Aphantasia, i.e., the congenital inability to experience voluntary mental imagery, offers a new model for studying the functional role of mental imagery in (visual) cognition. However, until now, there have been no studies investigating whether aphantasia can be linked to specific impairments in cognitive functioning. Here, we assess visual working memory performance in an aphantasic individual. We find that she performs significantly worse than controls on the most difficult (i.e., requiring the highest degree of precision) visual working memory trials. Surprisingly, her performance on a task designed to involve mental imagery did not differ from controls, although she lacked metacognitive insight into her performance. Together, these results indicate that although a lack of mental imagery can be compensated for under some conditions, mental imagery has a functional role in other areas of visual cognition, one of which is high-precision working memory.

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1. Introduction

Aphantasia refers to the inability to generate mental images (Zeman, Dewar, & Della Sala, 2015). Individuals affected by aphantasia cannot experience the sensory qualities of objects that are not physically presented to them. Although the phenomenon was already described nearly 150 years ago (Galton, 1880), it has recently (re)gained public and scientific interest (Zeman et al., 2010, 2015). A study by Zeman et al. described a case of acquired aphantasia as a result of a coronary angioplasty procedure (Zeman et al., 2010). They found that the patient behaved accurately on tasks of visual mental imagery and visual memory, from which they concluded that he must have utilized alternative cognitive processes, rather than mental imagery, to perform these tasks. fMRI data showed that he relied more heavily on frontal brain areas, whereas in controls a posterior network of brain regions was more active, corroborating the idea that he made use of an alternative cognitive strategy. Another study described a group of twenty-one individuals who had never experienced voluntary mental
imagery at any moment during their lifetime (Zeman et al., 2015). Many of these congenital aphantasics self-reported mood-related or cognitive difficulties. However, this study did not systematically examine the cognitive functioning of these individuals. Here, we examined the functioning of visual working memory in a case of congenital aphantasia.

Visual working memory and mental imagery are two processes that both depend on the representation and manipulation of visual mental content not driven by current visual input. Even though they share this important feature, within the field of cognitive psychology the two processes have been mostly researched independently (e.g., Tong, 2013), although some investigations on the link between visual working memory and visual imagery have been published. Early work did not find a positive relationship between the two cognitive processes (Heuer, Fischman, & Reisberg, 1986; Reisberg, Culver, Heuer, & Fischman, 1986; Reisberg & Leak, 1987), but more recently, strength of mental imagery was found to correlate with visual working memory performance (Keogh & Pearson, 2011), and working memory capacity (Keogh & Pearson, 2014). In addition, both processes have shown to be sensitive to visual interference by task-irrelevant visual input (Baddeley & Andrade, 2000; Keogh & Pearson, 2011, 2014, although see; Borst, Niven, & Logie, 2012), especially when the participants were strong-imagers (Keogh & Pearson, 2011, 2014), indicating that this subset of participants most likely adopts a cognitive strategy involving mental imagery when executing visual working memory tasks. At the same time, this would mean that for many individuals mental imagery is of no functional relevance for working memory. Thus even if (strong) imagery might be beneficial to visual working memory, it is not a prerequisite for adequate performance. On the other hand, there are studies showing that mental imagery relies on the same cognitive structures underlying visual working memory. Baddeley and Andrade (2000) have shown that disruption of the visuospatial sketchpad, one of working memory’s so-called slave systems, reduces the vividness of mental images representing information retrieved from long-term memory. A close correspondence between representations underlying visual working memory and visual imagery has been demonstrated, both cognitive (Borst, Ganis, Thompson, & Kosslyn, 2012), and neural (Albers, Kok, Toni, Dijkerman, & De Lange, 2013; Slotnick, Thompson, & Kosslyn, 2012). Clinical work with schizophrenic patients demonstrated that even though this patient group suffers from working memory impairments, they are faster at mental image generation than matched controls (Matthews, Collins, Thakkar, & Park, 2014). However, the same study also showed that the enhanced mental imagery capacity could be abolished by increasing the concurrent working memory load.

Here, we further examine this functional relationship by examining the working memory performance of an individual, who in her own experience is incapable of mental image generation since birth. We investigated multiple aspects of (visual) working memory, i.e., visual working memory capacity, metacognitive performance for remembered information, and the role of feature binding in visual working memory. We also carried out a general working memory capacity battery to control for any differences in working memory performance that are not specific to visual information. In a similar effort to rule out generic differences between our control sample and the individual under study, IQ was measured in all participants as well. We designed a spatial working memory task which tested participants’ memory for the contours of geometric shapes after a 4-sec delay period, and we included an equivalent mental imagery task that required participants to generate a mental representation of the same stimuli. We hypothesized that the aphantasic individual would perform worse than controls on the mental imagery version of the task. If mental imagery is essential to visual working memory, she would show impaired performance also on the working memory version. Alternatively, she could have developed compensatory strategies for those tasks in which typical individuals would resort to mental imagery. In that case, her performance pattern across visual working memory tasks could diverge from that of the typical individuals in any possible way. Finally, if there are no differences between the aphantasic individual and the control group, the parsimonious conclusion would be that mental imagery does not seem instrumental to visual working memory altogether.

We also included the change detection task designed by Wheeler and Treisman (2002) to measure visual working memory performance for feature-bound objects as opposed to single-feature working memory. Mental imagery involves the generation of integrated, featured-bound visual objects, but single visual features, like color or shape, can be passively and unconsciously stored in working memory without the need to be integrated into object-like representations. We therefore hypothesized that if the aphantasic individual shows visual working memory deficits, these might be limited to working memory for feature-bound stimuli, while leaving single-feature memory unaffected.

2. Methods

2.1. Participants

2.1.1. Aphantasic individual

The aphantasic individual (AI, not actual initials) was a female 31y9m of age. At the time of testing she was a PhD student. She had recently come across aphantasia through communications about the phenomenon in popular media, and found that her personal experiences were similar to the experiences described there. She contacted our research group to offer to volunteer in further research on the phenomenon of aphantasia. Her vision was corrected-to-normal. She was compensated for her participation through gift vouchers.

2.1.2. Control participants

11 control participants were included in the study. All of them were female and their average age was 31y0m (SD = 28 m). All control participants were in possession of at least a Master’s degree and had varying vocational backgrounds (7 graduate students or academics, 3 individuals working in business, 1 graphic designer). As average IQ scores did not match AI’s, we selected a subgroup of 4 participants with matching IQs to additionally compare her with (see Section 3.2). This subgroup had a mean age of 31y5m of age and consisted of 2 women...