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Invisible variations: Associations and subtypes of visual imagery vividness extremes

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1. Introduction

Close your eyes, and picture your home, your pet, or your favourite outfit. Following such instructions, most people would then genuinely *see* those items in their *mind's eye*, not simply *think about* them. Visual imagery is the process by which one experiences internally generated visual sensory information, without an external stimulus. As for all cognitive processes, there are extensive individual differences in the ability to create, maintain, and manipulate mental images with varying levels of detail, consciously and intentionally, or unintentionally. Some people, when closing their eyes and asked to "picture" their home, their pet, or their favourite outfit, *see* and *feel* images so vivid they resemble reality. Others *see* nothing at all.

Mental imagery is a complex cognitive process depending on a distributed neural network and a wide array of higher- and lower-level processes (Pearson, 2019), each of which might be subject to more than one kind of variation. Aphantasia, in its original definition, refers to the experience of limited or absent mental visual imagery (Zeman et al., 2015, 2025), with an approximate prevalence of 3.9% (Dance et al., 2022). Aphantasia can be acquired (Knowles et al., 2021) following neurological injuries (Thorudottir et al., 2020), medical procedures (Bumgardner et al., 2021; Zeman et al., 2010), and occur as a result of psychiatric or psychogenic conditions and emotional trauma (de Vito and Bartolomeo, 2016). However, most aphantasic people experience the congenital form of aphantasia, present from birth and sometimes familial (Zeman et al., 2015, 2020). At the opposite end of the mental imagery spectrum lies hyperphantasia, with a perception-like level of precision and richness, which so far has only been recorded as congenital and lifelong (Zeman et al., 2020).

There is an extensive diversity within congenital aphantasia and hyperphantasia, even when only focusing on the amount of imagery experienced. Using, for example, the Vividness of Visual Imagery Questionnaire (VVIQ (Marks, 1995)) that self-assesses visual imagery (score range: 16 = no imagery to 80 = vivid imagery), in the 1288 respondents of the EXTEND (http://exeter.crf. nihr.ac.uk/extend) biobank Zeman et al. (2020) found prevalence estimates of 0.7% for Extreme aphantasia (VVIQ score: 16/80), 2.6% for Moderate aphantasia (or hypophantasia (R. Reeder and Figueroa, 2022), VVIQ score: 17-23/80), 11.2% for Moderate hyperphantasia (VVIQ score: 75-79/80), and 2.6% for Extreme hyperphantasia (VVIQ score: 80/80). These estimates partially align with those that Wright et al. (2024) identified in international cohorts of 3049 and 9063 respondents: 0.9-1.2% scoring 16/80, 3.0-3.3% scoring 17-32/80, and 5.9-6.1% scoring 75-80/80. In addition to quality (i.e. clarity, level of detail), there is also diversity in the level of agency one has over their ability to conjure mental images. Indeed, in Zeman et al. (2020), over 60% of respondents scoring under 23 on the VVIQ report dreaming with images.

Importantly, mental imagery is multi-modal, and not restricted to vision. Likewise, aphantasia and hyperphantasia as cognitive profiles also extend to other sensory modalities outwith vision (Dance et al., 2021; Dawes et al., 2020). Zeman et al. (2020) reported that 54.2% of Extreme/Moderate aphantasic respondents and 47.8% of Moderate/Extreme hyperphantasic respondents declared that all modalities of sensory imagery (i.e. auditory, tactile, gustative, olfactive) were "faint/absent" or "vivid", respectively ("global" a- or hyperphantasia (Zeman et al., 2026)). Similar proportions (35.8% Extreme/Moderate aphantasic and 42.2% Moderate/Extreme hyperphantasic) reported that some other sensory modalities – but not all – were also impacted ("multisensory" a- or hyperphantasia (Zeman et al., 2026)), and around 10% of each population reported that only vision was concerned ("unisensory" or "visual" a- or hyperphantasia (Zeman et al., 2026)).

Although aphantasia and hyperphantasia remain underexplored cognitive constructs, a growing body of evidence suggests that they have ramifications beyond sensory imagery, involving multiple cognitive

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domains (Jin et al., 2024; Zeman, 2024). For example, aphantasic people are more likely to self-report poor autobiographical memory compared to hyperphantasic peers and typical visualisers (Zeman et al., 2020), in line with established correlations between imagery and autobiographical memory skills (Greenberg and Knowlton, 2014; Palombo et al., 2018). Indeed, multiple studies have now replicated the findings of lower performances amongst aphantasic volunteers (compared to typical visualisers) in episodic and autobiographical memory (Dando et al., 2023; Dawes et al., 2020, 2022; Milton et al., 2021; Monzel et al., 2022), as supported by neurological evidence (Monzel et al., 2024b). In addition, Severely Deficient Autobiographical Memory can co-occur with aphantasia (Watkins, 2018), though occurrence rates are not yet established.

Face imagery and recognition difficulties are also more frequently reported by aphantasic people, compared to hyperphantasic peers and typical visualisers (Milton et al., 2021; Palermo et al., 2022; Zeman et al., 2020), be that through the use of self-reporting or self-administered measures such as the 20-item Prosopagnosia Index (PI20; Dance et al., 2023; Shah et al., 2015) or standardised behavioural measures (Dance et al., 2023). However, Monzel et al. (2023a,b) reported no face-specific significant differences between aphantasics and typical visualisers, with aphantasic volunteers showing difficulties in both face and object recognition, even though the occurrence rate of developmental prosopagnosia does not appear to be higher in the aphantasic versus the general population (2-2.5%, Bowles et al. (2009)). Nevertheless, Grüter et al. (2009) found that adults with congenital prosopagnosia scored significantly lower in the VVIQ than neurotypical adults, supporting the hypothesis of a relationship between aphantasia and prosopagnosia. On the other end of the imagery spectrum, Palermo et al. (2022) found that those with object hyperphantasia – but not those with spatial hyperphantasia – self-rated their face recognition skills (as measured by the PI20) higher than typical visualisers did.

Beyond wakefulness, aphantasia and hyperphantasia also appear to shape dreaming experiences. Aphantasic people are significantly more likely than typical and vivid visualisers to report dreaming without images or feeling that they do not dream at all (Zeman et al., 2020). For those who do dream visually despite not visualising when awake, they report fewer and less rich dreams than typical visualisers (Dawes et al., 2020).

Finally, aphantasic people are less likely to report the experience of synaesthesia (of any kind) than those with hyperphantasia, who are themselves likelier than chance to experience it (Zeman et al., 2020). However, aphantasic people can still experience it, especially 'associator' (experienced within one's internal mental space or simply 'known') rather than 'projector' (experienced as projected outside one's mental space into the world) synaesthesia (Dance et al., 2021).

This evidence indicates that while many aphantasic people report a wide range of difficulties across multiple domains, others seem to only experience poor visual imagery, with varying degrees of quality, duration, and agency. Importantly, these quantitative accounts of the diversity of profiles within aphantasia mirror the diversity of lived experiences reported by aphantasic people in qualitative research (Digard et al., 2026). Together, this evidence calls into question approaches that treat aphantasia as a single entity.

To address the complex spectrum of aphantasia and hyperphantasia, Williams and Suggate (2024) conducted a latent profile analysis on a sample of 287 adults, and identified three main visualisation profiles: low (VVIQ-2 scores mean = 35.71, range = 32-75), mid-range (114.13, 60-148), and high (145.27, 97-160) visualisers. However, Williams & Suggate (2024) only used the volunteers' 32 VVIQ-2 responses (both the eyes open and eyes closed conditions) to identify these profiles, but did not consider any other associated features. As such, while their findings provide valuable information regarding the diversity of visual imagery skills within the population, the study is of limited scope. In addition, as they relied on the models' BIC (Bayesian information criterion) to identify the model with the best fit (in other words, the model with 3 profiles) and the BIC can underestimate the number of profiles in small samples such as the one involved in their study, this finding does not robustly preclude the existence of subtypes in aphantasia. For instance, evidence obtained thanks to larger samples shows that varying associations with the 'intensity' of aphantasia (i.e. Extreme aphantasia with no imagery versus Moderate aphantasia with poor imagery) already hint at significantly different profiles (Zeman et al., 2020)

Drawing on two larger samples of aphantasic volunteers (N = 964 and N = 1148), Dawes et al. (2024) conducted cluster analyses grounded in the self-rated imagery skills of seven sensory modalities (auditory, gustatory, kinaesthetic, olfactory, somatic, tactile, and visual), and identified two distinct and consistent subtypes: multi-sensory aphantasia with floor scores on all modalities (24.0-24.2%), and visual aphantasia with floor visual imagery but imagery in all other modalities (30.3-32.0%). In addition, two other less-defined subtypes characterised the remaining respondents: weak multi-sensory aphantasia with low but not absent imagery in all modalities (9.7-19.9%), and weak visual aphantasia with low but not absent visual imagery and typical imagery in all other modalities (24.0-36.0%). In additional analyses, the authors also identified smaller subdivisions, such as somatic-intact multi-sensory aphantasia (5.2%), auditory-intact multi-sensory aphantasia (3.7%), kinaesthetic-intact multi-sensory aphantasia (1.8%), and visual-kinaesthetic aphantasia (1.5%). These results point to differences in both the generalisation of aphantasia to one versus several sensory modalities, and in the degree of imagery experienced (absent versus poor). However, as detailed above, aphantasia appears to have ramifications outwith the sensory realm, which should be taken into account as we investigate its subtypes.

Delem et al. (2025) recently found evidence for subtypes of aphantasia using unsupervised clustering and assessments of cognitive strategies with a small sample of 45 aphantasic volunteers and 51 typical imagers. Amongst the three types of cognitive strategies they identified across the whole sample (visual imagery, spatial imagery, and verbal strategies), aphantasic volunteers were found within the latter two. Indeed, one group of aphantasic people showed low visual imagery but typical to high multisensory and spatial imagery, while the other showed generalised low imagery and a reliance on verbal strategies, thus mirroring and expanding the findings by Dawes et al. (2024). These findings, though observed in a small sample, consolidate the hypothesis that several subtypes of aphantasia exist, characterised by distinct sensory and cognitive features. It is now crucial to explore further the cognitive and sensory features of these different aphantasia subtypes.

Indeed, as aphantasia and hyperphantasia research gain momentum, it is crucial to assess whether the cognitive profiles and experiences of aphantasics are instead distinct enough to warrant a shift in the conceptualisation of aphantasia and our methodological approaches. Are there indeed "subtypes" within aphantasia, as hinted by the recent findings by Dawes et al. (2024) and Delem et al. (2025)? If so, are they defined solely by their absolute mental imagery skills (i.e., the intensity of aphantasia), or are there other key dimensions, such as cognitive or sensory features, that distinguish between those subtypes? Answering those questions will not only allow us to design more robust and meaningful research on aphantasia, but will also provide us with valuable information to hypothesise on the developmental trajectory(ies) of aphantasia.

The aim of the present study is, therefore, to explore the existence of these subtypes through a replication and extension of Zeman et al. (2020) based on a larger sample, investigating.

1. whether Zeman et al.'s (2020) findings on the differences between Extreme aphantasia, Moderate aphantasia, Moderate hyperphantasia, and Extreme Hyperphantasia (intensity as measured by the VVIQ) can be replicated with a larger sample, using an identical questionnaire;

2. whether, using additional self-reported cognitive and behavioural features linked with aphantasia, subtypes of aphantasia can be identified through latent class analysis;
3. if subtypes are found, what key similarities and differences can be identified between these subtypes through group comparisons.

2. Methods

2.1. Respondents

The total sample included 6436 respondents (Table 1), who completed the survey between October 2020 and January 2025. No respondents were present in the original sample presented in Zeman et al. (2020). Respondents joined the study either after finding it online through word of mouth within the aphantasic community, or after having emailed our research team seeking to participate in research. Respondents provided informed consent within the online questionnaire before accessing the questions, in compliance with ethical approval granted by the University of Edinburgh and the University of Exeter.

2.2. Online questionnaire

The Visual Imagery Assessment (VIA) is an online Qualtrics questionnaire available to view at https://osf.io/3t9zv/files/u7829. It replicates and expands the questionnaire presented by Zeman et al. (2020). The questionnaire was released in October 2020, and has been extended several times since. Some questions were therefore seen only by later but not by earlier respondents. In addition, only a few questions were mandatory. For all variables reported in this study, the number of respondents who answered said item is highlighted.

The latest version of the VIA contains the following 6 sections.

- Demographics: In addition to standard demographics, this section includes items recording career type, and family history of aphantasia or hyperphantasia;

Table 1
Respondents' demographics.

	Whole sample (n = 6436)
Age in years, M (SD, range)	39.7 (15.1, 16 – 100), n = 6328
Gender, n (%) [a]	n = 697
Female	450 (64.6)
Male	225 (32.3)
Other gender identity/Not disclosed	22 (3.2)
Highest Education, n (%)	n = 6328
Less than an undergraduate degree	2276 (35.4)
Undergraduate degree	2344 (37.0)
Master's degree	1307 (20.7)
PhD	401 (6.3)
Employment, n (%)	n = 6328
Student	1000 (15.8)
Employed	3998 (63.2)
Unemployed	690 (10.9)
Retired	640 (10.1)
Country of residence, n (%) [b]	n = 6302
UK	2316 (36.8)
USA	2190 (34.8)
Canada	345 (5.5)
Australia	264 (4.2)
VVIQ, M (SD, range), n (%)	29.1 (20.6, 16 – 80), n = 6436
Extreme aphantasia [VVIQ score = 16/80]	16.0 (0, 16 – 16), 3218 (50.0)
Moderate aphantasia [17-23/80]	19.5 (1.9, 17 – 23), 922 (14.3)
Mid-range [24-74/80]	44.3 (16.8, 24 – 74), 1817 (28.2)
Moderate hyperphantasia [75-79/80]	77.2 (1.4, 75 – 79), 278 (4.3)
Extreme hyperphantasia [80/80]	80 (0, 80 – 80), 201 (3.1)

[a] Gender was added to a later iteration of the demographics questionnaire.
[b] All other countries each represented under 3% of the respondents.

- Vividness of Visual Imagery Questionnaire (VVIQ);
- Window Counting task: this short questionnaire requires the respondents to count in their mind the number of windows in their home, then addresses the strategy they used to complete the task;
- Awareness & life impact: this section focuses on the time and ways in which the volunteers became aware of being aphantasic/hyperphantasic, on the emotional impact of this realisation, and self-identified links between mood and vision on mental imagery. It also contains items recording respondents' perceived link between their mental imagery skills and different aspects of their daily life, such as relationships, and self-reported link between career choice and mental imagery skills;
- Sensory/Cognitive profiles: this section records the self-assessed skills of the respondents in several domains, such as vividness of imagery in other sense modalities, autobiographical memory, navigation skills, dreaming, and reading speed;
- Neurodiversity profiles: this section addresses other diagnosed or suspected neurodivergent traits, such as autism, ADHD, dyslexia, synaesthesia, face recognition and imagination (prosopagnosia). As the questions about autism and ADHD were only added to the questionnaire in July 2024, they were completed by only 9.6% of the sample

Importantly, all volunteers joined the study because they self-identified as having either “faint/absent” or “vivid” imagery. Therefore, while the VVIQ scores indicated that many respondents scored outwith the standard aphantasia and hyperphantasia boundaries of the VVIQ, in the “mid-range” (Table 1), it should not be assumed that these respondents are typical or “true controls”.

2.3. Analyses

All analyses were completed in R 4.4.1 (R Studio, 2024.12.0 + 467).

2.3.1. Group comparison – replication

The group comparisons presented by Zeman et al. (2020) were computed to assess their replicability. Respondents were grouped according to their VVIQ score (Table 1). Continuous variables were compared between groups with one-way ANOVAs and post-hoc pairwise T-tests with Bonferroni corrections when relevant. Categorical variables were compared between groups with Pearson's Chi-Square tests of independence and post-hoc pairwise Chi-Square tests with Holm corrections when relevant. In the case of statistically significant post-hoc pairwise Chi-Square tests, follow-up comparisons were conducted via visual analysis of the standardised residuals, with values lower than −2 or greater than 2 indicating significant deviations from the expected counts under the null hypothesis of independence, and significant contributions to the overall Chi-Square statistics.

2.3.2. Latent class analysis

A latent class analysis (LCA) – a clustering method best suited when using categorical variables (Sinha et al., 2021) - was computed with the Extreme aphantasia (VVIQ score = 16/80) and Moderate aphantasia (17-23/80) volunteers only, to explore the existence of meaningful sub-groups within the categories of aphantasia – beyond the use of arbitrary VVIQ score boundaries – thus providing explanations for the diversity of profiles illustrated at the whole group level. No LCA was conducted with the Moderate hyperphantasia (75-79/80) and Extreme hyperphantasia (80/80) groups due to their limited sample size (Dziak et al., 2014). The LCA was computed using the R package poLCA (1.6.0.1). The indicator variables used were selected due to 1) having less than 10% of missing data within the sample, with other available candidate variables having over 50% missing data, and 2) showing significant differences between groups in previous research (see details in the Introduction).

- VVIQ group;
- family history of a- or hyperphantasia: "yes", "no", "unsure";
- number of other senses experiencing a- or hyperphantasia: "all", "some other", "no other", or "unsure";
- self-reported experience of autobiographical memory difficulties: "yes", "no", "unsure";
- dreaming experiences: "no dreams", "dreams without images", "dreams with images", "unsure";
- self-reported spatial navigation skills: "poor", "good", "unsure";
- self-reported experience of synaesthesia: "yes", "no", "unsure";
- self-reported experience of face recognition difficulties: "yes", "no".

To ensure statistical robustness with this sample size, the analysis was computed with a maximum number of possible classes of 5. Each model (from the model with 1 class of respondents to that with 5 classes) was estimated 15 times to identify the global (rather than only local) maximum of the log-likelihood function, and to return the solution with the highest log-likelihood (Linzer and Lewis, 2011). In addition, for each model, the maximum number of iterations run by the Expectation-Maximization algorithm during a model attempt was set at 9000, thus accommodating for Model 5's (model grouping the respondents in 5 classes) inability to reach the maximum likelihood under this threshold. Amongst the 5 models produced, the final model was selected as the solution with the lowest BIC (Bayesian Information Criterion), indicating the best model fit (Weller et al., 2020).

Of the total 4140 respondents in the Extreme and Moderate aphantasia groups, 3883 (3025 Extreme aphantasic, 858 Moderate aphantasic) had no missing data across all 8 indicator variables and were included in the analysis. The variable of self-reported reading speed compared to speaking speed was not included in the LCA as only 2097 of the 4140 aphantasic volunteers had answered this question. Due to the exploratory nature of this study and the anticipated small effect size, we prioritised a larger sample size over the inclusion of an additional indicator variable.

2.3.3. Class comparison

Classes obtained after the LCA were compared following the same strategy as the replication group comparison detailed above to clarify areas of similarity and differences.

3. Results

3.1. Group comparison replication: aphantasia versus hyperphantasia

Basic demographic information for each VVIQ group is presented in Table 2 and Supplementary Material 1. Gender is not included, as only 10.0% of the respondents reported it. All VVIQ group comparisons showed a significant effect of the VVIQ group, but see the complete account in the Supplementary material 1, with detailed statistics, supporting figures, and proportions for each VVIQ group and each variable.

Briefly, the Extreme aphantasia group was significantly older than the Mid-range and Moderate hyperphantasia groups, but with an over-representation of people with less than an undergraduate degree (38.8% of the Extreme aphantasia group who reported this information), and an under-representation of people with a postgraduate degree (23.6%) and people with a career in 'Arts, Design, Entertainment, Sports & Media' (10.6%). This group also had an over-representation of reporting that their mood did not influence their mental imagery (84%), nor did having their eyes open or closed (76%). Dreaming with images was under-represented in this group (60.6%) compared to other groups, and they also had an over-representation of dreaming without images (14.4%). In terms of sensory experiences, reporting aphantasia for all sensory modalities was over-represented in the Extreme aphantasia group (46.2%), with an under-representation of having only some senses impacted (27.2%, therefore an opposite pattern to the Moderate aphantasia group). There was also an over-representation of self-reported poor autobiographical memory and poor face recognition skills in both the Extreme aphantasia (45.9% and 36.7%, respectively) and the Moderate aphantasia (49.4% and 42.5%, respectively) groups. The Extreme aphantasia group also showed an under-representation of self-reported synaesthesia (3.3%), and an over-representation of self-reported bad spatial navigational skills (37.8%). This group also showed an under-representation of self-reported faster reading than speaking speed (25.5%) and an over-representation of self-reported similar reading and speaking speed (23.8%).

At the opposite end of the phantasia spectrum, having a family history with other members sharing their neurotype was over-represented for the Moderate hyperphantasia (33.1%) and the Extreme Hyperphantasia (36.0%) groups. Both groups also had an over-representation of dreaming with images (98.9% and 98.4% respectively) and an under-representation of dreaming without images. In terms of sensory experiences, reporting hyperphantasia across all senses was over-represented in the Extreme hyperphantasia group (67.0%). There was also an over-representation of self-reported good autobiographical memory and absence of face recognition difficulties in both the Extreme Hyperphantasia (65.3% and 84.7% respectively) and the Moderate hyperphantasia (68.4% and 81.4% respectively) groups. Both groups also showed an over-representation of self-reported synaesthesia (32.4% and 25.8%, respectively) and good spatial navigation skills (70.1% and 71.2%, respectively). The Extreme hyperphantasia group also showed an over-representation of self-reported faster reading than speaking speed (40.6%).

3.2. Latent class analysis

To explore the existence of meaningful groups within aphantasia beyond the use of arbitrary VVIQ score boundaries, an LCA was conducted on the subsample (n = 4140) of participants with a VVIQ score under 23 (the highest score for Moderate aphantasia), using the same predictors. Only 3883 had no missing data and were included in the computation. This LCA indicated that the model with the lowest BIC (54108.23) was the model containing 3 classes (but see Supplementary material 2 for a table detailing the different models built in this analysis). These classes and the estimated conditional probabilities of each response within each latent class are represented in Table 3. McFadden's pseudo R^2 of 0.011 indicated a low-to-moderate fit of the model to the data. The entropy-based classification accuracy of 0.45 indicated class assignments may be uncertain, with classes potentially poorly defined. Huberty's I-index of 0.63 indicated a moderate classification accuracy, with only 63% of the volunteers being confidently classified into a single latent class. The Cohen's w of 0.20 indicated a small effect size. Average posterior probabilities were as follows: Class 1 = 0.75, Class 2 = 0.75,

Tables 2
VVIQ group demographics.

	Extreme aphantasia	Moderate aphantasia	Mid-range	Moderate hyperphantasia	Extreme hyperphantasia
Age in years, M (SD)	41.0 (15.1)	39.5 (14.9)	38.3 (15.3)	36.6 (14.0)	38.5 (14.9)
Highest Education, n (%)					
Less than an undergraduate degree	1249 (38.8)	292 (31.7)	571 (31.4)	88 (31.7)	76 (37.8)
Undergraduate degree	1210 (37.6)	342 (37.1)	716 (39.4)	104 (37.4)	80 (39.8)
Postgraduate degree	759 (23.6)	288 (31.2)	530 (29.2)	86 (30.9)	45 (22.4)

Table 3
Conditional item response probabilities for the LCA
Note: For easier visual representation of the results and the model-based probabilities, each class is represented by one colour, with an intense colour illustrating a higher value. These expected proportions are estimated conditional probabilities based on maximum likelihood estimation and are not directly calculated from the assigned classes. They are not observed proportions in our sample.
[a] Predicted class membership: proportion of respondents assigned to each class in the sample. These proportions may not sum to 1 due to classification uncertainty.
[b] Estimated class population share: estimated true proportion of individuals in each class based on the model, derived from the estimated class membership probabilities. These proportions sum up to 1.

Classes (Predicted class membership [a] / Estimated class population share [b])		Class 1 (31.1% / 31.1%)	Class 2 (29.5% / 31.8%)	Class 3 (39.4% / 37.1%)
VVIQ group	Extreme aphantasia	90.0%	72.3%	72.5%
	Moderate aphantasia	10.0%	27.7%	27.5%
Other senses concerned	All senses	82.5%	45.3%	8.4%
	Some senses	3.4%	35.6%	49.7%
	No senses	1.5%	2.7%	12.4%
	Unsure	12.6%	16.4%	29.5%
Family history	Family history	25.4%	25.6%	17.7%
	No family history	31.8%	28.3%	23.4%
	Unsure about family history	42.9%	46.1%	58.9%
Autobiographical memory	Poor	44.2%	71.8%	27.5%
	Good	31.0%	6.2%	43.9%
	Unsure	24.8%	22.0%	28.6%
Spatial navigation skills	Poor	26.4%	62.1%	31.2%
	Good	61.7%	26.3%	56.6%
	Unsure	11.9%	11.6%	12.2%
Dreaming experiences	No dreams	12.4%	12.8%	6.1%
	Dreams without images	15.7%	17.4%	10.2%
	Dreams with images	56.7%	53.9%	71.5%
	Unsure	15.2%	15.8%	12.1%
Experiences of synaesthesia	Yes	1.2%	3.6%	5.5%
	No	96.1%	85.4%	84.5%
	Unsure	2.7%	11.0%	10.0%
Difficulties with face recognition	Yes	21.2%	73.8%	21.1%
	No	78.8%	26.2%	78.9%

Class 3 = 0.77, indicating moderate-to-strong class separation.

3.3. *Aphantasia classes comparison*

To better describe the 3 classes identified within the Moderate to Extreme aphantasia population, we conducted group comparisons (mirroring those presented above) with the 3883 volunteers included in the LCA. Basic demographic information for each class is presented in Table 4. Only 11.4% of the respondents indicated their gender, so this variable was not included in the group comparison. A summary of the comparisons is available in Table 5. All the details of the class comparisons are available in supplementary material 3.

A one-way ANOVA showed the classes significantly differed in age (F (1, 3880) = 15.5, $p < 0.0001$, generalised eta-squared ges $\eta^2_G = 0.008$ (small effect size), Table 4), with post-hoc pairwise T-tests with Bonferroni corrections clarifying that Classes 1 significantly differed from both Classes 2 and 3, which did not significantly differ from each other (Classes 1 vs 2: $p = 0.003$, Classes 1 vs 3: $p < 0.0001$).

Table 4
Class demographics.

	Class 1 n = 1208	Class 2 n = 1145	Class 3 n = 1530
Age in years, M (SD, range)	42.5 (15.5, 16 – 84)	40.5 (14.7, 16 – 99)	39.3 (14.6, 16 – 94)
VVIQ, M (SD, range)	16.3 (1.24, 16 – 23)	17.0 (1.88, 16 – 23)	17.0 (1.86, 16 – 23)
Highest Education, n (%)			
Less than an undergraduate degree	473 (32.7)	453 (31.3)	519 (35.9)
Undergraduate degree	448 (31.0)	407 (28.2)	588 (40.7)
Postgraduate degree	287 (28.8)	285 (28.6)	423 (42.5)

Table 5
Class comparisons summary.

Variable	Statistic results	Standardised residuals	Visualisation
VVIQ score	$F(2, 3880) = 56.8$, $p < 0.0001$, small effect size Class 1 ≠ (Class 2 = Class 3)		Table 4
Education	$\chi^2(4, 3883) = 13.2$, $p = 0.01$, small effect size (Class 1 = 2) ≠ Class 3	- Class 1 = Class 2: over-representation of “Less than undergraduate degree” - Class 3: over-representation of “Postgraduate degree”	Sup. Material, Fig. 18
Occupation	$\chi^2(14, 3333) = 42.8$, $p < 0.0001$, small effect size Class 1 ≠ (Class 2 = 3)	- Class 1: over-representation of “STEM” and “Trade & Labour” - Class 2: over-representation of “Education, Training, & Library” - Class 3: over-representation of “Arts, […] Sports, & Media”	Sup. Material, Fig. 19
Age of discovery	$\chi^2(16, 3879) = 40.2$, $p = 0.0007$, small effect size Class 1 ≠ (Class 2 = 3)	- Class 1: over-representation of late adulthood (50s+) discovery - Class 2: over-representation of mid-adulthood discovery (40s) - Class 3: over-representation of early adulthood discovery (20s)	Sup. Material, Fig. 20
Influence of mood	$\chi^2(4, 3883) = 75.5$, $p < 0.0001$, small effect size Class 1 ≠ Class 2 ≠ Class 3	- Class 1: over-representation of “No” influence of mood on imagery - Class 3: under-representation of “No” influence of mood on imagery	Fig. 1A
Effect of eye opening	$\chi^2(4, 3883) = 40.0$, $p < 0.0001$, small effect size Class 1 ≠ Class 2 ≠ Class 3	- Class 1: over-representation of “No” influence of eye opening on imagery - Class 3: under-representation of “No” influence of eye opening on imagery	Fig. 1B
Family history	$\chi^2(4, 3883) = 84.8$, $p < 0.0001$, small effect size (Class 1 = 2) ≠ Class 3	- Class 1: under-representation of uncertainty, sibling recurrence risk ratio of 15.7 for Extreme aphantasia - Class 2: over-representation of family history of aphantasia, sibling recurrence risk ratio of 13.1 for Extreme aphantasia - Class 3: over-representation of uncertainty, sibling recurrence risk ratio of 2.6 for Moderate aphantasia	Fig. 1C
Dreams	$\chi^2(6, 3883) = 165.5$, $p < 0.0001$, small effect size Class 1 ≠ Class 2 ≠ Class 3	- Class 1: over-representation of lack of dreams - Class 2: over-representation of lack of dreams, dreams without images, and uncertainty - Class 3: over-representation of dreams with images	Fig. 1D
Sensory experiences	$\chi^2(6, 3883) = 2647.4$, $p < 0.0001$, large effect size Class 1 ≠ Class 2 ≠ Class 3	- Class 1: over-representation of aphantasia in all sensory modalities - Class 2: over-representation of aphantasia in “some” other senses, under-representation of aphantasia in no other senses - Class 3: over-representation of aphantasia in “some” and no other senses	Fig. 1E
Autobiographical memory	$\chi^2(4, 3883) = 835.6$, $p < 0.0001$, medium effect size Class 1 ≠ Class 2 ≠ Class 3	- Class 1: over-representation of self-reported good skills - Class 2: over-representation of self-reported poor skills - Class 3: over-representation of self-reported good skills	Fig. 1F
Face recognition	$\chi^2(2, 3883) = 1800.5$, $p < 0.0001$, large effect size (Class 1 = 3) ≠ Class 2	- Class 1 = Class 3: over-representation of no face recognition difficulties - Class 2: over-representation of face recognition difficulties	Fig. 1G
Synaesthesia	$\chi^2(4, 3883) = 125.3$, $p < 0.0001$, small effect size Class 1 ≠ Class 2 ≠ Class 3	- Class 1: an over-representation of no experiences of synaesthesia - Class 2: over-representation of uncertainty, under-representation of no experiences of synaesthesia - Class 3: over-representation of experiences of synaesthesia	Fig. 1H
Window task	$\chi^2(8, 3877) = 33.8$, $p < 0.0001$, small effect size Class 1 ≠ Class 2 ≠ Class 3	- Class 1: over-representation of non-visualisation strategies - Class 2: over-representation of	Sup. Material, Fig. 29

(continued on next page)

Table 5 (*continued*)

Variable	Statistic results	Standardised residuals	Visualisation
		the "Not able", "Other", "Unsure" responses - Class 3: over-representation of visualisation strategies	
Amount of imagery	χ^2(4, 3878) = 137.5, $p < 0.0001$, small effect size Class 1 ≠ Class 2 ≠ Class 3	- Class 1: over-representation of total absence of imagery - Class 3: over-representation of brief flashes and uncertainty	Fig. 1I
Spatial navigation	χ^2(4, 3883) = 588.0, $p < 0.0001$, medium effect size Class 1 ≠ Class 2 ≠ Class 3	- Class 1: over-representation of self-reported good skills - Class 2: over-representation of self-reported poor skills - Class 3: over-representation of self-reported good skills	Fig. 1J
Reading speed	χ^2(8, 2097) = 26.703, $p = 0.0008$, small effect size (Class 1 = 3) ≠ Class 2	- Class 1: over-representation of similar speed of reading and speaking - Class 2: over-representation of a reading speed slower than speaking speed - Class 3: under-representation of a reading speed slower than speaking speed	Fig. 1K

4. Discussion

4.1. Summary

The present study sought to 1) replicate Zeman et al.'s (2020) comparisons of Extreme and Moderate forms of aphantasia and hyperphantasia (based on VVIQ scores); 2) expand the investigations of Williams and Suggate (2024), Dawes et al. (2024), and Delem et al. (2025) regarding possible subtypes of aphantasia, considering several cognitive features as well as imagery experiences; and 3) identify the similarities and differences between these subtypes. As expected, most of Zeman et al.'s (2020) findings based on 2000 volunteers were replicated in the present large sample of 6436 respondents. In fact, our study stands out in the field thanks to its large sample of new volunteers who provided wide-ranging information about their experience, allowing us to search for subtypes that previous, less-powered studies might have missed. Crucially, our analysis did identify 3 subtypes of aphantasia with specific patterns of strengths and difficulties within the wider sensory and cognitive domains. As such, this study is the first to report that beyond the imagery differences between Extreme versus Moderate aphantasia and between those with uni-versus multi-sensory aphantasia, another population exists that experiences a wide range of cognitive difficulties in domains linked to imagery. This finding – which should be considered within the boundaries of our methods' limitations – raises questions about the roots and wider impacts of weak imagery.

4.2. Key findings

Within our large sample of respondents, we replicated most of Zeman et al.'s (2020) findings: high visualisers were more likely than typical and poor (partial or total absence of imagery) visualisers to report an impact of their mood on their imagery skills, experiences of synaesthesia, using visual strategies to solve the window counting task, and family history of hyperphantasia. In contrast, people with poor or absent mental imagery were more likely than people with typical or vivid imagery to report poor autobiographical memory, poor face recognition skills, not dreaming or not having visual dreams, using nonvisual strategies to solve the window counting task, and no impact on their imagery of having their eyes open or closed. We found a sibling recurrence risk ratio for Extreme aphantasia of 13.2, similar to the 10-fold increase in the likelihood of aphantasia in siblings (compared to the general population) identified by Zeman et al. (2020). In addition, we also found that for both poor and vivid visualisers, the sibling recurrence risk ratio (detailed in Supplementary Material 1) was higher at the more extreme end of the visualisation group. Like Zeman et al. (2020), we also found that those at the extreme ends of the visualisation spectrum were more likely to experience poor or vivid imagery in all sensory modalities, while those closer to typical visualisers (the Moderate groups) were more likely to only experience poor or vivid imagery in some other but not all sensory modalities. This mirrors Dawes et al. (2024), where most volunteers with weak but not absent visual imagery had most to all other senses within the typical range. We also replicated the finding that poor visualisers were less likely than others to work in an art-, media- or sport-related field. However, in our sample, this group was not more likely to be working in STEM, instead showing a higher likelihood of working in business or management, though both may leverage similar analytical skills.

Our sample did not include a group of control participants who consider themselves typical visualisers. Instead, we have used as a baseline the group scoring within the mid-range of the VVIQ, even though those participants joined the study while self-identifying as having either poor or vivid imagery (see further comments about this group in the section *Limitations & future directions* below). It is possible that while this group scored within the typical range of the VVIQ, these volunteers differ from typical visualisers in other ways that are simply not captured by the VVIQ. Still, using this group had the advantage of comparing poor and vivid visualisers to a population with similar perceived imagery skills, whose only different characteristic is their VVIQ score. As such, we could explore similarities and differences between groups strictly based on VVIQ score, regardless of self-assignation. In addition, the similarity between our results and those of previous research – including Zeman et al. (2020), which included a 'true' typical visualiser group - suggests that relying on this group did not weaken our methodology.

Overall, our findings support the hypothesis that those with very low or absent imagery can differ from typical and vivid imagers in multiple domains beyond strict visualisation skills: poor visualisation skills are often associated with a range of sensory and cognitive features such as generalised poor imagery in all sensory modalities, autobiographical memory and face recognition difficulties, atypical spatial problem-solving strategies, and atypical dreams. Together, this supports the hypothesis of a strong link between imagery skills and cognitive processes, though group differences could also be linked to the observed demographic differences. Indeed, the Extreme aphantasia group being significantly older than some other groups, including Mid-range, and being more likely to have less than an undergraduate degree than the other groups, may have played a role in their increased likelihood to self-report lower skills than other groups in several cognitive domains, such as autobiographical memory. Yet, the congruence between our findings and those by Zeman et al. (2020), where there were no significant age differences between aphantasic and hyperphantasic volunteers, both significantly younger than the control group, suggests that true group

Fig. 1. Aphantasia classes comparisons.

differences exist beyond the role of age and education.

Still, some of our results here conflict with evidence reported elsewhere. For example, our results suggest that aphantasic people are more likely to self-report having poor spatial navigation skills. However, findings regarding spatial memory and spatial navigation are still somewhat inconsistent, with evidence showing both the presence (Crowder, 2018) and absence (Dawes et al., 2020) of significant difficulty in aphantasia compared to typical visualisers. Our results might be explained by the fact that we used a coarse-grained self-report tool to capture spatial navigation skills (as discussed further below), though another explanation could be the existence of subtypes. Indeed, when addressing this same discrepancy, Palermo et al. (2022) distinguished two subtypes of aphantasia: "spatial aphantasia" – with visuo-spatial mental imagery and navigation difficulties, and "object aphantasia" – with difficulties representing single items or events, noting that those could co-exist. This hypothesis of subtypes aligns with our group-based results: as found by Zeman et al. (2020), neither the Extreme nor Moderate aphantasia groups were monoliths in their sensory and cognitive profiles; instead, we observed a wide diversity of reports, both in terms of the quantitative assessments reported here and in the lived experiences described by aphantasic volunteers in Digard et al. (2026). Are the different experiences of poor visualisers spread across the population, or do they cluster in subtypes with distinct characterisations?

Even though our measures of each sensory and cognitive domain were coarse-grained, the LCA identified 3 subtypes of equal proportion within our large sample of Moderate and Extreme aphantasic respondents with distinct sensory and cognitive features, as subsequently confirmed by the class comparison. Those comparisons showed that the main features teasing apart the subtypes were the other sensory experiences, face recognition skills, autobiographical memory skills, and spatial navigation skills (all with a large effect size). Class 1, 'global aphantasia', was characterised by very low or absent imagery in most or often all sensory modalities (similarly to 'global aphantasia' described by Zeman et al. (2024)), regardless of the presence of distracting incoming visual information (eye opened or closed), including a lower likelihood of visual imagery during dreams (involuntary imagery), and a lower likelihood of one's mood impacting (involuntarily) their imagery skills; but with otherwise minor cognitive features. Class 3, 'non-global aphantasia', can be described as a non-global, visual or multisensory (Zeman et al., 2026) form of Class 1, with mostly low to absent imagery in some, though not all, sensory modalities, and otherwise limited to no cognitive difficulties. This class showed, however, a high likelihood of experiencing visual dreams, which prompts further investigation into their involuntary imagery. Finally, Class 2, 'aphantasia +,' was characterised by its more widespread cognitive difficulties. Alongside low or absent imagery in some to all sensory modalities (multisensory to global aphantasia), including during dreams, Class 2 also displayed poor autobiographical memory, poor spatial navigation skills, poor face recognition skills, and a high likelihood of slower reading speed.

In spite of our less fine-grained measures than those used by previous authors, our findings replicate and extend those by Dawes et al. (2024) and Delem et al. (2025) of distinct sensory and cognitive profiles in aphantasia, with subtypes characterised by two main dimensions: number (and type) of sensory modalities experiencing low imagery, and the intensity of aphantasia in the concerned sensory modalities (total lack of versus poor imagery). Here we go further by adding the dimension of cognitive correlates, with the presence versus absence of difficulties in other cognitive processes (outcome model with 2 classes), discriminating aphantasia subtypes before the generalised versus restricted sensory experiences (outcome model with 3 classes), thus highlighting the importance of those cognitive outcomes. In addition, the outcome models with 4 and 5 classes (Supplementary material 2) suggest that cognitive differences can occur with varying levels of intensity, regardless of the extent of the sensory differences. This also explains the diverse visual imagery skills included in Class 2, and suggests that absent imagery alone might not increase the probability of experiencing other cognitive differences.

4.3. Limitations & future directions

These findings must be interpreted cautiously in the light of their limitations. Indeed, despite the large sample size involved in this analysis, the various effect size indicators of the LCA yielded a weak to moderate fitness of the models to the data, with a moderate classification accuracy when assigning volunteers to classes. Of course, this could suggest that these dimensions (intensity and generalisation of sensory aphantasia, presence of cognitive correlates) are not robustly defined. The small effect size observed in the LCA could also reflect the mathematical approaches used, with other modelling strategies yielding different results. However, this could also be explained by the exclusive use of self-assessed and self-reported measures instead of objective correlates (Zeman, 2024). One issue with these measures is their limited and coarse-grained categorical answers ("Yes", "No", "Unsure"), levelling fine specificities of experiences. However, our replication of Dawes et al.'s (2024) findings suggests our approach is robust. Finally, across our entire sample of volunteers included in the group comparison, it is evident that there are discrepancies between some of the volunteers' perceptions of their skills and their measured performances. These inconsistencies may be due not to an under- or over-estimation of their skills, but to a misunderstanding of what is considered "typical" imagery, or a mismatch between the imagery processes they conceptualised and those measured by the VVIQ. Such discrepancies in subjective bias likely occurred within those scoring 23 and under on the VVIQ and included in the LCA, including in questions used for the classification. However, it is also possible that this discrepancy between self-perceived visual imagery skills and VVIQ scores is due to the experience of difficulties in other aspects of visual imagery not captured by the VVIQ (focused on vividness), such as generating, maintaining, or controlling visual imagery. Indeed, as described by Digard et al. (2026) and Kendle (2017), the experience of faint imagery can take many forms, for example, with the experiences of detailed flashes that cannot be sustained.

Future research should interrogate these findings, testing volunteers with a range of finer, more robustly defined, and validated assessments, ideally including select behavioural or neurophysiological measures in addition to self-reports (Larner et al., 2024). We recommend including specific assessments of imagery in a range of sensory modalities, like Dawes et al. (2024), measures of both voluntary and involuntary imagery, and measures precisely capturing the different elements of imagery, such as generation, maintenance and manipulation. We also recommend the inclusion of assessments capturing autobiographical memory, face imagery and recognition, spatial navigation, word processing, and socioemotional processing. Indeed, this later domain has received only limited interest so far even though some aphantasic people express feelings of socioemotional disconnection (Digard et al., 2026), and aphantasia is linked to both elevated rates of alexithymia and reduced emotional response to verbal emotional stimuli, compared to typical imagers (Monzel et al., 2024; Wicken et al., 2021; Zeman et al., 2026). In addition, the closed-ended items of the survey did not specifically address whether the respondents had acquired or congenital aphantasia; thus, a minority of our volunteers are likely to present an "acquired-specific" profile. Importantly, the distinction between acquired and congenital types may be more complex to identify than previously expected when the acquisition has potentially occurred during childhood, as suspected by some aphantasic people (Digard et al., 2026). In any case, future research should ensure the thorough recording of this variable, and investigate the potential existence of different forms of acquired aphantasia as well.

Finally, while this study did not gather a large enough sample of hyperphantasic participants to explore the existence of subtypes in hyperphantasia, future research should also address individual differences and ramifications of imagery skills at the other end of the mental imagery spectrum.

4.4. Implications

Our findings reinforce the need for a robust, evidence-based theory of aphantasia that allows for the variety of sensory and cognitive profiles identified here. Additional research is necessary to identify whether aphantasia represents the extreme of the normal distribution of visual imagery abilities, a distinct neurotype or set of neurotypes or a combination of the two.

Indeed, our results raise important questions regarding the roots and ramifications of poor visual imagery skills. Are co-occurring cognitive difficulties in domains that overlap with imagery (i.e. autobiographical memory, spatial navigation, face recognition) a consequence of poor imagery? If that were the case, these cognitive features would be observed in most people with totally absent imagery, but rarely in those with only somewhat poor imagery. Instead, we identified that half (outcome model with 2 classes, see Supplementary material 2) to two-thirds (outcome model with 3 classes) of our sample, including many without any visual imagery, did not experience them. This suggests that these cognitive difficulties are not an inevitable direct consequence of absent imagery. Therefore, we can consider two other hypotheses (Fig. 2): either 1) low imagery and these cognitive features are the results of (at least) two distinct neurodevelopmental phenomena that are likely to co-occur (i.e. phenomena A leading to low imagery, and phenomena B leading to the observed cognitive features), or 2) low or absent imagery can be the results of (at least) two distinct neurodevelopmental phenomena, with (at least) one of them also leading to a range of cognitive correlates (i.e. phenomena A leading to low imagery alone, and phenomena B leading to low imagery and the observed cognitive features). These developmental hypotheses are particularly relevant considering the overlap between aphantasia and types of neurodivergence (Monzel et al., 2023), especially autism (King et al., 2024). As such, researching aphantasia through a neurodiversity lens, and recording other neurotypes within the population (such as autism) is a priority.

As the limited neurological data currently available (see Zeman (2024) for a brief review) does not offer evidence to disentangle these hypotheses, a closer description of the various experiences of aphantasia (i.e. intensity, uni- and multi-modality, measure of accessibility, agency,

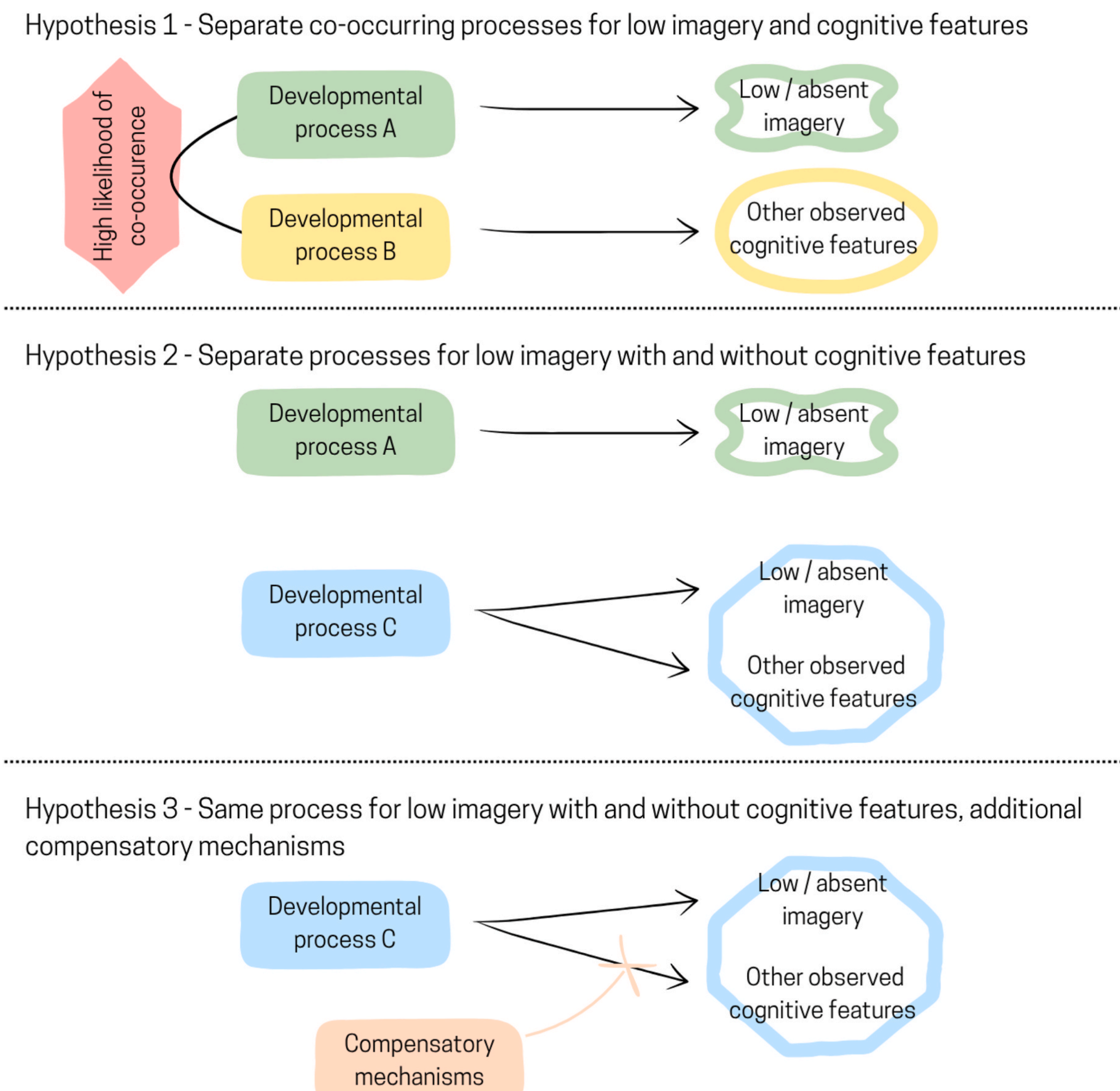

Fig. 2. *Neurodevelopmental process hypotheses*
Note. In hypotheses 1 and 2 presented in this infographic, both processes A and B could exist with varying levels of intensity, similar to compensatory mechanisms (hypothesis 3), thus accounting for differences in the amount of imagery experienced.

generation, maintenance, and exploration of imagery, with and without additional cognitive features) could provide some answers. Adopting a longitudinal lens would also allow us to map out the cognitive development of these skills, and identify factors that may increase or decrease the likelihood of experiencing low imagery. Indeed, while the comparatively high proportion of 1st-degree relatives with aphantasia may suggest a genetic component, other factors are also likely to be at play. Finally, one other possible explanation is that those with absent imagery who do not report additional cognitive difficulties rely on compensatory mechanisms or alternate cognitive pathways to typical visualisers, while those who experience these cognitive difficulties do not. Indeed, Keogh et al. (2021) and Reeder et al. (2024) found that while aphantasic volunteers performed similarly to typical visualisers on visual working memory tasks, there were significant differences in the strategies used to fulfil the tasks, with aphantasic volunteers relying more on non-visual spatial, sensorimotor, propositional or labelling strategies than typical visualisers (who relied more on visual strategies).

These questions have crucial ramifications for aphantasia and imagery research. Aphantasia has been primarily studied as a uniform experience varying along a single dimension, the richness (or lack thereof) of deliberate visual imagery. It has been operationalised as a straightforward condition of low or absent visual imagery, when the experiences of those who fit this criterion differ vastly from each other's and from that of typical visualisers, in multiple domains. Future research should therefore refrain from considering aphantasic volunteers as a homogenous group, and instead embrace a multidimensional approach that takes into account individual differences. Such a paradigm shift would ensure that existing cognitive differences between typical visualisers and precise subtypes of aphantasic people are not overshadowed by group-level similarities, and vice versa.

4.5. Conclusion

This study reasserts the heterogeneous nature of aphantasia: considering only people with low to absent visual imagery, we identified three subtypes of aphantasia that differ in the extensiveness of their sensory imagery and the presence (or absence) of difficulties outwith strict sensory imagery. These findings align with the sheer diversity of lived experiences that can be witnessed in the testimonies of aphantasic people. We raise questions regarding the roots and ramifications of low imagery, and we emphasise the need for a multidimensional approach to aphantasia in research, that captures individual differences beyond visual imagery.

Declaration of generative AI in scientific writing

No generative AI was used to write this manuscript.

CRediT authorship contribution statement

Bérengère Galadriel Digard: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Visualization, Writing – original draft. **Kealan Jones:** Methodology, Project administration, Writing – review & editing. **Fraser Milton:** Methodology, Writing – review & editing. **Zoe Foster:** Methodology, Project administration, Writing – review & editing. **Adam Zeman:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – review & editing.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.neuropsychologia.2026.109500.

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