The inner experience is an intimate and personal aspect of the human, unique to the person to which it belongs. When thinking about the inner experience, people might consider the mind, memories, senses, perception, and how they all work together. Many people can visualize images in their mind, like creating scenes while reading or picturing an object. This is referred to as mental imagery of the visual domain. Additionally, one may have conversations with themselves throughout the day or talk internally through routines. This capability is considered inner hearing, or inner speech, through the auditory domain. The present study focused on the two inner modalities of visual mental imagery and inner hearing, as well as the internal sensory experiences of the other modalities of touch, taste, and smell. This article discusses the variability in inner experiences and how people use them, while looking for possible connections amongst them. Specifically, we focused on the relationship between the usage of visual mental imagery and inner hearing, while further exploring the other modalities and their usage based on trait capabilities of visual mental imagery in an applied reading scenario.

As with most phenomena, there are extremes within the inner experience. Some people experience capabilities in extreme detail, which is referred to as hyperphantasia. Those with hyperphantasia may be able to internally visualize and describe a situation in detail, such as their dinner from the night before as if it were sitting in front of them. On the other end of the spectrum, some do not have the capabilities of inner experience, which is called aphantasia or 'blindness of the mind.' Zeman et al. (2010) studied patient MX, who claimed to have lost the ability to summon visual images after undergoing coronary angioplasty. In comparing fMRI results regarding neural patterns of patient MX and control subjects, they found an extreme reduction in activation of posterior regions of the brain and an increase in activation of the frontal regions for patient MX when attempting to create the visual images in their mind (Zeman et al., 2010). This suggests that there may be unique brain connectivity or activity leading to the capability to visualize mental imagery.

After studying patient MX, Zeman et al. (2015) were contacted by over 20 individuals with aphantasia, many of which had never obtained the internal visualization capabilities. Now, thousands of reports exist of patients on both ends of the phantasia spectrums (Zeman et al., 2020). Zeman et al (2020) distinguished group of internalizing visual capabilities by using the Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973). They grouped scores into the extremes of aphantasia (low scores between 16–23) and hyperphantasia (high scores between 75-80) while comparing them to controls (median scores between 55–60). Additionally, they measured a variety of variables, including occupation chosen, personal memories, and the ability to mentally count windows. Their main findings were that the hyperphantasia group chose more creative professions, but the aphantasia group chose more professions in science, technology, and math. Additionally, participants were using different strategies when asked to recount personal memories or a spatial visualization task (see Zeman et al., 2020 for full results). Milton et al. (2021) not only found different strategy usage for these groupings, but also differential brain activity in the anterior parietal lobe from fMRI and connectivity in the posterior visual network and prefrontal brain regions. They noted that there was a difference in IQ score, with the aphantasia group performing significantly higher, but no statistical difference in standard memory test performance between groups. For some, the inability to experience these aspects internally could seem like a deficit, but those with aphantasia can experience the world in terms of the five senses on an external basis, rather than internally (see Jacobs et al., 2017 for review). Although

most people fall in between these two extremes, the existence of these two endpoints supports the idea that inner experience is a phenomenon unique to each person's experience of the world.

The ability to mentally travel in time and space to imaginary places can be helpful for tasks such as problem solving, decision making, planning, and many more daily occurrences. Floridou et al. (2021) studied the different modalities of the inner experience and the intentionality levels of implementation. The goal of their study was to determine whether individual factors were associated with the variability of visual experience using self-report imagery questionnaires, including the VVIQ. Results of this study and others (see Pearson et al., 2015 for review) demonstrate that demographic factors and individuality can affect the vividness of visual mental imagery, suggesting the capabilities lie on a spectrum between the two extremes. Using functional MRI, Cui and colleagues (2007) found a strong correlation between the trait measure of visual mental imagery, measured with the VVIQ, and visual cortex activity when participants were asked to visualize themselves or someone else in two workout scenarios (bench-pressing or stair climbing). Their eight participants spanned a wide range of trait visual mental imagery and that suggests that brain activity, especially in the visual cortex, during the usage of visual internal visual mental imagery greatly varies. Although this study had a relatively small sample size, other studies have found a similar activity pattern in visual perception areas of the brain for visual mental imagery between the extremes (Reddy et al., 2010; Johnson & Johnson, 2014).

With much research focused on visual mental imagery, the auditory inner experience has also recently been investigated. Halpern (2015) modified the VVIQ to objectively measure internalization of musical, verbal, and environmental sounds. The results demonstrated that the internalization of different auditory sounds varied widely in their sample. Their measure provided reliability and construct validity to show that people have a wide range of inner auditory experiences too. Alderson-Day et al. (2016) studied the usage of inner speech, theory of mind, and perspective switching. Participants were presented with scenarios in which they were asked to use their inner speech capabilities to generate their own endings of the scenarios provided. They were then asked to rate the vividness of any visual mental imagery that was used to create these scenarios. Participants were also surveyed on characteristics of their inner speech, if applicable. Regarding the vividness of visual mental imagery and inner speech in generating these scenarios, inner speech was reported as significantly more vivid than visual mental imagery, although the use of visual mental imagery was still present in participants (Alderson-Day et al., 2016). Participants' vividness of visual mental imagery and inner speech was measured through self-report and high levels of inner speech were consistent throughout the sample, where measures of visual mental imagery were highly variable. The differences within these self-reports are important to consider when recognizing a higher level of inner speech used within the generation of these scenarios. These findings support the notion that more research with larger sample sizes is necessary to represent the correlation more accurately between modalities within the inner experience.

To further understand the utilization of the inner experience, it is important to consider applied situations like narrative transportation or being internally absorbed in a story. Isakoglou et al. (2021) investigated what happens within the mind as one becomes "lost" in story during narrative transportation. They found that the experience of narrative transportation was higher for high levels of empathy and specific genres. Taking this into

account, we questioned if mentally visualizing, hearing, and experiencing a narrative internally plays a role in the narrative transportation process. The use of internal generation may also lead to better retention of information. Donelly and Velayo (2004) investigated whether self- generation of visual or auditory information influenced memory. Participants were given concept pairs representing a combination of multiple modalities, either textual, pictorial, or auditory, and were asked to internally create a relationship between the items. They found that the use of visual elaborations resulted in the highest scores on the pairs test, especially compared to the auditory and textual groups. Using inner experiences may enhance memory and allow people to get 'lost' internally in their inner experience. The ability to use internal experiences directed our research to investigate the connection between visual mental imagery and inner hearing and their use in reading a short story.

Although visual mental imagery and inner hearing have been highly researched, investigations into the inner experiences of the other sensory modalities are becoming more prevalent. Andrade et al. (2013) developed the Plymouth Sensory Imagery Questionnaire (Psi-Q) to focus on the four internal sensory modalities of sound, taste, touch, and smell, and measure them independently. Using this measure, Speed and Majid (2018) focused on the nondominated senses of touch, taste, and smell to see how they contribute to meaning in language. Although their findings suggested that emotion played more of a role in understanding language than sensory modality, there could be a small contribution of these modalities and they should not be disregarded in the potential impact.

The internal experiences of the five senses have been explored separately, yet very little research has been conducted on the simultaneous use of the modalities and their relationships. In addition to further exploring these modalities and the individual variability within them, we aimed to find a correlation in their use. We hypothesized that there would be a positive correlation between visual mental imagery and inner hearing. The rationale for this would be the usage of one internal modality may give access to another, yet this has been under-explored. The measure used in the present study (Psi-Q) to assess inner hearing also assesses the other sensory modalities; therefore, additional correlations were conducted to explore potential correlations between abilities within all sensory modalities (sound, smell, taste, and touch).

Additionally, we wanted to better understand how people are applying both visual mental imagery and inner hearing capabilities. To explore the application of these modalities, our participants read a story and were asked follow-up questions assessing how well they were able to visualize the scenery or hear the dialogue illustrated within the short story. Our hypothesis for this was open-ended, but we wanted to see if there are group differences on trait levels of visual mental imagery and how they differed in their usage in this applied situation.

Method Participants

Participants (N = 137) were recruited through convenience sampling with the participant pool at the local Midwestern institution of higher learning and on the social media platforms of Reddit, Facebook, Snapchat, and Instagram. Data was collected through the online Qualtrics link active from March 2022 to April 2022. The ages of participants ranged from 18–85 (M = 34.67, SD = 16.68). Of those participants, 32 did not disclose gender and race/ethnicity. Out of the 105 people that chose to respond, 80 identified as female (58.4%), 24 identified as male (17.5%), and 1 identified as other. Ninety-six people

identified as White/European American (70.1%), 4 identified as Asian (2.9%), 2 identified as Black/African American (1.5%), 2 identified as Hispanic, Latinx, or of Spanish origin (1.5%), and 1 identified as other (.7%). This study met the ethical standards set by the Lindenwood Institutional Review Board. Those who participated through the participant pool were given extra credit through participating classes, but no additional compensation was given to participants.

Materials and Procedure

Institutional review board approval was received prior to collecting data for this study. This was a within-subjects design with naturally occurring observance of trait abilities for inner experiences of the different sensory modalities. After reading the consent statement and agreeing to participate, participants were asked to answer a series of questions to measure their inner experience. To obtain a trait measure of visual mental imagery, the Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973) was used. This 16-item survey consisted of four scenes (a relative/friend, rising sun, a shop, and a landscape), and participants were asked to visualize and rate the vividness of several aspects of the given scenes on a 5-point scale, ranging from 1 (*no image*) to 5 (*perfectly clear and vivid*). Total scores ranged from 16–80, where lower scores indicated less visual mental imagery and higher scores indicated more visual mental imagery. Marks (1973) reported a test- retest reliability coefficient of .74 and a split-half reliability coefficient of .85. Participants were analyzed by their total scores, as well as grouped into one of four categories of visual mental imagery based on their VVIQ total scores. The extreme scores on both ends of the VVIQ were grouped similar to Zeman et al. (2020) and Milton et al. (2021) where the aphantasia/low visual mental imagery scores ranged between 16–23 (N = 10) and hyperphantasia/high visual mental imagery scores ranged between 75–80 (N = 17). Although Zeman et al. (2020) and Milton et al. (2021) utilized a few participants as controls with VVIQ scores between 55–60 for their studies, we conducted a median split grouping with our remaining 110 participants into low/moderate visual mental imagery if they scored between 24– 59 (N = 56) and moderate/high visual mental imagery (N = 54). See Table 1 for descriptive information of the visual mental imagery groups.

To assess the inner experience of the other sensory modalities, subscales from the 35-item Plymouth Sensory Imagery Questionnaire (Psi-Q; Andrade et al., 2013) were used. This survey is divided into 4 subscales that assess traits and mental capabilities of generating specific sounds, smells, tastes, and textures of certain objects internally. In each subscale, participants were presented with five different scenarios or objects in which they would have to rate the vividness of their mental capabilities on a 6-point scale ranging from 1 (*no sound/taste/smell/feeling*) to 6 (*perfectly clear and vivid*). Participants were analyzed by averaging their scores for each subscale. Andrade et al., (2013) reported the Psi-Q to have a high reliability value of Cronbach's alpha of .96.

We created a story and, similar to Alderson-Day et al. (2016), we asked participants to use aspects of their inner experience to read, conceptualize, and continue the story. Our story, accessible at osf.io/rkfx9, was written with highly visible, concrete nouns and dialogue between characters to make it possible for participants to create different sounds for each character. The characters of Bunny and Blue Hippo are participating in different types of play and although Blue Hippo is outside getting muddy in the puddles and chasing butterflies, Bunny believes it would be best to stay inside and paint. As the short story

develops, Blue Hippo has fun outside, but Bunny feels that there is something missing from his indoor activity. We utilized mental creation/generation, rather than relying on memory of actual events that may have occurred. To ensure this story was appropriate for anyone in our sample to comprehend, a readability checker (readable.com) placed the story at the fourth-grade reading level on the Flesch-Kincaid Grade Level Scale. Participants were instructed to read the story and answer questions about their inner experience of the story. Questions about the vividness of the characters used the same 5-point scaling as the VVIQ with 1 (*no image*) to 5 (*perfectly clear and vivid*). The vividness of sound was assessed with the same 6-point scale from the Psi-Q with 1 (*no sound*) to 6 (*perfectly clear and vivid*). Lastly, participants were asked demographic questions about themselves. The study took less than 15 minutes to complete.

Table 1

Demographic Characteristics for Four Mental Imagery Groupings

Demographic variables	Aphantasia/low mental imagery (*n* = 10)	Low/moderate mental imagery (*n* = 56)	Moderate/high mental imagery (*n* = 54)	Hyperphantasia/ high mental imagery (*n* = 17)
VVIQ range	16–23	24–59	60–74	75–80
M(SD)	16(0)	49.38(8.97)	66(4.4)	77.94(1.78)
Age range	39-85	18–69	18–71	18–71
M(*SD*)	58.6(15.54)	31.27(14.8)	34.78(15.46)	31.47(16.58)
Gender	4 females/ 6 ND	32 females/ 13 males/11 ND	33 females/ 10 males/ 11 ND	11 females/ 1 male/ 5 ND

Note. VVIQ = Vividness of Visual Imagery Questionnaire (Marks, 1973); ND = Not Disclosed.

Results

Correlations of VVIQ, Psi-Q, and Age

Measures of VVIQ and Psi-Q ranged for participants, showing variability in each of the internal experiences of our sample. To analyze our first hypothesis, we conducted Pearson's *r* correlations between trait visual mental imagery and the other trait inner modalities (see Table 2). We found significantly positive relationships between visual mental imagery with inner hearing $r(135) = .72$, $p < .001$, visual mental imagery with smell, $r(135) = .62$, $p < .001$, visual mental imagery with taste, $r(135) = .62$, $p < .001$, and visual mental imagery with touch, $r(135) = .7$, $p < .001$. Additionally, inner hearing was positively correlated with smell, $r(135) = .72$, $p < .001$, taste, $r(135) = .70$, $p < .001$, and touch, $r(135) = .71$, $p < .001$. We also found significant correlations between smell with taste, $r(135) = .84$, $p < .001$, and smell with touch, $r(135) = .81$, $p < .001$. Finally, a significantly positive correlation was found between the modalities of taste and touch, $r(135) = .81$, $p < .001$. This indicates those who were experiencing high levels of inner experiences in one modality were also experiencing high levels within the other modalities. Similarly, when someone had low

levels in one modality, they also experienced low levels within the others. Although not originally considered, the large spread of age prompted additional exploratory correlations. There was a weak, negative correlation between participants' age and VVIQ score, $r(135) = -.24$, $p = .005$. This indicates that those with less visual mental imagery were older and those with higher capabilities of visual mental imagery were younger.

Table 2

Correlations Matrix for Measured Variables

Measure	*M*	*SD*	1	2	3	4	5
1. VVIQ-trait visual mental imagery	57.04	16.58	_				
2. PsiQ-trait inner hearing	4.57	1.49	.72**	_			
3. PsiQ-trait inner smell	4.06	1.58	.62**	.72**	_		
4. PsiQ-trait inner taste	4.07	1.58	.62**	.7**	.84**	_	
5. PsiQ-trait inner touch	4.5	1.47	.7**	.71**	.81**	.81**	_
6. Age	34.67	16.68	-.24*	-.19*	.1	-.1	-.24*

Note. VVIQ = Vividness of Visual Imagery Questionnaire (Marks, 1973); PsiQ = Plymouth Sensory Imagery Questionnaire (Andrade et al., 2013).
*$p < .05$, two-tailed. **$p < .001$, two-tailed.

VVIQ Group Differences

As expected, a Univariate ANOVA found significant differences in the VVIQ score between the four visual mental imagery groups, $F(3,133) = 256.81$, $p < .001$, $\eta^2 = .85$. Pairwise comparisons indicated that the VVIQ score for the aphantasia/low visual mental imagery group was significantly lower than the other three, followed by low/moderate visual mental imagery group, then moderate/high visual mental imagery group, with the hyperphantasia/high visual mental imagery group scores being significantly highest (*p*s < .001; see Table 1). A contingency chi-square did not reveal any gender differences across the groups, $\chi^2 (6) = 4.96$, $p = .55$. There were significant differences in age between the four groups, $F(3,133) = 9.28$, $p < .001$, $\eta^2 = .17$. Pairwise comparisons showed that only the aphantasia/low visual mental imagery group was significantly older than each of the other groups (*p*s <.001) but no other pairings were significantly different (*p*s > .23; see Table 1).

A Univariate ANOVA was also conducted to see how the four visual mental imagery groups differed in how they used their capabilities to envision various elements of the story. There were significant differences between groups on how vividly they could picture the characters of Bunny, $F(3, 133) = 21.45$, $p < .001$, $\eta^2 = .33$, and Blue Hippo, $F(3, 132) = 30.18$, $p < .001$, $\eta^2 = .41$. Post hoc analysis revealed statistically significant group differences for all four visual mental imagery groups for vividness of Bunny with aphantasia/low visual mental imagery ($M = 1$, $SD = 0$), low/moderate visual mental imagery ($M = 2.96$, $SD = 1.13$), moderate/high visual mental imagery ($M = 3.67$, $SD = 0.7$), and then hyperphantasia/high visual mental imagery ($M = 4.47$, $SD = 0.8$; *p*s < .002).

Additionally, the same significant differences and pattern appears for all four visual mental imagery groups for vividness of Blue Hippo with aphantasia/low visual mental imagery (M = 1, SD = 0), low/moderate visual mental imagery (M = 2.63, SD = 0.98), moderate/high visual mental imagery (M = 3.43, SD = 1.01), and then hyperphantasia/high visual mental imagery (M = 4.29, SD = 1.1; ps < .002). Interestingly, the exact same groupings in the visual modality displayed the same pattern for how clearly they could hear the conversation between the two characters, $F(3, 132) = 32.49$, $p < .001$, $\eta^2 = .43$, with significant differences between each group of aphantasia/low visual mental imagery (M = 1, SD = 0), low/moderate visual mental imagery (M = 3.65, SD = 1.43), moderate/high visual mental imagery (M = 4.43, SD = 1.21), and then hyperphantasia/high visual mental imagery (M = 5.53, SD = 0.8; ps < .002).

Discussion

The current study was conducted to explore the correlation between the trait measures of inner experiences from the five sensory modalities. Although prior research investigated both visual mental imagery and inner hearing separately, the relationship between these capabilities had yet to be determined. Our primary hypothesis was supported in finding a positive correlation between visual mental imagery and inner hearing. The results of our study showed that participants with higher levels of visual mental imagery had higher levels of inner hearing, and people with lower levels of visual mental imagery had lower levels of inner hearing. Additionally, the three other inner experiences of smell, taste, and touch showed positive correlations with visual mental imagery and inner hearing, as well as each other. This supports our idea that trait capabilities lie on a continuum and should be measured as such. Those with high levels in one modality appear to also display high levels across all of them, and similarly with moderate levels and low levels.

Although our second hypothesis was open-ended on group distinctions between visual mental imagery on being able to use inner experience capabilities, our results showed participants were statistically different on usage based on grouping. Those in the hyperphantasia/high mental imagery group were able to vividly, internally visualize Bunny and Blue Hippo, as well as internally hear their conversations. Those in the aphantasia/low visual mental imagery performed at floor in the capability to visualize Bunny and Blue Hippo and could not internally hear their conversations. The two moderate groupings were stair stepped in pattern with the capability to use their visual and auditory internal capabilities for the applied story. The crossing of internal sensory modality suggests there is a connection between the inner experience of each of the senses.

Inner experience appears to be on a spectrum with hyperphantasia on the high side and aphantasia on the low end. Most of our participants fell between those end points, suggesting that people vary greatly in their internal experiences. It is still unknown how common phantasia appears in the general population, but this may be an indication of their rarer occurrences for inner experience at either end point of the spectrum. In recognizing a lack of diversity in our sample, it is important to consider that these findings are primarily represent English-speaking females who are White/European American. Although our findings can act as a baseline to further build upon, future researchers should work to ensure a more diverse sample to properly represent the population and the variety of genders and racial/ethnic backgrounds. Additionally, the variability of sample ages should also be considered a limitation of our study, as we had a wide range of ages among our participants.

The differentiation between cognitive abilities at different ages was not initially considered, however, additional exploratory correlations showed a weak, negative correlation between participants' age and VVIQ score. For our sample, there tended to be more older individuals in the aphantasia/low mental imagery group. This may not be the case with a larger sample or indicative of the population because Zeman et al. (2020) had more older individuals in their control group and Milton et al. (2021) did not show any age differences between their groupings. More research should be conducted to determine if differences in age and sample size yield the same results as our study or if data differs.

Another limitation to be considered in future research is the use of self- report measures. The Psi-Q (Andrade et al., 2013) and VVIQ (Marks, 1973) are both self-report measures and used to measure participant inner experience capabilities. The use of self-report measures leaves the possibility for possible measurement errors and potentially inaccurate answers, as participants may select answers based on social desirability or metacognitive understanding of their own capabilities, rather than objective measures. Using experimental manipulations rather than self-report measures could provide a measure of cause and effect of the usage of internal capabilities.

In looking at how people are using their inner visualization in everyday life, our findings expanded upon those of Donelly and Velayo (2004), who studied the relationship between learning through different imposed modalities of either visual imagery or auditory elaborations and memory. Their research reported on a real- world application of inner sensory usage, which was another aim of our study. Although they focused on mental elaborations, we took the inner modalities of both visual mental imagery and inner hearing and focused on their applications. Despite the differences in our study designs, we found that capabilities of visual mental imagery potentially influenced capabilities in picturing aspects of the story presented in our study, like Donelly and Velayo (2004) found higher visual mental imagery capabilities influenced capabilities of memory and processes of perception. Isakoglou et al. (2021) explored differences in narrative transportation or "getting lost" within a story based on the genre and found that the concept of narrative transportation is highly psychological. We propose that the inner experience influences the ability to experience a story internally, expanding upon the idea that narrative transportation in reading a story is highly psychological or internal.

One potential direction for further investigation is educational settings. Higher inner experience capabilities could lead to a greater understanding or enjoyment of narratives, literature, and creative pursuits. In contrast, those in the middle or low ends of the continuum may need different forms of explanations and/or external experiences to better grasp concepts. In classroom settings, high levels of inner experience could impact academic success due to internal comprehension of material, but those with lower capabilities may need different avenues of representation. Understandings of individual inner hearing and visual mental imagery capabilities could contribute to how people use their internal workspace to encode and store new information in all settings. It could also potentially influence how that information is retrieved for later use. Psychologists could also better differentiate individual differences and emphasize the uniqueness of each mind. The emotional impact and the vividness of the mental images can vary based on how the information was stored in one's memory (Blackwell, 2019). Because many people encode and store memories differently, they may visualize the same stimuli in completely diverse ways. Two individuals can experience the same event at the same time and perceive it in

opposite or unmatched ways.

Although these findings are basic in nature, they can be applied in a wide variety of scenarios. From individualized treatment options for those suffering with disorders like specific phobias to further investigations of overall quality of life and success, there is still much to be discovered in the inner experience. If someone has high or low levels of internal experiences, knowing that it could be used to cross modalities and potentially impact other forms of the inner experience can potentially help. Further research could include visual mental imagery processing and inner hearing during exercise and activities in competitive sports or performance areas to potentially lead to performance improvements. Understanding the uniqueness that lies in all internal experiences can give way to understanding the intimate and personal aspects of being human.

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