# Is Phenomenological Control related to Illusion Sensitivity

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# Abstract

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# Is Phenomenological Control related to Illusion Sensitivity

Visual Illusions are an interesting type of stimuli highlighting the ease with which our phenomenological conscious experience can become dissociated from physical reality. Their robust and reliable effect makes them useful stimuli to explore how perception is constructed and shaped, and several theoretical models have been put forth to explain how they work. In particular, illusions have been recently reframed using a predictive coding account of perception (Notredame et al., 2014) in which the brain optimally combines, using some flavour of Bayesian inference, perceptual inputs with prior knowledge to make sense of ambiguous environments (Friston, 2010).

Such computational model(s) propose to conceptualize illusions as stimuli providing weak or conflicting sensory evidence (Gershman et al., 2012; Sundareswara & Schrater, 2008) that bias perception toward prior knowledge. In other words, the weight of priors, in the form of perceptual knowledge about the world (e.g., internalized rules of perspective) is amplified when the sensory input is confusing. For instance, in the Müller-Lyer illusion, we “compute” the two (actually identical) lines as being of different lengths because the line flanked with converging fins is misinterpreted as being further away (Notredame et al., 2014). In this context, measuring sensitivity to illusion can be operationalized as indexing the parameters of the Bayesian inference process (e.g., prior precision).

These accounts also provide a compelling framework to explain existing findings reporting interindividual variability in the sensitivity to illusions. Indeed, several studies suggest a relationship between psychopathology and lower illusion sensitivity. Schizophrenic patients, for instance, constantly exhibit lower scores on visual illusion tasks (Costa et al., 2023). Proposed explanations, under this framework, emphasise alterations in metacognitive components whereby greater confidence is given to sensory evidence over prior knowledge, which show as reduced susceptibility to the effect of illusions (Notredame et al., 2014). While evidence for lower visual sensitivity is less established in autistic individuals (Gori et al., 2016), reduced biases in the effects of illusions have also been attributed to diminished influence of top-down processes such as prior knowledge (Mitchell et al., 2010) and greater emphasis on sensory information (Palmer et al., 2017). Evidence beyond psychopathology suggests illusion sensitivity variation in the general population, which could be correlated for instance with personality traits such as higher agreeableness and honest-humility (Makowski et al., 2023) and open-mindness and flexibility of cognitive control (Shoshina & Shelepin, 2014).

However, the exact nature of this interindividual variability and its potential origin remains unclear. The somewhat mixed evidence in the literature regarding its generalizability and strength could be related to the variety of the paradigms used and the type of processes being mobilised (Makowski et al., 2023). Indeed, traditional methods frequently focus on participant’s experience by prompting them to assess the difference between two identical targets, estimate the target’s physical properties, or adjust the targets to match a reference stimulus (Todorović, 2020). Relying on metacognitive judgments about one’s subjective experiences adds an additional layer to the measure that might not be desired when attempting to measure illusion sensibility. Moreover, paradigms often face challenges in diversifying the illusory effects (i.e., using multiple stimuli to experimentally manipulate the strength of the illusion) and the illusion types (i.e., using various illusions, such as Müller-Lyer, Ebbinghaus, Delboeuf which might rely on a different admixture of mechanisms), hindering the potential of obtaining a comprehensive, valid, and reliable measure of illusion sensitivity (Makowski et al., 2023).

The “Illusion Game” paradigm (Makowski et al., 2023) has been recently developed to measure illusion sensitivity to various illusion types through its behavioural impact (on response time and error rate) in a perceptual decision task (where participants have to respond as fast as possible; e.g., “which of the left or right circles is bigger”). The stimuli for different classical illusions are created using the Pyllusion software (Makowski et al., 2021), which allows researchers to modulate the strength of the illusion as a continuous dimension, independently from the difficulty of the perceptual task. This paradigm, inspired by psychophysics, lends itself to the computational modelling of illusion sensitivity through its interference effect, hopefully bypassing some of the metacognitive processes at stake in other paradigms.

Interestingly, the fact that inter-individual variability in illusion sensitivity seems to persist in this task suggests that it is not solely explained by metacognitive abilities difference, and gives rise to the following question: is the variability in illusion sensitivity related to low-level perceptual processes (e.g., baseline precision of perceptual priors), or rather to the ability to actively control and “resist” the illusion in a top-town fashion in order to achieve the task at hand (higher-level modulation of the perceptual inference parameters). If the latter is true, then illusion sensitivity measured in contexts with strong task-demand characteristics, e.g., in paradigms where participants’ performance is explicitly or implicitly assessed (i.e., where there is an incentive to downplay the illusion effect) might correlate with one’s ability to alter one’s subjective experience following suggestions - a mechanism referred to as “phenomenological control”.

The idea that we are endowed with the potential to unconsciously alter our subjective experience and distort reality - even momentarily - to meet the goals at hand is not novel. While this phenomenon has been historically often studied under the label of “hypnotisability” - the tendency to alter our conscious experience to match external demands (Lush et al., 2021), the term “phenomenological control” (PC) has been recently introduced to disconnect this concept from the potentially negative associations with hypnosis and the misconception that a hypnotic context is necessary for responding to imaginative suggestions (Dienes et al., 2022).

To encourage the empirical exploration of our ability and tendency to alter our phenomenological experience and further accelerate investigations away from the hypnotic context, Lush et al. (2021) adapted the Sussex-Waterloo Scale of Hypnotisability (SWASH**,** Lush et al., 2018) by removing all its references to hypnosis, to measure trait phenomenological control. This newly developed phenomenological control scale (PCS) consists of 10 imaginative suggestions followed by subjective ratings for each suggestion on a 6-point Likert scale and has been demonstrated to be compatible with online experiments (Lush et al., 2022).

Interestingly, Lush et al. (2022) did test for a relationship between PC and illusion sensitivity using the Müller-Lyer illusion (in which the arrangement of the arrowheads flanking two lines makes them appear as having different lengths), and reported evidence in favour of an absence of correlation between the two measures. This finding was interpreted as indicative of the cognitive impenetrability of illusions, implying that the effect is driven by low-level processes and therefore not influenced by top-down mechanisms such as PC. The goal of this study is thus to replicate the results from Lush et al. (2022) pointing to an absence of a relationship between phenomenological control and illusion sensitivity, by generalising them to a different illusion task that would encompass other illusion types.

# Methods

## Participants

We aim to recruit around 500 (in line with the sample sizes used in Lush et al., 2021; Lush et al., 2022) adult English native speakers with a desktop device using Prolific (www.prolific.co). Participants will be first presented with an explanatory statement and the consent form, and can proceed by pressing a button to confirm they have read and understood the information. This study will be approved by the ethics board of the School of Psychology of the University of Sussex (XX/XXXX).

## Procedure

The experiment’s setup follows the born-open principle (De Leeuw, 2023). The online experiment, implemented entirely using JsPsych (De Leeuw, 2015), has its code stored on GitHub and will leverage the power of the platform to host the experiment for free. Participants’ raw data files are then automatically stored on a European server on OSF; and the deanonymized and ready-to-use data (downloaded from OSF and formatted using a reproducible script) will be made available in the same GitHub repository, alongside the scripts used for the analysis.

Participants will be presented with a consent form followed by demographic questions (gender, education level, age, and ethnicity). Participants will then be administered the PCS and the Illusion Game task (IG) in a counterbalanced order.

**Phenomenological Control Scale (PCS)**. Participants will be asked to put on their headphones and await further auditory instructions. The PCS procedure starts with a recorded introduction explaining that a series of tests will be applied to evaluate how experiences can be created through imagination. This will be followed by 10 suggestions in a fixed order (see Lush et al., 2021), such as “now extend your arms ahead of you, with palms facing each other, hands about a foot apart” and “as you sit comfortably in your chair with your eyes closed, a picture of two balls will be displayed on the computer screen”. Once the 10 suggestions are completed, participants will be asked to rate their subjective experiences and response to each suggestion on a 6-points Likert scale. Phenomenological control will be indexed by averaging the scores from the 10 scales.

**Illusion Game**. The task is an adaptation of the one used in Makowski et al. (2023) to make it shorter and more reliable, in which participants must make perceptual judgments (e.g., “which red line is the longer”) as quickly and accurately as possible. It includes 3 illusion types, namely Ebbinghaus, Müller-Lyer, and Vertical-Horizontal. The procedure encompasses 2 sets of 80 trials for each illusion type. Each set will include, in a random order, the 3 blocks of illusion types, in which trials are separated by a fixation cross, temporally (uniformly sampled duration of 500 - 1000s) and spatially jittered (around the centre of the screen in a radius of a 1 cm) to attenuate its potential usefulness as a reference point. After each illusion type block, a score is presented (computed as a scaled Inverse Efficiency Score) as a gamification mechanism to increase motivation to perform to the best of one’s abilities.

For each illusion type, two continuous dimensions are orthogonally manipulated (see Makowski et al., 2021 for details on the rationale and execution), namely task difficulty and illusion strength, so that each trial corresponds to a unique combination. Task difficulty corresponds to the difficulty of the perceptual decision (e.g., if the task is to select the longest red line, task difficulty corresponds to how the lines are objectively different). Illusion strength corresponds to the degree to which the illusion elements (e.g., the black arrow lines in Müller-Lyer) are interfering with the aforementioned task. Note that the illusion effect can be “incongruent” (biasing perception in the direction of the incorrect response) or “congruent” (facilitating, i.e., biasing perception in the direction of the correct response). Participants respond with a key arrow (left vs. right; or up vs. down), and their reaction time (RT) and accuracy are recorded.

Visual illusion sensitivity will be measured as the average error rate in the incongruent condition, separately for the 3 illusion types. Although the error rate is arguably a crude score, which does not take into account the effect of varying illusion strength, the interaction with task difficulty and the possible adjustments in response strategy (speed-accuracy tradeoff), it is also the most simple and easy to reproduce, hence its usage as our primary outcome for the current preregistration.

The two sets of 3 illusion blocks will be separated by 2 short questionnaires acting as a break, namely the IPIP-6 (Sibley et al., 2011), measuring 6 personality traits with 24 analogue scales items, and the PID-5 (Krueger et al., 2011), measuring 5 maladaptive personality traits with 25 Likert scales items.

## Data Analysis

The PCS will contain several manipulation check indices to identify problematic participants. Participants should not answer “no balls were presented” when queried about the colour they observed on the screen following the negative visual hallucination suggestion, and should execute at least 5 space presses upon instructions to do so.

Illusion Game outliers will be flagged based on their RT distributions, following the same procedure as in (Makowski et al., 2023). If the RT is collapsed to the left (i.e., has > ⅓ of ultra-fast responses - typically < 200 ms) in the first block, the entire participant will be discarded (suggesting that they did not properly do the text), but if only the second block is bad, then only the second block will be discarded (as the illusion sensitivity can still be estimated, albeit with less precision). In addition, the removal of individual trials will also be performed [RT < 200 ms or > 3 SD; following Thériault et al. (2024)].

After removing problematic participants and trials, the outcome measures (PC and VI sensitivity scores) will be computed and the Bayesian correlation (with medium prior on the coefficient, i.e., r-scale parameter set to 1/3) will be computed [using the BayesFactor package; Morey and Rouder (2024)]**.** Following Lush et al. (2022), we expect to collect evidence against (BF10 <= 1/3) a relationship between PCS and VI sensitivity. Data analysis will be carried out using R, using tidyverse (Wickham et al., 2019) and easystats (Lüdecke et al., 2020, 2022; Makowski et al., 2019, 2022; Patil et al., 2022). The analysis script and additional information are available at https://github.com/RealityBending/IllusionGamePhenomenologicalControl.

# References

Costa, A. L. L., Costa, D. L., Pessoa, V. F., Caixeta, F. V., & Maior, R. S. (2023). Systematic review of visual illusions in schizophrenia. *Schizophrenia Research*, *252*, 13–22. <https://doi.org/10.1016/j.schres.2022.12.030>

De Leeuw, J. R. (2015). jsPsych: A JavaScript library for creating behavioral experiments in a web browser. *Behavior Research Methods*, *47*, 1–12.

De Leeuw, J. R. (2023). DataPipe: Born-open data collection for online experiments. *Behavior Research Methods*, *56*(3), 2499–2506. <https://doi.org/10.3758/s13428-023-02161-x>

Dienes, Z., Lush, P., Palfi, B., Roseboom, W., Scott, R., Parris, B., Seth, A., & Lovell, M. (2022). Phenomenological control as cold control. *Psychology of Consciousness: Theory, Research, and Practice*, *9*(2), 101–116. <https://doi.org/10.1037/cns0000230>

Friston, K. (2010). The free-energy principle: a unified brain theory? *Nature Reviews Neuroscience*, *11*(2), 127–138. <https://doi.org/10.1038/nrn2787>

Gershman, S. J., Vul, E., & Tenenbaum, J. B. (2012). Multistability and Perceptual Inference. *Neural Computation*, *24*(1), 1–24. <https://doi.org/10.1162/neco_a_00226>

Gori, S., Molteni, M., & Facoetti, A. (2016). Visual illusions: An interesting tool to investigate developmental dyslexia and autism spectrum disorder. *Frontiers in Human Neuroscience*, *10*. <https://doi.org/10.3389/fnhum.2016.00175>

Krueger, R. F., Eaton, N. R., Derringer, J., Markon, K. E., Watson, D., & Skodol, A. E. (2011). Personality in*DSM5:*Helping Delineate Personality Disorder Content and Framing the Metastructure. *Journal of Personality Assessment*, *93*(4), 325–331. <https://doi.org/10.1080/00223891.2011.577478>

Lüdecke, D., Ben-Shachar, M. S., Patil, I., & Makowski, D. (2020). *Extracting, computing and exploring the parameters of statistical models using r.* *5*, 2445. <https://doi.org/10.21105/joss.02445>

Lüdecke, D., Ben-Shachar, M. S., Patil, I., Wiernik, B. M., Bacher, E., Thériault, R., & Makowski, D. (2022). *Easystats: Framework for easy statistical modeling, visualization, and reporting*. <https://easystats.github.io/easystats/>

Lush, P., Moga, G., McLatchie, N., & Dienes, Z. (2018). The Sussex-Waterloo Scale of Hypnotizability (SWASH): measuring capacity for altering conscious experience. *Neuroscience of Consciousness*, *2018*(1). <https://doi.org/10.1093/nc/niy006>

Lush, P., Scott, R. B., Seth, A. K., & Dienes, Z. (2021). The Phenomenological Control Scale: Measuring the Capacity for Creating Illusory Nonvolition, Hallucination and Delusion. *Collabra: Psychology*, *7*(1). <https://doi.org/10.1525/collabra.29542>

Lush, P., Seth, A., Dienes, Z., & Scott, R. B. (2022). *Trait phenomenological control in top-down and bottom-up effects: ASMR, visually evoked auditory response and the müller-lyer illusion*. <http://dx.doi.org/10.31234/osf.io/hw4y9>

Makowski, D., Ben-Shachar, M. S., & Lüdecke, D. (2019). *bayestestR: Describing effects and their uncertainty, existence and significance within the bayesian framework.* *4*, 1541. <https://doi.org/10.21105/joss.01541>

Makowski, D., Lau, Z. J., Pham, T., Paul Boyce, W., & Annabel Chen, S. H. (2021). A Parametric Framework to Generate Visual Illusions Using Python. *Perception*, *50*(11), 950–965. <https://doi.org/10.1177/03010066211057347>

Makowski, D., Te, A. S., Kirk, S., Liang, N. Z., & Chen, S. H. A. (2023). A novel visual illusion paradigm provides evidence for a general factor of illusion sensitivity and personality correlates. *Scientific Reports*, *13*(1). <https://doi.org/10.1038/s41598-023-33148-5>

Makowski, D., Wiernik, B. M., Patil, I., Lüdecke, D., & Ben-Shachar, M. S. (2022). *Correlation: Methods for correlation analysis*. <https://CRAN.R-project.org/package=correlation>

Mitchell, P., Mottron, L., Soulières, I., & Ropar, D. (2010). Susceptibility to the Shepard illusion in participants with autism: reduced top-down influences within perception? *Autism Research*, *3*(3), 113–119. <https://doi.org/10.1002/aur.130>

Morey, R. D., & Rouder, J. N. (2024). *BayesFactor: Computation of bayes factors for common designs*. <https://CRAN.R-project.org/package=BayesFactor>

Notredame, C.-E., Pins, D., Deneve, S., & Jardri, R. (2014). What visual illusions teach us about schizophrenia. *Frontiers in Integrative Neuroscience*, *8*. <https://doi.org/10.3389/fnint.2014.00063>

Palmer, C. J., Lawson, R. P., & Hohwy, J. (2017). Bayesian approaches to autism: Towards volatility, action, and behavior. *Psychological Bulletin*, *143*(5), 521–542. <https://doi.org/10.1037/bul0000097>

Patil, I., Makowski, D., Ben-Shachar, M. S., Wiernik, B. M., Bacher, E., & Lüdecke, D. (2022). *Datawizard: An r package for easy data preparation and statistical transformations*. *7*, 4684. <https://doi.org/10.21105/joss.04684>

Shoshina, I. I., & Shelepin, Yu. E. (2014). Effectiveness of Discrimination of the Sizes of Line Segments by Humans with Different Cognitive Style Parameters. *Neuroscience and Behavioral Physiology*, *44*(7), 748–753. <https://doi.org/10.1007/s11055-014-9978-2>

Sibley, C. G., Luyten, N., Purnomo, M., Mobberley, A., Wootton, L. W., Hammond, M. D., Sengupta, N., Perry, R., West-Newman, T., Wilson, M. S., et al. (2011). The mini-IPIP6: Validation and extension of a short measure of the big-six factors of personality in new zealand. *New Zealand Journal of Psychology*, *40*(3).

Sundareswara, R., & Schrater, P. R. (2008). Perceptual multistability predicted by search model for Bayesian decisions. *Journal of Vision*, *8*(5), 12. <https://doi.org/10.1167/8.5.12>

Thériault, R., Ben-Shachar, M. S., Patil, I., Lüdecke, D., Wiernik, B. M., & Makowski, D. (2024). Check your outliers﻿! An introduction to identifying statistical outliers in R with easystats. *Behavior Research Methods*. <https://doi.org/10.3758/s13428-024-02356-w>

Todorović, D. (2020). What Are Visual Illusions? *Perception*, *49*(11), 1128–1199. <https://doi.org/10.1177/0301006620962279>

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L. D., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., Kuhn, M., Pedersen, T. L., Miller, E., Bache, S. M., Müller, K., Ooms, J., Robinson, D., Seidel, D. P., Spinu, V., … Yutani, H. (2019). *Welcome to the tidyverse*. *4*, 1686. <https://doi.org/10.21105/joss.01686>