Testing the involvement of low-level visual representations during spoken word processing with non-Western students and meditators practicing Sudarshan Kriya Yoga

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Abstract

Previous studies, using the Continuous Flash Suppression (CFS) paradigm, observed that (Western) university students are better able to detect otherwise invisible pictures of objects when they are presented with the corresponding spoken word shortly before the picture appears. Here we attempted to replicate this effect with non-Western university students in Goa (India). A second aim was to explore the performance of (non-Western) meditators practicing Sudarshan Kriya Yoga in Goa in the same task. Some previous literature suggests that meditators may excel in some tasks that tap visual attention, for example by exercising better endogenous and exogenous control of visual awareness than non-meditators. The present study replicated the finding that congruent spoken cue words lead to significantly higher detection sensitivity than incongruent cue words in non-Western university students. Our exploratory meditator group also showed this detection effect but both frequentist and Bayesian analyses suggest that the practice of meditation did not modulate it. Overall, our results provide further support for the notion that spoken words can activate low-level category-specific visual features that boost the basic capacity to detect the presence of a visual stimulus that has those features. Further research is required to conclusively test whether meditation can modulate visual detection abilities in CFS and similar tasks.

Key words: continuous flash suppression, embodiment, meditation, replication, spoken words, visual representations, yoga

Embodied cognition refers to the view that cognition involves re-activation or 'simulations' of sensory, motor, or affective states that are similar to those engaged during action and perception (Barsalou, 1999; Glenberg, 1997; Wilson, 2002; and many others; for critical discussion see Ostarek & Huettig, 2019). Embodied cognition for example predicts that the processing of spoken words ('object words') referring to concrete objects activates (or pre-activates) visual representations of what the objects look like (e.g., hearing the spoken word '*bottle*' should activate the visual form of what bottles look like, Lupyan & Ward, 2013).

Congruency effects between linguistic stimuli (such as spoken or written words) and visually-presented objects (or actions) have become a prime methodology and testing ground for theories of embodiment (Stanfield & Zwaan, 2001). In sentence-picture verification tasks, for instance, participants are typically presented with sentences that imply a certain object form (e.g. the visual form of an eagle sitting on a nest or the 'stretched-out wings' visual form of an eagle flying). Reading or listening to such sentences tends to result in faster responses to subsequently presented congruent than incongruent pictorial stimuli (e.g. the picture of an eagle sitting on a nest is responded to faster than a picture of an eagle flying if the sentence implied an eagle sitting on the nest, Zwaan et al, 2002; Zwaan & Pecher, 2012; cf. Rommers et al., 2013). Such effects are typically interpreted as consistent with and providing support for the notion that language comprehension (for example) involves the simulation of modality-specific states (visual representations in this case) rather than the manipulation of abstract, arbitrary, and 'disembodied' symbols.

Interpretation of the results of these kinds of sentence-picture verifications tasks, however, is difficult because crucial aspects of the processing and interaction of sentential and pictorial stimuli tend to be conscious and involve multiple processing stages. Accuracy rates and reaction times do not allow a straightforward arbitration between embodied and amodal ‘disembodied’ accounts as we cannot be sure at what stage interactions arise (Mahon & Caramazza, 2008).

One response by researchers to such criticisms has been to construct experimental settings in which participant responses are likely required at only one processing (for example visual) stage. Lupyan and Ward (2013) and Ostarek and Huettig (2017), for instance, used continuous flash suppression (CFS) to tap the visual level because visual detection of objects in CFS has been shown to be contingent on the processing efficiency of visual features of suppressed pictorial stimuli. CFS has been found to render pictures invisible for extended time and is used in experimental research on subconscious processing (Tsuchiya & Koch, 2005). Furthermore, it does not hinder other cognitive processing, for example the processing of auditory stimuli such as spoken words (cf. Stein et al., 2015).

Ostarek and Huettig (2017) observed in this regard that individuals detected *otherwise invisible pictures of objects* in CFS when the corresponding spoken word was heard shortly before the picture was presented. Detection of congruent (spoken word “bottle”, picture of a bottle) was facilitated compared to incongruent (spoken word “bottle” picture of a banana) trials. These results show that spoken words can activate low-level category-specific *visual* representations very rapidly and that such activation affects what we see (the mere detection of a visual stimulus). Findings like these provide strong support for the notion that spoken words *can* activate modality-specific visual representations that on one hand are ‘low level enough’ to be informative in relation to a given token but also are ‘abstract enough’ to be significant for previously seen tokens and the generalizing to novel exemplars (Ostarek & Huettig, 2017). It is also noteworthy that other studies with slightly different methods obtained similar results (see for example Forder et al., 2016; Paffen et al., 2021).

The present study had two aims. The first goal was to replicate the Ostarek and Huettig (2017) study in a different culture (Indian culture) and with non-native (but highly proficient English) speakers. Most psychological researchers now share the view that there is an urgent need for such replications (see Zwaan et al. 2018, and the comments to their target article), since the attempt to replicate 100 well-known research findings in psychology resulted in a successful replication of only 39 of the studies (Baker, 2015). Replications of findings in embodied cognition are arguably particularly pertinent as many seminal effects have failed to replicate. The seminal action-sentence compatibility effect (ACE, Glenberg & Kaschak, 2002, cited more than 3000 times according to Google Scholar) for example could not be successfully replicated in a recent well-controlled multi-lab study (Morey et al., 2021). All 12 labs testing native-speakers failed to find any evidence for the claim that movements are facilitated when the direction of the movement (for example toward) matches the direction of an action in a sentence that is to-be-judged (e.g., *Veeky gave you the bottle* describes an action toward you). We asked non-native speakers of English to take part in our study because we reasoned that it is important to establish whether (language-mediated) experimental effects extend beyond native speakers. Indeed, all six labs testing non-native-speakers in the multi-lab ACE replication study (Morey et al., 2021) also failed to replicate the action-sentence compatibility effect (Glenberg & Kaschak, 2002).

The second aim of the present study was to *explore* the potential impact of meditation on the congruency effect found in Ostarek and Huettig (2017). We chose to explore meditation because recent research has suggested that meditation may influence aspects of cognitive control and visual perception (Srinivasan et al., 2020). Laukkonen and Slagter (2021) for example have argued that (deconstructive) meditation disengages anticipatory processes. They proposed that meditation can bring a person to a state of 'pure awareness' by reducing 'deep cognition' until conceptual processing is halted. Studies on the long term effects of meditation (MacLean et al., 2010), moreover, may suggest improvements in visual discrimination that are linked to increased visual sensitivity during sustained visual attention.

Biedermann et al. (2016) found that acoustic representations in sensory memory that form the basis for low-level auditory attention was superior in meditators (compared to non-meditators) in both state (while meditating) and trait (whether meditating or not) conditions.

A previous neuroimaging study, moreover, reported that activation levels (i.e. BOLD responses) for *congruent* stimuli in the right medial frontal gyrus, middle temporal gyrus and lentiform nucleus of regular meditators were *higher* compared to non-meditators in an attention task. *Incongruent* stimuli, in contrast showed the reverse pattern: *lower* activation levels for regular meditators compared to non-meditators. The authors (Kozasa et al., 2012) took this pattern of imaging results to argue that regular meditators may process congruent and incongruent stimuli quite similarly (in contrast to non-meditators). Such an interpretation however is questionable and hence requires further work exploring the influence of meditation on congruency processing.

The meditator group, in the present study, consisted of meditators who had practiced Sudarshan Kriya Yoga for many years. Sudarshan Kriya makes use of various rhythmic breathing techniques that have their roots in traditional Indian Yoga practices (Zope & Zope, 2013) and are thought to help practitioners to reach a meditative state of mind. A typical Sudarshan Kriya Yoga 45 minutes practice session may consist of three parts. In the first part the practitioner may inhale and exhale at equal length in a calm and relaxed manner. In the second part the practitioner may exhale twice as long as she inhales, in the third part she may inhale twice as long as she exhales. Chanting ‘om’ with prolonged expiration is also often part of a practice session. Sudarshan Kriya has been found to reduce anxiety, relieve stress (Korkmaz et al. 2024) and appears to increase practitioner’s ability to focus (to improve their attentional abilities in other words, Zope & Zope, 2013). Sudarshan Kriya, which is a Sanskrit term meaning “proper vision by purifying action”, in short can be conceptualized as the recurrent and highly controlled practice of breathing consisting of rhythmic, cyclical breathing with slow, medium, and fast cycles.

There are many techniques practiced by meditators and many other forms of meditation including mindfulness meditation, loving-kindness meditation, or non-dualistic meditation and so on, which potentially can produce differing outcomes. We chose Sudarshan Kriya for two reasons: 1) it is widely practiced in the Indian state of Goa (our testing site) and 2) it has a good track-record in the scientific literature of not only affecting physiological parameters such as improved respiratory functions (Seppäla et al., 2014) and increased heart rate variability (Mathersul et al., 2022) but also cognitive effects including decreased posttraumatic stress (Seppäla et al., 2014) and decreased manifestation of clinical depression (Doria et al., 2015; Sharma et al., 2017). We note however that the 'meditator part' of our study is exploratory: Though many neurophysiological mechanisms of the effects of yogic breathing techniques on attentional abilities (for instance involving enhanced states of 'calm or relaxed alertness', Brown & Gerbarg, 2005) have been discussed, little is known about how Sudarshan Kriya exerts its neurophysiological and cognitive effects on a precise mechanistic level. To the best of our knowledge, the present study is the first that explores whether Sudarshan Kriya has an influence on the ability to detect otherwise invisible pictures of objects when they are presented with the corresponding spoken word shortly before the picture appears.

Method

Participants

Forty-three participants from a graduate university in India (BITS Pilani Goa) and a meditation centre (Art of Living, Panjim, Goa) participated in the study from October – November, 2019. All participants were right-handed with no recent history of medication for neurological conditions. All participants were Indian non-native speakers of English but had received their formal education in the English language as medium of instruction (a common practice in India).

Participants with existing respiratory or neurological conditions were excluded from the data collection. We attempted to recruit a sample size similar to the sample size of the Ostarek and Huettig study (2017; N=24). Participants in the present study had an age range of 18 to 30 (mean age: 20.62 years) and no hearing impairments, with normal or corrected-to-normal vision (Meditators – 19 Male, 1 Female, Non-Meditators – 16 Male, 7 Female). The meditator population (practicing Sudarshan Kriya Yoga) was recruited by contacting the "Art of Living" centre in Panjim, Goa. Participants who had been practicing meditation for more than two years and were regularly practicing meditation every week were categorized as meditators. The non-meditator population was recruited by online advertisement within the university.

Participants included in the final analysis consisted of two groups: (Sudarshan Kriya Yoga) meditators (N_M=15, 14 males, 1 female, mean age: 20.3 years) and non-meditators (N_{NM}=19, 13 males, 6 females, mean age: 20.05 years) groups. Six participants were excluded because of technical glitches (incorrect binocular overlap, power failure). We excluded two further participants because of false alarm rates higher than 50%, and one participant because of a hit rate lower than 5% (cf. Ostarek & Huettig, 2017).

All participants provided written informed consent before participating in the experiment. The study was carried out according to the protocols outlined in the Declaration of Helsinki, and was approved by the BITS Pilani Human Ethics Committee (IHEC) with the approval number: IHEC 40/16-1.

Stimuli, Apparatus, and Procedure

Participants' view field was straightened using custom-made prism glasses (prism diopter: 10Δ), while audio cues were provided by means of headphones, which were placed on their head. Participants comfortably placed their head on a chinrest. The screen was 80 cm away from the chinrest. A separator was positioned from the centre of the chinrest to the computer screen so that participants saw only half of the screen from each eye (Figure 1). The stimuli were presented on the computer screen using PsychoPy (Peirce et al., 2019) (version 1.90.3 www.psychopy.org). The distance to the screen was varied slightly from participant to participant to ensure optimum interocular fusion. The designed protocols conformed to the Declaration of Helsinki.

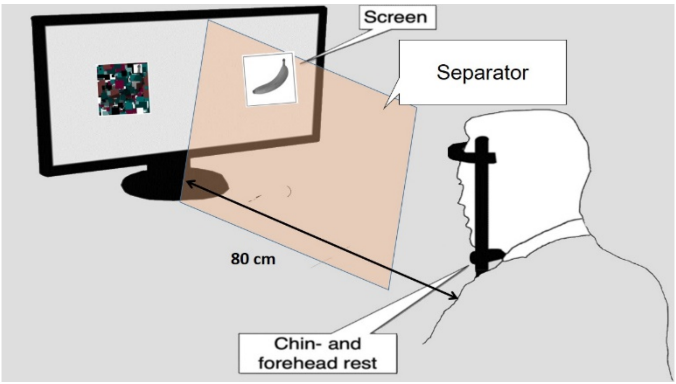

Figure 1. Experimental Setup

CFS masks (Figure 2) were randomly selected from a set of 80 Mondrian-type images for every trial (similar to Hesselmann et al., 2016). Target pictures were selected from the normed database (De Groot et al., 2017; total number of target pictures = 16). The images were converted to grayscale and edges were blurred using a gaussian filter with a radius of 3 pixels in Adobe Photoshop CC 2019 so that pictures could be sufficiently suppressed. Cue words were spoken by a female Indian speaker proficient in English, recorded, and spliced into single audio files using Audacity 2.3 (www.audacityteam.org).

The spoken cue words were presented through headphones with a suitable volume that was comfortable to the participants. The implemented experiment closely followed the design of the Ostarek and Huettig (2017) study such that all words appeared an equal number of times in picture-present and picture-absent trials. In picture-present trials, 50% of the stimulus items were congruent ('banana' -> picture of a banana) with the spoken word, and 50% were incongruent ('cat' -> picture of banana). All the picture stimuli were evenly distributed over the experimental conditions.

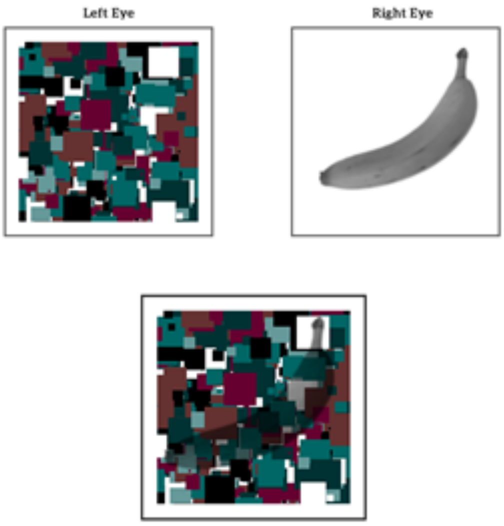

Figure 2. The Left Visual Field exposed to changing Mondrian frames (Top-Left) while Right Visual Field exposed to object of variable transparency (Top-Right) together forming the CFS Masks (Bottom)

At the beginning of each trial, a square black box with a fixation cross at the centre was shown in both halves of the screen for 500ms (see Figure 3). This was directly followed by the audio file of the spoken cue word, presented binaurally through headphones. In picture-present trials, 200ms after the word onset, the target picture appeared as illustrated in

Figure 3. The CFS mask was presented on the left side (Mondrian-type colourful rectangular shapes changing randomly at 12Hz), and a grayscale picture of an object on the right side. The stimuli remained on the screen for 800 ms. This was followed by the printed question "Was there a picture?" on the display. Participants were asked to respond to the question by pressing either "Left Shift" (No) or "Right Shift" (Picture Yes). For picture-absent trials, a blank white square was shown instead of objects appearing on the right of the screen. Participants were informed that hearing the word neither predicted that the picture was present nor that it was the same as the word in picture-present trials.

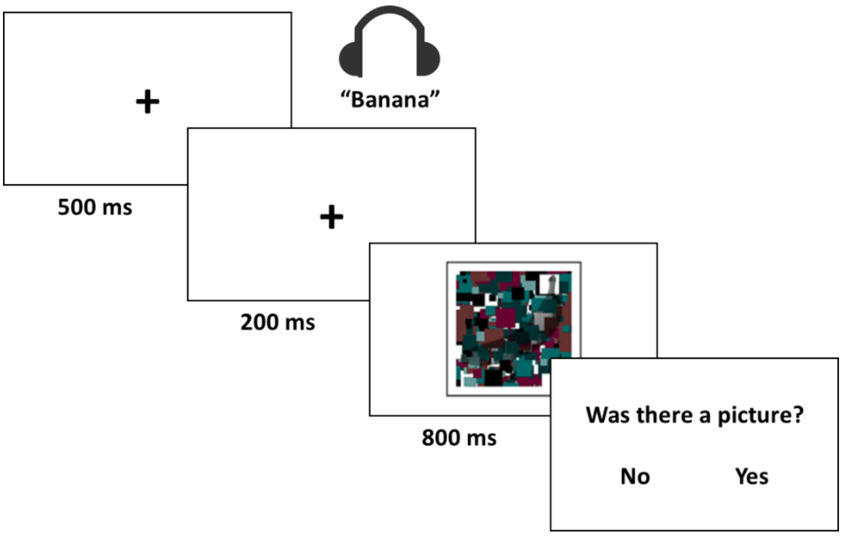

Figure 3. Experimental Timing.

The experiment consisted of a total of 256 randomly-distributed trials out of which 128 were picture-present, and 128 were pictures-absent trials (Figure 4). Importantly, out of the 128 picture present trials, 64 were congruent and 64 were incongruent with the cue word. None of the pictures appeared consecutively.

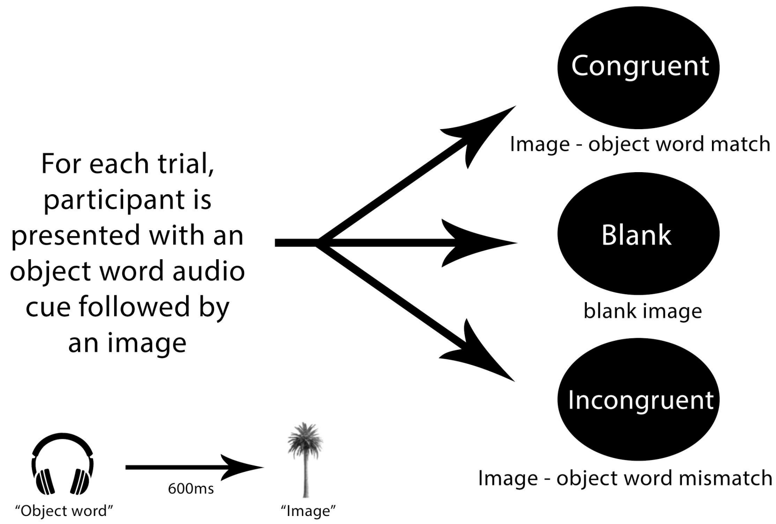

Figure 4. Experimental Conditions.

An object detection rate of around 50% was aimed for to avoid ceiling and floor effects. In order to ensure reasonable control over suppression strength, prior to the main experiment, an image-only version of the main experiment including a staircase with 96 trials was conducted in the absence of the auditory cue word. For every hit (participant correctly indicates that the object was present or correctly indicates the absence of the object), the contrast of the object image presented on the right was reduced by 5%. For every miss (the object was present but the participant indicates that it was not or the object was not present but the participant indicated that it was present), it was increased by the same amount so that the suppression strength converged to 50% following the example of Experiment 3 in the Lupyan and Ward (2013) seminal study. In the staircase procedure, when no target was shown, the intensity of the targets was not altered (regardless of the participant's response). Only trials where target images were present influenced their intensity change on subsequent trials. The final contrast computed in the staircase experiment was used in the main experiment to adjust for individual differences in visibility of various participants and also to avoid floor/ceiling effects.

Statistical Analyses

We first computed hit rate (proportion of trials in which an object was presented and correctly identified as present by the participant) and sensitivity (d' – the z-transformed hit rate divided by the z-transformed false alarm rate, where false alarms were defined as the proportion of trials in which an object was not presented but the participant indicated that there was an object present), because although these two measures both reflect detection rates, the latter takes into account participants' individual level of response bias, should that exist. To assess accuracy corresponding to the hit rate we first carried out generalized linear mixed effects model (GLMM) analyses of the single-trial data. The GLMM for the accuracy data was designed on the data with the model definition:

ACC ~ Group * Congruency + (1 + Congruency | Participant) + (1 + Group | Item)

where ACC is the dependent variable indicating the response accuracy of the participant for each trial. ACC is a binary response bit where 1 represents a correct response and 0 represents an incorrect response. The GLMM evaluates the effects of Group and Congruency on the accuracy (ACC) of participants' responses. The GLMM was designed using a binomial family and logit link function, implemented using JASP 0.17.1.0 (JASP Team, 2023) and the lme4 package (Bates, Mächler, Bolker, & Walker, 2015). We then used Repeated Measures Analysis of Variance (ANOVA) to assess the influence of Congruency (congruent/incongruent) and Group (meditators/non-meditators) on the d' measure of detection rate. As d' values are by definition aggregated across trials within each level of the factors of interest, single-trial analyses are not possible for this measure of detection rate. This ANOVA was carried out using JASP 0.17.1.0 (JASP Team, 2023).

For all tests, P-values below 0.05 were considered statistically significant.

Exploratory Bayesian Analysis

The statistical analyses suggest strong effects of Congruency but no effect of Group (i.e., the CFS effects are not influenced by whether participants had a history of practicing the Sudarshan Kriya Yoga or not). In order to further probe the null hypothesis that there are no group effects, we carried out Bayesian Repeated Measures ANOVAs on the d' scores using JASP (JASP Team, 2023).

The Bayesian Repeated Measures ANOVA has the advantage of quantifying the evidence for both the null hypothesis and the alternative hypothesis, summarized as a Bayes Factor for each predictor in the model, indicating how much more likely the data are under the model with that predictor included than they are under the null model (BF_{10}), or vice versa (BF_{01}). The null model attempts to predict the data (dependent variable) based on participant variability and random effects alone, and subsequent models add the predictors Congruency, Group, their interaction, and random slopes for all repeated measures (fixed-effects) predictors. Aggregated model comparison was carried out using Bayes Factors (BF_{incl}), quantifying the evidence in favour of the inclusion of each subsequent predictor in the model over all preceding, less complex models which did not include that predictor. By default JASP sets uninformative priors for these Bayesian ANOVAs. By convention a BF_{10} between 1 and 3 is considered weak evidence for the alternative hypothesis (or model), a BF_{10} between 3 and 10 is considered moderate evidence, and a BF_{10} greater than 10 is considered strong evidence. Similarly, a BF_{10} between 1 (= 1/1) and 0.33 (= 1/3) is considered weak evidence for the null hypothesis (or model), a BF_{10} between 0.33 (= 1/3) and 0.1 (= 1/10) is considered moderate evidence, and a BF_{10} less than 0.1 (= 1/10) is considered strong evidence.

Results

Descriptive Statistics

First we present some descriptive summary statistics. Table 1 shows the mean values for hit rate for each Group (meditators – M, and non-meditators – NM), broken down by Congruency (congruent/incongruent).

Table 1. Summary Statistics for Hit Rate

Group	Congruency	N	Mean	SD	Coefficient of variation
M	Congruent	15	0.586	0.238	0.406
	Incongruent	15	0.477	0.252	0.529
NM	Congruent	19	0.595	0.158	0.266
	Incongruent	19	0.508	0.210	0.412

Note. M = meditator group; NM = non-meditator group.

Table 2 presents the d' scores for each Group broken down by Congruency.

Table 2. Summary Statistics for d' Scores

Congruency	Group	N	Mean	SD	Coefficient of variation
Congruent	M	15	1.907	0.927	0.486
	NM	19	1.551	0.765	0.493
Incongruent	M	15	1.367	0.727	0.532
	NM	19	1.164	0.913	0.784

Note. M = meditator group; NM = non-meditator group.

ANOVA for d'

We conducted repeated measures ANOVA evaluating the effects of Congruency and Group on d' scores.

Table 3 shows the ANOVA results where the dependent variable is the d' scores. These analyses revealed a statistically significant effect of Congruency: $F(1,32) = 9.806$, $p < 0.005$. There was neither a Group effect nor any interaction between Group and Congruency.

Table 3a. Within-participant Effects for d'						
Cases	Sum of Squares	df	Mean Square	F	P	η^2
Congruency	3.604	1	3.604	9.806	0.004	0.070
Congruency * Group	0.098	1	0.098	0.267	0.609	0.002
Residuals	11.762	32	0.368			

Table 3b. Between-participant Effects for d'						
Cases	Sum of Squares	df	Mean Square	F	P	η^2
Group	1.304	1	1.304	1.257	0.271	0.026
Residuals	33.215	32	1.038			

GLMM Analysis for Accuracy

The GLMM analysis similarly showed an effect of Congruency on accuracy ($p < 0.001$) but no effects of Group and no interaction between Group and Congruency (Table 4).

Table 4. Generalized Linear Mixed Models				
Fixed Effects Estimates				
Term	**Estimate**	**Standard Error**	**T**	**P**
Intercept	0.216	0.346	0.624	0.532
Group	-0.068	0.207	-0.329	0.742
Congruency	0.304	0.075	4.075	< .001
Group * Congruency	0.043	0.075	0.576	0.565

Post-hoc Bayesian Analyses

We replicated the frequentist ANOVA results for d' scores using a Bayesian approach. As is clear from Table 5, there was strong support for the model including the predictor Congruency ($BF_{10} = 11.57$) over the null model. Moreover, there was weak support for the null model over the model including the predictor Group ($BF_{10} = 0.54$), the model including the predictors Congruency and Group ($BF_{10} = 6.88/11.57 = 0.6$), as well as the model including the predictors Congruency, Group, and their interaction ($BF_{10} = 2.57/6.88 = 0.37$).

Table 5. Bayesian ANOVA for d'					
Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
Null model	0.200	0.044	0.185	1.000	
Congruency	0.200	0.513	4.209	11.572	0.748
Congruency + Group	0.200	0.305	1.755	6.882	1.729
Congruency + Group + Congruency * Group	0.200	0.114	0.515	2.574	2.687
Group	0.200	0.024	0.098	0.542	1.233

Note. All models include participant, and random slopes for all repeated measures factors.

Aggregated model comparison (Table 6) provided moderate evidence that inclusion of the predictor Congruency led to a better model fit over the null model (BF_{incl} = 9.09), but none of the models including other factors improved model fit over the model including Congruency alone.

Table 6. Aggregated Model Comparison for d'					
Effects	P(incl)	P(excl)	P(incl|data)	P(excl|data)	BF_{incl}
Congruency	0.600	0.400	0.932	0.068	9.093
Group	0.600	0.400	0.443	0.557	0.530
Congruency * Group	0.200	0.800	0.114	0.886	0.515

In sum, these Bayesian results are in agreement with the frequentist output reported earlier, suggesting that there is a clear effect of Congruency on sensitivity (d'), but no effect of Group or the interaction between Congruency and Group. Moreover, we obtained weak evidence against the inclusion of Group or any interaction with Group, providing additional (albeit weak) support for the absence of any influence of meditation status on d'.

Discussion

The present study successfully replicated Ostarek and Huettig (2017) in a different culture (Indian culture) and linguistic population (non-native but proficient Indian English speakers):

Congruent English cue words resulted in significantly higher detection sensitivity than incongruent English cue words. This result provides further support for the notion that object words (spoken words that refer to concrete objects and activate visual representations of what the objects look like) can make the 'invisible visible' or more precisely that spoken words can activate low-level category-specific visual features that can boost the basic capacity to detect the presence of a visual stimulus that has those features.

We have also observed that years of practicing the Sudarshan Kriya Yoga do not to appear to modulate such detection abilities (both on hit rate and d' scores). This conclusion is supported by traditional frequentist statistical methods and Bayesian analyses: We observed robust effects of Congruency on sensitivity (both on hit rate and d-prime), but no effect of Group nor an interaction between Congruency and Group. Bayesian analyses however provided only weak evidence against the inclusion of Group or any interaction with Group, which indicates that additional research could usefully further explore whether meditation can modulate visual detection abilities in Continuous Flash Suppression and similar tasks.

Our study has some limitations despite the successful replication of the Ostarek and Huettig (2017) study with types of populations that have so far not been tested in the CFS task (non-western bilingual university students and meditators). Here we discuss the issues of demographics, sample size and type of meditation. One important limitation of our study was that the meditator and non-meditator groups were not well matched on baseline demographic factors. This makes it impossible to rule out that such differences may have been the cause of any observed differences, but also may explain the absence of a group difference in our study. Future work should carefully match these factors between the two groups to allow for stronger conclusions to be drawn about differential influences of meditation on detection rates in the CFS task.

Further cross-sectional research could usefully increase sample size, in particular of the meditator group, to increase the power to detect an effect of Sudarshan Kriya in CFS and other visual perception and cognitive control tasks. Longitudinal studies (ideally), moreover, could teach various types of meditation and assess changes in CFS performance as a continuous variable over time in individual participants.

The meditator group in our study consisted of experts in the breathing techniques of Sudarshan Kriya. There are however many other meditation techniques (including mantras involving the continuous repetition of certain phrases). Most interestingly perhaps for the present study, there are various visualization meditation techniques including guided positive imagery (visualizing positive images), color visualization (for example associating positive feelings with a color and visualizing it), and focused visual attention on various visual anchors. In focused visual attention meditation techniques, the meditator choses one particular (inner) anchor of visual choice. The aim of the meditator is to avoid any distraction by focusing all attention on the visual anchor as much as is possible. Future research may consider assessing the influence of different types of meditation on participant performance in visual attention and detection tasks.

To conclude, the present study provides further support (from a different culture and linguistic population) that spoken words can activate low-level category-specific visual features that boost the basic capacity to detect the presence of a visual stimulus that has those features. Testing Sudarshan Kriya practitioners, the exploratory aspect of our study, did not provide any evidence that the practice of meditation had an influence on congruency effects in Continuous Flash Suppression. Additional empirical work is required to conclusively test whether long-time experience with meditation can modulate visual detection abilities.

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