The multitude of aphantasia subtypes and their respective cognitive differences and pathological considerations: A review on the emerging condition.

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Mental imagery is one of the most important cognitive tools that we possess to modulate higher-order cognitive functions concerning sensory information. These higher-order cognitive functions include but are not limited to memory retrieval and encoding, semantic processing, navigation, problem-solving, decision-making, emotional modulation, and communication (Monzel et al., 2024d; Pearson et al., 2008; Speed et al., 2024; Wicken et al., 2021; Zeman et al., 2020). Mental imagery itself refers to our ability to reactivate and manipulate representations in the absence of the corresponding stimuli (Zeman et al., 2024). This process is modulated across all sensory domains and is often complex and associated with widespread networks including both modal and supramodal regions (Zeman et al., 2024). Modal regions interface specifically with the reactivation of a particular sense – in the case of visual imagery, this may include areas such as the visual cortex (Keogh & Pearson., 2018). Supramodal regions on the other hand include areas that integrate abstract representations that are common to more than one source of sensory data (Keogh et al., 2021a). One prime example of this region, especially related to visual imagery would include the higher-order visual cortices and parts of the default mode network that is active when an individual is not focused on a task or during self-referential thought (Zeman et al., 2024). The integration of modal and supramodal regions creates widespread and complex networks that allow for the representation of different mental imagery. Owing partially to the complex nature of these networks the generation of mental imagery is often considered a spectrum constituting a wide variety of abilities dependent on individual differences (Jin et al., 2024). While the heterogeneous nature of sensory modalities and their representations has been thoroughly explored it is often taken for granted that all individuals, regardless of ability, possess a complete profile of these mental representations and their associated abilities.

However, this notion has been recently challenged by the reintroduction of aphantasia into the general realm of scientific inquiry. First examined by Galton in 1880 the condition disappeared from wider study until it was recently coined as aphantasia by Zeman and colleagues (Zeman et al., 2015). The term was renamed and given the general definition of 'reduced or absent voluntary imagery' (2015). However, while many studies continue to honor this original definition (Monzel et al., 2023a; Pearson, 2019; Pounder et al., 2022; Siena & Simons, 2024) there are a considerable number that are elaborating on this definition. Some studies only consider the original definition under the condition that aphantasia is congenital (Dawes et al., 2022 Palermo et al., 2022; Wicken et al., 2021; Wittmann et al., 2022) while others consider both congenital and acquired (Jin et al., 2024; Keogh et al., 2021a; Takahashi et al., 2023; Zhao et al., 2022). Some studies attempt to simplify aphantasia from a mental imagery deficit to a visual imagery deficit alone (Dawes et al., 2022; Dando et al., 2023; Milton et al., 2021) to draw firm conclusions considering a majority of early aphantasia research – despite its differing name – focused on mental imagery over all other modalities. While many studies above attempt to simplify the condition to facilitate its study others are working to expand upon the original definition to create a more accurate overview. There are emerging studies that suggest that aphantasia may not constitute a lack or reduction of voluntary imagery but also involuntary imagery (Furman et al., 2022; Keogh et al., 2021a). Some go even further to declare that instead of voluntary and involuntary imagery terminology it should instead be denoted that aphantasia lacks conscious mental imagery but not unconscious (Nanay, 2020). In examining each of these definitions several conclusions can be drawn. Since aphantasia has been associated with deficits outside of the visual modality it does not constitute a simplification to only the visual domain but instead demonstrates that these studies are examining the visual subtype of aphantasia. The cases of involuntary and voluntary inclusion are more nuanced and while they may also be related to different subtypes it seems that overall, there is no solid evidence of preserved involuntary imagery (Krempel & Monzel, 2024; Monzel et al., 2022b) thus researchers should attempt to either generalize their definition or elucidate why they are choosing to focus on either the voluntary or involuntary aspect. The same complication is present in conscious and unconscious imagery especially as multiple studies do not bother to work on this dimension (Nanay, 2020). Thus, it becomes increasingly clear that each definition can be sufficient if it is properly quantified within the realm of the condition being examined. In light of these comments, the overarching definition of aphantasia as it will be considered in this review is the reduced or absent mental imagery with the specific modality considered being added as a qualifier (i.e. visual mental imagery).

The lack of complete consensus on the definition of this condition often stems from the complex historical nature of its study. As previously mentioned, the first mention of this condition was by Galton in the 1880s. He famously conducted the breakfast table study which consisted of him asking several constituents what they could visualize relating to what they had for breakfast (Galton, 1880). Upon doing so he considered the illumination, duration, and coloring that each individual provided and noted that some – including himself – could not form a mental image of the scene when reflecting upon it (Galton, 1880). Despite this original study research on the condition was disrupted in the early to mid-20th century due to the behavioralist revolution (Keogh et al., 2021a). Behavioralists considered it unscientific to study unobservable phenomena and this included internal mental representations. The condition was brought back into circulation during the 1970s due to the re-emergence of the visual debate (Keogh et al., 2021a). This debate centered on whether mental imagery is propositional or depictive. Propositional theory claimed that visual images were not distinctively represented in the brain and were instead representational with the relationships between objects being preserved instead of an image (Kosslyn et al., 2001). On the other hand, depictive theory argued that images had distinct properties within the brain that were separate from perceptual mechanisms (Kosslyn et al., 2001). Despite the reawakened interest, most study was limited to visual causes that occurred after head injury (Monzel et al., 2023c). These case studies made it difficult to elucidate a particular cognitive profile or etiology. Furthermore, until its reintroduction as aphantasia in 2015 there was no consensus on a term for the condition making it difficult for any comparisons between studies leaving little to no solid conclusions drawn on the prevalence, etiology, impacts, and symptoms of the condition.

With the reintroduction of the term, there is finally a general basis for researchers to collaborate, replicate, and make inferences across multiple studies. However, due to the recent nature of this term, there is a lack of comprehensive study across all aspects of aphantasia. This review aims to summarize the recent research on the condition, elucidate theoretical viewpoints on aphantasia, and then examine and investigate the gap in knowledge and research on different subtypes of aphantasia.

History

After Galton's seminal study on aphantasia research was primarily limited to acquired cases. In 1883, a patient known as Monsieur X developed aphantasia, prosopagnosia, agnosia, and avisual dreaming (Keogh et al., 2021a). This case was unique in that it was one of the first reported cases to be likely due to a psychiatric illness and not a head injury. A case with similar symptoms of aphantasia, prosopagnosia, and cessation of dreaming occurred in 1887 due to an occipitotemporal infarction (Keogh et al., 2021a). Interestingly enough after these cases and others like them in the late 1800s and early 1900s, much of aphantasia research disappears. This interruption is theorized to be caused primarily by the behavioralist revolution led by John B. Watson in the mid-1900s who denied the study of consciousness and the existence of mental images (Keogh et al., 2021a; Kosslyn et al., 2001). This led to an extended dearth of aphantasia research until the 1970s when interest was sparked in mental imagery due to the onset of the imagery debate (Kosslyn et al., 2001). One side of the debate argued that there was nothing distinctive about images in the brain and that they were symbolically represented like language known as propositional theory (Kosslyn et al., 2001). The other side of the debate argued that there were distinct brain regions representing mental images and that an overlap with perception made this possible known as depictive theory (Kosslyn et al., 2001). Extended debate on the topic with both sides providing ample evidence for their position led to the focus of research back on mental imagery in an attempt to solve this debate.

The most well-known study following this debate was done by Farah in 1984. He examined 37 patients with acquired aphantasia and classified each based on information processing models. He classified 5 with an introspective disorder, 8 with a generation deficit and intact perception, and 13 with a long-term visual memory deficit that affected both imagery and perception (Farah, 1984). He was unable to classify 10 of them as the patients did not have sufficient detail on their condition for him to be confident in a diagnosis (Farah, 1984). While he did not have any direct evidence for the cause of each of these deficits, he theorized that posterior left hemisphere lesions were responsible for those with generation deficits while the other deficits were more in line with visual recognition and thus shared common neural architecture along these pathways (Farah, 1984; Keogh et al., 2021a).

Throughout the late 1990s research on aphantasia continued in the mode, focusing specifically on acquired case studies. In 1992 a patient known as CK acquired object agnosia but could still perform well on standard measures of imagery (Keogh et al., 2021a). In 1995, three patients with extensive damage to visual cortices resulting in cortical blindness were examined and two were found to still be able to perform well on imagery tasks (Keogh et al., 2021a). In the same year, a patient known as DF acquired object agnosia after carbon monoxide positioning and still had visual dreams and could do imagery and mental rotation tasks (Keogh et al., 2021a). In 1996, a patient with achromatopsia following bilateral temporo-occipital strokes could still perform some color imagery tasks and in 1998 a patient with impaired visual perception and preserved mental imagery was discovered as a result of similar successive bilateral temporo-occipital strokes (Keogh et al., 2021a). These studies show a trend of dissociation between mental imagery and perception and a preserved ability to solve tasks that should have been directly impacted by their particular condition. Unfortunately, much of the etiologies of these cases could not be determined likely due to the lack of access to magnetic resonance imaging until the 1990s (Zeman et al., 2010).

Starting in the early 2000s, cases with similar symptomology began to be examined on a structural basis. In 2008 patients with intact perception and impaired visual imagery were discovered to have damage to their left temporal lobe and parietal lobe with a spared primary visual cortex (Keogh & Pearson, 2018). Soon after 2012 a patient known as SBR had BOLD responses in the intraparietal sulcus, fusiform gyrus, and parahippocampal gyri in response to mental imagery despite damage to the primary visual cortex (Keogh et al., 2021a). While most cases arose from direct injury to the brain there was a study in 2011 that looked at 25 patients who had intact perception with disrupted mental imagery likely to successive depressive or anxious episodes combined with depersonalization and derealization (Keogh et al., 2021a).

Due to the overwhelming disparate nature of both the causes of the aforementioned conditions as well as the variation in symptomology many of these cases were not examined in parallel and were considered isolated events that could give information about the brain areas involved but little else. This idea was reinforced by the fact that in most cases the condition was given a different label by each researcher including visual reminiscence (Nielsen, 1946), image generation process deficit (Farah, 1984), defective revisualization (Botez et al., 1985), and blind imagination (Zeman et al., 2010). This differing terminology made it difficult to find existing literature on the condition as well as determine if the same condition was being studied. This problem was compounded by the fact that research was only focused on acquired aphantasia – there was no consensus that these isolated cases constituted any particular condition. However, this trend changed in 2010 with the case of MX.

MX had a loss of object imagery after undergoing a coronary angioplasty (Zeman et al., 2010). This study prompted many individuals to reach out to the author of the study and claim that they had the same deficit of object imagery (Zeman et al., 2020; Zhao et al., 20222). Interestingly enough these individuals claimed that this experience was life-long and not due to any kind of injury (Zeman et al., 2020). This prompted the author to create a follow-up study on these individuals and to first define the condition as aphantasia (Zeman et al., 2020). This paper received widespread press interest via the BBC and quickly became known to a broader audience which led subsequent papers to adopt aphantasia as a term to describe the condition (Monzel et al., 2022b). This prompted even more individuals to contact the author describing what is now known as congenital aphantasia (Milton et al., 2021). The 2015 paper was the first time that aphantasia was described as being an actual lifelong condition and not just an acquired symptom of brain injury. This discovery shifted research on aphantasia away from acquired cases and allowed for more rigorous inquiry into the etiology of congenital aphantasia as well as the prominent cognitive profile.

Etiology

The exact etiology of acquired aphantasia is nuanced and depends on the patient. However, there seem to be two primary groups of causes – neurogenic and psychogenic. While most case studies on acquired aphantasia arose from strokes, head trauma, or oxygen deprivation other more unique causes can lead to neurogenic aphantasia. One such case can be seen in a patient who acquired aphantasia after an autologous stem cell transplant due to myeloma (Bumgardner et al., 2021). The condition was likely due to transplant complications that led to air leaking between the lungs and chest wall leading to lung collapse depriving the central nervous system of oxygen (Bumgardner et al., 2021). Another case of aphantasia was acquired in a woman after experiencing COVID-19. She experienced only a mild infection and yet two months after the onset she complained of a lack of mental imagery with deficit dreams (Gaber & Eltemamy, 2021). Upon an MRI scan there was evidence of diffuse white matter changes in her brain (Gaber & Eltemamy, 2021). These two cases highlight that there is no one specific etiology for neurogenic acquired aphantasia – each patient needs to be examined on a case-by-case basis due to the widespread number of causes and outcomes that can all lead to similar presenting symptoms.

The etiology of acquired aphantasia is further complicated by the implications of psychogenic acquired aphantasia brought about as a result of some psychological or psychiatric disruption. There are a couple of notable cases that elucidate the nature of this form of acquired aphantasia. One such case is that of Monsieur X. While there was no evidence for the cause of onset researchers concluded afterward that it was likely left temporal damage that spared the occipital cortex despite not utilizing brain imaging (De Vito & Bartolomeo, 2016; Keogh et al., 2021a, Milton et al., 2021). However, just before the onset of the disorder, Monsieur X complained of severe mental alienation following several depressive episodes indicating that this may have been the actual cause (De Vito & Bartolomeo, 2016). While this specific case can be contested another study by Cotard showed direct links between patient psychology and the onset of aphantasia. He examined two participants, M.P. and M**, who after severe and successive depressive and anxious symptomology experienced visual imagery loss that concurred with Cotard's syndrome in one patient (De Vito & Bartolomeo, 2016). Another similar case in 1960 described four patients who also experienced loss of visual mental imagery after complex histories of anxiety, depression, depersonalization, and derealization (De Vito & Bartolomeo, 2016). Attempting to study aphantasia as a condition based on acquired cases seems to be an impossible task due to the wide variety of causes as well as the general lack of etiology information from early case studies. The further split of acquired into neurogenic and psychogenic further complicates this as it seems that both structural and functional changes play a specific role in these cases and attempting to determine one etiology is extremely unlikely.

Congenital aphantasia on the other hand is present from birth and is not due to any psychiatric or psychological cause or injury. Therefore, it follows that this condition is likely to be less heterogeneous and easier to classify than any specific acquired cases despite the likelihood of multiple different subtypes. Despite this, there seems to be little consensus on the actual etiology of the condition. While there is evidence for a high sibling recurrence risk which may indicate a genetic basis (Zeman et al., 2024) this evidence is mixed. There seem to be some correlations between individuals of family history (Jin et al., 2024) but the lack of consensus seems to be primarily due to a lack of data. Most current research is focused either on the possible deficits of aphantasia or specific brain regions with little study currently being done on any genetic or root causes. It may simply be that congenital cases like acquired cases have a multitude of causes; however, the commonality of damage to the posterior and temporal lobe in much acquired research indicates that this may not be the case. There likely are common underlying structural and functional connectivity issues in those with congenital aphantasia as seen by the interplay of damage to multiple brain regions to aphantasia onset in acquired aphantasia. There simply needs to be more investigation into the neural architecture of congenital aphantasia to come to any kind of consensus on its specific etiology.

Prevalence

The prevalence of the population that has aphantasia, despite the intensive research on the condition since 2015, is largely disputed. Some studies claim that less than 1% of the population has this condition (Milton et al., 2021; Zeman et al., 2024). This seems to be unlikely however as most studies examining the prevalence of different aphantasia subtypes estimate only complete aphantasia – with no mental imagery in any sense modality – as this low (Dawes et al., 2024; Milton et al., 2021). Other studies on the other hand estimate more than 10% of the population has this condition (Takahashi et al., 2023). This extrapolation seems to occur on the mistaken assumption that only visual aphantasia is being considered in the studies estimating aphantasia as being between 1-4% of the population. While it is certainly true that many studies only consider visual aphantasia – loss of only visual mental imagery - and this is a prominent reason for differing prevalence rates, many subtypes will have symptoms that coincide with visual aphantasia. Studies that claim to only measure visual aphantasia may also include individuals with multisensory aphantasia that also just happens to impact visual mental imagery. This leads to incomplete prevalence rates, but it also does not follow that extrapolations based on these numbers would be this high.

Most studies seem to place aphantasia between 2% and 6% of the population (Dawes et al., 2020; Dawes et al., 2022; Dawes et al., 2024; Dance et al., 2022; Hashim et al., 2024; Jin et al., 2024; Keogh et al., 2020; Krempel & Monzel, 2024; Liu & Bartolomeo, 2023; Monzel et al., 2021; Monzel et al., 2022a; Monzel et al., 2024a; Nanay, 2020; Palermo et al., 2022; Takahashi et al., 2023; Witman & Satirer, 2022; Zeman et al 2015; Zeman et al., 2020; Zeman et al., 2024). The discrepancy in these studies can likely be attributed to the inconsistent definition and measurement of aphantasia. The original definition of 'reduced or absent voluntary imagery' is honored in some studies (Monzel et al., 2024a, Pearson, 2019, Pounder et al., 2022, Siena & Simons, 2024) while others only consider congenital aphantasia and not acquired (Dawes et al., 2020, Palermo et al., 2022, Wicken et al., 2021, Witman & Satirer, 2022). Many different studies also misinterpret the definition from the original study as only referring to visual mental imagery (Dando et al., 2023, Milton et al., 2021) instead of mental imagery as a whole. This causes many differences in prevalence numbers as each study is either looking at only a subtype of aphantasia or only a specific etiology. Not only that but each study also adopts its own cutoff for what constitutes aphantasia leading to not only a lack of subtype inclusion in prevalence measures but also possible reduced estimations of those with visual aphantasia. The best prevalence estimate is likely 4.2% (Dawes et al., 2022) as it includes acquired and congenital cases as well as multiple subtypes with cutoffs from the original aphantasia paper. However, there is still no solid objective proof that the original paper cutoffs correlate to actual observable differences in groups. A final factor that makes determining the prevalence difficult is that most individuals never realize that they have it and if they do it is not until their late twenties in most cases (Zeman et al., 2010). This likely implies that most prevalence estimates based on research do not reflect the actual population. All of these confounding factors make it difficult to determine the actual prevalence in the population and until they are addressed there is not likely to be a consensus anytime soon. Outside of ascribing a population prevalence, there does not seem to be a gender disparity with males and females having similar rates of aphantasia (Jin et al., 2024). This is a distinct avenue for further study as little research has been done on gender and aphantasia, however, females, in general, tend to have stronger mental imagery vividness (Pearson et al., 2008). It may be beneficial to determine if this has any impact on aphantasia presentation and if there is indeed no gender difference.

Common measures and new objective ones

Much of imagery research, and indeed aphantasia research is based on the Vividness of Visual Imagery Questionnaire (Marks, 1973). The VVIQ is a subjective, self-report measure that presents individuals with 16 scenarios to visualize and then rate on a Likert scale from 1 (no image at all, you only know that you are thinking of the object) to 5 (clear and vivid, as real as seeing) (Zeman et al., 2015). Scores can range between 16 to 80 with aphantasia usually scaling between 16 (no mental imagery at all) to 32 (dim or vague mental imagery) (Zeman et al., 2015). Currently, the VVIQ is primarily used to identify individuals with aphantasia though this method is not without its criticisms. As with any self-report measure, different researchers have questioned whether the VVIQ demonstrates a deficit in mental imagery as individuals cannot always accurately report on their own internal states (Pounder et al., 2022; Siena & Simons, 2024). Others argue that this is not a concern due to the VVIQ's strong construct validity. In a review of studies, it was found that comparisons were statistically significant in a theoretically predicted or meaningful direction, only in a minority of studies were statistically significant comparisons counterintuitive, and in many correlational studies the VVIQ scores correlated significantly with other variables related to the vividness of visual imagery (Marks, 1989). While this does not completely rectify the issue, studies have also found that the VVIQ correlates with fMRI activity in the early visual cortex (Cui et al., 2007) giving the questionnaire some objective backing. Despite this, there is a major problem with using the VVIQ as a diagnostic tool for aphantasia. The VVIQ only looks at visual imagery and so assumes all aphantasic individuals have impaired visual mental imagery when this is not the case. While the VVIQ does capture some subtypes other than visual aphantasia, such as multisensory, it also misses a large number of these individuals. Any combinatorial type of aphantasia – aphantasia with the lack of some senses but not all – that does not include visual imagery deficits is automatically excluded. This is a twofold issue – if studies claim to only study visual aphantasia their results could be skewed in that multisensory and combinatorial types of aphantasia would also be included. Furthermore, if a study claims to be studying aphantasia as a whole it would be leaving out a large number of subtypes if the VVIQ was the only measure employed for diagnostic purposes.

This issue has been attempted to be rectified by the inclusion of other questionnaires in aphantasia diagnostic. A few examples include the object and spatial imagery questionnaire (OSIQ) which has 15 object and spatial items to visualize (Takahashi et al., 2023). However, this questionnaire is not widely adopted and it still only looks at visual mental imagery – specifically its dissociations and thus can only capture spatial and object subtypes of visual imagery. Another questionnaire that has been proposed is the questionnaire upon mental imagery (QMI) which examines visual, auditory, cutaneous, kinesthetic, gustatory, olfactory, and organic imagery

(Takahashi et al., 2023). While far more able to capture subtypes of aphantasia, this questionnaire is far less sensitive to imagery differences causing subtypes within a specific type of aphantasia (such as object or spatial in visual aphantasia) to be overlooked. It also does not seem permissible to simply combine multiple questionnaires as this may lead to respondent fatigue. It therefore seems beneficial to clarify which subtype of aphantasia is being studied and diagnosis based on the needed criteria. While a useful starting tool, it seems beneficial to refine the criteria used to diagnose participants with aphantasia to actually select for the required group.

Due to the issues inherent with self-report measures, there has been an attempt to create more objective measures meant to elucidate the nature of aphantasia as well as become a diagnostic tool for future research. The most prevalent is the usage of the binocular rivalry task. In this task, it has been found that displaying two different patterns – one to each eye – causes competitive interactions leading to only one image being dominant (Pearson et al., 2008). The other image is completely suppressed from perception, and it has also been found that when individuals are cued to image one pattern over the other this imagery primes subsequent perception (Sherwood & Pearson, 2010). In a recent study, individuals with aphantasia underwent this task and it was found that they could not be primed by their imagery (Keogh & Pearson, 2018). The author took this to mean that individuals with aphantasia did not have any imagery that could prime their perception leading to the conclusion that aphantasia was indeed an actual deficit and not just misreporting by individuals on self-reports (Keogh & Pearson, 2018). While this is one of the first objective measures to confirm aphantasia as an actual mental imagery deficit it falls prey to the same issues that the VVIQ does. This task necessitates that visual mental imagery is not available and thus does not include many different subtypes. It is a powerful tool for those studying visual aphantasia or a multisensory or combinatorial type with visual mental imagery deficits, but it misses individuals with intact visual mental imagery. However, if a similar effect could be replicated in other sensory domains it would not only lend credence to less studied subtypes, but it could create easier methods for researchers to diagnose a specific type of aphantasia.

The most recent objective measure for aphantasia is based on the pupillary light response. This is an involuntary physical response in which pupils constrict in response to brightness and dilate in dark conditions (Kay et al., 2022). Past research has found that the process is sensitive to higher-order perceptual processes and that mental imagery is involved in the response (Kay et al., 2022). When individuals simply imagine themselves in a brighter area their pupils will constrict even though there are not any perceptual stimuli to elicit this response (Kay et al., 2022). Therefore, a recent study had individuals with and without aphantasia view bright lights as well as imagine themselves in bright lights (Kay et al., 2022). This study found that both individuals with and without aphantasia had their pupils constrict in the presence of bright light but individuals with aphantasia did not have this same pupil constriction when merely imagining themselves in bright light (Kay et al., 2022). Much like the binocular rivalry task this shows that individuals with aphantasia not only have intact perception but also that aphantasia constitutes an actual visual mental imagery deficit as their involuntary response cannot be impacted by it (Keogh & Pearson, 2024b). Interestingly enough the study also found that individuals with aphantasia had a greater pupil diameter in imagery indicating that they were actively engaging with attempted imagery and exerting greater cognitive effort than the controls were (Kay et al., 2022). Not only is this a good objective measure, but it also provides an objective argument against researchers claiming that those with aphantasia may not be properly attempting the task due to their notions about their visual imagery (Siena & Simons, 2024). This study displays that individuals with aphantasia often attempt visual imagery tasks with more cognitive effort than those who do not have aphantasia. However, this task also relies on higher-order processes from the visual mental imagery system, and it is unlikely this effect would be seen in those with an aphantasia outside of those with a visual component. Both subjective and objective measures of aphantasia currently being used in research are heavily biased towards visual aphantasia and may miss the nuances of multisensory aphantasia and ignore entire groups of combinatorial aphantasia altogether. There needs to be an effort by researchers either to choose a measure that lines up with the subtype of aphantasia that they wish to study or to indicate the subtypes that they are excluding. This will not only allow researchers to properly ascribe specific symptoms and neural mechanisms to the appropriate subtype but also allow for better discrimination of severity and its relation to everyday activities. It will also allow other researchers to better compare their results to actual populations they want to study instead of a mixture of groups leading to more validity and clarification.

Aphantasia subtypes

While aphantasia as a whole is taken to be a ‘lack or deficit of voluntary mental imagery’ (Zeman et al., 2010) this definition is lacking in what sensory modality it considers. The vague nature of this definition is intentional as it seems there are a multitude of subtypes that cover a range of different modalities depending on the individual. While most research focuses on visual imagery half of the participants that are usually included in these visual mental imagery studies describe an absence of imagery in any sense modality with many having intact imagery in one or more other modalities (Zeman et al., 2020). This makes it highly likely that aphantasia has unique etiological profiles dependent on the subtype and that these groups in themselves are heterogeneous with different classifications of symptoms and behaviors. Despite this there has been little investigation into the differing subtypes of aphantasia and most of the work that has been done is exploratory. Also, due to the likely inclusion of individuals with multisensory aphantasia into the visual aphantasia group, it is likely that the cognitive profile currently being created around visual aphantasia can be partially attributed to multisensory aphantasia. This makes it difficult to determine what behaviors can be attributed to visual mental imagery and what behaviors cannot, especially due to the numerous aphantasia subtypes.

With visual aphantasia being the main focus of research there have been some conclusions that can be drawn despite the possible intervening influence of other sense modalities. Visual imagery, much like many other senses, can be dissociated between the ventral and dorsal pathways or what and where pathways. In visual imagery in particular the ventral pathway is responsible for object imagery and runs from the occipital lobe to the temporal lobe while the dorsal pathway is responsible for spatial information and runs from the occipital lobe to the parietal lobe (Keogh & Pearson, 2018; Kosslyn et al., 2001; Milton et al., 2021; Pearson, 2014). This indicates that there is a possibility for each pathway to be impacted independently of each other indicating individuals could be missing only object visual imagery or only spatial visual imagery. Many different experiments indeed seem to support this conclusion and have differentiated between object visual aphantasia and spatial visual aphantasia. In a study utilizing the OSIQ researchers found that some individuals with aphantasia had only impaired visual imagery while others had impaired spatial imagery (Palermo et al., 2022, Zeman et al., 2024). Another study examining mental rotation in individuals with aphantasia found that some individuals with aphantasia did utilize object imagery as a strategy to support their lack of spatial imagery (Kay et al., 2024). Despite these findings, many different sources cite the intact nature of spatial imagery as a feature of aphantasia (Bainbridge et al., 2021; Siena & Simons, 2024;

Zeman et al., 2010; Zhao et al., 2022). This assumption is perpetuated by the use of VVIQ which only considers the vividness of object imagery and does not have a spatial component. This could have a couple of implications for current visual aphantasia research. Some researchers when employing mental rotation tasks find no differences in accuracy or response times in those with aphantasia when compared with controls (Siena & Simons, 2024) while others find intact accuracy but longer response times in those with aphantasia (Zeman et al., 2010). In the case of researchers who find no differences, they then argue that aphantasia must still have intact imagery but individuals with aphantasia simply have difficulty introspecting (Siena & Simons, 2024). On the other hand, researchers who find longer response times but intact accuracy argue that object imagery is helpful for rotation tasks and that an alternative strategy is utilized to compensate for this lack (Zeman et al., 2010). These results seem hard to reconcile unless spatial aphantasia is included. Both sides of the argument may include individuals with spatial aphantasia in their control groups or individuals with other types of aphantasia. The larger groups of participants included in the study the greater the moderating effect may be seen as a confounding influence of spatial aphantasia, and this does seem to be the trend. In smaller studies where spatial imagery is assumed to be intact reaction times seem to be longer and accuracy seems to be the same as controls (Bainbridge et al., 2021; Zeman et al., 2010; Zeman et al., 2020) but the difference in reaction times decreases among larger groups (Pounder et al., 2022; Siena & Simons, 2024). Of course, it could simply be that regardless of spatial or object imagery deficits accuracy and reaction time stay the same in aphantasic individuals, but this seems highly unlikely due to the use of mental imagery in mental rotation tasks and the relationship between increased angle and increased response time (Siena & Simons, 2024). This discrepancy in results that has led to a lengthy debate on the nature of visual aphantasia demonstrates just how important subtype consideration is in aphantasia research. Even the most studied subtype, visual aphantasia, has a multitude of conflicting results especially in the realm of object and spatial imagery tasks that may be better explained by considering each type instead of grouping them together either accidentally or through ignorance.

While there is no comprehensive list of aphantasia subtypes, the most prominent subtype outside of visual aphantasia is known as multisensory aphantasia. Despite the acknowledgment by multiple studies that some individuals have a reduction of mental imagery in all sensory modalities (Blomkvist & Marks, 2023; Dance et al., 2021b; Keogh et al., 2021b; Monzel et al., 2022b; Takahashi et al., 2023) there has been little to no research on the cognitive profile of this subtype even though an estimated 26% of individuals with aphantasia have this subtype making it the second most common after visual aphantasia (Dawes et al., 2020). One study utilized a barrage of different questionnaires to determine that the sensory domains in multisensory aphantasia impacted include visual, tactile, gustatory, auditory, and olfactory as expected but also extend into bodily, motor, and feeling-based mental imagery (Dawes et al., 2020). The widespread nature of this form of aphantasia makes it likely that many different processes that impact these systems could be largely impacted especially areas that rely on the combination of these areas such as problem-solving, motor learning, and even priming or classical conditioning (Dawes et al., 2020). Unfortunately, outside the fact that multisensory aphantasia probably shares commonalities with visual aphantasia considering its accidental inclusion in visual aphantasia research not much can be concluded about its etiology, symptoms, stability, or emotional effects as studies focused on it rely on questionnaires that determine if mental imagery is impacted and are preliminary at this point.

Outside of multisensory and visual aphantasia, there are a variety of subtypes that have been preliminarily identified. Various forms of combinatorial aphantasia have been proposed. This type of aphantasia is defined as any form of aphantasia that involves a complete knock-out of more than one form of mental imagery that does not constitute a multisensory or complete knock-out of all senses (Dawes et al., 2020). This creates aphantasia involving any combination of senses leading to a large amount of heterogeneity. In the same exploration study into multisensory aphantasia it was found that somatic intact aphantasia makes up 5.16% of those with aphantasia, auditory intact makes up 3.74%, kinesthetic-intact makes up 1.75%, visual and kinesthetic impaired makes up 1.47%, and all other combinations made up less than 1% of individuals with aphantasia (Dawes et al., 2020). This alone demonstrates the enormity of the condition and the various issues with the study of the condition. Even though these groups make up relatively little of the aphantasia group when added together their accidental conclusion as pure visual aphantasics or controls can skew study results trying to elucidate concrete differences between individuals with aphantasia and those without. This is especially clear when one considers that combinatorial aphantasia as a whole makes up an estimated 12% of the aphantasia population (Dawes et al., 2024). Thus, it is increasingly important for researchers to clarify what groups they are studying or to simply study the groups together and see if any generalizations can be made of the condition as a whole.

Despite the seemingly pedantic nature of subtype separation, it is abundantly clear that there are conflicting research results that may be largely caused due to a lack of consideration of these differences. While most studies group individuals with aphantasia as a whole there is evidence from the binocular rivalry task that when those with aphantasia are split into no visual imagery (score of 16 on the VVIQ) as opposed to dim or vague imagery (17-32) there were differences in priming scores (Keogh et al., 2024b). Those with complete visual imagery could not be primed but those with dim or vague were more split on who could or could not be primed which the author took to mean that some individuals with aphantasia may have unconscious visual imagery (Keogh et al., 2021b). The differences observed by separating those with no and vague imagery could be a reason why studies have conflicting results especially as some studies are more conservative with what scores count as aphantasia. Studies considering floor scores on the VVIQ could be seeing a larger cognitive difference than those considering the full breadth of aphantasics and while both claim to be studying the same population their results may not be comparable based on subtype separations. A prominent example of the ambiguity that emerges when studying the entire population of those with aphantasia arises from a study attempting to determine aphantasics cognitive style. This style reflects an individual's characteristic mode of thinking about and remembering things and often falls into verbalizer or visualizer (Takahashi et al., 2023). While researchers predicted aphantasics would be predominantly verbalizers they instead found that those with aphantasia had nonspecific characteristics – they didn't fall into either category (Takahashi et al., 2023). The researchers theorized that this lack of clarity may be characteristic of aphantasia, but it could also be a feature of their study. Those with complete aphantasia may have more of a tendency to be a verbalizer than a visualizer and the opposite may be true of those with vague imagery leading to inconclusive results. While one study seemingly contests this result by examining if there was a difference between no and some visual imagery and finding none, this study defined aphantasia as visual alone in nature (Hashim et al., 2024). Therefore, the author cannot make this assumption as they were likely also examining individuals with combinatorial and multisensory aphantasia and there's no way to know how these interactions impact each other.

Another interesting avenue in aphantasia subtype research is that auditory and visual aphantasia tend to co-occur more than any other combination (Hinwar & Lambert, 2021). Despite this finding recent research does not show strong evidence for this as a possible aphantasia subtype (Pounder et al., 2024). In an auditory study, researchers recruited individuals with visual aphantasia and attempted to determine how strongly auditory mental imagery deficits occur as well as what cognitive differences may arise. They did so by having individuals identified as having both visual and auditory mental imagery deficits through questionnaires undergo a pitch determination and voice recall task where individuals were asked to identify if a pitch was higher or lower than the last as well as to determine if they had heard the voice before (Pounder et al., 2024). Since the researchers found no evidence of reduced performance or increased response times, they concluded that not only was there not strong evidence for this subtype but that it wasn't cognitively different from visual aphantasia (Pounder et al., 2024). This study seems to run into the same issue that visual aphantasia study does. While the individuals may have a poor ventral auditory pathway, they could still have a dorsal auditory pathway leading to compensation. This is compelling in that pitch determination and voices have spatial characteristics. Like visual aphantasia, it is possible that auditory aphantasia could also have dissociations between spatial and object that were not considered in this paper. It could also be the case that auditory mental imagery is not as specialized as visual mental imagery but further study into this specific aphantasia type needs to be conducted to make this conclusion.

Another emerging subtype of aphantasia that has just garnered attention is kinesthetic motor imagery (Dupont et al., 2024a). While fairly preliminary there is evidence that individuals with this type of aphantasia don't experience corticospinal excitability in response to visualizing motor movements of themselves or others and tend to view movements from an outsider perspective which may lead to differences in motor learning and decision-making (Dupont et al., 2024a). Another recently described subtype is that of deep aphantasia. This type of aphantasia indicates that the visual brain area is not shaped by prior expectations as it is in most individuals or that there is a lack of inhibitory feedback (Bouyer & Arnold, 2024). While fairly unstudied it seems to include issues with extrapolation or integration of visual information across space, lack of bi-stable visual phenomenon experience, and lack of illusions shaped by prior experience such as face pareidolia and three-dimensional experience of the Necker's cube (Bouyer & Arnold, 2024). Yet aside from these symptoms, it cannot also form at least visual mental images as well, in addition to being unable to have imagined sensory experiences there also are atypical experiences of actual sensory inputs (Bouyer & Arnold, 2024). While it is unclear if deep aphantasia should be classified as the same condition, it is clear that it shares the symptomology of lack of visual imagery which has always been grouped with aphantasia. The multitude of subtypes present demonstrates the importance of clear definitions, diagnostic tools, and cutoffs. Ignoring the subtypes often leads to conflicting or inconclusive results that make understanding the condition even more difficult. While there are many different subtypes, and it seems that considering each on its own is an impossible task moving toward this mode of study will allow for a clearer determination of the cognitive profile of each form of aphantasia. Taking the time to make this differentiation will ensure that not only are researchers studying the same group population, but it will also make comparisons between different types of aphantasia much more concrete and specific.

Cognitive Theories of Aphantasia

While research on aphantasia is still fairly new three general theories attempt to describe its occurrence: metacognition, lack of voluntarily generated mental imagery, or deficits in general mental imagery capacities. The theory of metacognition arose initially since aphantasia was only able to be studied through the VVIQ, a subjective report based on introspection (Zeman et al., 2024). Researchers, rightfully, are skeptical of introspection and so some theorized that individuals with aphantasia did not have an actual mental imagery deficit but instead had issues with their metacognitive abilities – the images are present but just could not be accessed (Keogh & Pearson, 2024a, Zeman et al., 2020, Zeman et al., 2015). Most of the current evidence to support this is the lack of difficulty in cognitive tasks often thought to be dependent on mental imagery. One of the first studies to expound on this examined whether visual and spatial aspects of first-person episodic recall were impaired in aphantasia (Siena & Simons, 2024). The researchers noted that there was an inconsistency between the vividness ratings and performance with individuals with aphantasia having no object or spatial deficits but there was an increased response time (Siena & Simons, 2024). The author concluded that it was likely that individuals with aphantasia had a deficit in conscious awareness rather than mental imagery. A similar study was done afterward having participants perform a mental rotation task of complex three-dimensional cube figures where the author determined that people with aphantasia performed similarly on the tasks to the control but had the same increased response time noted by Siena (Pounder et al., 2022). The author also concluded that a lack of conscious awareness was more likely than an actual visual imagery deficit. A final study examined object imagery by giving participants a word and then two objects and asking them to indicate which object best matched it and then were later tested on object memory (Liu et al., 2024). The researchers found that the object memory of those with aphantasia was just as accurate as the controls and again concluded a metacognitive deficit (Liu & Bartolomeo, 2023). While this study did not note an increased response time the authors did note that much of their data relied on extensive knowledge of celebrity names and French cities which may have relied more on semantic memory and been less familiar to some participants (Liu & Bartolomeo, 2023). These confounding variables as well as the lack of explanation for the increase in response time despite preserved accuracy raise several questions about the metacognitive theory.

With the advent of objective measures outside of the VVIQ, many researchers have worked extensively to refute the metacognitive theory. One of the major arguments against this theory is that individuals with aphantasia often describe mental imagery dissociations and intact dreams (Wicken et al., 2021; Zeman et al., 2024). The preservation of some forms of imagery and the loss of others would be exceedingly difficult to explain under the terms of faulty metacognitive mechanisms. While the argument could still be made that individuals still don't have a complete picture of their mental imagery there is emerging evidence that subjective reports are strongly correlated with new objective reports. When participants reported imagery vividness during binocular rivalry the degree of vividness predicted the likelihood that imagery would bias subsequent perception (Pearson, 2014). This direct correlation seems to indicate that individuals with aphantasia have good metacognition.

Aside from the correlational data, there are a growing number of objective measures that seem to confirm the nature of aphantasia as a mental imagery deficit. Recent work into binocular rivalry tasks indicates that individuals with aphantasia could not be primed by their imagery (Keogh & Pearson, 2018; Keogh et al., 2024b). In these tasks, individuals are presented with two images to each eye simultaneously so that competitive inhibition occurs meaning one stimulus is suppressed from perception. However, mental images can be utilized for participants to be primed to have specific stimuli enter into perception. This phenomenon could only occur if there were no representational templates – conscious or unconscious for the participants to draw from.

Thus, the lack of imagery does not appear to be due to a metacognition deficit. Emerging evidence from the pupillary light response reflex seems to support this notion. Individuals with aphantasia not only had an intact pupillary light response for perception of bright light but they also showed a lack of this involuntary response when utilizing mental imagery (Kay et al., 2022; Zeman et al., 2024). While it could be argued that individuals with aphantasia were not exerting the same amount of effort as controls to utilize mental imagery it was found that individuals with aphantasia also had greater pupil diameter during the imagery task suggesting they were actively engaging in the task and fact exerting more effort than controls (Kay et al., 2022). In other imagery tasks focused on mental rotation individuals with aphantasia lack an RRN component – an event-related potential that occurs during mental rotation tasks in individuals with intact imagery (Zhao et al., 2022). If individuals with aphantasia did indeed have intact imagery this component would still show up despite a lack of access to the image.

There have also been an increasing number of varied studies examining more broad physiological responses during imagery tasks in aphantasia. In one such task, aphantasic individuals were shown images meant to elicit fear and sentences of a story meant to elicit fear (Wicken et al., 2021). Researchers found that during the perception condition, individuals with aphantasia had similar skin conductance levels (SCL) to controls while in the imagery condition, they did not (Wicken et al., 2021). SCL is a measure indicative of arousal as in higher stress situations individuals allow more electrical current to flow across the surface of their skin (Zeman et al., 2024). The fact that this level was lowered in perception suggests that individuals with aphantasia still have appropriate fear responses when imagery is presented to them which suggests a lack of mental imagery associated with reduced fear levels (Wicken et al., 2021). Another study examining explicit and implicit motor imagery in individuals with aphantasia found no increase in corticospinal excitability often associated with this imagery (Dupont et al., 2024b). Showing an objective correlation outside of simply visual aphantasia demonstrates that visual aphantasia is not an exception to the metacognition theory – it seems that multiple subtypes of aphantasia are likely to be exceptions as well. Metacognitive theories also seem to fail to consider acquired cases of aphantasia. Individuals with this type of aphantasia can still remember what it was like to experience visual imagery (Dance et al., 2021a). While acquired and congenital aphantasia likely do not have identical etiologies the consistency of symptoms across them seems to indicate similar disruptions whether functional or structural. This makes it unlikely that congenital aphantasia can be adequately explained by an introspection deficit. This growing body of evidence makes it increasingly unlikely that the metacognition theory is the best fit to explain the condition. Despite this, some researchers suggest that metacognitive aphantasia could be a subtype (Siena & Simons, 2024); however, there seem to be far more unified and explanatory theories presented.

A current theory that seems to have far more explanatory power is that aphantasia represents a deficit in the generation of voluntary mental imagery. The dissociations between spatial and object imagery, at least in visual mental imagery, fit well into the current sensory theories of dorsal and ventral pathways in the brain (Zeman et al., 2024). In sensory information flow information relating to what an object is moves to the temporal lobe while information relating to where something is moves to the parietal lobe. This pathway segregation seems to be maintained in mental imagery, especially visual aphantasia where spatial and object aphantasia can be separated. This current mode of sensory dissociation is incorporated into what is known as the reverse hierarchy model to explain the possible mechanisms behind aphantasia. There is mounting research that mental imagery is akin to perception in the absence of any external stimuli and is also a product of sensory information retrieved from memory (Sherwood & Pearson, 2010). Since perception is a bottom-up process imagery is thought to be engaged in a top-down manner; the path of vision from the occipital lobe to the temporal and parietal lobes along the what-where pathways is reversed in imagery instead of traveling from temporal and parietal lobes to the occipital lobe (Pearson, 2019; Zeman et al., 2010). Therefore, since perception is intact in individuals in aphantasia under this reverse hierarchy model something about the reverse structural or functional nature of mental imagery must then be impaired. There is evidence that regions supporting perception overlap with regions supporting mental imagery (Pearson, 2019; Zeman et al., 2010). In particular, the degree of vividness of mental images has been linked to the specific neuroarchitecture of the visual-spatial working memory system that integrates multiple systems (Sherwood & Pearson, 2010). According to this model, there could be a structural or functional disconnection between the anterior regions required for imagery generation and the posterior regions that support the content of both perception and imagery (Zeman et al., 2010). There is a specific alteration in the reverse connectivity between prefrontal executive areas and visual cortices that is not found in the forward connectivity (Dawes et al., 2020; Keogh et al., 2021a; Palermo et al., 2022; Pearson, 2014; Pearson, 2019). While the specific regions involved in this disconnect are not known, this theory seems to find support in both the disconnection of spatial and object imagery in visual aphantasia and in the fact that perceptual skills in aphantasics do not seem to be impaired. However, this theory specifically seems to base itself on the presence of visual aphantasia and cannot be adopted for aphantasia as a whole until more evidence is provided that the features of visual aphantasia are indeed reflected in other aphantasia subtypes.

A newer mental imagery general deficit theory seems to work to fill in the gaps in the reverse hierarchy model based on the consideration of multiple subtypes. This model assumes the reverse hierarchy model but also the scene construction theory. This theory assumes that autobiographical memory and visual imagery share the same neural mechanism (Monzel et al., 2023c). Both of these theories rest on the same idea that the hippocampus is involved in generating mental images from memory (Monzel et al., 2024c). Instead of functional or structural disconnects specifically between pathways responsible for each mental imagery experience, this model assumes a disconnect between the hippocampus and mental imagery pathways. This model can help explain multisensory aphantasia as well as specific subtypes of aphantasia due to connectivity issues with the hippocampus. However, since neural mechanisms of aphantasia are just starting to be elucidated it is not clear if aphantasia aligns more with the general mental imagery deficit theory or the voluntary mental imagery deficit theory. Another emerging theory working to explain multisensory aphantasia in light of cortical excitability has also emerged (Dance et al., 2021a). This theory posits that multisensory aphantasia is due to a decreased activation in the specific sensory cortex. The author concludes that this could be due to lower levels of excitatory glutamatergic synaptic activity or higher inhibitory GABA-ergic synaptic activity in areas involved in sensory modulation/regulation such as the thalamus (Dance et al., 2021a). Again, there is little neural evidence focused on synapses in aphantasia, so it is impossible to say for sure which theory aligns best with current research. With the heterogeneous nature of aphantasia, it is possible that all of these theories at least describe part of the mechanistic nature of aphantasia and at this time none can be ruled out entirely.

Cognitive processing

By far the most robust area of aphantasia research is cognitive processing. However, despite the focus on this specific area of focus much of this form of research focuses on congenital aphantasia alone and not acquired aphantasia. Researchers are attempting to create a unified understanding of impacted and preserved cognitive abilities in those with aphantasia to better elucidate possible underlying mechanisms and provide thorough support for certain theories of aphantasia. Much of this research arose due to the debate about whether visual mental imagery in particular plays a role in cognition or if propositional knowledge is sufficient for supporting performance on tasks associated with visual imagery (Kosslyn et al., 2001; Zeman et al., 2010). Interestingly enough aphantasia, particularly visual aphantasia results in the loss of imagery usually in the absence of other cognitive deficits (Zeman et al., 2010). This idea lends credence that individuals with aphantasia use alternative mechanisms to support their performance on visual imagery tasks. It also seems to indicate that cognition does not rest on visual imagery alone. While much of the research on aphantasia's cognitive abilities has focused specifically on visual aphantasia there are numerous studies working to investigate further into multiple subtypes. Despite this progression the largest feature of aphantasia, and indeed the most studied, is the lack of mental imagery.

Imagery

Due to the characterization of aphantasia as a lack of mental imagery research has primarily focused on the impacts that this lack has on tasks directly associated with this ability. Primarily due to evidence from the VVIQ researchers have determined that at least in the visual domain object imagery is greatly impacted (Blomkvist & Marks, 2023; Kay et al., 2022; Keogh et al., 2021a; Siena & Simons, 2024; Zeman et al., 2010). Despite initial reliance on the VVIQ for this observation more recent objective tasks seem to support this claim such as the binocular rivalry task (Pearson, 2019) and the pupillary light response (Kay et al., 2022). Oddly enough, despite the deficit of visual mental imagery individuals with aphantasia appear to perform similarly to controls on tasks meant to probe mental imagery. When examining recall after being shown object shape, object color, written words, faces, and spatial relationships aphantasics had comparable accuracy (Liu et al., 2024). Also, during a drawing recall experiment that had a phase to study an image of a room and then attempt to recreate it aphantasics while drawing fewer objects than controls drew the correct items in the correct locations (Bainbridge et al., 2021). This implies that a lack of object imagery does have an impact on some forms of recall but does not prohibit it entirely leading to the theory that aphantasics have some kind of compensatory mechanism they utilize. One claim on a possible mechanism in aphantasia comes from the Shepard-Metzler task where a 3D cube is shown on the left with a target image on the right where the target is either an identical or mirrored image of the cube and positioned at different degrees of angular disparity (Kay et al., 2024). When aphantasic individuals perform these tasks, they show increased response time in reaction to increased angular disparity much like controls but while their accuracy was similar to controls their response times were much slower (Kay et al., 2024). The slower response times with preserved accuracy seem to indicate that aphantasic individuals are using a different cognitive strategy than controls to solve the task. When participants were asked about their strategy, they were far less likely to use object-based holistic location and instead used primarily analytic or criteria-based rotation (Kay et al., 2024). This result has been confirmed in numerous mental rotation task studies. When examining the understanding of spatial relationships individuals with aphantasia showed a normal response time that was not found when examining object relationships (Liu et al., 2024). In a letter rotation task with the same canonical or mirror-reversed setup, the same response time increase with increasing angular disparity as expected was shown by participant M.X. with longer response times than controls (Zhao et al., 2022). These studies seem to confirm the idea that different strategies are utilized in tasks thought to require object imagery. This led to the idea that there might be dissociations in visual mental imagery in which different pathways are preserved in individuals with aphantasia. Despite the overwhelming evidence for preserved spatial imagery, one study by Kay and colleagues found that individuals with aphantasia were slower and more accurate but did not show an increase in response time as a function of increasing angular disparity (2024). While this result may seem contradictory the likelihood of dissociation between spatial and object visual mental imagery can explain this result. Simply because most cases of visual aphantasia are characterized best by intact spatial mental imagery and loss of object imagery does not mean that this is necessarily the case. If the opposite were true and individuals could also have spatial aphantasia with intact object imagery then it would necessitate that response times would indeed not increase as these individuals are not using mental rotation, even feature-based. Visual aphantasia on its own has been shown to have different subtypes making it likely that study results can be skewed based on the proportion of spatial or visual aphantasics included considering that the VVIQ often classifies both as such. Despite the confound of subtypes, it does seem that the dissociation tends to result in object aphantasia far more commonly than spatial.

The specific dissociation seems to involve the common what and where pathways of sensory information. Specifically in individuals with aphantasia, the above mental rotation tasks seem to imply that while object imagery is deficient spatial imagery is intact in most cases (Bainbridge et al., 2021; Keogh et al., 2021b; Zeman et al., 2010; Zeman et al., 2024; Zhao et al., 2022). Several studies seem to confirm the prevalence of this dissociation. The drawing recall task found that when recreating the image of the room previously observed aphantasic individuals while relying more on symbolic representations indicative through their use of text had spatial accuracy equivalent to that of controls and drew fewer false objects overall (Bainbridge et al., 2021). This seems to indicate that not only was spatial mental imagery preserved in the aphantasia group but that the lack of object mental imagery may have made their encoding of visual information less susceptible to interference leading to fewer false memories. Another study examining results from the VVIQ and the object and spatial imagery questionnaire (OSIQ) found that aphantasic individuals were much more likely to score poorly on the VVIQ with comparable scores to controls on the OSIQ (Dawes et al., 2020; Keogh et al., 2021a). Again, there are mixed results with another 3D object and spatial memory task manipulating the visuospatial perspective. In this experiment, participants studied the location and color hue of objects in three-dimensional space in either first or third person and then attempted to reproduce the image as well as recall its location (Siena & Simons, 2024). This study found that aphantasia had lower object imagery but also lower spatial imagery though their performance was only slightly less accurate than controls. This study could be indicative of two things, either individuals with aphantasia can only be supported by their compensatory mechanisms to a certain point before spatial imagery is no longer preserved making difficulty a prominent feature in aphantasia tasks, or a different subtype population was being studied than previous experiments. Outside of the possible inclusion of spatial and object aphantasics in the same studies in different proportions, these studies all used the VVIQ for diagnostic purposes meaning it is exceedingly likely they included individuals with multisensory and combinatorial aphantasia. This consideration makes it difficult to determine if visual aphantasia alone is characterized by this dissociation or if it is present in multiple subtypes. It also makes it difficult to claim that object aphantasia is more common as the only intended population to be studied is visual aphantasics and yet these are not the only individuals included in these studies. Given these concerns, it is difficult to create a unified understanding of the cognitive profile of aphantasia even from its most obvious and well-studied symptom.

Memory

Outside of mental imagery, the next most explored cognitive impairment in aphantasia centers around memory. Much of the focus comes from the idea that mental imagery is involved not only in memory encoding but also retrieval and thus lack of this ability may lead to more difficulty in these faculties associated with different areas of memory (Sherwood & Pearson, 2010). There is only preliminary evidence that sensory strength predicts visual working memory performance (Pearson et al., 2008) with most focus on long-term forms of memory. Despite this, it seems that iconic memory, based on sensory memory from visual input is not impacted in aphantasia (Pearson, 2019). This is likely because perception heavily influences this type of memory and most sensory memory is discarded rapidly while the transferred information makes its way into working memory requiring its own processes. Aphantasia has also been utilized to examine the two models of visual working memory. There is debate on whether working memory works as a discrete slot with a fixed number of items that can be held or if it’s a flexible resource model being spread across multiple images at varying levels of precision (Keogh et al., 2021b). In a visual working memory task, individuals were instructed to remember the orientation of multiple Gabor patches with the set size increasing as time went on. Aphantasics were less likely to report visual imagery as expected however, they performed just as well on this task as controls except when more fine-grained representations were necessary. Interestingly enough individuals with aphantasia did not show an oblique effect for orientation, meaning they were not faster at recognizing vertical or horizontal lines as opposed to oblique angles (Keogh et al., 2021b). This seems to indicate that working memory may fit either model and that individuals with aphantasia seem to have an impact in their working memory not on their ability to process or manipulate images but on their ability to use prior knowledge housed in visual mental imagery (Keogh & Pearson, 2018). Another study specifically focused on spatial working memory attempted to elucidate the specific dissociation associated with spatial imagery. Participants were shown a sequence of flashing squares and had to repeat the sequence and they also were shown an arrangement of three colored balls that they had to mentally rearrange to match a given arrangement and calculate the number of moves it would take in their heads (Pounder et al., 2022). Aphantasic individuals showed no difference in spatial working memory indicating that it is indeed not the manipulation of objects in working memory that is affected but instead, mental imagery in working memory requires object imagery. Examination of short-term memory prompted comparison to long-term memory in later research. In a later study, participants were given an audio recording of a list of words and then asked to list the words containing at least one r meant to probe verbal short-term memory (Monzel et al., 2023c). Then participants were presented with a screen of seven squares with lines of different orientations and asked to indicate the orientation meant to probe visual short-term memory. Next, they were given a list of fifty-six words and then later had to decide if each word was part of the list, they had previously seen meant to probe verbal long-term memory. Finally, the participants were given five complex geometric figures and then selected incomplete versions of previously seen figures meant to probe visual long-term memory. The study found that aphantasics performed worse in all investigated memory components but were much worse in visual short-term memory than verbal short-term memory (Monzel et al., 2023c). This study seems to indicate that visual mental imagery is indeed important in encoding and retrieval of information into memory, but verbal mental imagery may also be. While controls may have used visual mental imagery to encode verbal information this same strategy was not available to aphantasic individuals. The lack of visual mental imagery likely contributed to worse performance though it is worth noting that this author included individuals with multisensory aphantasia meaning that lack of auditory mental imagery may have also interfered with the encoding and retrieval of verbal information if indeed mental imagery in general and not just visual information contributes to memory processes.

While very few conclusions can be drawn about working memory or short-term memory in aphantasic individuals there is far more focus on different forms of long-term memory particularly that of episodic memory. Based on memory questionnaires researchers hypothesized that aphantasic individuals would have more trouble with autobiographical memory than any other kind of memory (Zeman et al., 2015). In a series of autobiographical interviews, it was determined that those with aphantasia had far fewer internal details than controls, but no difference was found in external details (Milton et al., 2021). Internal details relate to episodic details about events such as sensory information or emotional states while external details deal more with semantic or factual statements of the event as well as factors such as repetition of information (Milton et al., 2021). This again seems to apply a dissociation in aphantasia between episodic long-term memory and semantic long-term memory. This dissociation can be seen in the completion of the window task in aphantasic individuals. In this task, participants are asked to count, from memory, how many windows are present in their home (Zeman et al., 2015). When given this task aphantasic individuals can perform this task likely due to their access to semantic information and not mental imagery stored in episodic memory. A follow-up study looked at multiple memory domains thought to be essential to different imagery processes. Declarative memory was examined by having participants recall words with neutral valence as well as recognize patterns they had been shown previously (Pounder et al., 2022). Aphantasic individuals showed no difference in episodic memory as compared to controls. There may be a couple of reasons for this result. Former research into long-term memory has found that there is a fundamental difference in actual episodic memory as compared to lab-simulated long-term memory (Dawes et al., 2022; Palermo et al., 2022; Pounder et al., 2022). This could indicate that the lab results do not reflect the reality of episodic memory in the condition. Furthermore, the time duration of probed episodic memory is often more solidified than in lab studies. Participants before autobiographical interviews have likely gone over their memories multiple times leading to changes as well as the protective factor of repetition and this same experience cannot be easily replicated in lab settings. It could also be that autobiographical deficits are far less impacted than previous research depending on questionnaires and interviews suggests. On the other hand, it could be the case that there is a fundamental difference in this form of memory in aphantasic individuals with dim or vague mental imagery as opposed to a complete lack of mental imagery. Pounder and colleagues in this study made sure to follow the VVIQ cut-off from the original aphantasia study (16-32) meaning they included more individuals with dim or vague memory which may have led to them finding no differences to controls (2022). It could be that visual mental imagery does support memory, but that increased vividness does not correspond to a better memory. Another autobiographical interview study found nearly identical results to the first study. Individuals with aphantasia reported fewer internal details for past and future events with no difference in external details (Dawes et al., 2022). However, aphantasic individuals still had good details for the event, time, place, emotion, thought, or other non-visual details and were most impacted by perceptual and visual internal details. This does seem to imply that any lack of visual mental imagery may impact memory, but that long-term memory is spared when it correlates with more non-visual details. It seems to follow that autobiographical memory, to some extent, is impacted in aphantasic individuals though to what degree is heavily debated. It may be that differences arise from experimental settings under which long-term memory is tested as opposed to autobiographical interviews that rely on memories that have already been formed. This seems plausible considering the differences in episodic memory with individuals with aphantasia are found most commonly between these styles of evaluations. It may be beneficial to instead evaluate the impact of autobiographical memory on everyday functioning to determine the level of detriment provided to aphantasic individuals to conclude which mechanism of study tends to be more effective and accurate.

Details of recall in long-term and short-term memory have been heavily studied but the process of associative binding can also reveal why there may be deficits in episodic memory in aphantasics. In an associative binding task, participants were asked to determine if two different stimuli matched without being instructed to remember the information for later. They were examined on binding between stimulus pairs, an object and its location, and an object and its specific perceptual features (Witman & Satirer, 2022). The participants then underwent a retrieval-cued forced-choice recognition where words were presented instead of the original pictures and participants were asked to indicate the screen location, the target word that matched the stimulus, and the color as well as rate their confidence in their response. In aphantasia the reduced mental imagery led to a decreased likelihood of perceiving connections which led to lower confidence in their responses however they were just as accurate at the forced-choice task as controls (Witman & Satirer, 2022). It therefore seems that associative binding is not reliant on mental imagery alone. While this is a persuasive conclusion it should be noted that recognition depended on information different than was encoded. It is known that when encoding matches retrieval performance tends to be better on these tasks than on tasks where these features don't match (Sherwood & Pearson, 2010). Controls likely had a reduced performance due to these differences while aphantasics were able to perform as well as they did due to the possibility of semantically encoding the information which would match with the retrieval conditions. This may have led to the researchers' assumption that mental imagery does not relate that heavily to associative binding processes though more investigation is required to support this point. This point seems especially prudent in research focusing on eyewitness accounts. A recent study examined three retrieval conditions of mental reinstatement of context where participants were asked to remember the physical and psychological context of a video they witnessed, a sketch reinstatement of context where they were asked to draw the event, or no support with interview two days after watching the video (Dando et al., 2023). The researchers found that aphantasics recalled less episodic information and their accounts were less complete, but they improved recall and accuracy over the interview process (Dando et al., 2023). This improvement is likely because during the interview aphantasic individuals did not need to utilize mental imagery and instead accessed semantic information. This seems to contribute to the idea that when encoding matches retrieval performance tends to be better. This is especially clear as when aphantasic individuals underwent interviews requiring mental imagery they performed much worse than controls. Further investigation into memory encoding and retrieval focused on creating face composites. Participants were given a target and then asked to create holistic representations where they selected approximations from given options and based on their selections chose an approximation from presented options or featural representations where each part of the face was selected separately and then refined (Dance et al., 2023). It was found overall in aphantasic groups that there was no difference in accuracy produced by featural or holistic methods. Controls had a reduced accuracy on featural representations. Again, this seems indicative of the importance of encoding and retrieval features. It has been suggested that faces are special in perception and are processed holistically (Dance et al., 2023). Therefore, it follows that controls would have better performance with holistic retrieval as it matches the encoding method. Interestingly, aphantasia does not follow this process which raises the question of if faces are processed differently in those with aphantasia or if another factor such as mental imagery lack is responsible for the lack of performance differences.

Perception

What makes aphantasia such a promising condition to utilize in research is the fact that perception seems to be mostly spared leading to a dissociation between perception and mental imagery. This unique disconnection could be endlessly valuable in studying the interplay between imagery and perception, the overlapping brain regions, and the influence of other cognitive factors such as emotion or memory. The activation of the binocular rivalry response in perception and not in visual mental imagery is an objective measure of this disconnect (Keogh et al., 2024b; Pearson, 2019). Furthermore, in a drawing recall experiment while recreating the image of a room from mental imagery was impaired in object visual mental imagery those with aphantasia could copy the drawing just as well as controls indicating no perceptual difficulties (Bainbridge et al., 2021). When comparing functional connectivity in perception and mental imagery reduction in activity between the visual cortices and higher-order areas was only found during the mental imagery condition indicating that perceptual pathways in the brain are intact (Milton et al., 2021). Another objective measure focusing on emotional reactions found a similar finding. Researchers measured participants' skin conductance level (SCL) associated with the fear response in individuals under an imagery and perception condition. In the imagery condition participants read a story with no images and in the perception condition participants were shown pictures meant to evoke fear (Wicken et al., 2021). Aphantasic individuals had reduced SCL levels in the imagery condition but not the perception condition. This indicates that while they are deficient in mental imagery they still have proper interpretation of their surroundings and appropriate responses as a result of these surroundings. Despite these consistent results, there is evidence that those with aphantasia have lower confidence in responses on tasks involving the perception of shapes and faces (Liu et al., 2024) though this confidence does not often relate to actual performance levels indicating mental imagery deals more with confidence levels than accuracy. It is important to note that those with aphantasia were less accurate at recognizing a series of target faces and yet were just as accurate at creating face composites (Dance et al., 2023). While the author argues that this is due to a perceptual deficit this is unlikely when considering that target faces were not present at the time of identification and instead likely relied heavily on semantic information which has a much more sensitive response than mental imagery to task difficulty (Blomkvist & Marks, 2023). This indeed seems likely when looking at the accuracy of aphantasic individuals when creating face composites. While this seems counterintuitive, it has been shown that aphantasic patients often relay fewer false memories than controls (Bainbridge et al., 2021, Cui et al., 2007). Eyewitness testimony and composite sketches are famously flawed often due to misremembered events which may be facilitated by mental imagery. While aphantasic individuals are less likely to encode false information they may still score similarly to controls as they have to rely more heavily on semantic memory when recreating faces from memory. Overall, it seems fairly consistent to say that perception is mostly spared in aphantasia though there could be some rare or more extreme cases where it too is impacted.

Language and Comprehension

Due to the embodied theory of language comprehension that assumes that much of our understanding of abstract and concrete concepts comes from sensorimotor systems as well as mental imagery, there is an emerging issue of whether aphantasics may have problems with language comprehension. After reading a short story and being given a recall test, it was determined that individuals with aphantasia performed just as well as controls indicating intact comprehension (Speed et al., 2024). This seems to partially refute the embodied theory (Keogh et al., 2021a) as there was no impairment in language abilities in those with no imagery despite the intentional engagement of imagery during story reading. It does not necessarily follow that comprehension is completely intact given that different subtypes of aphantasia may be impaired. When examining a specific group with a reduction in motor stimulations there indeed was a deficit in reading comprehension (Dupont et al., 2024b). This seems to suggest that voluntarily engaged mental stimulations that occur during reading do improve comprehension and can indeed contribute to representations that remain available for future manipulation. However, this study was specifically focused on mental imagery eliciting actions and motion. Therefore, it seems likely that comprehension may vary widely across subtypes and depend on what mental imagery domains are impacted. It seems likely that different forms of mental imagery help contribute to comprehension of different elements and the synthesis of them may also lead to better comprehension performance. Investigation into subtypes can not only reveal the commonality of language comprehension deficits but also help determine which types of mental imagery contribute the most heavily to this form of understanding. It is entirely possible that motor imagery plays a much larger role in story understanding than sensory areas such as auditory or olfactory.

Face Recognition

While it seems that most forms of perception remain intact in aphantasia there seems to be a specific focus on face recognition as an area with a possible deficit. This is likely due to the fact that face recognition relies not only on perception but also on higher-order perceptual areas that often overlap with mental imagery and are influenced by this leading to this detriment (Dance et al., 2021a). Therefore, this feature of aphantasia is not likely to rely on perception and instead is likely deficient due to its interplay with mental imagery. When examining individuals with object aphantasia it was determined that while these individuals had poor face recognition it was not severe enough to be associated with prosopagnosia (Palermo et al., 2022). This idea was echoed in a study that examined performances on the Cambridge face memory test and the Cambridge car memory test (Monzel et al., 2023a). Not only did this study determine that recognition deficit is not specific to face stimuli, but this difference disappears when object recognition is removed. It makes sense that face recognition as well as car recognition would be affected as both areas have been known to rely on the fusiform face area which relates to processing objects when expertise is involved and the superior temporal sulcus which integrates imagery with perception (Keogh et al., 2021a). Despite this impairment, it is not severe enough to count as prosopagnosia in this study as well (Monzel et al., 2023a). While aphantasia is associated with face recognition deficits it does not seem to be a perceptual issue and instead a synthesis issue requiring the use of representational items that are missing in those with aphantasia. Furthermore, it is not severe enough in those with aphantasia to count as prosopagnosia and does not seem to have too much impact on day-to-day life.

Visual Search

Another interesting task impaired in aphantasia that appears to be perceptual is that of visual search. Those with aphantasia tend to be slower at visual search likely due to the lack of visual imagery aids (Monzel & Reuter, 2024). Visual imagery could likely allow for enhanced attentional guidance due to priming mechanisms where relevant information is filtered, and irrelevant information is suppressed from awareness. It could also be that visual imagery impacts the decision-making process (Monzel & Reuter, 2024). Visual search is disrupted in aphantasia which could be due to impacted attention. The researcher thus proposed that individuals lacked attentional guidance through visual imagery but did not lose it completely due to a compensatory priming process that is weaker than traditional priming (Monzel et al., 2021). A follow-up study specifically examined attentional templates due to their neural similarities with visual imagery. Attentional templates act as a form of preparation to aid in search performances where the target image is focused into attention creating a template to help find the item more quickly and efficiently by selecting salient information and suppressing irrelevant information (Keogh et al., 2021a, Keogh & Pearson, 2024b). During a visual search task, there was no evidence of attentional templates as individuals with aphantasia were much slower at detecting the target. The following experiment had participants perform the binocular rivalry task and researchers attempted to determine if instructing aphantasic individuals to pay attention to a certain stimulus could prime them. (Keogh & Pearson, 2024b). The researchers found that they could be primed in this way which showed that they did have feature-based attention and therefore likely used feature-based strategies instead of attentional templates leading to slower response times but preserving the ability to detect the target. While again it appears that perception is impacted in individuals with aphantasia close examination of results implies that attention and information integration, both reliant or similar to visual imagery are what cause specific deficiencies in aphantasia to arise.

Verbal overshadowing

An emerging area in aphantasia research is working to move away from just visual imagery and towards other forms such as verbal or auditory information and its perception and integration. The first study into this realm examines the verbal overshadowing effect in those with aphantasia. This effect results when the verbal description of past sensory input impairs subsequent recognition of the same stimulus (Monzel et al., 2024d). The primary theory of why this effect occurs is the transfer inappropriate retrieval hypothesis where the verbalization causes processing to go from global to feature-based meaning the way the information is encoded and retrieved does not match though this effect only occurs in more abstract words. Monzel and colleagues examined this effect in aphantasia and found that it does not occur in these individuals (2024d). This is likely since there is no visualization for the verbalization effect to occur which seems to be supported by the fact that those with aphantasia had shorter response times in retrieving the information and higher recognition accuracy after verbalization. Both of these factors are likely due to the idea that aphantasic patients encoded the information they were instructed to visualize more featurally rather than globally like the controls. Therefore, when verbalization was introduced not only did it not disrupt their visualization but the match between encoding and retrieval actually made performance on the task better.

Cognitive Style

With the lack of visual imagery studied most thoroughly in aphantasia research as well as the existence of individuals with multisensory aphantasia, many researchers have begun to examine how those with aphantasia think and perceive their cognition. Recent research has suggested the use of unsymbolized thinking, an experience of thought that does not include words, images, or any other symbols, particularly in those with multisensory aphantasia. This type of thought is not unique to aphantasia and is actually one of the most common types of thought (Krempel, 2023). It appears that individuals with aphantasia, based on a questionnaire, utilize this type of thought more frequently than others, and in the case of multisensory aphantasia is the primary type of thought though some can utilize inner speech without any auditory imagery (Krempel, 2023). This seems to be a common mode of thought for those with aphantasia particularly as their cognitive style tends to be unclear (Takahashi et al., 2023). When examining if aphantasic individuals tend to be a verbalizer or a visualizer researchers found nonspecific characteristics in the aphantasia group. This could be due to the primary use of unsymbolized thinking but could also be complemented by different subtypes. Individuals with visual aphantasia would be far more likely to be a verbalizer while auditory aphantasia would be far more likely to be a visualizer. Considering this effect as well as the prevalence of multisensory aphantasia in study groups it seems likely that the unsymbolized thought of the multisensory group as well as the inclusion of pure visual aphantasics likely skewed results. This makes it unclear to determine if the cognitive style is unclear among all aphantasics or if specific subtypes have a stronger relationship with one over the other.

Hallucinations

With hallucinations being strongly implicated with more vivid mental imagery a recent study has attempted to determine if aphantasia can have an attenuating effect much like stronger visualization tends to be a predictor of hallucination probability (Keogh et al., 2021a). Researchers utilized a Ganzflicker task that rapidly blinks between a red and black screen at frequencies meant to mimic brain waves that alter how information is filled in by the sensory system (Konigsmark et al., 2021). Due to this anomalous perception of sensory information, the task is known to produce pseudo-hallucinations. Participants in this study underwent this task and then were asked about their experience with the pseudo-hallucinations. If any occurred, they were asked to discuss the complexity, emergence time, duration, intensity, and frequency. The study found that those with aphantasia were far less likely to see pseudo-hallucinations and it was seen the hallucinations were often weak and insubstantial as well as less complex. Despite this, there was no difference in emergence time, duration, or frequency in the pseudo-hallucinations between the aphantasics and the controls (Konigsmark et al., 2021). The researchers concluded that the lack of complexity likely had to do with activity in V1 meant for processing simple forms as well as disruption in higher-order visual cortices that often overlap between imagery and perception.

Dreaming

Commonly in individuals with aphantasia dreaming tends to be intact which many researchers take to mean that many involuntary forms of imagery and therefore also intact in individuals with aphantasia (Whiteley, 2021). Despite this assumption, the experience of dreaming seems to be slightly more nuanced in the condition. In the initial case study that sparked reawakened interest in aphantasia, participant MX entirely lost his ability to dream at first before regaining it (Zeman et al., 2010). Interestingly his VVIQ scores also changed. When he reported no dreaming experience, he received a floor score of 16 and when his dreams returned he reported a higher VVIQ score of 23. It seems likely then that involuntary imagery may be impacted by aphantasia as well and also may be dissociative like voluntary imagery. This is especially compelling as while MX regained his ability to dream he did not regain the ability to voluntarily induce mental images. Dreaming is indeed less uniform in aphantasia than most assume with aphantasic individuals more likely to report the absence of dreams though many do indeed dream (Zeman et al., 2020). Taking the assumption that because most aphantasics dream to indicate involuntary imagery is intact is misguided twofold. First, it assumes that involuntary imagery is uniform and that since one area is impacted all areas must be despite lack of evidence. Also, it completely ignores the fact that there is clear evidence of those with aphantasia who do not dream and glosses over any reasoning for why this occurs. This likely dissociation of involuntary imagery can also be seen in a study quantifying daydreams as well as night dreams. There was no evidence of a difference in daydreams in those with aphantasia though many reported fewer night dreams (Dawes et al., 2022). Also important to note is that many aphantasics who did dream reported lower awareness and control of dreams, less vivid emotions, and less clear dreamer perspective. It seems that even if involuntary imagery is intact based on just dream evidence it can be vague or dim much like voluntary imagery in aphantasia which does seem indicative of deficits in involuntary imagery as well. Dreaming in aphantasia needs to be further addressed and better utilized when examining the impact of involuntary imagery in aphantasics as it seems likely it may dissociate similarly to voluntary imagery in these individuals.

Priming

An increasingly complex feature of aphantasia relates to individuals' ability to be primed. The first evidence for a lack of visual priming in these individuals comes from the binocular rivalry task in which image grating is presented with a display and individuals are asked to indicate their dominant eye which is adjusted for (Keogh & Pearson., 2018, Keogh & Pearson, 2024b). After this adjustment, individuals are asked to imagine a specific grating which usually makes it more likely to enter into perception than the other grating presented simultaneously but this is not seen in aphantasic individuals (Keogh & Pearson, 2018; Monzel et al., 2021; Pearson, 2014,). After this initial study, there have been attempts to create other paradigms that support this finding. Moriya's task allows researchers to examine attentional guidance in visual search tasks. In this task, participants are asked to imagine one of three colors and then indicate whether one of two presented colored squares was open at the top or bottom (Monzel et al., 2021). There was no difference between controls and aphantasic participants in accuracy though those with aphantasia did tend to have slower response times. However, the researchers noted many participants complained about the length and had a high dropout rate. This caused them to form another task since they assumed that participants may have stopped attempting the imagination task due to the demanding nature of the task. In this task, participants were asked to merely pay attention to a specific cue instead of being asked to imagine it. In this case, aphantasics could be primed by this focus of attention suggesting that some forms of priming are intact (Monzel et al., 2021). Since only visual and attention-based priming have been examined with differing results it may be prudent to categorize the types of priming capable of eliciting response in those with aphantasia as well as determine if subtypes change the outcomes. For instance, while pure visual aphantasics cannot be primed by their imagery it seems absurd to then assume that individuals with intact visual mental imagery but loss in other domains would show this same response pattern.

Sensory Sensitivities

Due to the seemingly protective nature of aphantasia in some cases such as lack of priming, fewer false memories, and reduced response to pseudo-hallucinations all of which relate to mental imagery researchers began to search for other symptomology connections. It is known that cortical excitability relates to mental imagery and thus likely influences all the above protective features. Therefore, some researchers predicted that since cortical excitability also relates to sensory sensitivities individuals with aphantasia may also experience them less often than controls. In a series of questionnaires probing sensitivity, researchers found that those with aphantasia did indeed report fewer sensory sensitivities both hyposensitivity and hypersensitivity except audition (Dawes et al., 2024). The result of lack of audition sensitivity is curious and the researchers do not explain its occurrence. It could be that there is something about sound that is particularly abrasive, but this result seems odd due to the high co-occurrence of auditory and visual aphantasia that would seem to work to reduce this sensitivity. Auditory aphantasia is as under-researched as many other subtypes so it is hard to make any conclusions about it based on one study. Due to the results of the previous study Dawes and colleagues also had participants undergo a pattern glare task (Dawes et al., 2024). In this task, participants viewed achromatic gratings on grey backgrounds differing in spatial frequency meant to overexcite the visual cortex. Normally medium and high frequency lines are rated as more uncomfortable and have more associated visual effects, but they were greatly reduced in those with aphantasia (Dawes et al., 2024). It seems that visual discomforts and effects related to the primary visual cortex of the brain have reduced impacts on those with aphantasia implicating this heavily as a disrupted area in the condition.

Visual Conditions

While most cognitive features of aphantasia are contained in the aforementioned sections there are a few unique aspects of aphantasia that do not naturally fit into any of these categories that deal with mental imagery specifically associated with color. In a color naming test, a specific background color was flashed before showing a color word with a different color than the one previously where the color of the word did not match the color the word was describing (Cui et al., 2007). Individuals were then asked to report the color the word was describing. While controls were influenced both by the background color and the color of the word and tended to form illusory conjunctions between them those with less imagery vividness were far less susceptible to this color-naming influence. It then follows that mental imagery priming can occur when dealing with more abstract thoughts such as colors. Recent research has also found the presence of grapheme-color synesthesia (colors triggered by numbers or letters) in aphantasics at the same prevalence as found in controls. While this seems perfectly rational in specific combinatorial subtypes of aphantasia it is most striking that this effect persists in multisensory and visual aphantasia (Dance et al., 2021a). However, the experience of synesthesia is different with individuals having significantly stronger association traits – they simply knew what colors letters, and numbers must be. These phenomena indicate the complexity of aphantasia and cast doubts on many conditions and tasks thought to be simply the result of mental imagery.

Voluntary vs. Involuntary Debate

Since the original definition of aphantasia, most research has defined the condition's mental imagery deficit as only impacting voluntary imagery. Most arguments for intact involuntary imagery in individuals with aphantasia come from the fact that most aphantasics have intact mental imagery in dreaming (Krempel & Monzel, 2024; Palermo et al., 2022; Whiteley, 2021; Zeman et al., 2010). Another argument for intact involuntary imagery also comes from the idea that individuals with aphantasia have intact representational templates but are not able to access them (Siena & Simons, 2024) though this distinction assumes that aphantasia is a metacognitive deficit which does not seem to be supported by the majority of current research. However, when examining visual working memory individuals with aphantasia perform just as well as individuals without aphantasia which could suggest some form of involuntary imagery is intact (Keogh et al., 2021b). This idea is supported by the fact that some individuals with aphantasia can have fleeting, uninduced imagery (Zeman et al., 2010) as well as the fact that the oblique effect for orientation is not shown in those with aphantasia (Keogh & Pearson, 2024a). This effect describes the deficiency in perceptual performance for oblique orientations when compared to horizontal and vertical orientations which is hypothesized to arise from representational templates created due to experience (Keogh & Pearson, 2024a). Horizontal and vertical lines are much more prevalent in the environment and are thus more salient than oblique orientations (Keogh & Pearson, 2024a). Another study examining associative learning found no difference in response time when asking individuals to identify if well-known fruits and vegetables were darker or lighter than the other (Palermo et al., 2022). The author took this to mean that involuntary imagery is therefore intact in those with aphantasia. The lack of response time difference meant these individuals were utilizing the same cognitive processes as those without it (Palermo et al., 2022). Other tasks such as the binocular rivalry task and lack of imagery priming perception in aphantasic individuals (Nanay, 2020; Pearson, 2019) as well as the intact perception of afterimages (Krempel & Monzel, 2024) also seem to indicate that involuntary imagery does remain intact in these individuals.

Despite these studies, there is a growing movement to include involuntary imagery as deficient in individuals with aphantasia. It is indeed true that the initial assumption for intact involuntary imagery comes from the fact that individuals with aphantasia can still dream with mental imagery. However, not only does this evidence tend to apply to visual aphantasia there is also evidence that not all participants with aphantasia do dream (Krempel & Monzel, 2024). In fact, in the initial case study of MX leading to the paper that defined congenital aphantasia, the participant initially completely lost the ability to dream and only regained it later (Zeman et al., 2010). Even among those with aphantasia who can dream visually, there does seem to be attenuation to vividness that is also reflected in the attenuation of the vividness of afterimages (Dawes et al., 2020; Keogh & Pearson, 2024b; Krempel, 2024) which seems to suggest that involuntary imagery is indeed impacted at least to some extent. This leads to an interesting contradiction in which involuntary imagery tends to be treated uniformly in aphantasia research while voluntary imagery is separated. A prime example can be seen in visual aphantasia where the voluntary processes of object and spatial imagery are dissociated while at the same time, intact dreaming is taken to mean that all forms of involuntary imagery in aphantasia are unimpaired. It makes little sense that only voluntary imagery would be dissociated in such a way and this does seem to be reflected in involuntary imagery due to the differences present in dreaming in aphantasic individuals.

Interestingly enough there is also a movement to show that some researchers have interpreted their study results as a deficit in voluntary imagery when instead an alternative explanation, and possibly a more succinct one, could be given in terms of involuntary imagery. This argument comes from the fact that in some aphantasia studies, individuals are not implicitly asked to form mental imagery, and thus any formation is involuntary (Krempel & Monzel, 2024). One study that demonstrates this phenomenon is a study on attentional templates. In this study, participants were asked to perform a visual search task and researchers then probed their strategy during the search after completion of the task (Keogh & Pearson, 2024a). Attentional templates are thought to be induced much like mental imagery and while researchers assumed that these templates are a form of voluntary imagery that suppresses irrelevant information and allows greater focus on salient information they did not instruct participants to adopt this strategy.

Therefore, it is highly likely that any imagery formed in attentional templates is likely involuntary (Krempel & Monzel, 2024). Therefore, the fact that participants with aphantasia took longer on visual search tasks indicates that not only is voluntary mental imagery impaired but so too is involuntary imagery. Furthermore, while traditional binocular rivalry tasks do show deficient voluntary imagery more recent research also seems to demonstrate that involuntary imagery can also prime this task. In this study, participants were not instructed to form a particular image just to attend to the cued image (Keogh & Pearson, 2024a). Yet despite this controls were still primed while individuals with aphantasia were not suggesting that the controls had involuntarily formed imagery around the cue while the same did not occur in individuals with aphantasia. Another objective task that seems to suggest impaired voluntary image follows in a similar vein. In a perception and imagery SCL task where individuals were asked to both view images meant to elicit fear and read stories meant to elicit fear individuals with aphantasia had lower SCL levels in the imagery condition than controls (Wicken et al., 2021). The authors took this to mean voluntary mental imagery was impaired and yet they did not instruct participants to attempt to form mental imagery around the story. This also suggests that again involuntary imagery may be impaired in the task (Krempel & Monzel, 2024) with similar results being found in a follow-up empathy study (Monzel et al., 2024c). Finally in a study examining the features and formation of pseudo-hallucinations in aphantasics induced by the Ganzflicker task, it was determined that individuals with aphantasia were less susceptible to these pseudo-hallucinations (Konigsmark et al., 2021). Again, the participants were not instructed to attempt to form mental imagery during the task lending more credence to the idea that these pseudo-hallucinations tap into a form of involuntary not voluntary imagery.

Despite these criticisms, it could still be argued that the study of associative learning by Palermo does provide evidence that involuntary imagery is indeed intact. The authors took the fast response time to canonical colors of the fruits and vegetables to mean that involuntary imagery had to be intact (2022). However, studies that claim to show that color memory affects the actual experience of color have been subject to heavy skepticism in the past. When individuals are asked to adjust the canonical colors of fruits and vegetables to grey participants do not do this they instead adjust to a type of blue-grey color since their associative learning still shows a faint presence of canonical color even in the grey figure (Krempel & Monzel, 2024). But when asked to select the odd one out in a multitude of fruits and vegetables in grey they select the same image they originally adjusted the canonical color to. This demonstrates that color experience and color perception are not all that closely related to each other, they don't react as strongly as the associative learning study seems to indicate. The authors also take the fast response to the images to mean that involuntary imagery must be intact (Palermo et al., 2022). However, they do not consider alternate explanations for the speed of the response time such as semantic processes that have shown to not only be able to compensate for tasks that seem to be driven by mental imagery but can also be similar in processing time especially as multiple manipulations were not required in their study. It is therefore likely that much like voluntary imagery in aphantasics, involuntary imagery also has its specific patterns of deficits due to likely dissociations present in this form of mental imagery. More research needs to focus specifically on involuntary imagery as well as clarify their definitions of voluntary and involuntary imagery to make sure that the tasks they are providing to their participants measure the type of imagery that they intend to examine.

Emotional Processing

While most investigation into the nature of aphantasia has focused on its cognitive profile there are some emerging studies working to investigate how the condition can modulate the experience of emotional processing. Most research seems to agree that those with aphantasia have normal emotional reactions during perceptual experiences. It has been found that individuals with aphantasia have lower SCL when being exposed to a verbal story format as opposed to images meant to elicit fear (Wicken et al., 2021). This seems to indicate that despite the dampened fear response for verbal content, the lack of mental imagery elicited nominal perception also translates into normal fear responses to perceptual stimuli (Wicken et al., 2021). Along these same lines, an emotional discrimination task in which aphantasic individuals were asked to view the faces of emotional individuals showed that they performed just as well as controls in determining what emotion was being displayed (Hashim et al., 2024). While they still had reduced emotional responses to imagined stimuli this did not seem to impact their ability to recognize and discriminate between different types of emotions present in their perception. While it seems that emotional processing based on perception is relatively intact, there is a recent study that presented participants with images and descriptions of people in danger that found an attenuated effect of emotion regardless of the mode of presentation (Monzel et al., 2024c). This seems to directly contradict the previous studies that found no drastic impacts. However, it is important to note that the first two studies followed the original cutoff for aphantasia on the VVIQ (16-32) while the second study took a much more conservative approach (16-23). Therefore, it is highly likely that the degree of mental imagery vividness has an impact on emotional processing which may be a unique feature of different aphantasia subtypes. More research needs to be done to conclude if this is a subtype issue or just an issue in participant selection, but it does seem that the level of vividness of imagery may have a large impact on emotional processing overall.

It is commonly assumed that thoughts that take on the sensory format of mental images connect our thoughts with emotions indicating that vivid imagery acts as a sort of emotional amplifier (Keogh & Pearson, 2024b). Preliminary studies into emotion and aphantasia do seem to confirm this long-held theory. Despite the attenuated emotional response to the previous sympathy task researchers did find that aphantasic individuals were just as accurate in recognizing the correct emotion but took longer to do so than controls (Monzel et al., 2024c). This dissociation between recognition and perceived emotional sympathy seems to suggest a dissociation in which mental imagery amplifies the impact of emotion yet does not cause a lack of emotional discrimination ability. This is further apparent in the same study as aphantasia correlated with a more externally oriented thinking style and more difficulties describing personal feelings, but not identifying them (Monzel et al., 2024c). The same dissociation between felt emotion and semantic understanding of emotion can also be traced in preliminary studies examining the emotional experience of reading and music in individuals with aphantasia. When individuals with aphantasia were instructed to read a short story they were less absorbed than controls. They were also less likely to feel sympathy and yet had just as much resonation with their memories. Interestingly enough they also read roughly the same amount per year as controls and liked similar genres as well as indicating similar levels of liking for the short story they read (Speed et al., 2024). This demonstrates that while individuals with aphantasia have a more difficult time eliciting emotions towards others likely due to the lack of mental imagery other aspects of the story such as liking despite being an emotional experience tend to be preserved. This same trend seems to also hold during music listening. Individuals with aphantasia demonstrated a decreased personal emotional attachment to music but found it just as rewarding and were less susceptible to evaluative conditioning in cases of multisensory aphantasia (Hashim et al., 2024). This again dissociates mental imagery as an emotional amplifier from the actual appreciation of music. Interestingly enough, it also seems to tentatively confirm the proposed idea that subtypes of aphantasia might alter the experience of emotions. The lower susceptibility of evaluative conditioning (the ability to change an attitude due to pairing with positive or negative valence stimuli) also indicates that mental imagery may play a wider-than-expected role in emotional associations. Multisensory or complete visual aphantasia may have a larger impact on emotional processing than aphantasic individuals who still preserve vague imagery in one domain or imagery in multiple other sensory domains.

Due to the attenuation of emotional responses due to mental imagery deficits, some researchers have posited that aphantasia may be a protective feature in the case of intense emotional experiences (Blomkvist & Marks, 2023; Dawes et al., 2020; Keogh & Pearson, 2024b; Wicken et al., 2021). The lack of mental imagery would allow individuals with this condition to move through difficult emotions in possibly a more productive way as well as be less impacted overall by intrusive emotions associated with mental images (Dawes et al., 2020). Some preliminary research has been done into aphantasia and its protective factors and yet no research has seemingly been done on the possible negative impacts that emotional attenuation may have on these individuals. Mental imagery in particular has not only been named an emotional amplifier but is also considered as a protective factor against many different types of emotional disorders (Dawes et al., 2022; Wicken et al., 2021). Emotional processing has only begun to be thoroughly studied in individuals with aphantasia and it seems vital not only to separate the differing effects due to differing subtypes of aphantasia and the possible negatives and positives that may be associated with the lack of mental imagery.

Mental Health Considerations

Much like emotional processing mental health considerations associated with aphantasia are in their infancy in the research realm. It is known that variations in imagery vividness are associated with the risk of several psychiatric disorders such as schizophrenia, higher PTSD flashbacks, more intrusive memories in anxiety and depressive syndromes, hallucinations in Parkinson's, and intrusive thoughts in OCD (Cavedon-Taylor, 2022; Keogh & Pearson, 2024b; Pearson, 2019; Wicken et al., 2021; Zeman et al., 2021). Considering the reduction of mental imagery in aphantasia there have been some tentative suggestions that aphantasia may actually be a protective factor against many different psychological conditions (Konigsmark et al., 2021;, Pearson, 2014; Pearson, 2019; Zeman et al., 2024). While mental imagery is strongly associated with certain mental illnesses it contradictorily also often acts as a protective factor in itself (Blomkvist & Marks, 2023; Monzel et al., 2022a; Pearson, 2014). Therefore, some studies have done some work to determine if aphantasia is more protective or determinantal in these specific cases. Despite the strong evidence for mental imagery in these conflicting cases most research seems to suggest based on mental health questionnaires that there is no difference in the prevalence of mental imagery-associated disorders in those with aphantasia (Dawes et al., 2024; Fulford et al., 2018; Milton et al., 2021). A recent study attempted to examine aphantasia by creating a PTSD paradigm. Individuals with and without aphantasia watched the aftermath of a fatal crash and then reported associated symptoms for a couple of weeks (Keogh & Pearson, 2024b). While aphantasics had fewer acute visual intrusions and long-term intrusions they had more verbal and tactile and though those with aphantasia seemed less likely to develop PTSD after exposure the difference in the symptoms of those who did possess some serious implications. The lack of difference in some mental disorder prevalence as opposed to PTSD does seem to be able to be related to the vividness of visual imagery experienced by individuals, but the lack of mental imagery in itself does not seem to be inherently protective. This seems to be confirmed by a follow-up study examining general trauma symptomology in which individuals with aphantasia showed no differences in emotional arousal or reactivity and in fact, had greater negative changes in mood and cognition (Dawes et al., 2022). The unique presentation of symptoms makes it more likely that individuals with aphantasia may have a harder time being diagnosed or may even be subjected to higher levels of misdiagnosis.

Not only does the difference in aphantasia symptomology with certain mental disorders raise problems with diagnostics currently used but the same concerns can be applied to some common therapeutic methods currently in place. Imagery is one of the most widespread tools in mental health treatment (Monzel et al., 2022a; Pearson, 2014; Wicken et al., 2021 Zeman et al., 2020 Common methods of therapy of cognitive-behavioral therapy including imagery rescripting and imaginal exposure could be far less effective in individuals with aphantasia (Pearson, 2014; Wicken et al., 2021). In these forms of therapy mental imagery is used to stand in for real events as the mental images are perceptually similar and trigger physiological and emotional responses through the same associated memory structure (Monzel et al., 2023b). Exposure therapy in particular is dependent on strong emotional activation and integration of incompatible information leading to emotional reduction (Monzel et al., 2023b) and it seems that the emotional amplification of mental imagery makes this strong emotional activation possible. It is therefore highly unlikely that exposure therapy would be as effective in individuals lacking this strong connector between memory and emotion. While there are not currently any studies on the impact of these therapies on the treatment of individuals with aphantasia it is a legitimate concern that needs to be addressed. The complication of possible high rates of missed diagnoses or incorrect diagnoses as well as non-efficient treatment could compound and lead to large percentages of aphantasics not receiving the proper care for mental health conditions.

Tangentially it also seems that some labels inherent to aphantasia that are starting to appear in research could give rise to even further complications in the mental health of individuals with aphantasia. There is a strong impairment-oriented narrative (Monzel et al., 2022a) developing in research discussing aphantasia that may cause some of the distress surrounding the condition. Many studies have labeled aphantasia as a disorder despite the lack of basis to classify it as such (Blomkvist & Marks, 2023). This negative narrative being formed characterizing aphantasia primarily as deficiencies along with a strong negative label could be a contributing factor to negative psychological states as well as inviting stigma. Due to the increasing negative evaluation of aphantasia in increasing amounts of research, a wide-reaching study examined criteria relating to mental disorders to determine if aphantasia indeed fell into this category. This study examined the criteria of statistical rarity, violation of social norms, inappropriate behavior, impairment in activities of daily living, and personal distress (Monzel et al., 2022a). The only significant criteria that aphantasia met was that of statistical rarity; while there was evidence that some individuals had memory deficits they were not severe enough to impact any of the criteria and personal distress ranged widely from individual and was often dependent on the vividness of mental imagery as well as any other confounding mental health considerations. It was also unclear if aphantasia itself caused the distress or if it was due to discovery, attribution error, or underlying personality traits (Monzel et al., 2022a). The discovery of a condition being labeled as a disorder could be enough to cause an individual distress or they may falsely attribute negatives in their lives to aphantasia. Therefore, there is no direct correlation that aphantasia in itself is particularly distressing especially as many individuals during the study did not experience many negative emotions around the condition (Monzel et al., 2022a). This study concluded that aphantasia itself is not a mental disorder and that many diagnosed with it may suffer more from its discovery than the condition itself.

As a follow-up to this general classification, it was proposed that a neurodivergence model would be a better way to classify aphantasia than a disorder model. The study examined the social model of disability, the medical model of disability, the neurodiversity paradigm, and aphantasia associations with autism to determine if this model would be a good fit (Monzel et al., 2023b). Socially aphantasia does have some impairments but it also seems to have some advantages as it can lead to fewer false memories (Bainbridge et al., 2021; Keogh & Pearson, 2024b), lower sensory hyper-sensitivities (Dance et al., 2021b) and less emotional distress in certain situations (Keogh et al. 2024b; Wicken et al., 2021). The biggest barrier socially seems to be a lack of understanding from others as many people assume a lack of mental imagery is a lack of knowledge even though individuals with aphantasia can perform easily on tasks thought to rely solely on mental imagery (Monzel et al., 2023b). It is difficult to argue that the biological differences under the medical model of disability would classify aphantasia as such since this would pathologize all neurological differences ever described (Monzel et al., 2023b). Based on the lack of categorization possible under the social and medical model of disability it seems that aphantasia does make sense in a neurodiversity paradigm especially since it is suspect if a ‘normal’ human brain even exists. The final argument to classify aphantasia as a disorder arises from its similarities to autism, though this condition also fits the neurodiversity paradigm quite well. A study examining aphantasia through the spectrum of autism found that individuals with aphantasia did report higher traits associated with autism than controls though the only significant relationships fell into the social skills and imagination subscale (Dawes et al., 2022). These similar traits do not seem enough to pathologize aphantasia as many different mental illnesses share similar traits and only a small cluster of traits is not enough evidence to draw parallels between the two conditions. As current research stands it makes sense to move away from the disorder narrative surrounding aphantasia especially as there is no evidence for this characterization and the condition fits much better into a neurodivergence paradigm.

This shift in characterization should not only be made for scientific clarification but also for the well-being of those who are diagnosed with aphantasia. Despite the relative lack of functional differences in those with aphantasia they consistently report less confidence in their abilities even when no objective differences are found (Keogh et al., 2021a; Monzel et al., 2023b; Wicken et al., 2021; Zeman et al., 2015; Zhao et al., 2022). Some research indicates that this lack of confidence may be magnified or even caused by disorder labeling leading to self-stigmatization (Monzel et al., 2023b). This seems like a fair position to take especially as it has been shown that individuals with aphantasia do have good metacognition (Keogh et al., 2021b). These individuals are aware of their lack of mental imagery and report relatively few instances in their lives where aphantasia has a large impact; however, the assumptions of others may lead to a greater likelihood of self-stigmatization. Since aphantasia can’t be classified as any kind of neurological, cognitive, or psychological condition (Blomkvist & Marks, 2023) the labeling of it as such is not only inaccurate due to the lack of evidence but may have potentially damaging impacts on individuals with aphantasia as well as how others perceive them. Based on these considerations, it seems prudent to classify aphantasia as a neurodivergence as well as work to elucidate not only the deficits present in aphantasia but other possible advantages or simple differences in cognition with no specific connotation. Not only will this make the discussions in literature more accurate, but it will protect individuals as they discover this condition either personally or in the general population.

Associated Neural Findings

Much of the earlier research into the neural basis of aphantasia resulted from electroencephalography (EEG). After the discovery of MX's preserved ability to mentally rotate objects, researchers had him undergo this task during EEG to elucidate any possible differences in brain activity. In mental rotation, there is a rotation-related negativity (RRN) of the event-related potential (ERP) that is considered to correlate with the mental rotation tasks. This potential is elicited from the parietal lobes around 350 ms after the beginning of the task and becomes more negative with a larger angular disparity (Zhao et al., 2022). When M.X. performed mental rotation for canonical letters he displayed this RRN component; however, during mirror-reversed trials, this component was not displayed. While imagery retrieval from memory was associated with early visual areas and transformation with the posterior parietal cortex, it became clear due to the lack of the RRN in the mirror-reversed trials that M.X. did not require mental imagery to perform the mental rotation task. Therefore, it seemed as if changes in functional connectivity with the parietal cortex and visual cortices were a strong contender for this acquired case of aphantasia.

Another task MX performed while undergoing EEG was forming mental imagery of a face. It is known that an early ERP marker of face processing is N170 which arises from the occipital and temporal lobe modulated by the frontal lobe (Furman et al., 2022). After this marker, a P200 response is associated with attentional recruitment and emotional face processing. Finally, N250 is related to facial recognition and access to long-term memory. In participants without aphantasia when evoking face imagery early areas recruited include sections of the frontal lobe to drive top-down processes. However, in MX's case, superior temporal areas at N170 such as the superior temporal lobe, left temporal pole, and left insula were recruited first with frontal areas not recruited until the P200 marker. His N170 component did not require the use of the bilateral occipital lobe as it did in the control group; in fact, no posterior visual areas were recruited in the first 300 seconds with the left ventral pathway including the left anterior temporal lobe and insular lobe being used predominantly (Furman et al., 2022). Also, while the left temporal and frontal lobe are normally recruited during the P200 component MX demonstrated most activation in the bilateral frontal areas. Finally, while the bilateral occipital lobe is again recruited for the N250 component M.X. instead recruited the left frontal facial areas. All this suggests that other areas of the brain need to compensate for face recognition due to functional connectivity issues between the occipital and frontal lobes with the temporal lobes taking over early frontal activity and then the frontal taking over later from the temporal. While this neural basis focuses only on disconnections in visual aphantasia that seem to support the reverse hierarchy model there is evidence that mental rotation tasks in individuals with aphantasia do activate motor areas like the premotor and supplementary areas just like controls do (Pounder et al., 2022). This would fit with the subjective evidence for intact spatial mental imagery in many cases of visual aphantasia.

Another theory focuses on the idea that the excitability of the visual cortex might play a role in imagery strength (Pearson, 2019). In the Ganzflicker task, it was reported that individuals whose brain oscillations around the alpha band (associated with top-down processing, active inhibition, and information grating as well as attention and mental imagery) matched the stimulation frequencies of the task had a higher likelihood of experiencing these pseudo-hallucinations (Konigsmark et al., 2021). This seems to indicate that higher cortical excitability reflects weaker imagery and lower alpha power which could be specific to just the visual cortex or more widespread areas as well. While early EEG research seemed to provide evidence for functional connection issues there also seem to be some possible developmental differences related to excitability. Not only is this excitability different in the cortex but it can also be seen in other areas for different subtypes. Corticospinal excitability, measured with transcranial magnetic stimulation, is known to increase in individuals without aphantasia during action observation or action reading (Dupont et al., 2024b). However, when probing kinesthetic or motor imagery in aphantasic individuals with combinatorial, multisensory, or motor aphantasia corticospinal excitability is not modulated in this way. While there is not much EEG investigation outside of case studies nor is there much evidence on excitability changes outside the motor realm these preliminary studies indicate possible developmental causes for aphantasia as well as the possibility for functional disconnection between occipital, frontal, and parietal lobes in visual aphantasia.

Outside of case studies or subtype investigations, most neurological mechanism understanding of aphantasia comes from functional magnetic resonance imaging though this research is mostly in its infancy with few studies to draw from. In most cases, perception in aphantasia activates similar regions as typical images including domain-specific regions like the interior occipital lobe and fusiform gyrus (Liu et al., 2024; Zeman et al., 2010). General perception in normal imagers and those with aphantasia activated early and higher-level visual areas (Fulford et al., 2018; Liu et al., 2024). Both normal imagers and those with aphantasia activated the left lateral occipital cortex and bilateral medial frontal gyrus for shape perception, patches in the bilateral medial frontal cortex, parahippocampal gyrus, and the central orbitofrontal cortex in color perception, bilateral posterior frontal gyrus in word perception, right fusiform gyrus and bilateral amygdala in face perception, the parahippocampal place area, bilateral left posterior cingulate gyrus, precuneus, and angular gyri when viewing a map (Liu et al., 2024). The only noted difference in perception was increased activity in the right interior frontal gyrus and supramarginal gyrus in those with aphantasia which are important for reorienting attention and interaction with conscious perception (Fulford et al., 2018; Liu et al., 2024). This may indicate the disruption of the subjective experience of maintaining mental imagery as in many cases perception and mental imagery can interact and overlap (Fulford et al., 2018; Keogh et al., 2021b; Liu et al., 2024; Zeman et al., 2010). It seems likely then that while most perception is intact in aphantasia regions that are overactive may reflect the difficulty of perceptual processes that are usually supported or integrated with mental imagery. This neural data seems to align well with reports that perception is generally fairly intact in those with aphantasia. While perception in aphantasia is fairly straightforward, there are far more complications in fMRI imagery studies that have led different researchers to differing conclusions based on inconsistent activation of brain areas. One of the first determinations researchers wanted to make was the location of overlap between perception and mental imagery. (Liu et al., 2024; Olivetti et al., 2009; Zeman et al., 2010). Most studies agree that there is no overlap of imagery and perception in early visual areas and instead in the higher-level visual cortex (Keogh & Pearson, 2018; Liu et al., 2024; Zeman et al., 2010. This would indicate that aphantasia has more deficits related to early visual areas, which seems to be the case due to enhanced deactivation in the primary visual cortex during imagery (Liu et al., 2024).

When specifically focusing on visual imagery individuals with aphantasia seem to have decreased activation overall in their posterior network (Liu et al., 2024; Olivetti et al., 2009;

Zeman et al., 2010). This deactivation is primarily found in the inferior occipital gyrus, superior temporal sulcus, superior temporal gyrus, and calcarine sulcus (Liu et al., 2024; Zeman et al., 2010). However, one study instead associated the inferior and middle occipital gyri with a negative correlation, the less activation the more imagery which directly contradicts the previous studies (Fulford et al., 2018). This contradiction is difficult to explain but may be because the inferior occipital gyri are usually associated with face processing and the study that found a negative correlation was examining visual imagery of non-faces. One study also found evidence for lower right lingual gyrus activity (Olivetti et al., 2009). Not only is there deactivation in the posterior network but there is also evidence for reduced resting state connectivity between the prefrontal cortices and visual network (Furman et al., 2022; Monzel et al., 2021) specifically between the prefrontal cortex and visual-occipital lobe (Liu et al., 2024; Milton et al., 2021). This reduced activation of the posterior network confirms the idea that posterior brain regions such as the superior occipital gyrus, superior and middle temporal gyri, precuneus, posterior cingulate, fusiform gyrus, and parahippocampal have a positive correlation with vividness (Fulford et al., 2018). Hypoactivation was also found in the fusiform gyrus (Fulford et al., 2018; Liu et al., 2024) which could reflect the failure to suppress activity that could interfere or by compensatory activation of executive regions (Fulford et al., 2018). Along with the hypoactivation of this region, a specific high-level visual region in the fusiform gyrus known as the fusiform imagery node (FIN) showed no functional connectivity to prefrontal networks (Liu et al., 2024). This is striking as the fusiform gyrus is known to be active for all imagery modalities as it processes semantic and visual content for both imagery and perception (Liu et al., 2024; Zeman et al., 2010). It is especially important for semantic retrieval, visual mental imagery, object recognition, and retrieval of object information (Olivetti et al., 2009).

Furthermore, those with aphantasia activated the precuneus, precentral gyrus, inferior frontal gyri, supramarginal gyrus, insula, and anterior cingulate cortex more than controls (Fulford et al., 2018; Liu et al., 2024; Zeman et al., 2010). The higher activation of the inferior frontal gyri and supramarginal gyrus is likely due to increased reliance on semantic retrieval in aphantasics and the selection process they are undergoing (Liu et al., 2024). The increased activation of the anterior cingulate responsible for error prediction, performance monitoring, and task difficulty likely reflects the difficulty in attempting mental imagery as well as the search for alternate strategies (Zeman et al., 2010). The FIN region also works heavily with the inferior frontal gyrus and intraparietal sulcus for coding semantic content (Liu et al., 2024). It seems that individuals are more likely to hyperactivate regions across both hemispheres with only areas in the medial frontal lobe and insula activated more strongly in the high vividness group (Fulford et al., 2018). This may relate to the concept that higher resting activity and excitability levels in the visual cortex relate to less vivid imagery (Monzel et al., 2021). This pattern may be reflected across multiple sensory regions especially in multisensory aphantasia thus causing hyperexcitability across most of the cortex. It is thought that this higher resting activity is high enough to overwhelm mental imagery signals while still allowing for the detection and integration of perceptual signals (Fulford et al., 2018; Keogh et al., 2021b; Zeman et al., 2010). It could be that higher excitability and functional disconnection from FIN are more prominent in multisensory aphantasia while pure visual aphantasia is dependent on functional dysconnectivity between the frontoparietal and occipital areas.

While there are already few studies examining the neural basis of aphantasia, even fewer studies are examining brain regions impacted by multisensory aphantasia. Only one known fMRI study could be found that examined visual, gustatory, kinesthetic/motor, somatic, auditory, and olfactory imagery. The visual domain is discussed above and fits in well with the newly emerging research. For gustatory mental imagery, Olivetti and colleagues found that the left anterior insula and left middle frontal gyrus were less active in those with low mental imagery (2009). These regions are primarily responsible for top-down control of information retrieval from long-term memory. For kinesthetic/motor imagery the pre-central gyrus and anterior cerebellum were only activated in the high vividness group and not the low vividness group. This seems to implicate the pre-central gyrus in the integration of motor imagery and the cerebellum in not only the extraction of kinematic information from movement but from motor imagery as well. Somatic, or body imagery, includes a lack of recruitment of the right post-central gyrus in low vividness groups. This area of the brain is the location of the primary somatosensory cortex and likely deals with the retrieval of proprioceptive information for imagery purposes. There was no significant modality-specific activation for auditory or olfactory mental imagery (Olivetti et al., 2009) which may be due to the difficulty of generating a sound or smell from a mental image. The authors also considered the fact that auditory imagery may have been disrupted due to the scanner noise present during the experiment. Based on this single experiment it is difficult to determine if these same regions are impacted in aphantasia especially as this study does not consider the condition at all and is just looking at vividness differences. While aphantasia is indeed a vividness difference there is no consideration of how multisensory aphantasia may differ considering its complete lack of all mental images.

There has also been some examination of the neural basis of autobiographical memory in aphantasia. When attempting to remember episodic events aphantasics have reduced activation of bilateral hippocampi, including left anterior, left posterior, right anterior, and right posterior hippocampi (Monzel et al., 2024b). Furthermore, they also have no functional connectivity between the right hippocampus and left visual-perceptual cortices while controls had negative functional connectivity between these regions. The areas hyperactivated during this task were the bilateral visual perception regions specifically the lingual gyrus in the occipital lobe. This increased activation in the visual-perceptual cortices may be the reason that aphantasics cannot detect weaker imagery-related signals that may be present. The negative functional connectivity between the hippocampus and the visual-perceptual cortices likely is responsible for selectively inhibiting imagery-irrelevant actions as well as initiating the retrieval processes in primary sensory brain regions (Monzel et al., 2024b). Despite the lack of connectivity between the hippocampus and visual cortices when in a resting state aphantasic groups have a stronger connection between the left hippocampus and region of anterior cingulate; the left dorsal attention network and middle frontal gyrus; the left frontoparietal control network and orbitofrontal cortex. Weaker activation of the left anterior parietal region in aphantasia (Furman et al., 2022; Milton et al., 2021). The strengthened connection between the hippocampus and anterior cingulate is likely indicative of increased attempts to enable context and past experiences in the form of mental imagery to influence goal-oriented behavior. It is likely that the increased left dorsal attention network and middle frontal gyrus also reflect the increased attention being devoted to sensory imagery processing. The increased frontoparietal control network and orbitofrontal cortex connection are likely the result of attempting to control top-down attention by modulating sensory brain regions to assist in sensory integration including imagery.

Conclusions and Future Directions

One of the most prominent issues in aphantasia research is the lack of basic definitions and cutoffs for measures that make creating a concrete understanding of aphantasia extremely difficult. Different definitions of aphantasia are constantly used in research with some researchers following the original definition of the condition as a ‘lack or reduction of voluntary mental imagery’ (Zeman et al., 2010) while many others interpret voluntary mental imagery as visual mental imagery, incorrectly. Recent papers are attempting to propose the definition of dyskinesia to refer to multisensory aphantasia based on this misunderstanding (Dance et al., 2021). This leads to conflict between researchers examining visual aphantasia as opposed to researchers examining aphantasia as a whole. The definition also differs on whether researchers are referring to involuntary imagery, voluntary imagery, or both and if there is a reference to a specific kind of imagery often there is a lack of evidence provided for why the author chose to define aphantasia in the way they did. This makes it exceedingly difficult to compare research as there is no clear understanding of the term and one researcher may be discussing a completely different group of aphantasic individuals than another. Also, even if a common definition is agreed upon there is no clear measurement paradigm being utilized to identify aphantasia. Most researchers rely on the VVIQ which not only misses large subgroups of those with aphantasia such as different combinatorial and other pure types lacking visual imagery deficits but also may cause researchers to include unwanted study participants. Individuals with specific types of multisensory and combinatorial aphantasia may present the same as individuals with visual aphantasia on the VVIQ but their lack of mental imagery in other sensory domains may skew study results leading to contradictory or inconclusive results among and between studies. Based on this there is no good reason to utilize only the VVIQ to identify aphantasia.

Not only does the VVIQ cause researchers to recruit participants that give an incomplete or possibly confused version of the population the researchers are attempting to study there is also no set VVIQ cut-off to define aphantasia. The initial research study (Zeman et al., 2015) defined aphantasia as ranging from a score of 16 (no mental imagery) to 32 (dim or vague mental imagery). However, this has not stayed consistent across studies. Some researchers only consider the floor score of 16 to represent aphantasia while others take a more conservative approach and define aphantasia as a score from 16 to 23 (Milton et al., 2021). This makes comparing research results also difficult as there could be fundamental differences between these populations meaning results that seem to be contradictory could make sense in the context of vividness differences within the same aphantasic groups or in different subtypes. Due to the numerous debates on the object or spatial preservation in aphantasia (Pounder et al., 2022; Siena & Simons, 2024; Zeman et al., 2015; Zhao et al., 2022) as well as different findings in the cognitive profile, it seems likely that some, if not most, of these discrepancies may be due to the lack of subtype consideration. With the majority of studies focusing currently on visual aphantasia it is important not only to correctly define the subtypes but to elucidate the specific form of aphantasia. There are also a multitude of assumptions in aphantasia research that seem to pose numerous issues. Most researchers assume intact involuntary imagery based on dreaming (Krempel, 2023; Whiteley, 2021) even though there is evidence that some individuals with aphantasia do lack the ability to dream (Zeman et al., 2015), or if they do dream, they tend to be less vivid (Monzel et al., 2024a). Due to the dissociation between what and where pathways in voluntary imagery it seems vitally important to determine if this distinction holds for involuntary imagery as well. Another problematic assumption that is emerging is that of the disorder narrative starting to surround aphantasia. The condition is being labeled as such with no concrete evidence to reinforce this belief (Blomkvist & Marks, 2023) which may lead to unjustified stigmatization and distress levels in a group who already may find it more difficult to be diagnosed with specific mental illnesses (Keogh et al., 2021b).

Being cognizant that many studies seem to outright contradict each other and that much of this disagreement may arise due to different subtypes it is important to note when considering the conclusions a study comes to. Different study results have been utilized to propose different theories of aphantasia as well as different neural bases dependent on the results without consideration of possible group differences. This becomes especially incumbent when research demonstrates that differences in results tend to line up quite neatly with different aphantasia cutoffs. Different subtypes have been shown to have different impacts on brain regions and functional connectivity and if they are not differentiated from each other then brain areas may be falsely attributed to different types of aphantasia. This segregation between subtypes is made near impossible by the fact that these subtypes have not yet been studied in depth. The lack of widespread knowledge and investigations of these subtypes not only contributes to improper definitions of experimental groups but also inconclusive results. This is especially a possible large area of effect since after visual aphantasia, multisensory aphantasia is the next most likely and is largely involved in many different studies as it can mask itself to respond the same as visual aphantasia on the VVIQ (Dawes et al., 2022). The lack of specific studies leads researchers to be unable to make distinctions about aphantasia as a whole and leads to misinterpretation of results.

Future research not only needs to work on determining the different cognitive styles of multisensory and combinatorial types of aphantasia but it also needs to investigate further into specific neural basis of each subtype. Currently, functional magnetic resonance imaging (fMRI) research on aphantasia is very limited and if subtypes are properly defined before future research it can help clarify what regions are involved in each specific type. Outside of subtypes, there needs to be more investigation into the long-term stability of aphantasia specifically how it influences mental health and its possible relationships with other syndromes and conditions. There also needs to be more investigation into the long-term impacts of emotional processing that seems to be quite frequently attenuated in aphantasia (Monzel et al., 2024c; Wicken et al., 2021). Some studies have also found protective factors of aphantasia such as the lack of sensory sensitivity (Dance et al., 2022b), fewer emergences of false memories (Bainbridge et al., 2021), reduced distress after a single traumatic event including less intrusive visual memories and less emotional distress (Keogh & Pearson, 2024b), and possible use of feature-based coding to support semantic retrieval as a compensatory mechanism for visual imagery (Witman & Satirer, 2022). More research should investigate if aphantasia can have other advantages as a protective factor and why this protective factor does not seem reliable in cases of mental illnesses. Due to the recent reemerging interest in this condition a clarification of definition, objective measures, common diagnostic tools, and subtype clarification will go a long way in creating a foundational base of research to build off of. Aphantasia has interesting research potential in cognition such as memory, learning, dreaming, and integration of mental imagery into a multitude of systems. Creating a greater understanding of the condition will not just reveal more about specific individuals with aphantasia but may also provide an interesting research group to provide a deeper understanding of some of cognitive neurosciences' most frequently asked questions.

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