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SPECIAL SUBSECTION

Special Subsection Afterword: ESP Research and Cognitive Neuroscience: Possibly Incompatible - But Methodologically Complementary

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HIGHLIGHTS

Despite their different assumptions, mainstream neuroscience and experimental parapsychology can definitely help each other to refine research methods and explanatory models about subjective experiences and cognitions.

ABSTRACT

This commentary considers the fields of extrasensory perception (ESP) research and cognitive neuroscience, discussing points of conflict and domains where they may be complementary. ESP research challenges the assumption in cognitive neuroscience that the mind is the product of known physical processes in the brain. Cognitive neuroscience methods and tools applied to ESP research could benefit and bridge the gap between the two fields. Firstly, concurrently studying subjective experiences and neural activity during ESP tasks would allow us to better characterize subjective states typically associated with ESP. Secondly, similarities between mind-wandering and free-response ESP experimental designs allow us to speculate on the potential implication of the default-mode network during the percipient's experience. Finally, tools developed in computational neurolinguistics and natural language processing may become valuable to automatize judging procedures in free-response ESP paradigms such as remote viewing. Despite potentially incompatible assumptions about the mind and the brain, ESP research can gain new insights from cognitive neuroscience methods and approaches and can contribute in its own way to the study of human subjective experiences and cognition.

KEYWORDS

Neuroimaging, psi, experimental parapsychology, mind-body problem, altered states of consciousness, neurophenomenology, natural language processing.

INTRODUCTION

I was kindly invited to write a commentary from the perspective of a cognitive neuroscientist for this special subsection on 'non-local perception' (Piao & Katz, 2023; Storm & Tressoldi, 2023; Tressoldi & Katz, 2023) – which I will label 'ESP' from now on for 'Extrasensory Perception'. I accepted this challenging but interesting exercise.

Two papers (Storm & Tressoldi, 2023; Tressoldi & Katz, 2023) are meta-analyses of forced-choice and Remote Viewing (RV) experiments, showing significant effects for both types of designs but with much weaker effect sizes for the forced-choice ones. By updating previous meta-analysis reports, they demonstrate consistency and robustness in the effects reported in the literature. The third paper (Piao & Katz, 2023) is an empirical paper using a single-blind RV protocol and introducing a new method to assess the closeness of the percipient's description from the target.

I was invited for this commentary to touch upon how these papers, and ESP in general, challenge or may contradict current neuroscientific theories. The short answer is that non-local perception contradicts the most fundamental assumptions of how neuroscientists view the mind. In the first section, I briefly invite the reader for a peek into the rabbit hole of the Mind-Body problem, admittedly in a very simplified manner.

In the second section, I describe, in a formalized way, different ways in which neuroimaging techniques could advance our understanding of reported ESP effects and how, by adding a focus on subjective experiences, ESP research can contribute to more mainstream topics in neuroscience.

The third section is a continuity of the latter, noting the similarities between free-response ESP tasks and the study of mind-wandering, and speculates about the potential significance of the default-mode network in ESP-prone states.

Finally, in the continuity of the RV methodological paper by (Piao & Katz, 2023), the third section describes how recent advances in neurolinguistics and natural language processing could be used for judging free-response reports in ESP tasks, and in particular, RV.

ESP Goes Against the Intuitive Worldview of (Most) Cognitive Neuroscientists

Cognitive neuroscientists are interested in understanding *the brain*, this enormously complex part of the body where our thoughts, personality, memories, perception, and consciousness appear to lie. The brain is a physical organ that most neuroscientists would compare to a computer that implements various routines, from which ultimately emerge our perceptions, thoughts, feelings, and behavior. Most cognitive neuroscientists more or less implicitly adopt a mechanistic-functionalist view of the mind, whereby brain states produce (or are equivalent to) mental states. These brain states are the product of the state of the individual neurons, elementary computational units that are governed by the laws of physics and follow the principles of causality (see Pulvermüller et al., 2014 as a very good illustration of this view). According to this view, all percepts emerge from – or simply are – physical processes: an object is perceived visually thanks to rays of light stimulating receptors in the retina, which send chemical-electrical information to the visual cortex, then producing a downstream pattern of activity that would finally generate the visual percept (Fig. 1a). And although most computational models describe neural activity stochastically, I think most cognitive neuroscientists tend to implicitly hold a deterministic view of the brain – and therefore of the mind –, in part because of the strong influence of cybernetics in the field. The recent successes in the field of machine learning have further reinforced this algorithmic view of the mind. 'Deep neural network' computing systems, composed of large arrays of simple computational units ('neurons'), are now able to generate highly complex human-like content or behavior, as exemplified by conversational agents such as *ChatGPT* (*OpenAI, Inc.*, CA, USA).

The idea of ESP is that information about an object or event can be gained outside of the known physical means. According to the worldview I described above, there is naturally little room for this phenomenon. A purely physicalist account for ESP would imply the existence of unknown fields, forces, and interactions, an unknown way to reach and receive that information across space – and time if one wants to account for precognition (Fig. 1b). There is the argument that ESP would not be *in principle* incompatible with what we know about the physical world – for instance from quantum mechanics (e.g., Radin, 2006), but a cognitive neuroscientist may respond that, at the present time, there is no need nor demand to recruit concepts such as non-causality, quantum entanglement or other yet-to-be-discovered mechanisms to account for cognition. However, while neuroscientists have underlying assumptions or beliefs about the mind-body problem, cognitive neuroscience as a field does not have definite answers to provide yet, and neuroscientists more versed in the niche topics of free will or mental causation may have more nuanced views (see, e.g., Delnatte et al., 2023; Roskies, 2006). The concept of ESP and other psi phenomena are difficult to reconcile with a purely physical, mechanistic, and deterministic account of the mind (Kelly et al., 2010), and ESP could be to physicalist cognitive neuroscience what the precession of Mercury was to Newtonian physics: an observed anomaly that cannot be explained without a radical change of paradigm. Indeed, ESP and psi phenomena may be easier to conceptualize if one accepts the idea of mental causation, where the mind operates somehow independently of the body, allowing for weaker and rarer interactions for access to information throughout space and time (Fig. 1c) (See Kelly et al., 2015 for the description of various alternative worldviews that could account for ESP.) In any case, ESP challenges the overarching model under which cognitive neuroscience operates, which is why it is such a subversive idea.

However, the tools, methods and models developed by cognitive neuroscience have shown undeniable

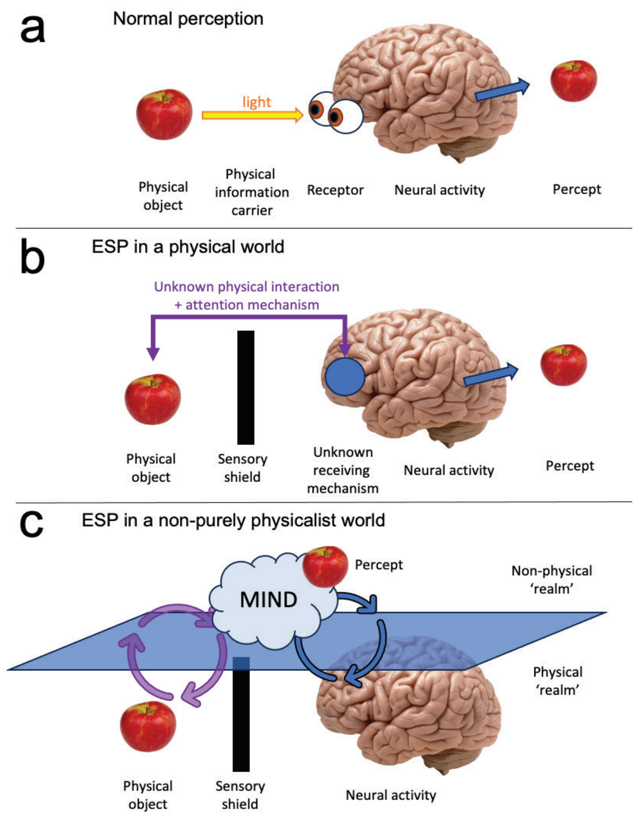

Figure 1. Normal Perception and extrasensory perception (ESP) and the brain. a) Accepted general physicalist model accounting for perception. A stimulus excites a receptor, which generates a wave of neural activity, generating or equating to a percept. b) ESP in a purely physicalist worldview. Unknown physical and attentional processes must take place for an ESP percept to arise. c) ESP in a non-purely physicalist world. In this view, the mind and the body are separate but interact. ESP could be seen as an interaction between the mind and the object of the same nature as between the mind and the body. [Brain image from FlickR.com by _DJ_, CC BY-SA 2.0 license]

success and progress. They may prove very useful for the study of measured ESP effects despite this conceptual incompatibility. This is what I will develop in the subsequent sections.

Neuroimaging and ESP: Approaches and Framework

Purely behavioral (i.e., response-based) paradigms are the most common in parapsychology. By looking at variables such as participants' individual differences and manipulating the target and other parameters in the protocol can probe some of the characteristics of and mechanisms underlying ESP – very much like mainstream experimental cognitive psychology operates. Because of the absence of a mechanistic model for ESP, ESP in the laboratory is defined as an anomalous statistical deviation, i.e., a deviation that cannot be explained by any known physical means. Without a model, positive results are more difficult to interpret but also to communicate to the rest of the research community. Adding into the picture physiological features that could systematically be associated with observed ESP effects could potentially help on both these fronts. Except for the presentiment paradigm (Duggan & Tressoldi, 2018; Mossbridge et al., 2012) and a few notable studies (see Krippner & Friedman, 2010), to my knowledge, very little experimental research has been devoted to studying the physiology of participants undergoing psi tasks.

There are three general approaches that can be taken: Firstly, in an extension of individual differences research trying to identify traits for high-scoring individuals, one approach is to look for biological markers – or for a neuroscientist, *neuromarkers*: biological features lying in the brain of individuals. These neuromarkers can be of structural or functional nature. Structural markers can be, for instance, cortical thickness in certain areas, the size of brain structures, and structural connectivity between areas, all of which can be measured using a scanner. Functional markers are signatures in neural activity as measured, for instance, by functional magnetic resonance imaging (fMRI) or electro-encephalography (EEG), at rest or during specific standardized tasks. The question addressed in this approach is: If higher ESP scoring is an individual trait, are there associated traits lying in the brain reflecting this high ESP scoring test?

Secondly, if anomalous perception events can be generated and identified in time with sufficient precision and in a repeated manner, an associated trace can, in principle, be measured using event-related designs. This approach would intend to identify the neural correlates of ESP per se in the same way as we can observe stereotypical EEG traces following visual or auditory stimulation. This was the approach adopted e.g., by McDonough et al. (1992) and Moulton & Kosslyn (2008) – see also Acunzo et al. (2013) for a critical review – and corresponding to Figure 2, side c. For this approach to be truly informative, individual 'hit' trials must be observed and identifiable as veridical ESP hits. With very small effect sizes such as the ones reported for forced-choice designs (~0.02; Storm & Tressoldi, 2023), most hits will be imputable to chance, according to the expected 'hit' probability under the null hypothesis. In that case, the signal-to-noise ratio for the difference in brain activity between 'hit' and 'miss' trials will be extremely low, and any existing ESP signal will be extremely difficult to observe.

Finally, a third approach is to characterize and identify prolonged neural states that are associated with hits in ESP tasks (psi-prone states, Fig. 2, whole triangle d.). As in the second approach, this necessitates concurrent recording of brain activity while the participant is undergoing an ESP task. In an experimental or applications setting, these identified states could, in principle, help to predict when higher probabilities of hits will occur. If the characteristics of such states are known, the ways to induce or provoke them can be made easier, for instance, by using methods inspired by neurofeedback. In particular, various altered-states of consciousness (ASCs) have been associated with ESP in the literature – often some type of dissociative state, sleep, trance induced by rituals, psychedelic substances, and/or meditation (Cardeña et al., 2014; Kelly & Locke, 2009), while some of the most successful ESP experiments involved induced ASCs such as in the Ganzfeld or sleep (Sherwood & Roe, 2003). Characterizing these psi-associated states may, therefore, be a key element to the understanding of ESP (Fig. 2, side a) and is an approach highly compatible with free-response designs, which appear to be the way forward for this field, given the higher effect sizes (Storm & Tressoldi, 2023; Tressoldi & Katz, 2023). Various tools and approaches have been developed to probe the subjective experience of individuals undergoing these ASCs,

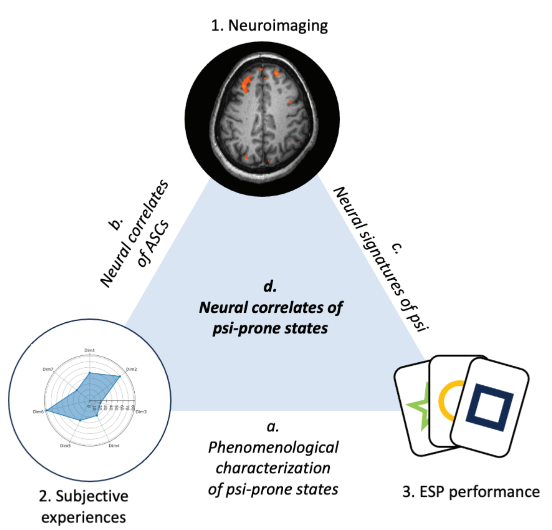

Figure 2. General framework for the neuroscientific study of altered states of consciousness (ASCs) and extrasensory perception (ESP) in the laboratory. Using concurrent neuroimaging (1.), experience reports (2.), and ESP performance (3.) measures can help the neural characterization of psi-prone states. Using only two of these measures also provide valuable insights. For a description and thorough discussion of a more complete framework, see (Kelly & Locke, 2009). [Brain image for illustration, from Kim et al. (2010). PLoS One. 11;5(8):e12068, CC BY 2.5 license]

but come with methodological challenges: concurrent experience sampling may interfere with the experience itself, while retrospective interviews can suffer from various biases, distortions, and poor recollection and temporal precision (see Cardeña & Pekala, 2014 for a thorough discussion). This is where neuroimaging methods can be helpful and complementary in the study of ASCs. They can provide signatures allowing us to compare the similarity and differences between different types of ASCs, identify the dynamics and transitions necessary to go from one state to another, provide clearer interpretation of subjective reports, and may inform us on certain disorders (e.g. dissociative disorders, schizophrenia). By obtaining a measure of the different experiential components of the ASCs (e.g., sense of agency, sense of self…), concurrent neuroimaging recording opens the way to identifying the neural correlates of each component. This is the 'neurophenomenological' approach (Varela, 1996), which has gained momentum in recent years, in part thanks to the rise of psychedelics research, and has been advocated for the study of ASCs in a recent opinion paper (Timmermann et al., 2023). This same approach can be applied during psi tasks, including in free response designs. It also offers the advantage for the researcher to provide additional hypotheses to test: since ESP behavioral results are so elusive in the laboratory, valuable insights can be gained from the neuroscience of ASCs per se, regardless of ESP results (Fig. 2, side b).

Free-Response ESP Designs and the Default Mode Network

The Default Mode Network, or Default Network (DN; Raichle et al., 2001), is a set of brain areas that are more active when the participant is at rest and less active when the participant is engaged in a task (for a recent review on the DN, see Menon, 2023). The discovery of this network contributed to the emergence of task-free imaging studies. Rapidly, it became apparent that the DN does not simply reflect the absence of engagement in a task but rather engagement to self-generated, internal tasks. Most particularly, the act of "mind wandering" (i.e., when individuals disengage their attention from their perceptual environment and engage in introspective thoughts) was identified as contributing to the activation of the DN (Christoff et al., 2009). One can easily see the similarity between mind-wandering on the one hand and a Ganzfeld, Remote Viewing, or mediumistic reading session on the other hand. While the tasks are different and the subjective experience will greatly differ, they are both families of internally generated experiences with attentional disengagement from sensory input. They are, therefore, close enough so that methods of study (and observations) can overlap.

These similarities would allow us to use mind-wandering and resting states as control conditions for free-response ESP tasks. Because a free-response ESP task also involves internally generated thoughts and sensations, it is likely to somehow recruit aspects of the DN. It may, therefore, be a fruitful avenue to try and identify what may be specific regarding the DN when apparent anomalous cognition occurs, in terms of patterns of activation, but also connectivity between nodes, co-activations, and switching with other networks. One can speculate that when participants engage in a free-response ESP task, nodes of the DN would display a diminished activity, as is the case in various states of consciousness that have been reportedly associated with psi perception in the literature, in particular, meditation (see e.g., Brewer et al., 2011), REM sleep (Hong et al., 2021) and psychedelics (Carhart-Harris et al., 2012; Dos Santos et al., 2016).

Because parapsychology is not a heavily-funded field of inquiry (Zingrone et al., 2015), and neuroimaging methods such as magneto-encephalography (MEG), fMRI, or positron emission tomography (PET) are very costly, they will likely not be the preferred modality in the field. However, other non-invasive techniques, such as EEG and functional near-infrared spectroscopy (fNIRS), allow us to measure neural activity non-invasively at a much lower cost. Some compromises have to be made when using these methods, such as head coverage and spatial resolution, but they also offer some benefits, including ecological validity, movement tolerance, and safety. The characterization of the measured signals in these neuroimaging modalities in terms of how they relate to large-scale networks such as the DN is still a topic under development, but even studying contrasts between conditions (ASC vs. control, or 'hit' vs. 'miss' trials) and correlations with subjective reports (Fig. 2a, d) while remaining agnostic to the specific areas involved will still provide valuable insights.

Using Advances in Computational Neurolinguistics for ESP Research

The third paper of the series (Piao & Katz, 2023) tackles the difficult question of rating the correspondence between a percipient's description of the target to the target itself in an RV paradigm. They propose an extension of the fuzzy set approach developed by May et al., (1990), inspired by telecommunication engineering. I will now discuss an idea of how neuroscience tools can also contribute to this topic. Many free-response designs use one or several blind judges to rate the correspondence between the percipient's account on the one hand and the target and decoys on the other hand. This is a difficult and time-consuming exercise for which there is often no definite correct answer, which is why methods to formalize this process are being developed.

The fields of computational neurolinguistics and neural language processing (NLP, a subfield of machine learning and computer science) are currently developing tools and models that could greatly help the encoding and analysis of free-response reports. In particular, there are now freely-available pre-trained NLP models, such as BERT (Devlin et al., 2018), that can transform (encode) words, sentences, and paragraphs into embeddings, i.e., an array of numbers. These encoding models are trained on massive text databases and are an essential component of automated translation tools such as *Google Translate* (*Google LLC*, CA, USA) or generative models such as *ChatGPT*. They allow interesting semantic calculations, such as the typical examples: *Rome - Italy + France = Paris*, or *king - man + woman = queen*. Importantly, these embeddings allow us to calculate semantic similarities between pairs of words, sentences, or paragraphs using operations such as cosine similarity. Such similarity measures allow, for instance, to calculate that the word *cat* is more semantically related to *dog* than it is to the word *apple*. These methods are successfully being used in cognitive neuroscience and are now part of the tools that neuro-linguists apply in the study of how humans understand and produce language and how the meaning of concepts is reflected in the brain (see, e.g. (Acunzo et al., 2022; Pereira et al., 2018).

Getting back to RV and free-response paradigms, it would therefore be possible, in principle, to encode into embeddings (1) textual descriptions of the target and decoys, which would be prepared by hand in advance by an experimenter and (2) the report given by the percipient about the target. Similarity measures can subsequently be applied to compare the closeness of the percipient's report on the one hand and the target and decoys descriptions on the other hand, allowing to conveniently automatize the rating procedure (Fig. 3). Naturally, such a method would have to be evaluated, possibly on past data, before being deployed, but I believe it may be a fruitful direction to take in terms of methodological development for the field. If proved reliable, it could greatly improve efficiency and reduce the human cost of experimental designs that traditionally necessitate one or several judges.

One important limitation in using these embeddings is that they are not easily interpretable by humans. They are generated automatically by the algorithms, and the numbers are meaningless to us. However, Chersoni et al. (2021) and Turton et al. (2020) developed methods

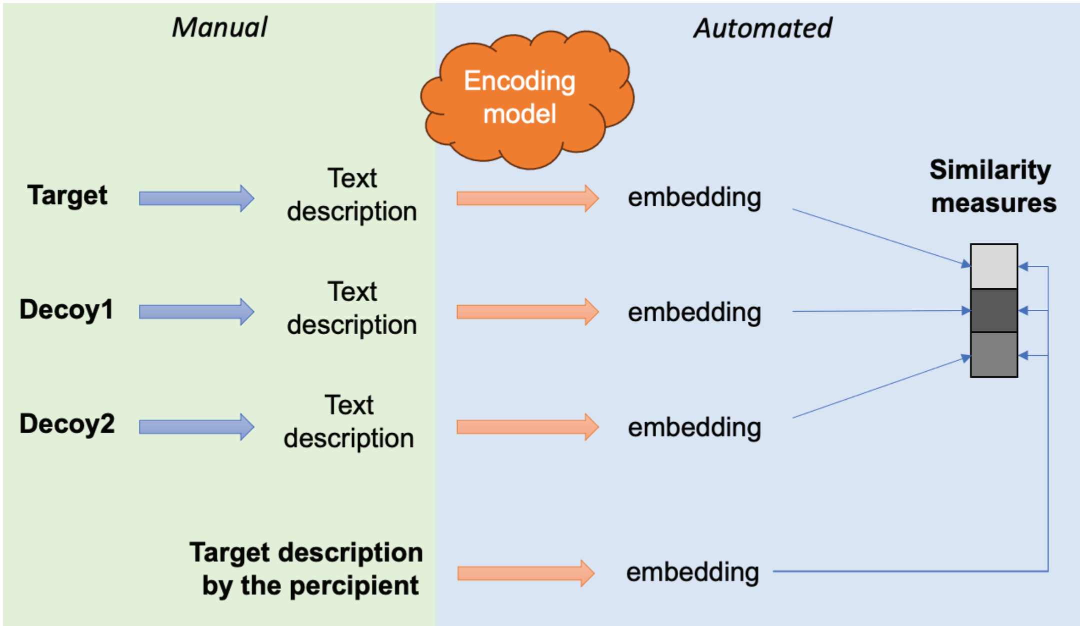

Figure 3. Proposed general method for an automated judging procedure using natural language processing (NLP) techniques. Experimenters prepare a text description of all targets and decoys. The textual description by the percipient, as well as all the text descriptions, are encoded into embeddings. A similarity measure can be applied, quantifying the correspondence between the percipient's description and the target and decoys, removing the need for blind judges.

to project these embeddings onto an interpretable set of dimensions developed by a team of neuro-psycholinguists (Binder et al., 2016). These embeddings consist of ratings on sensory, motor, spatial, temporal, affective, social, and cognitive dimensions. Using such interpretable embeddings opens the possibility to more easily study the various dimensions and assess, for instance, whether some of them appear to be more consistently captured (or missed) by the percipient. More generally, NLP offers a new array of techniques allowing us to study verbal reports of ASCs and spontaneous anomalous experiences that could prove very valuable to the field.

Concluding Words

In conclusion, even though ESP results appear to contradict underlying cognitive neuroscience assumptions about the brain and mind, neuroscientific techniques have a lot to offer to the study of ESP. Including some neuroscientific methods and approaches in ESP designs will provide new insights and ways to use and interpret the data. Conversely, studying ESP in the laboratory jointly with subjective reports and with neuroimaging techniques will help to bridge together the currently rather segregated fields that are cognitive (neuro)science and parapsychology.

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