fig. 7. Results of Study 5. Participants imagined the supermarket scene, and were asked about different properties with an open-ended question. For each property, the lower bars (coral) show the proportion of responses that included specific descriptions of the property, as opposed to “not sure”, “none”, “didn’t think about it”, and so on. The results of Study 2 for the same scene are included for comparison: the upper bars (maroon) show the proportion of participants that reported “Yes, it was part of my mental image”. Error bars show standard errors. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

was part of their scene (“I don’t know”, “I don’t remember”, and “Other”) made little difference: only a tiny fraction of participants chose these other options.²³

Non-commitment is not driven by a small subset of participants: almost everyone reports that there are properties of the scene that they do not imagine. This includes participants in the top quartile on standard scales that measure individual differences in the overall vividness of one’s mental imagery (Marks, 1973; Reisberg et al., 2003), and participants who rated the clarity of their specific imagined scene as a 6 or 7 (on a 7-point scale) before they were asked questions about it. Thus, at least some participants treat vividness differently to non-commitment (see Kind, 2017, for a discussion).

When asked to describe particular properties of a mental scene, without the explicit option of non-commitment, essentially all participants offer rich descriptions. This is in stark contrast to Studies 1–4. For example, only approximately 25% of participants in Studies 1–4 report that they imagined the person’s clothes. However, when instead given an open prompt (in Study 5) to “describe the clothes”, nearly 100% of participants give descriptions, ranging from “solid red shirt, blue jeans” to “long trench coat type jacket that’s tan, button up pink blouse underneath, waist-high jeans and black boots with a zipper on the sides and decorative corset-type string pattern on the fronts”. We suggest that when people are not given the explicit option to report that they did not encode properties of the scene, they confabulate details. This confabulation may result from people re-activating their original mental image

²³ We’ve also often asked non-commitment questions in-person. Mostly these were posed to other psychologists, as they’re the ones willing to put up with us. Anecdotally, people do not seem to notice their own non-commitment until it is pointed out. When asked about a basic property that they didn’t imagine, a common reaction is “Huh!” followed by a snicker, rather than something like “Obviously there are lots of properties I didn’t imagine”. This sentiment was echoed by a participant who commented, “So when I saw that some details you asked about I didn’t even think about, that kinda blew my mind a bit.”

and adding details to it on demand, or from people creating a new mental image and adding the necessary details to it. Either way, these results are in line with the confabulation found in other research, for example on false memory and on the post-hoc reasons people give for their decisions (Hirstein, 2009; Johnson & Raye, 1998; Nisbett & Wilson, 1977).

We next consider four alternative explanations that do not assume non-commitment, and point out challenges to such alternatives. One alternative account is that when some participants answer “No, it was not part of my mental image” they actually mean something else, for example that they do not understand the task. This is unlikely, since even when provided with options that would let them express confusion and the like (Study 3), participants reported that they did not imagine the property.

Another alternative account is that participants did imagine the properties, but then forgot them. While we cannot definitively rule out such a memory account, various factors argue against it. First, only about 1% of responses were “I don’t remember whether it was part my mental image” when given this as an option (Study 3). This suggests that people at least do not have awareness that they may have forgotten. Second, we note that the time between imagining a scene and reporting on its properties was very short. Finally, a memory account would suggest that properties asked about later are less likely to be remembered, and so more likely to be reported as non-committed. However, the order in which the properties were presented had no effect on the size of non-commitment in any of the studies. Closely related to this alternative, is the possibility that people fully imagine the scene, but do not commit all of its properties to working memory in the first place. The lack of order effects may then not be relevant.

A third alternative is that the results are due to survey answering biases or carelessness. However, much research on acquiescence bias shows that when asked ‘Yes/No’ question people tend to answer ‘Yes’ as the default answer (Schuman & Presser, 1996), whereas in our studies it is ‘No’ that reflects non-commitment. Furthermore, an analysis of our

results at the participant level shows that individual participants do not simply answer all 'No', but rather respond 'No' for particular properties across studies and scenes.

A fourth alternative concerns a different interpretation of the mismatch between the results of Studies 1–4 (pervasive non-commitment) and Study 5 (approximately zero non-commitment): it is possible that Study 5 correctly reflects that people richly imagine scenes, whereas Studies 1–4 produce confabulation. But this alternative does not account for why, if a person fully imagines an individual's clothes (and when asked to describe them truthfully reports 'tight neon pants with floral patterned shirt'), they answer 'No' to a simple binary question about whether they imagined the clothes. By contrast, people are known to confabulate when asked open-ended questions that imply that they know the answer (Hirstein, 2009; Johnson & Raye, 1998; Nisbett & Wilson, 1977).

We next consider the potential implications of our results for the ongoing debate on mental imagery. Non-commitment was originally discussed as an argument against the pictorial view (Pylyshyn, 1978, 2002), and our results thus seem to speak against the pictorial view in that we found pervasive non-commitment. In an important response to the original argument, Kosslyn et al. (2006) proposed that non-commitment simply reflects the same limitations present in perception (it is difficult to report how many stripes a tiger has, whether real or imagined), and so does not present a problem for the pictorial view. However, the non-commitment that we found involves basic properties, of the kind that are readily distinguishable in real images.

While our results are consistent with a propositional account of imagery, this is not the only possibility. Consider a scene-construction algorithm that proceeds in a hierarchical fashion from a propositional statement (for example, 'Pushes(Person, Ball)') to a rendered image (Battaglia, Hamrick, & Tenenbaum, 2013; Ullman, Spelke, Battaglia, & Tenenbaum, 2017). Such an algorithm could answer questions about the scene, such as the approximate location, orientation, trajectory, and shape of entities, without reaching the rendering stage (Bass, Smith, Bonawitz, & Ullman, 2021; Li et al., 2022; Smith et al., 2019). This is similar to models of 'lazy evaluation' in computer science (Henderson & Morris Jr, 1976), which evaluate expressions only when needed. Approximate simulations like these encode analogical details beyond the original propositional statement, and allow for commitment to some properties (e.g., position), without being committed to other properties (e.g., color). This account partially overlaps with Block's 'sketch' account (Block, 1983), but a sketch could be fully rendered, whereas the account above could terminate prior to rendering.

Our results may be of interest to discussions in philosophy on the phenomenology of the imagination. Building on discussions about the meaning of 'vividness' in imagery (e.g. Cornoldi et al., 1991; Denis, 1995), Kind has questioned its usefulness, and argued that it is not captured by the amount of imagined detail (Kind, 2017). Our empirical results also support a distinction between measures of vividness and non-commitment. Another debate concerns the similarity between the phenomenology of perception and imagination (see e.g. Martin, 2002; Noordhof, 2002). Within this debate, Nanay gives a 'similar content' account (Nanay, 2015, 2016) that explains how perceptions and visual images can have the same content, while allowing for images to not specify certain details. Brogaard and Gatzia (2017) build on this discussion, and propose an amendment to the pictorial model that maintains a depictive view, while allowing for a dissociation between vision-for-recognition and vision-for-action in imagination. Our results are in line with these proposals in that they show empirically that mental images can lack in basic properties that should be clear in perception.

Beyond contributing to various debates over the format of mental imagery, we hope our work spurs further research in cognitive science on the content of imagery. Put differently, when one imagines a ball, it is important to consider whether the format of that representation is more like a sentence or more like a picture, but it's also interesting to ask about the color of the ball, when and why people say they didn't bother

thinking about it, and why so many people say 'red'? While our studies have demonstrated pervasive non-commitment, more people committed to some properties than others. For example, across our studies, few people committed to the clothes of a person, whereas most people committed to properties such as size and shape. This raises several interesting questions for future research. What kind of properties do people commit to, and why? Are people more likely to commit to an entity that is active rather than passive, or to spatial properties rather than texture? How do factors such as how familiar or personal a scene is to a respondent, its complexity, and the specific imaginative task affect non-commitment? Additionally, instead of asking about particular properties of the scene, one could ask people to freely describe the overall scene, and analyze which properties are mentioned.

We relied throughout on subjective reports, but there are other exciting possibilities for future research. In particular, one could borrow recent tools used by vision science to probe mental imagery (Morales & Firestone, 2023), for example priming and binocular rivalry (Pearson, Clifford, & Tong, 2008), or pupillometry (Kay, Keogh, Andrillon, & Pearson, 2022), to study non-commitment specifically. Future research should also directly compare the properties that people commit to in imagined scenes, with the properties people remember after viewing the corresponding actual images or videos.

Mental images fill our daydreams, fuel our fancies, and color our memories. People often experience these images as richly detailed, making the imagination seem like a talented artist quickly painting a lifelike scene before our mind's eye. Our results suggest that while the imagination may indeed be a good artist, it's on a deadline, and stingy about paint.

Author note

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CRediT authorship contribution statement

Eric J. Bigelow: Methodology, Data curation, Formal analysis, Investigation, Writing – original draft, Visualization. **John P. McCoy:** Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Visualization, Supervision. **Tomer D. Ullman:** Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Visualization, Supervision.

Data availability

All data is available at the following OSF repository: https://osf.io/mzg42/?view_only=d0d4dfeb289e42758825a77a4e63b2e9.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.cognition.2023.105498>.

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