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Citation

Waters, F., Barnby, J. M., & Blom, J. D. (2020). Hallucination, imagery, dreaming: reassembling stimulus-independent perceptions based on Edmund Parish’s classic misperception framework. *Philosophical Transactions Of The Royal Society Of London Series B : Biological Sciences*, *376*(1817), 20190701. doi:10.1098/rstb.2019.0701

PHILOSOPHICAL TRANSACTIONS B

royalsocietypublishing.org/journal/rstb

Opinion piece

Cite this article: Waters F, Barnby JM, Blom JD. 2021 Hallucination, imagery, dreaming: reassembling stimulus-independent perceptions based on Edmund Parish's classic misperception framework. *Phil. Trans. R. Soc. B* **376**: 20190701.
https://doi.org/10.1098/rstb.2019.0701

Accepted: 13 July 2020

One contribution of 16 to a theme issue 'Offline perception: voluntary and spontaneous perceptual experiences without matching external stimulation'.

Subject Areas:
behaviour, cognition, computational biology, neuroscience, taxonomy and systematics

Keywords:
dissociation, illusion, neurodegenerative disorder, Parkinson's disease, psychosis

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Hallucination, imagery, dreaming: reassembling stimulus-independent perceptions based on Edmund Parish's classic misperception framework

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Within the broad field of human perception lies the category of stimulus-independent perceptions, which draws together experiences such as hallucinations, mental imagery and dreams. Traditional divisions between medical and psychological sciences have contributed to these experiences being investigated separately. This review aims to examine their similarities and differences at the levels of phenomenology and underlying brain function and thus reassemble them within a common framework. Using Edmund Parish's historical work as a guiding tool and the latest research findings in the cognitive, clinical and computational sciences, we consider how different perspectives may be reconciled and help generate novel hypotheses for future research.

This article is part of the theme issue 'Offline perception: voluntary and spontaneous perceptual experiences without matching external stimulation'.

1. Introduction

Throughout history, we have been faced with the question of how to classify human perceptions. The term 'stimulus-independent perception' refers to a broad subcategory of perceptions that are decoupled from the sensory environment [1]. They include experiences such as hallucinations, dreams, imagery, daydreams and fantasies, which are created entirely by the brain, without the intervention of the senses [2].

Commonalities between them include the internal representation of an image, which can occur in one or more sensory modalities, and which can be 'seen' or 'heard' or 'felt' within one's mind. Several early scholars viewed them as occurring on a continuum of perceptual experiences utilizing similar brain areas and pathways [3,4]. Contemporary notions, however, tend to separate these experiences. Traditional divisions between psychiatry and psychology have often favoured a separation along the line of 'normality'. Because hallucinations can cause significant distress and functional burden, they could be viewed as deviations or anomalies that can help demarcate the point at which a person requires a psychiatric evaluation and/or treatment [5,6]. Frequency rates also separate them: hallucinations are more likely to be found in a proportion of the population with mental or neurological disorders [7,8] compared with imagery and dreams, which are universal human experiences that occur almost on a daily basis [9]. Finally, they involve different states of consciousness, with dreams occurring while asleep, and with contents rarely available to memory recall or introspection in most people.

These issues have made it difficult to study these experiences in relation to each other. Comparisons have been made between hallucinations and dreams

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Figure 1. Edmund Parish (1861–1916) in his thirties. Image provided by Dr Esther Sophia Sünderhauf of the Von Parish Kostümbibliothek, Munich, Germany.

[10–12] and between hallucinations and imagery [13–15], although, to our knowledge, no other study has reported on multiple comparisons. In the present paper, we therefore outline the similarities and differences in phenomenological expression and underlying brain function of hallucinations, imagery and dreaming, and attempt to reassemble these experiences using the umbrella term 'stimulus-independent perception'. We suggest that a better understanding of their descriptive features and underlying brain mechanisms can provide a common framework with which to understand how they might occur independently of external input. We also draw on the work of the newly re-discovered German scholar, Edmund Parish (1861–1916; figure 1), who was the first to articulate the notion of shared operations among all types of perception [4,16].

The scope of this paper is hallucinations, imagery and dreaming. While acknowledging their broad phenomenological diversity and expression [17–19], for the purpose of operationalizing Parish's framework for the present era, we have limited ourselves to those aspects and experiences that have been well documented, i.e. vision and audition as the most prominent sensory modalities, hallucinations in schizophrenia and neurodegenerative disorders where they are common symptoms, and dreams occurring during rapid eye movement (REM) sleep as common physiological phenomena (table 1).

2. Historical and theoretical framework

The overlap between hallucinations, dreams and imagery has long fascinated philosophers and scientists. Many nineteenth century scientists considered how the mind is capable of constructing an internal world without the intervention of the external environment. Etienne Esquirol [20], for example, maintained that hallucinations and dreams are perceptual constructions that do not involve the sense organs. By contrast, John Hughlings Jackson [21] argued for a key role in 'sensory discharges' due to peripheral or central sensory reactivity that have the capacity to spread from one part of the brain to another. A more nuanced proposal was advanced by Edmund Parish [4,16]. Starting from his belief in the brain's economic use of resources, he proposed that all perceptual experiences use the same network of brain areas and pathways. He presented a unifying model to explain all 'fallacies of perception', in which he included dreams, daytime reveries, hallucinations, illusions, distortions and even some negative disorders of perception.

He proposed that illusions and hallucinations use a common perceptual system and may occur with our senses in full working order. Moreover, he introduced the concept of 'dissociation', described by him (in contrast with our present-day usage of the term) as a change of routing of information gathered by the senses in the direction of unrelated brain areas. Such disruptions in the brain's associative and connective pathways would have the capacity to conjure entirely different percepts. Finally, he suggested that the contents of (especially complex) 'fallacies of perception' are drawn from personal experiences [4]. This suggestion regarding the contribution of top-down processes is well aligned with modern conceptualizations about sensory perception, which draw on probabilistic models of Bayesian feed-forward and inference models [22,23].

3. Phenomenological features

This section presents the descriptive features of hallucinations, imagery and dreams.

(a) Hallucinations

Hallucinations can be experienced in all sensory modalities and vary considerably in complexity. Visual hallucinations (common in older adults and in some psychiatric conditions) [24,25] may range from simple flashes or geometric shapes to static percepts involving people, faces, animals or objects, as well as dynamic scenes unfolding before the eyes [26]. Auditory hallucinations are more frequently encountered in psychotic disorders [27] and may take the form of simple sounds, such as a telephone ringing, or more complex sounds, such as music or voices. The linguistic properties of voices can also range from low complexity (e.g. single words) to high complexity (e.g. conversations between people) [28]. Hallucinations may be brief in duration or longer lasting.

A fundamental attribute of hallucinations is their detailed perceptual quality, which can mimic sensory events perfectly [5]. This generates a percept with a sense of reality that is perceived as 'present' in a very concrete sense. While other people may not see or hear anything, the person may attempt to move towards or away from the hallucinated object, or engage in conversation. This subjective reality often elicits emotional reactions, which may include surprise, amusement, validation, religious ecstasy, as well as fear and distress [28,29].

Another common feature, in a majority of hallucinations, is a lack of control and intentionality [26,30]. In many clinical disorders, hallucinations are perceived as unbidden, intrusive and involuntary. The lack of control may be crucial in the development of distress and contribute to the misattribution to an external agency. Hallucinations may be explained as supernatural realities and interpreted as symbolic and meaningful within the person's own cultural background and historical narrative [31].

(b) Imagery

The term 'imagery' tends to be used quite loosely to denote a private experience presenting in the mind or inner subjective space [9,18,32]. It is often differentiated from non-symbolic thoughts and from general sensory awareness, because it

Table 1. Traditional definitions of stimulus-dependent (SD) and stimulus-independent (SI) perceptions [17].

Illusion (SD): a stimulus-dependent percept, experienced while awake, that is based on a corresponding signal from the senses, but is either misinterpreted or misperceived (e.g. hearing music in the drone of a computer fan, mistaking a moving curtain for an intruder)

Distortion (SD): a stimulus-dependent percept, experienced while awake, that is based on a corresponding signal coming from the senses, but one in which either one or several highly specific aspects are changed (e.g. seeing things much larger or smaller than they are, seeing all faces with grossly distorted eyebrows, seeing all straight lines as wavy)

Imagery (SI): a stimulus-independent, quasi-perceptual representation of objects or events, experienced while awake (e.g. reimagining a concert, seeing Sydney Opera House 'in the mind's eye')

Hallucination (SI): a stimulus-independent percept, experienced while awake, in the absence of a corresponding signal coming from the senses (e.g. hearing a voice when no one is around, seeing a cat that is not there)

Dream (SI): a (mostly) stimulus-independent percept (or series of percepts, often with a narrative structure), experienced while asleep (e.g. experiencing that one can fly, experiencing that one is in first grade again)

manifests as the recall or representation of a meaningful percept, sometimes described as 'visualizing' or 'mental imagery' [33]. Research has often focused on the visual senses (seeing in the mind's eye), but imagery can occur in many sensory modalities. Auditory images may include elementary features (e.g. sound pitch) and complex sounds (e.g. the sound of breaking glass or melodies).

In most cases, intentionality and voluntary control are key features of imagery [34]. Imagery thus allows for the volitional manipulation or transformation of imagined percepts, which is an important point of difference with hallucinations. While individual differences exist in the ability to internally manipulate images, the image generally fades rapidly [35,36].

Crucially, imagery lacks the precise perceptual details of hallucinations. To grasp the difference, it may help to try to retrieve a memory image of Sydney Opera House (which most people can) and then seek to count the number of 'shells' comprising its rooftops, which most people cannot, because the final product lacks the clarity and finer details of externally derived perceptions and hallucinations.

(c) Dreams

While hallucinations and imagery occur during an awake state, dreams are experienced during sleep, or during the transition between wake and sleep [19,37]. They are difficult to study using conventional methods, but descriptions from people after waking up suggest a predominance of the visual modality (99% of the time). Auditory and somatic experiences are reported less often (60 and 30%) and often simultaneously with visual ones [38]. Scenes tend to be fluid and rapidly changing and often have a narrative structure involving a replay or recombination of past experiences and fantastical elements [19,38,39]. Dreams can also evoke a range of intense emotions, congruent with the dream's content. Previous studies that compared them with hallucinations [10–12] show differential features that also apply to imagery. A key feature of dreams is that they are totally immersive experiences, replacing all other perceptions. By contrast, hallucinations and imagery are superimposed on and can coexist with, regular sense perceptions (panoramic or scenic hallucinations being an exception) [17]. Another point of difference is that bizarre or implausible scenarios are readily accepted during sleep, and the dreamer is both an actor and spectator [12]. Finally, dreams involve a continuous stream of perceptions that is often forgotten upon waking [40], which contrasts with hallucinations and imagery, which are usually well remembered and available for conscious retrospection.

(d) Similarities and differences

One key point of similarity between hallucinations and dreams is that they are described as vivid and as accompanied by a sense of reality. Imagery, by contrast, lacks these attributes and is therefore rarely mistaken for actual perception. There are, however, some exceptions where frequent practice can sharpen the perceptual qualities and intensity of imagery [36]. One example is the act of praying, which is a communicative discourse that makes use of mostly linguistic, visual and auditory images. Anthropological studies show that focused imagery can transform such images into detailed perceptual experiences with an apparent external reality and independent agency [41]. Shamanic training, for example, involves a learnt practice of projecting images into external space in the context of metaphysical beliefs, which can develop over time into religious visions [41]. Similar to hallucinations, these may have clear substance and form, may be entirely convincing and may be interpreted symbolically or even literally.

One commonly cited difference between these three experiences involves a division along the 'normality' line, where hallucinations are defined as clinical and anomalous because they are intrusive, unwanted and/or negative in content, or simply because they co-occur with other symptoms of the disease. This line becomes blurred if one considers examples of hallucinations reported in the general population by individuals without a need for care [42]. These hallucinations are more often reported as positive, valuable and controllable than those experienced in the context of mental disorder. In addition, imagery and dreams are not always benign as they too form a part of a continuum that extends to intrusive thoughts and nightmares. In clinical psychiatry and psychology, intrusive thoughts are considered diagnostic features of conditions such as obsessive–compulsive disorder. Similar to hallucinations, intrusive thoughts can be perceived as uncontrollable and fundamentally non-self in origin and lead to significant distress and burden. Finally, dream contents are often neutral or benign, but may also provoke fear and distress when they manifest as nightmares or parasomnias such as the incubus phenomenon [43,44]. Thus, several attributes of hallucinations, imagery and dreams appear to be shared, even though they are commonly described as 'core' or 'fundamental' properties within their own definitions.

4. Perceptual systems in the brain

This section discusses the perceptual systems that are active during hallucinations, imagery and dreams. Their connectivity to other brain networks is discussed in the next section.

(a) Hallucinations

Neuroimaging studies show that hallucinations clearly involve brain areas that are active during the processing of incoming perceptual stimuli [45]. Neural activations in perceptual regions precede activity in other brain areas, so it is possible to locate the perceptual system as a key site of origin of hallucinations [46,47]. Regions that are activated are closely linked to the sensory modality of hallucinations. Thus, visual hallucinations are linked to changes in the visual system, including the primary and secondary visual cortex, as well as to extensive activity in association cortex and subcortical centres such as the thalamus [24,48]. In comparison, auditory hallucinations coincide with activation of speech-sensitive and auditory processing areas and networks, including the primary auditory cortex, association cortex and the planum temporale [46]. The engagement of the primary sensory regions is thought to contribute to the vividness and salience of hallucinations [49], and the planum temporale is thought to project the experience onto external space, thus endowing it with 'external' qualities [45,50].

One important finding is that of spontaneous cortical activity in primary sensory areas, detected with resting-state MRI and electrophysiological methods. These show that people reporting visual and auditory hallucinations are prone to spontaneous activity in early visual cortex [51] and auditory cortex [47]. The spontaneous cortical activity can influence large brain networks [52] responsible for conscious perception. This offers an explanation for the involuntary and often sudden appearance of hallucinatory events. Of note, early sensory processing deficits and changes in early visual and auditory cortex are a common, but not necessary feature of clinical disorders with hallucinations, as hallucinations can also occur without any clear deficits in these early processing areas.

(b) Imagery

Functional neuroimaging research shows that imagery coincides with activity in brain areas that strongly overlap with those of regular sense perception [53,54]. What is more, intact sensory regions appear to be crucial for the development of mental imagery. An experimental study in people who are congenitally blind, for example, found that mental imagery was less accurate and slower compared with people with intact sight who were blindfolded [55]. In addition, cortical lesions in visual or auditory areas impact on imagery performance in a modality-specific way [36]. For example, visual imagery selectively interferes more with visual than with auditory perception [56]. Moreover, the loss of visual imagery due to cortical lesions is often accompanied by a general loss of dreams in all sensory modalities [57], speaking to common networks.

Brain activity is also closely related to the type of object being imagined. The right fusiform face area as well as bilateral occipital face areas are activated while imagining faces, and parahippocampal regions while imagining landscapes, showing overlap with brain regions that are activated when people look at photo images [58].

There is ongoing debate regarding the involvement of primary sensory areas during imagery, including whether visual imagery engages early visual areas [59–61]. However, there are suggestions that this might depend on the level of vividness [32]. A recent study that directly compared brain activity during imagery of complex objects (i.e. faces, scenery) [58] found that the BOLD signal resembled that generated by photo images, although the magnitude of activation was lower in imagery. In support, Ganis *et al.* [60] found only partial overlap in the brain areas subserving imagery and stimulus-dependent perception, with imagery being less likely to engage primary sensory areas.

(c) Dreams

Neuroimaging and electrophysiological studies of dreaming have drawn similarities with brain mechanisms underlying hallucinations, thus prompting suggestions of a common physiology [10,11]. During sleep, the brain is highly active in cortical and subcortical areas [62]. Similar to hallucination networks, dreams depend on activity in perceptual circuitry, notably association cortices which serve to integrate sensory information released from specialized (visual, auditory and somatosensory) areas [63]. The ventral visual stream (located in inferior temporal regions and the fusiform gyrus) is particularly active, in keeping with the visual prominence of dream contents [64].

During REM sleep, the processing of incoming sensory information is largely absent, leaving dream contents predominantly neurobiologically driven and contained. Their creation is largely dependent on the release of acetylcholine (ACh) in the midbrain [65–67], which causes autonomous and internally segmented perceptual activity. ACh release increases γ-aminobutyric acid (GABA) levels, which triggers a surge of activity in secondary sensory processing areas, and to a lesser extent in primary sensory areas [65]. The perceptual release also involves reactivation of memory traces from the thalamus [68,69].

(d) Summary

In summary, the perceptual circuit in the brain, notably the association cortex, is a common feature of hallucinations, imagery and dreams. There is evidence of involvement of lower-level (primary) cortical areas in hallucinations, and in dreams to a lesser extent. By contrast, the primary sensory areas only seem to be engaged during salient, vivid and complex imagery (but not at all times).

5. Relationship with other brain functions

All perceptions are intrinsically linked to a broader functional network involving memory, language and other executive functions. Different interactions may therefore contribute to a variety of stimulus-independent perceptions.

(a) Hallucinations

In addition to the changes in perceptual processing described above, the notion of disruption between functional brain networks is central to most definitions of hallucinations [21,46].

In disorders with common auditory hallucinations (such as schizophrenia), neuroimaging studies show disruptions in structural and functional connectivity between the auditory cortex and the prefrontal cortex (PFC), cingulate gyrus, supplementary motor area and cerebellum [46,70]. In disorders with common visual hallucinations (such as Parkinson's disease), extensive disruptions have also been found to visual thalamocortical networks, as well as impaired connectivity to the frontal lobe and hippocampus [24,48,71].

Connectivity problems with the PFC are considered to be particularly important, because they negatively impact on the downregulation of sensory activity, reality monitoring [72] and inhibition of unwanted mental contents [30]. Deficits in the integration of different perceptual networks may also contribute to distinct phenomenological features of hallucinations. Hallucinations involving memory recall may occur singly and independently of spatial and temporal attributes. Contextual properties are typically represented in dual-stream cortical pathways (the ventral 'what' and dorsal 'where' pathways), and it has been suggested that incorrect integration may strip objects from their context cues, contributing to the sense of estrangement and alienation [73,74].

(b) Imagery

The ability to imagine and thus mentally 'manipulate' objects that are absent in the immediate environment speaks to the involvement of memory and other higher order functions [75]. Accordingly, a core functional neural network has been suggested for imagery, regardless of the task [76], and which includes somatosensory processing areas, PFC and the parietal lobes. During mental performance or activity within the sensory cortices, medial PFC areas such as the anterior cingulate cortex are engaged, consistent with the notion of frontal control and neural efficiency [77]. The role of ventromedial frontal regions is to engage goal-oriented behaviour and regulate higher order processes that allow for switching between different brain nodes [78]. This network involving frontal and parietal regions is the same one that is activated during sensory-dependent perception [60,79], and this is understandable in terms of the level of control required for the regulation and control of mental images. Intact cognitive control also allows for self-monitoring and self-recognition, and studies show that the relationship between reality monitoring and the capacity for imagery covaries as a function of individual differences in medial PFC [80]. This can help to localize the medial-PFC region as a pivotal area in both imagery and hallucinations contributing to their phenomenological variability in aspects such as self-monitoring and cognitive control.

(c) Dreams

The brain activity coinciding with dreaming during REM sleep has been said to have the same functional impact as frontal lobe dysfunction [19,63]. As the brain transits from light sleep to other sleep stages such as NREM (non-REM) and REM, gradual changes occur in the regional flow of information [81]. Reactivity and awareness of external stimuli decrease and the brain focuses inwards, becoming less constrained by external stimuli [68].

The dreaming brain during REM sleep, however, is still highly active [63]. ACh-mediated activity from thalamocortical centres results in a surge of perceptual activity [65] accompanied by the disengagement of frontal functions. Known as the thalamic 'gate' [68], this disengagement process with the frontal lobes has major consequences for perceptual signal propagation. Such dissociation from prefrontal executive regions results in limited signal distribution to mostly posterior regions. During REM-related dreaming, the brain effectively operates as a 'closed system' that is dissociated from top-down control, reality monitoring and memory encoding capacity of the frontal regions. As a consequence, dreams occur independently and without the restraints from influences such as reality monitoring, goal-directions, conscious awareness and introspection, and are usually forgotten when the person wakes.

Similarities have been drawn between REM dream experiences, which are unavailable to prefrontal context processing, and the functional disconnection between posterior and anterior regions that occurs in hallucinations [70]. One key difference, however, is that the disconnection is not absolute in hallucinations. Instead, it undergoes a process of competition for physiological resources [82] so that hallucinations can occur alongside or superimposed on regular sense perceptions.

6. Summary and conclusion

When we examine the similarities and differences between hallucinations, imagery and dreaming, and realize that they are usually separated along convenient clinical and methodological divides, the historical work of Edmund Parish reveals itself to be helpful in reconciling these experiences within the unifying framework of 'stimulus-independent perceptions'.

Descriptions of their core phenomenological features often draw attention to differential features, but our detailed analysis reveals that many of these attributes are shared rather than unique and differential. Similarly, our examination of brain mechanisms indicates that the perceptual system contains modality-specific areas that are common to all three types of experience, and that can accommodate their origins, content and a variety of phenomenological qualities such as vividness. Finally, what was said about the role of higher order brain areas confirms that hallucinations, imagery and dreams are associated with different disconnectivity patterns and yet share similarities through the functional roles of the PFC such as the downregulation of sensory activity and reality monitoring, and with major consequences for perceptual signal propagation and conscious awareness.

In terms of limitations, it should be noted that our overview neglects other important types of perception, such as illusions, distortions and hypnagogia, which constitute mainly stimulus-*based* perceptions, and a variety of sleep-related manifestations. They, too, lie on a continuum between (normal) perceptions and (clinical) hallucinations, but because our focus was on the latter three groups, we were unable to include them in this paper.

With regard to future research, it would be interesting to investigate the fate of perceptual information coming from the senses when people hallucinate, and to find out whether it reaches its designated sensory cortical areas but fails to register consciously owing to hallucinatory activity competing for shared physiological resources, or whether the incoming information is indeed side-tracked, as envisaged by Parish, to activate unrelated brain areas. Secondly, it would be interesting to take into account the role of social connections in the mediation of hallucinations, imagery and dreams. Current biological theories described in the present paper suggest plausible neural mechanisms, but neglect to explain the social context, which probably plays an important role in shaping their content [19,83,84]. Since this may also influence the way people feature in dreams, hallucinations, illusions and other misperceptions, this too, may be worthy of future research.

Data accessibility. This article has no additional data.

Authors' contributions. F.W. contributed to the conception and design of the work, and wrote the first drafts. J.M.B. and J.D.B. contributed to individual sections and revised the work. All gave approval for the final version of the manuscript to be published.

Competing interests. The research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Funding. This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Acknowledgements. The authors thank Dr Esther Sophia Sünderhauf of the Von Parish Kostümbibliothek, Munich, Germany, for making available the photograph of Edmund Parish.

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