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Why Successful Performance in Imagery Tasks Does Not Require the Manipulation of Mental Imagery

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Abstract

Nanay (2017) argues for *unconscious* mental imagery, *inter alia* based on the assumption that successful performance in imagery tasks requires the manipulation of mental imagery. I challenge this assumption with the help of results presented in Shepard and Metzler (1971), Zeman et al. (2010), and Keogh and Pearson (2018). The studies suggest that imagery tasks can be successfully performed by means of cognitive/propositional strategies which do *not* rely on imagery.

Keywords: mental imagery; mental rotation; aphantasia; pain; unconscious imagery.

1. Introduction

Nanay (2017) argues that pain perception is a mixture of sensory stimulation-driven perception and mental imagery. He construes neural activity in the primary and secondary somatosensory cortices and the anterior cingulate cortex as pain-related mental imagery. His understanding of mental imagery involves the claim that mental images can be unconscious, a claim that is *prima facie* counterintuitive because the paradigmatic case of mental images is the visualization of images (with one's eyes closed), and such images seem to be things of which we are always conscious.

2. Mental Imagery

In the *Stanford Encyclopedia of Philosophy* (SEP) entry for "Mental imagery," three different senses of the expression "mental imagery" (or "mental images") are given:

A. quasi-perceptual conscious experience *per se*;
B. hypothetical picture-like representations in the mind and/or brain that give rise to (A);
C. hypothetical inner representations of any sort (picture-like or otherwise) that directly give rise to (A) (see Thomas, 2018).

The author of the SEP article, Nigel Thomas, argues that we should define mental imagery in terms of (A) because in this way we can distinguish mental images from other cognitive phenomena, while at the same time staying neutral on the controversial nature of mental imagery.[1] If we follow Thomas, then mental images are per definition something of which we are conscious (see also Thomas, 2009, p. 447).[2]

In accordance with (A), Nanay introduces the notion of mental imagery in an early paper from 2010 by adopting a definition by psychologist Alan Richardson, according to which "[m]ental imagery refers to all those quasi-sensory or quasi-perceptual experiences of which we are […] consciously aware, and which exist for us in the absence of those stimulus conditions that are known to produce their genuine sensory or perceptual counterparts…" (Richardson, 1969, p. 2, cited in: Nanay, 2010, p. 249). Back then Nanay

[1] Since the 1970s, cognitive scientists and philosophers have engaged in the so-called "analog-propositional debate," and argue whether phenomena such as mental rotation (Shepard and Metzler, 1971) and mental scanning (Kosslyn, 1973, 1975, 1976) are better explained by assuming that the mental representations that we experience as imagery have intrinsic spatial properties and should therefore be considered picture-like, or whether these phenomena are better explained by assuming that the relevant mental representations are like linguistic descriptions (of, for example, visual scenes). Stephen Kosslyn is most famous for arguing for the former, "analog" camp, whereas Zenon Pylyshyn is the most prominent advocate of the latter, "propositional" camp. Even though Kosslyn (1994) claimed that his quasi-pictorial account of mental imagery, which started as a computational model (Kosslyn, 1980) and in the meantime became a neurological one (Kosslyn et al., 2001), won the analog-propositional debate, opponents like Pylyshyn (1981, 2002, 2003b) keep on criticizing inter alia that the quasi-pictorial account looks plausible only because its notion of picture is used ambiguously and thus incoherently.

[2] This is also in accordance with how Brogaard and Gatzia (2017) use the term "mental imagery" in the narrow sense. Brogaard and Gatzia use "mental imagery" in a broad and in a narrow sense. In the broad sense, it refers to "both re-experiences of an original stimulus as well as imagination" (Brogaard and Gatzia, 2017, p. 1, n. 1). In this broad sense, mental imagery comprises a variety of forms, sometimes involving the formation of particular mental images, sometimes involving having a propositional attitude with a particular content ("propositional imagery"), and sometimes both. But in a narrow sense, "mental imagery" refers only to "the maintenance of a stable conscious representation in the absence of (relevant) sensory stimuli" (p. 3), that is, to a re-*experience* of an original stimulus. Used in this narrow sense, mental imagery is thus necessarily something of which we are conscious. Brogaard and Gatzia do hold that there can be unconscious "imaginings" (p. 6), but these imaginings are not included in the mental imagery in the narrow sense.

implicitly accepted that mental imagery is something of which we are (always? necessarily?) conscious.[3] However, he has since changed his mind[4] and now defends the claim that we are not always conscious of mental images.

In his 2017 paper, he suggests that the view that mental images are something we are always conscious of is based on ignorance, given that he now distinguishes between the everyday concept of mental imagery used by (ignorant) philosophers and folk, and the scientific concept of mental imagery allegedly used by (knowing) psychologists and neuroscientists. Nanay does not dwell on the everyday concept, but I take it that it is based on such paradigm examples as visualizations, dreams, and episodic memories. In the everyday concept, mental imagery is defined from a first-person perspective and hence is necessarily something of which the subject is conscious (in the sense of access consciousness). By contrast, the scientific concept of mental imagery refers to "early perceptual processing that is not triggered by corresponding sensory stimulation in the relevant sense modality" (Nanay, 2017, p. 486).[5] The concept is thus defined in neurophysiological terms, and hence is not necessarily something of which the subject is conscious (p. 488).[6]

Now, Nanay had the option to claim that the everyday and the scientific concepts of mental imagery simply refer to *different* things, and that his claims are not claims about mental

[3] The full definition by Richardson is the following: "Mental imagery refers to (1) all those quasi-sensory or quasi-perceptual experiences of which (2) we are self-consciously aware, and which (3) exist for us in the absence of those stimulus conditions that are known to produce their genuine sensory or perceptual counterparts, and which (4) may be expected to have different consequences from their sensory or perceptual counterparts." (Richardson, 1969, pp. 2–3; italics in the original). The part omitted in Nanay's citation is (being) "self-" (consciously aware of something), which Richardson defines as the ability of the subject to report on what he has "perceived" (Richardson, 1969, p. 3).

[4] In a paper from 2015 Nanay again cites Richardson's definition to introduce the term "mental imagery," but this time omits point (2) in Richardson's original definition (see last footnote), i.e. the reference to consciousness (Nanay, 2015, p. 1724).

[5] In the quote above, Nanay does not make a metaphysical claim *per se*, but only a linguistic one. The full quote goes, "What psychologists and neuroscientists *mean by* mental imagery is early perceptual processing that is not triggered by corresponding sensory stimulation in the relevant sense modality" (2017, p. 486; italics added). Still, from the other passages in his paper, it becomes clear that he wants to claim what mental images *are*, not just what some people mean by "mental image." For example, Nanay writes, "This way of thinking about mental imagery needs some unpacking. First, mental imagery *is* not necessarily visual: there is …" (p. 486; italics added); "some other instances of perceptual processing—mental imagery—are not…" (p. 486); "there are cases (e.g., phantom limb pain and the thermal grid illusion) where pain perception is fully constituted by mental imagery (*that is*, by pain processing that is not triggered by nociceptors)." (p. 485; italics added); "The earlier stages of this line of [neural] processing are more clearly perceptual than the later ones. And we can safely assume that cortical processing is perceptual processing. If we have such early cortical processing but no corresponding sensory stimulation, we clearly have (visual) mental imagery" (p. 487); "mental imagery, the way psychologists and neuroscientists use the term, *is* not necessarily conscious" (p. 488; italics added); "If there is perceptual processing in these [brain] regions that is not triggered by retinal input, we have to talk about mental imagery." (p. 490).

[6] Nanay does not make explicit whether by "conscious" he refers to access or phenomenal consciousness. I assume that Nanay's claim refers to a possible lack of access consciousness.

imagery as understood by folk and philosophers; however, this is not what Nanay did. He wants to revise the everyday concept of mental imagery and convince us that mental imagery can thus be unconscious.

One problem with Nanay's suggestion is that it is imprecise regarding the exact relationship between neural processing and the quasi-perceptual conscious events to which it arguably gives rise. For example, Nanay does not make explicit whether he holds that mental images are *identical* to certain neural activity, or whether he holds a weaker metaphysical claim about mental images, say, that they *supervene on* such neural activity. Even though some remarks suggest the stronger claim, I am going to assume that Nanay holds the weaker claim. First of all, we lack the neurophysiological evidence to make such a bold psycho-neurophysiological identification. In the case of pain, for example, a meta-analysis by Apkarian et al. (2005) shows that even though one could claim that the six brain areas most commonly mentioned in neurological pain studies (namely ACC, S1, S2, IC, Th, and PFC) constitute important brain areas involved in the formation of pain sensations, there are too many differences across studies to conclude that the neural correlate of pain sensations has been found. Likewise, we have not reached a consensus on the neural correlates of pain-related mental imagery.

Secondly, if we attribute the stronger claim to Nanay, then it is trivially true that we are not necessarily conscious of mental images. That is, if mental images are identical to neural activity, then surely we do not have access (and phenomenal) consciousness of mental images, since we are not conscious of our neural activity. By contrast, the claim that mental images supervene on certain neural activity retains the idea that mental images are phenomenal states to which we can (but also may not) have access consciousness. This claim is much more interesting, and it will be the one I attribute to Nanay.

3. Evidence for *Unconscious* Mental Imagery?

Nanay's main evidence for his claim that mental imagery can be unconscious consists in the fact that

> there are subjects (and in fact, surprisingly many of them) who have no conscious experience of mental imagery whatsoever, and at least some of these subjects are still capable of performing tasks that are assumed to require the manipulation of mental imagery—for example, the mental rotation task (Zeman et al., 2007, 2010, 2015). (Nanay, 2017, p. 488)

The subjects Nanay refers to are called "aphantasics." These are otherwise healthy people who lack the experience of visual and/or other mental imagery. Nanay's argument for unconscious mental imagery can be rephrased in the following way:

I. Successful performance of imagery tasks requires the manipulation of mental imagery.
II. Aphantasics have no conscious mental images.
III. Aphantasics successfully perform imagery tasks.
IV. Aphantasics use (and thus have) unconscious mental images.

In the rest of my paper, I am going to argue that premise (I) is false, and thus that the argument is not sound. Accordingly, the fact that aphantasics perform normally in imagery tasks does not prove that there is unconscious mental imagery.

Let's look at the alleged evidence for unconscious mental imagery. Nanay referred to three papers by Zeman et al., of which only the 2010 article is relevant. In Zeman et al. (2010) the authors demonstrate that a person, called "MX," who lost his ability to voluntarily generate and sustain conscious mental images, can nevertheless successfully perform imagery tasks, such as the mental rotation task (see below). Nanay assumes that this requires the manipulation of mental imagery, but this is not the only possible account. There are at least two ways to explain MX's successful performance in imagery tasks:

1. MX uses imagistic means but is unaware of it.
2. MX uses cognitive means (e.g. propositional processes and tacit knowledge).

There are two pieces of evidence which argue against explanation (1). First, there is the behavioral evidence which made Zeman et al. (2010, p. 154) themselves reject (1). In two behavioral tests (mental rotation task; Brooks' tasks) MX's performance qualitatively differed from the performance of normal subjects. This suggests that the mechanisms responsible for MX's performance differ from the mechanisms used by normal subjects to perform these tests: whereas normal subjects accomplish such tests by manipulating mental imagery, MX seems to use some other technique. I will describe each test and show how exactly MX's performance differed from normal subjects.

4. The mental rotation task

In the mental rotation task (Shepard & Metzler, 1971), subjects are presented with 3D objects comprising 10 cubes joined in different configurations. The participants have to decide whether two adjacent objects are identical or not. In the 1971 study, the adjacent objects could either be brought into congruence by rotation in the picture plane (see fig. 1), by rotation in depth, or they could not be brought into congruence by any rotation (and are thus not identical).

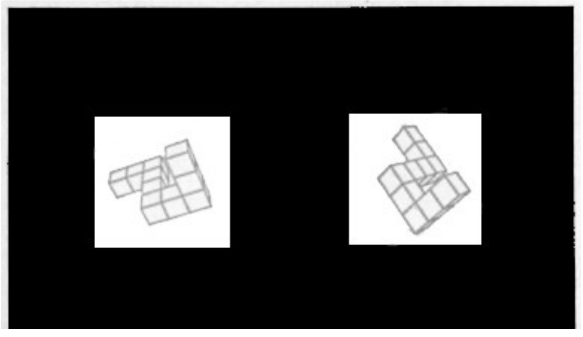

Figure 1

Shepard and Metzler (1971, p. 701) found that the reaction time (in the *identical* pair drawings) increases *linearly* with the angular difference in the portrayed orientation. In other words, the more the first object had to be rotated in order to be congruent to the other one, the longer the subjects needed to recognize their identity. Except for an angular difference of 100° and 180° between the two 3D objects, the same is true for the normal control subjects tested by Zeman et al. (2010, pp. 151–152). By contrast, MX's response time is *not* a *linear* function of the angular difference in the portrayed orientations of the two 3D objects (see figure 2). The difference in the functions suggests that MX is using a different strategy from the control participants to perform the task.

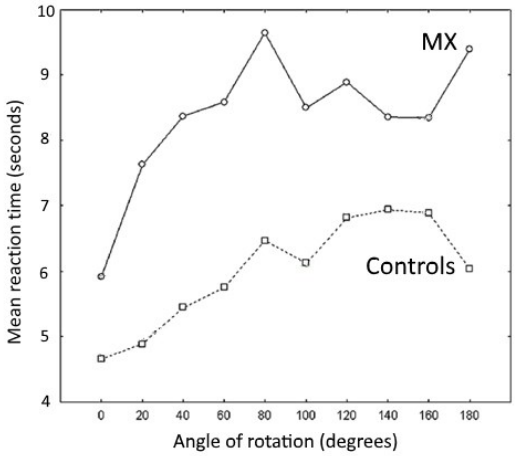

Figure 2

What kind of strategy might that be? One plausible suggestion comes from Pylyshyn's account of what is going on in such a task. Pylyshyn (1979, p. 25; 2002, p. 165) rejects accounts according to which participants rotate the whole figure as a rigid form through a continuum of angles. Rather, he points to several studies which suggest that the test subjects compare salient *features* of the two items involved, and thus analyze the items rather than perform a holistic operation. In general, Pylyshyn claims that in order to accomplish imagination tasks such as the mental rotation task or scanning mental images (Denis & Kosslyn, 1999), subjects simulate real processes, and hence use cognitive means based on their knowledge of past events:

> when asked to imagine something, people ask themselves what it would be like to see it, and they then simulate as many aspects of this staged event as they can and as seem relevant. […] [This explanation] appeals only to the tacit knowledge that people have about how things tend to happen in the world, together with certain basic psychophysical skills. (Pylyshyn, 2003a, p. 114)

I do not suggest that Pylyshyn's proposal is a good account of the strategy used by all test subjects, but it is a plausible explanation of the strategy MX might have used. That this strategy is a cognitive one is further supported by MX's performance in the Brooks' tasks.

5. The Brooks' Tasks

The second behavioral test in which MX's performance qualitatively differed from the performance of normal subjects are the Brooks' tasks (Brooks, 1967; Salway & Logie, 1995), which consist of two tests. In the Brooks' *matrix* task, subjects are asked to *imagine*, say, an empty five-by-five matrix or grid, and to listen to nine sentences, for example:

> In the starting square put an A.
> In the next square *down* put a B.
> In the next square *down* put a C.
> In the next square *to the right* put a D.
> …

The starting square is predefined as the square in the second row and the second column. The goal is to remember the positions of the letters in the grid and to recall these positions after the last position has been announced (see figure 3). Subjects respond by writing the letters in the appropriate positions in a blank grid printed in an answer booklet.

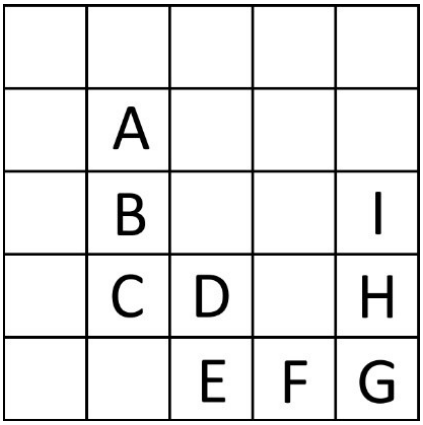

Figure 3

In order to see whether imagining a grid was helpful for accomplishing the task, the Brooks' *matrix* task is combined with a Brooks' *verbal* or *nonsense* task. Here, the subjects listen to seven mostly nonsensical sentences, for example:

> In the starting square put an A.
> In the next square to the *good* put a B.
> In the next square *slow* put a C.
> In the next square *to the quick* put a D.
> …

The goal is to remember the adjectives that were paired with the letters from A to G in the sentences. Subjects respond by writing adjective–letter pairs (e.g. good-B) in a blank answer booklet immediately after the last sentence has been read out.

According to Zeman et al. (2010, pp. 150–151), highly educated healthy subjects can correctly memorize about 8–10 items in the matrix task, and 5–7 items in the verbal task. This is to be expected, since the spatial information given in the matrix task invites the test subjects to memorize what has been said by imagining a grid. By contrast, such a technique cannot be used in the verbal task. Here test subjects have to memorize the pairs without the help of any straightforward mnemonic aid. This assumption is confirmed by what the test subjects themselves say about the techniques they used to accomplish the tasks. In Brooks' original study from 1967, the participants reported that they performed the matrix task by *picturing* the pattern formed by the letters, and then "reading" from the pattern when giving their response. When completing the verbal task, however, they merely tried to retain the sequence of adjectives and reinsert it in the grammatical context (Brooks, 1967, p. 292).

Coming back to MX, Zeman et al. (2010, p. 150) found that, in contrast to normal subjects, MX's performance in the matrix task was *lower* than in the verbal task (4.33 items in the matrix task as opposed to 6.33 items on average in the verbal task). In a modified follow-up test four weeks later, MX was able to improve his performance in the matrix task. He then scored 6.8 items in the standard matrix task (that is, when undistracted by secondary tasks), 4.7 items when he had to repeat aloud the word "the" throughout presentation of the nine sentences, and 6.9 items when he had to tap on the table in a figure-of-eight pattern throughout the presentation. The secondary tasks in the second and third series are meant to reveal the strategy used by the test subject to accomplish the task. The secondary task in the second series (the repetition of "the") leads to articulation suppression, and normally reduces performance if the test subjects use *verbal* information in short-term memory tasks. Because MX used a verbal strategy, his score indeed dropped. By contrast, the secondary task in the third series typically reduces performance if the test subjects use visuo-spatial information in short-term memory tasks (Zeman et al., 2010, p. 151). Hence, if MX had used an imagistic strategy which relies on visuo-spatial information, then his score would have dropped—something which did not happen.

The increase from 4.33 in the original matrix task to 6.8 items (while undistracted) in the follow-up matrix task shows that MX either changed his strategy or learned a new one to do better. Given that MX had the ability to visualize at will in the past, it is plausible to assume that in the original matrix task he *tried* to use the spatial information given in the nine sentences and to create a mental grid in the way he would have done before he lost his ability to create mental imagery. But due to the loss of his ability to visualize, this strategy did not work out well, such that MX's performance in the initial matrix task was relatively bad.

In the follow-up test it is highly likely that MX switched to a verbal strategy. This is supported by the fact that *articulatory* suppression disrupted MX's performance, whereas the pattern tapping did not. Moreover, MX's values in the follow-up *matrix* task (6.8 when undistracted; 6.9 when tapping) are similar to the values he achieved in the *verbal* task (6.33 on average) as well as similar to the values highly educated healthy subjects typically achieve in the verbal task (5–7 items). We have thus several reasons to believe that MX used a verbal strategy in the Brooks' tasks.

6. No Priming Effect of Imagery on Binocular Rivalry in Aphantasic People

When I compared the two ways to explain MX's successful performance in imagery tasks, I wrote that there are *two* pieces of evidence which militate against thesis 1:

> MX uses imagistic means but is unaware of it.

The second piece of evidence comes from a recent study by Keogh and Pearson (2018) which strongly suggests that aphantasics such as MX are unable to imagine visually, rather than having unconscious mental images and failing to attend to them.

The study makes use of a phenomenon called binocular rivalry. This is a phenomenon in which one image is presented to the left eye and a different image to the right eye of a subject. The rivalry results in one of the images becoming dominant while the other is suppressed outside of awareness. Which image becomes dominant can be influenced by a visual presentation of a weak instance of one of the two images prior to actual rivalry or by the generation of a corresponding mental image, that is, by a form of priming. Priming is a process in which the processing of a target stimulus is manipulated by a previously presented stimulus (the prime). Because priming effects are documented even in cases in which the prime was presented for such a short duration that the test subjects are not able to recognize its presence (see for example Dehaene et al., 1998), a stimulus can have a priming effect even if the test subjects do not have access consciousness to it. Accordingly, the unconscious mental images allegedly used by aphantasics should also have a priming effect.

In the study by Keogh and Pearson, fifteen self-described congenital aphantasics as well as 209 control subjects were cued to imagine one of two images (a red patch consisting of horizontal stripes or a green patch consisting of vertical stripes) and had to imagine this image for 6 seconds; they were presented with the corresponding binocular rivalry display, and eventually reported which color they saw.

Keogh and Pearson found that aphantasics had significantly lower priming effects than controls. Indeed, the aphantasics' priming scores were not significantly different from chance. In other words, the aphantasics' imagery has little effect on subsequent binocular rivalry, which suggests that aphantasics *lack* mental imagery rather than have it and are unaware of it.

7. Conclusion

I have argued that Nanay's argument for unconscious mental imagery is not sound because his premise that successful performance of imagery tasks requires the manipulation of mental imagery is false. The premise is false because MX's performance in the Brooks' tasks and the mental rotation task suggests that he uses a cognitive rather than an imagistic strategy to accomplish these tasks. Moreover, mental imagery has no priming effect on subsequent binocular rivalry in aphantasics, which suggests that people like MX do not use unconscious mental images when performing these tasks. Accordingly, we do not have to revise our concept of mental images as a quasi-perceptual conscious experience.

Does this mean that cases of unconscious mental imagery are impossible? Even though I do believe that a reference to quasi-perceptual conscious experience is essential in order to distinguish mental imagery from other mental phenomena (note that "mental imagery" even in the sense of [B] and [C] above makes reference to [A]), cases of unconscious mental imagery might be possible. Once neuroscientists find the neural correlates of quasi-perceptual experiences, we could extend the concept of "mental imagery" to cover cases in which these neural correlates are active even though the subject in question does not have any quasi-perceptual experiences. We could say that such cases are examples of unconscious mental imagery. However, neuroscientists have not yet reached a consensus on the neural correlate of mental imagery in the sense of (A), and the argument offered by Nanay does not in itself demonstrate that there is unconscious mental imagery.

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