Cultural Differences in Visual Perceptual Learning

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Abstract

Cultural differences in visual perceptual learning (VPL) could be attributed to differences in the way that people from individualistic and collectivistic cultures preferentially attend to local objects (analytic) or global contexts (holistic). Indeed, individuals from different cultural backgrounds can adopt distinct processing styles and learn to differentially construct meaning from the environment. Therefore, the present work investigates if cross-cultural differences in VPL can vary as a function of holistic processing. A shape discrimination task was used to investigate whether the individualistic versus collectivistic backgrounds of individuals affected the detection of global shapes embedded in cluttered backgrounds. Seventy-seven participants – including Asian (collectivistic background) and European (individualistic background) students – were trained to discriminate between radial and concentric patterns. Singelis' (1994) self-construal scale was also used to assess whether differences in learning could be attributed to independent or interdependent self-construal. Results showed that collectivists had faster learning rates and better accuracy performance than individualists following training – thereby reflecting their tendency to attend holistically when learning to extract global forms. Further, we observed a negative association between independent self-construal – which has previously been linked to analytic processing – with performance. This study provides insight into how socio-cultural backgrounds affect VPL.

Keywords: culture, self-construal, visual learning, perception, Glass patterns

Cultural Differences in Visual Perceptual Learning

Introduction

Visual perceptual learning (VPL) refers to the acquisition of visual skills through training to improve our ability to detect useful information in cluttered scenes (Dosher & Lu, 2017). Indeed, the perceptual experiences gained through training allows individuals to perform an initially difficult visual task relatively precisely (Gerlach & Starrfelt, 2018; Liu & Luo, 2019; Mayhew et al., 2012). The extensive literature on VPL has evidenced improvements in numerous tasks such as orientation discrimination, phase identifications, pattern discrimination, and object identification following training (Dosher & Lu, 2017; Gerlach & Starrfelt, 2018; Liu & Luo, 2019; Mayhew et al., 2012; Mollon et al., 2017). Cumulatively, these studies have reported considerable evidence of individual differences in VPL. However, cross-cultural differences in VPL and how VPL could vary as a function of differential processing styles across cultures remains largely unexplored. Furthermore, since it is difficult to detach VPL processes from attentional mechanisms (Dosher & Lu, 2017), people may develop differential visual learning and perceptual strategies based on the attentional or processing styles dominant in their culture (van der Kamp et al., 2013).

Sustained exposure to cultural systems (as defined by frameworks such as individualism and collectivism or independent and interdependent self-construals) could influence how people attend to or process informational variables from the environment (Blais et al., 2021; Caparos et al., 2020; Davidoff et al., 2008). For instance, individualism and independent self-construals which are widespread in Western cultures, as well as collectivism and interdependence in Eastern cultures have been associated with analytic and holistic processing styles respectively (Choi et al., 2007). These processing differences have been evidenced in how people from different cultural backgrounds detect visual changes or make categorical judgements (Boduroglu et al., 2009; Boduroglu & Shah, 2017; Hedden et al., 2008; Nisbett et al., 2001). Specifically, the individualism-collectivism framework has been used as a general descriptor of Western and Eastern cultures at national or group levels (Oyserman et al., 2002), while at the individual level, culture can be conceptualised by independent or interdependent self-construals (Singelis, 1994). Notably, these individual- and group-level cultural frameworks can be linked to differential distributions of attention (Choi et al., 2007).

To illustrate, the emphasis on individualism and independence in Western societies such as those in Europe have been linked to analytic thinking styles and more localised attentional patterns towards focal objects (Boduroglu et al., 2009; Boduroglu & Shah, 2017; Choi et al., 2007; Nisbett et al., 2001). In contrast, the emphasis on collectivism and interdependence in Eastern societies such as those in Southeast Asia have been associated with more holistic thinking styles and broader distributions of attention towards objects as well as the context in which the object is embedded (Jenkins et al., 2010; Nisbett et al., 2001). As an example, the persistent effect of cultural differences in attention towards irrelevant contextual information amongst East Asians (but not in Westerners) has clearly evidenced their tendency for holistic processing and a global attentional bias (Amer et al., 2017). Furthermore, there is also extensive empirical research evidence that further illustrates the influence of cultural-specific patterns of analytic and holistic processing (e.g., Boduroglu & Shah, 2017; Boduroglu et al., 2009; Choi et al., 2007; Jenkins et al., 2010; Nisbett et al., 2001). Given that VPL improves our ability to detect useful information in cluttered scenes (Dosher & Lu, 2017), cultural differences in the selection of relevant sensory information during analytic and holistic processing could similarly facilitate VPL processes.

During VPL, individuals learn to attend to the key visual features for interpreting a scene while ignoring ambiguous information (Dosher & Lu, 2017; Gerlach & Starrfelt, 2018; Liu & Luo, 2019; Mayhew et al., 2012; Mollon et al., 2017). However, following initial exposure to the visual stimuli, individuals from different cultural groups could first detect either local or global informational variables consistent with the analytic or holistic processing styles prevalent in their cultures (Boduroglu & Shah, 2017; Jenkins et al., 2010; Nisbett et al., 2001). For instance, East Asians – due to their increased tendency for global processing – were reported to be more susceptible to global illusory biases compared to Westerners (van der Kamp et al., 2013). This cultural difference further diverged as Westerners were significantly quicker than their East Asian counterparts at identifying the useful informational variables following feedback (van der Kamp et al., 2013). Nevertheless, performance converged post-training (van der Kamp et al., 2013), indicating that although differential processing styles across cultures may result in initially inaccurate perceptual judgements, individuals could learn to shift their focus to key features and improve performance through training.

Van der Kamp et al.'s (2013) study provides an important foundation for advancing VPL research as East Asians initially appeared less flexible in changing their use of informational variables following feedback to reduce the illusory bias. It would thus be compelling to examine differences in VPL as a function of cultural differences in analytic and holistic processing. Furthermore, like Amer et al.'s (2017) study, van der Kamp et al. (2013) also did not assess participants' cultural inclinations. It would be useful to expand the investigation to examine how the individual- (e.g., independent-interdependent self-construal) and group-level cultural constructs (e.g., individualism-collectivism) differentiating Western and Eastern cultures can be associated with VPL processes. To our knowledge, there is a lack of research on whether and how differential analytic and holistic tendencies across different cultures may influence VPL (e.g., van der Kamp et al., 2013).

It is important to select tasks that fulfil research objectives as cultural differences in information processing may manifest differentially (Hedden et al., 2008). The Glass (1969) pattern discrimination task is an example of a visual categorisation task that requires holistic or global processing to overcome sensory uncertainty (Mayhew et al., 2012). Radial and concentric patterns are embedded within noise in this task, and observers are required to extract and integrate relevant features into global forms to effectively discriminate the patterns. Observers learn how to translate sensory inputs into meaningful categories despite the perceptual uncertainties induced by noisy backgrounds (Mayhew et al., 2012). Therefore, they are likely compelled to focus on the global rather than local features of the stimuli during training. Notably, there is evidence to suggest a common global advantage during visual processing as stipulated by the global precedence hypothesis (Gerlach & Starrfelt, 2018; Liu & Luo, 2019). Despite this, it is estimated that the analytic and holistic processing differentiations between cultures could still impact how individuals perceive their environments and learn (Blais et al., 2021; Caparos et al., 2020; Davidoff et al., 2008; van der Kamp et al., 2013). The Glass (1969) pattern discrimination task could thus provide important evidence on the influence of culture on VPL as it can reveal if cultural differences in task performance manifest despite the global precedence effect (Gerlach & Starrfelt, 2018; Liu & Luo, 2019).

Research has yet to evidence the impact of differential analytic and holistic processing mechanisms on VPL abilities across cultures. Therefore, in this paper, we aim to examine cultural differences in the perception and differentiation of information embedded in cluttered visual scenes during VPL. To narrow the focus of our investigation, the present study concentrates on the potential impact of cultural differences on global attentional mechanisms during VPL. The Glass (1969) pattern discrimination task which requires holistic processing was used to identify cultural differences in VPL by comparing accuracy performance in categorical judgements between an Asian and European sample. As the stimuli in this task cannot be associated with any semantic meaning, culture relevant differences in factors such as language, skills, expertise, and qualifications could not interfere with performance (Ueda et al., 2018). Additionally, to investigate the relationship between cultural influences on VPL in the task, we considered both the independence-interdependence and individualism-collectivism cultural frameworks which represent individual and group level constructs respectively as each may differentially impact VPL processes (Grossmann & Jowhari, 2018; Singelis, 1994). Singelis' (1994) self-construal scale (SCS) was used to assess the differences in independent and interdependent self-construal at the individual level, while European and Asian students recruited for this study represented individualistic and collectivistic cultural groups. We hypothesised that Asians would exhibit faster learning rates and better performance compared to their European counterparts in this global pattern discrimination task following training as collectivists and those with interdependent self-construal have a greater propensity to attend to global information (van der Kamp et al., 2013).

Materials and Methods

Design

The present study employed a between-subjects design comparing two groups from different cultural backgrounds; half originated from collectivistic backgrounds, while the other half were from individualistic backgrounds. Response accuracy of correct pattern identifications was recorded for each participant following previous work on glass patterns (Frangou et al., 2019; Mayhew et al., 2012) to enable a comparison of visual perceptual learning differences between individualistic and collectivistic cultures. The experiment also adopted a cued-response design whereby there was a delay between stimuli presentation and response. This was a standardisation feature that ensured similar reaction times (RTs) when participants are making a response (Li et al., 2012). The recorded RTs are thus not a reflection of learning ability, but rather of participant’s motor response (keypress) to the cue.

Participants

Participants were recruited through opportunity-sampling in a UK university. Eighty-three participants were recruited for the present study. Among these, 41 were international students (18 Malaysians, 13 Chinese, 7 South Asians, 1 Vietnamese, 1 Emirati, and 1 Azerbaijani) who were studying in the UK and had lived in the UK for less than five years (M =

18.44 months; SD = 16.18) representing the collectivistic group, while 42 were British or European students representing the individualistic group. The European students who were from countries such as Spain, Romania, Sweden, Bulgaria, Cyprus, and Denmark had been in the UK for between 18 months to 17 years. Two students, both aged 22, who were native English speakers reported that they were not born in the UK; one participant who was born in Jamaica had been living in the UK for 13 years, while the other who was born in Tanzania had been living in the UK for 20 years. As both have spent most of their youth in the UK, they were assigned to the individualistic group.

Due to the difficulty of the task, participants who had scores with two standard deviations from the mean of the first run (Run 1) were excluded from the analysis. Additionally, one participant was further excluded for performing below chance level throughout training, suggesting they did not understand the task instructions. Therefore, six participants were excluded, and the analysis was conducted on seventy-seven participants who had a mean age of 21.31 (SD = 2.55) from individualistic (n = 40) and collectivistic (n = 37) backgrounds based on their nationalities. All participants had normal or corrected-to-normal vision and did not use special-coated eyewear.

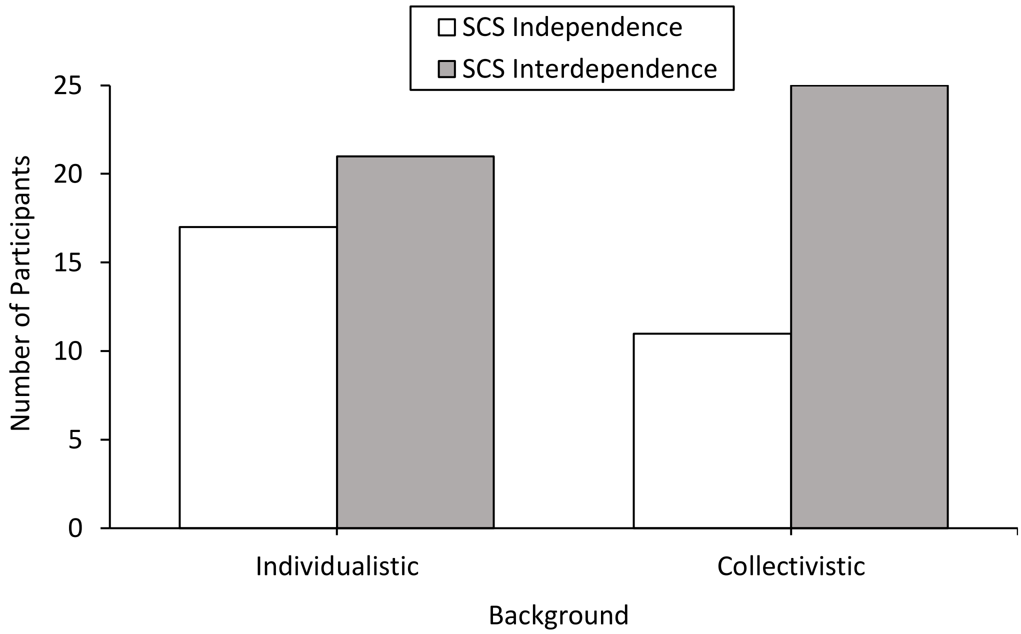
Materials

Demographics Questionnaire. The questionnaire which identified background information such as nationality, gender, age, language, ethnic background, birthplace, and years lived in the UK was used to ensure that participants were assigned to the corresponding experimental groups (individualistic or collectivistic backgrounds).

Self-construal Scale (SCS). Singelis' (1994) 24-item SCS was used to identify self-construal differences between the individuals of both experimental groups. The SCS consisted of items that measured participants' independent self-construal (e.g., 'I enjoy being unique and different from others in many respects') and interdependent self-construal (e.g., 'I have respect for the authority figures with whom I interact'). Responses were measured on 7-point Likert scales which ranged from 1 (*Strongly Disagree)* to 7 *(Strongly Agree)*. Each participant had two scores and was assigned with having either independent or interdependent self-construal depending on their scores in each subscale. Scores were calculated for each subscale by summing up the responses and dividing the sum by the number of questions in the subscale (n = 12). Three participants with equal scores on both subscales were excluded from this analysis as they could not be categorised. Cronbach's reliability (α) for the overall scale was .732; Specifically, α values for the 12 independent and 12 interdependent items were .785 and .665 respectively. Figure 1 shows that the individualistic group of participants were equally likely to hold independent or interdependent self-construal, whereas the collectivistic group appeared more likely to hold interdependent self-construal. However, there was no statistically significant association between the SCS and background variables, X^2 (1, N = 74) = 1.58, p = .209, thus indicating that both individualist and collectivists were equally likely to possess independent and interdependent self-construal. Nevertheless, past studies have similarly reported inconsistent findings between independent and interdependent self-construal constructs (e.g., Na et al., 2020), and these can be attributed to factors that will be detailed further in the discussion section.

Figure 1

Self-Construal of Participants from Individualistic and Collectivistic Backgrounds

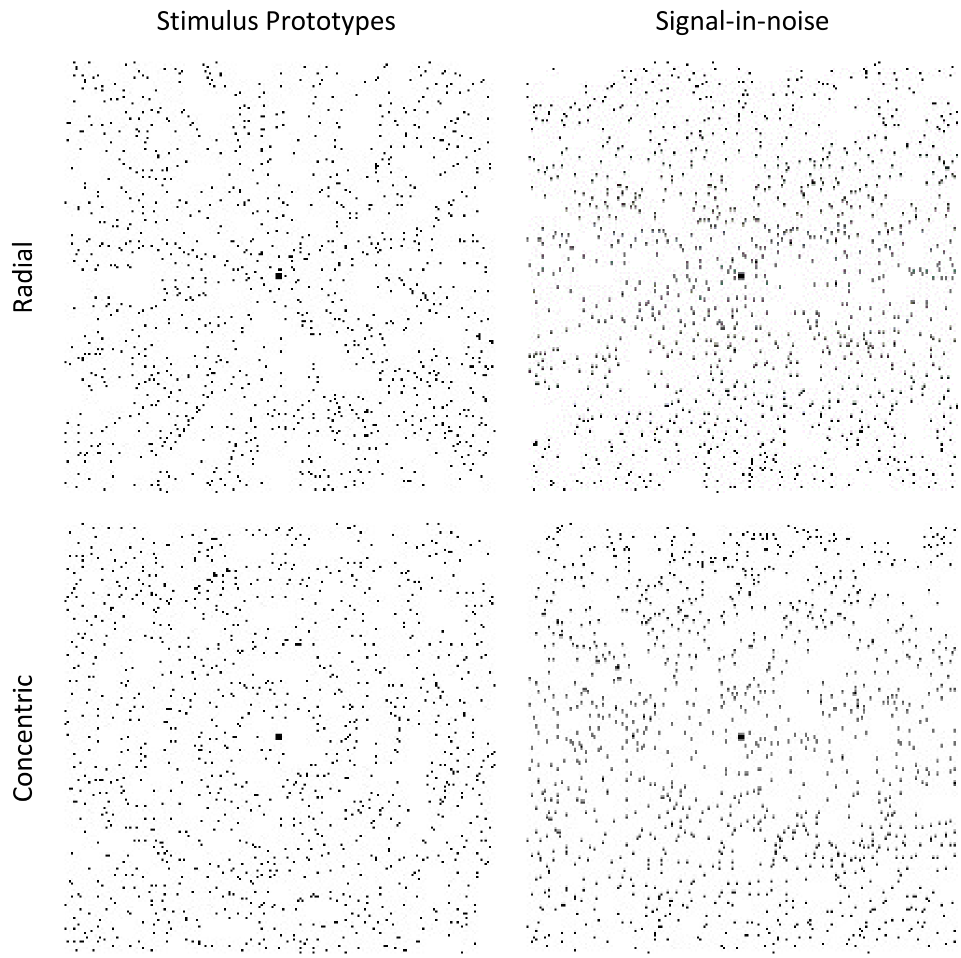


Note. The collectivistic group were more likely to hold interdependent than independent self-construal, while the individualistic group were equally likely to hold independent or interdependent self-construal although these differences were not significant.

Stimuli. We used MATLAB 2015a in conjunction with Psychtoolbox-3 for stimulus generation and presentation. Participants were tasked with discriminating radial and concentric Glass (1969) patterns (Frangou et al., 2019; Mayhew et al., 2012) to identify the cultural differences in perceptual learning processes. Specifically, the discrimination task was adapted from (Mayhew et al., 2012) experimental paradigm to assess how observers learn to extract global shapes embedded in cluttered backgrounds. Each stimulus consisted of pairs of dots (2.3 × 2.3 arc min^2) or dot dipoles that were aligned according to the specified spiral angle (signal dipoles), displayed within a square aperture (7.9°×7.9°) against a black background (100% contrast). Dot density was set at 3%, and the distance between the dot dipoles was 16.2 arc min (Frangou et al., 2019). The spiral angle for each dot dipole is characterised by the angle between the dot dipole orientation and the radius from the centre of the dipole to the centre of the stimulus aperture (Frangou et al., 2019). Concentric patterns were formed by tangentially placed dipoles, while radial patterns were constructed by orthogonally placed dipoles. In the present study, radial patterns were generated using a spiral angle of ±0° whereas concentric patterns were generated using a spiral angle of ±90°. These patterns comprised of 35% or 40% signal (i.e., aligned dot dipoles) and were embedded in a background comprising of randomly positioned and oriented dipoles. Patterns were rotated clockwise or anticlockwise across trials in a randomised order (see Figure 2). Spiral angles were jittered across stimuli (±3°) to control for potential local adaptation and ensure that participants would learn to discriminate global shapes rather than just local features during stimulus categorisation.

Figure 2

Example of Radial and Concentric Glass (1969) Patterns



Note. The radial (top) and concentric (bottom) patterns are presented with inverted contrast for illustration purposes. The stimulus prototypes with 100% signal are also shown for comparison purposes only. The signal-in-noise patterns are generated with 37.5±2.5% signal.

Participants completed a total of four experimental runs. Each run constituted a total of 108 trials that were randomised between two stimulus conditions (radial and concentric). Each trial consisted of a 200 ms stimulus presentation followed by a 1300 ms fixation. A response cue then appeared for 1000 ms to prompt participants to identify the pattern by pressing key ‘1’ for radial patterns and key ‘2’ for concentric patterns. The fixation between stimulus presentation and the response cue ensures that RTs are standardised across participants and groups. A 500 ms fixation dot was displayed on the screen before the next trial onset.

Procedure

Ethical approval was granted by the university's research ethics committee. Once informed consent was obtained, participants completed the demographics and SCS questionnaires. Participants were assigned to either the collectivistic or individualistic groups depending on the demographic information provided. The computer task began with an initial familiarisation phase which consisted of 15 mock presentation trials. Participants were shown an image of the sun (representative of radial patterns) and an image of a target (representative of concentric patterns) to allow them to familiarise themselves with the keypresses. Results were not recorded during the familiarisation phase. Following this, participants completed four experimental runs with breaks in between each run. Response accuracy (number of correct pattern identifications) and RTs for each participant was recorded. Participants were debriefed upon completion of the study.

Data Analysis

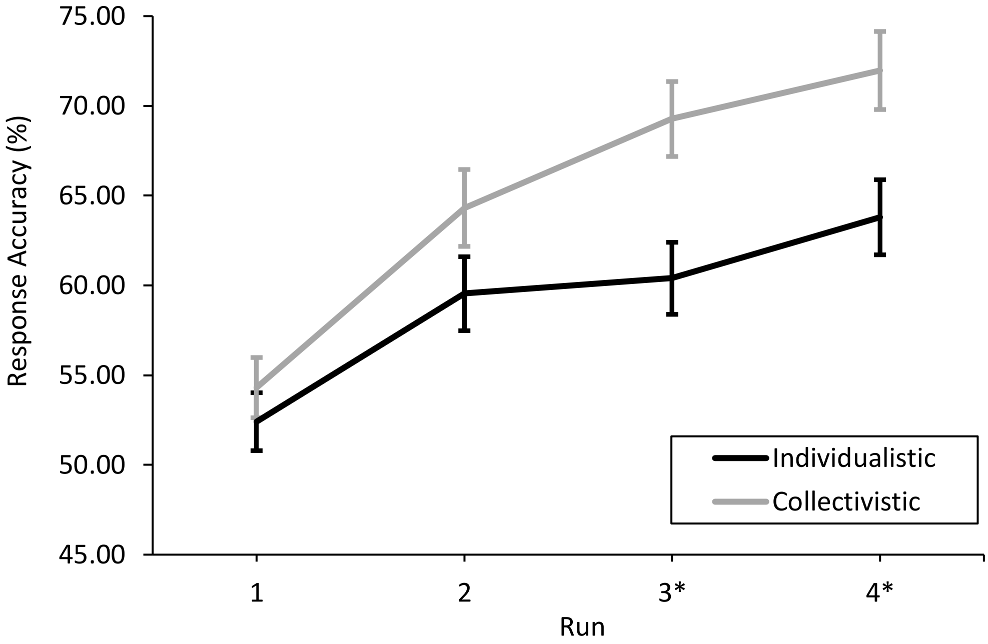
The data, which met parametric assumptions, was analysed in four steps; first, an analysis was conducted to test the hypothesis and identify if participants from collectivistic backgrounds had greater response accuracy compared to participants from individualistic backgrounds across each run. The second analysis examined cultural group differences in learning rates to substantiate the findings of the preceding analysis. Learning rates in the present study is defined as the slope of the linear line fitted for accuracy across four runs. A third analysis was then carried out to identify if group differences in performance accuracy could be attributed to the independent or interdependent self-construal categories that participants adhered to. Three participants whose scores were equal on both subscales were excluded from the third analysis as these participants could not be classified in either category. Lastly, a regression analysis revealed if cultural background and SCS values were predictive of overall accuracy and learning rates. Overall accuracy and learning rates (slope) represent different learning indices; the former reflects the general ability of participants to engage in global processing to support overall learning, while the latter reflects the rate at which participants learned to discriminate the patterns.

Results

We first compared response accuracy between the individualistic and collectivistic groups. A 2 (Background: Individualistic or Collectivistic) × 4 (Run: 1, 2, 3 and 4) mixed-measures ANOVA showed an interaction between background and runs ($F(2.58, 193.72) = 3.95$, $p = .013$, $\eta^2_p = .050$, Greenhouse-Geisser Corrected), suggesting learning differences between the individualistic and collectivistic groups. A main effect of runs ($F(2.58, 193.72) = 59.19$, $p < .001$, $\eta^2_p = .441$, Greenhouse-Geisser Corrected) indicated that both groups improved during training, while a main effect of cultural background ($F(1,75) = 7.30$, $p = .009$, $\eta^2_p = .089$) indicated that individualistic and collectivistic groups differed significantly in performance accuracy (see Figure 3). Importantly, post-hoc t-tests with multiple comparison adjustments revealed that although both groups initially exhibited similar accuracy performance at Run 1 ($p = .381$) and Run 2 ($p = .087$), the collectivistic group subsequently exhibited significantly better performance than the individualistic group at Run 3 ($t(75) = 9.59$; $p = .001$; Cohen's $d = .756$) and Run 4 ($t(75) = 8.83$; $p = .005$; Cohen's $d = .664$). These results suggest that the collectivist group had greater improvements during training compared to the individualistic group.

Figure 3

Line Graph of Response Accuracy between Individualistic and Collectivistic Groups



Note. Performance of the collectivistic (n = 37) group were consistently better than the individualistic group (n = 40). Response accuracy data is presented in percentages. The error bars represent standard errors.

To explore the difference in improvement during training further, we examined cultural group differences in learning rates (slope of accuracy across runs). A Welch's t-test for unequal variances conducted on the learning rates revealed a significant difference between the individualistic (M = 3.78; SD = 3.44) and collectivistic (M = 6.26; SD = 4.72) groups, t (75) = 7.00; p = .011; Cohen's d = .600, where the collectivistic group exhibited higher learning rates. These findings provide further validation for the interaction reported for the ANOVA above and illustrates the influence of culture on VPL. Indeed, the absence cultural group differences in RTs across all runs also suggest that the cultural variations in task performance are not confounded by the effects of differential response times (see

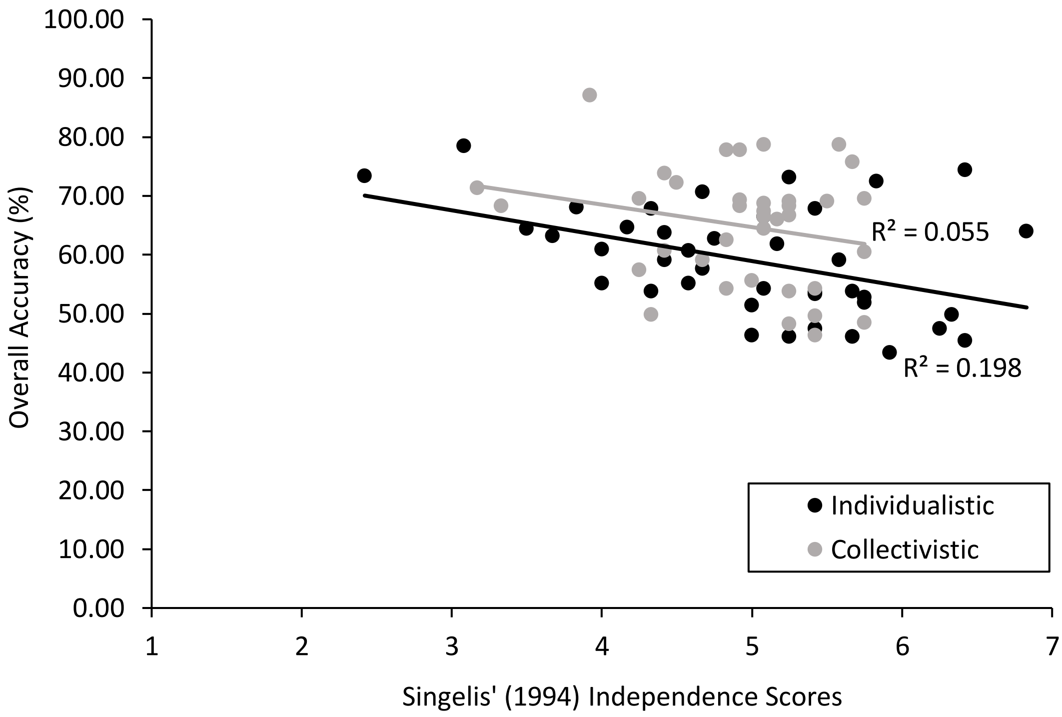
Figure S1). It can thus be presumed that the behavioural differences in accuracy performance and learning rates can instead be attributed to cultural group differences in global processing strategies.

The next analysis of participants' responses on Singelis' (1994) self-construal scale revealed that more participants identified with an interdependent self-construal (n = 46) than with an independent self-construal (n = 28), while three participants identified equally to both categories. A mixed-measures ANOVA revealed a non-significant interaction between self-construal and response accuracy across four runs (p = .792), while the between-subjects effect only approached significance (p = .091). A Welch's t-test on learning rates also revealed no significant difference between the independent (M = 4.43; SD = 4.29) and interdependent (M = 5.08; SD = 4.25) groups (p = .524). Taken together, it appears that the SCS cannot be used as dichotomous categories to explain cultural difference in VPL. However, since independent and interdependent SCS constructs can also be seen as continuous value dimensions rather than categorical traits at the individual level (Oyserman et al., 2002), people can adhere to both values in varying degrees on a continuum. A regression analysis was thus carried out to identify if variability in independent and interdependent scores, used as continuous rather than binary regressors, in addition to cultural background could be associated with overall performance and learning rates (see Figure 4 and 5).

For the first regression analysis, accuracy scores across all runs were collated to determine overall accuracy. Using the enter method, a multiple regression was run to predict the variability in overall accuracy (M = 267.25; SD = 43.36) using cultural background (individualistic or collectivistic), as well as independent (M = 4.96; SD = .808) and interdependent self-construal (M = 5.16; SD = .637) as predictor variables for the model. The assumptions relating to multicollinearity and independence of observations were met. Together, the predictor variables explained 17.2% (Adjusted R^2 = .172) of the variability in overall accuracy. The overall association between the predictor variables and accuracy performance was significant, F (3, 76) = 6.28, p = .001. Specifically, the individualistic (b = -23.97; p = .011) and independence (b = - 18.32; p = .002) variables had a significant and negative association with overall accuracy. Since both variables have been linked to analytic thinking (Choi et al., 2007), the lower predicted accuracy could be due to conflicting thought processes during VPL of global patterns. Conversely, interdependent values that are linked to holistic thinking was, as anticipated, positively associated with overall accuracy in the global processing task although it was not a significant predictor variable (b = 3.97; p = .585).

Figure 4

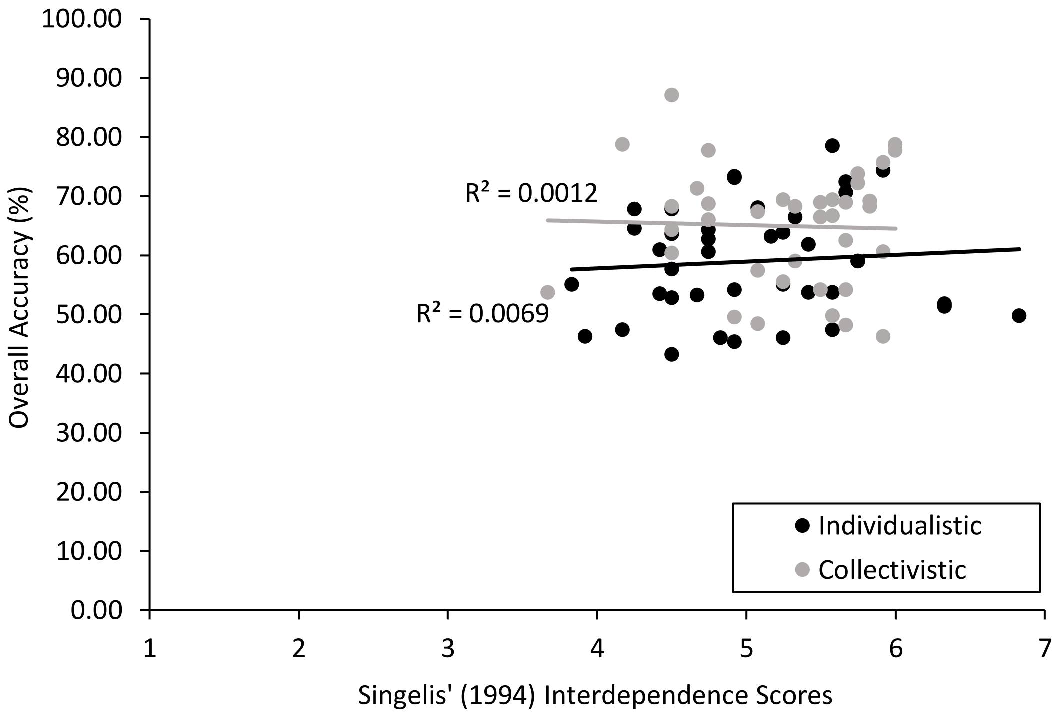
Scatterplot Depicting the Relationship between Independence SCS Scores, Cultural Background, and Overall Response Accuracy



Note. Individualistic cultural backgrounds and independence SCS scores were significant and negative predictors of overall accuracy.

Figure 5

Scatterplot Depicting the Relationship between Interdependence SCS Scores, Cultural Background, and Overall Response Accuracy



Note. The positive association between interdependent scores with overall accuracy was not significant.

The second regression analysis on learning rates revealed that the predictor variables explained 8.2% (Adjusted R^2 = .082) of the variability in learning rates, F (3, 76) = 3.26, p = .026. However, only individualistic backgrounds had a significant and negative association with learning rates (b = - 2.23; p = .021). Singelis' (1994) independence (b = -.635; p = .279) and interdependence scores (b = .995; p = .188) did not contribute significantly to this model. The inconsistent predictive influence of independent self-construal on different learning indices, i.e., overall accuracy and learning rates, will be considered in the discussion.

Discussion

The present study aimed to identify the influence of culture on VPL using training on a shape discrimination task. As hypothesised, the collectivistic group (Asian students) had greater performance accuracy and faster learning rates in this discrimination task compared to the individualistic group (European students). The greater learning rates and improvements in accuracy following training suggest an increased sensitivity to global forms amongst the collectivistic group despite the perceptual uncertainties evoked by embedded noise in the stimuli. These findings are in line with previous work in the area of cross-cultural research suggesting that collectivists are more holistic and attuned to the relationships between objects and events in the environment (Boduroglu et al., 2009; Boduroglu & Shah, 2017; Choi et al., 2007; Jenkins et al., 2010; Nisbett et al., 2001). To our knowledge, this is the first study to suggest cultural influences in VPL.

Interestingly, we observed cultural differences in VPL despite the global precedence effect (Gerlach & Starrfelt, 2018; Liu & Luo, 2019). Although both groups exhibited learning in the global pattern discrimination task, the learning trajectory appeared to diverge, with the collectivistic group showing greater accuracy by the end of the task. The group differences in the perception and learning of the global information in the shape discrimination task provide support for the proposition that Asians are more holistic (Jenkins et al., 2010; Nisbett et al., 2001). In contrast, it is possible that the propensity of Westerners to be more analytic and attentive to local information made it more difficult for them to improve in the perceptual learning task involving global forms. Our findings suggest that the analytic-holistic distinction between cultures influences VPL, particularly in tasks involving perceptual uncertainties. Furthermore, our results indicate that the behavioural differences observed between groups distinguished by their nationalities suggest that cultural influences may impact cognitive and behavioural processes (Blais et al., 2021; Caparos et al., 2020; Davidoff et al., 2008), although further research is needed to examine the specific cultural mechanisms underlying any differences in cognition and behaviour. Whilst the individualism and collectivism dimensions are useful for cultural group analyses, it is also important to consider an individual level of analysis to examine the dynamic influence of cultural systems on an individual's cognition and behaviour (Taras et al., 2016).

A standardised individual-level measure accounts for individual variations in goals, abilities, attitudes, and beliefs (Singelis, 1994). However, contrary to previous research (e.g., Hedden et al., 2008), we did not find significant cognitive or behavioural differences between participants with independent or interdependent self-construal as measured using Singelis' (1994) SCS. This could be due to limitations of the SCS and its possible insensitivity in measuring cultural distinctions. For instance, cross-cultural research participants are often highly susceptible to confounding variables such as socio-historical backgrounds, linguistic abilities, cognitive abilities (e.g., memory, attention) and ecological differences (e.g., Hakim et al., 2017). Alternatively, there could be a deficiency of cultural influences at the individual level on VPL abilities. The international sample, for example, may have skewed the results of the present study, as individuals who voluntarily immigrated may have psychological affinities to the culture they chose to live in (Morris et al., 2015). They may also amass multiple cultural identities through their exposure to varying sociocultural contexts (Morris et al., 2015). It is thus important to be cautious when generalising and interpreting contradictory evidence of cultural differences in cognition and behaviour.

Indeed, despite the lack of individual-level differences when self-construal was used as dichotomous traits, the regression outcomes for independence scores on the SCS still serves as an intriguing foundation for expanding research in this interdisciplinary domain of culture and VPL. For instance, independent self-construal, when applied as a continuous variable, was predictive of lower overall accuracy in the discrimination task. As mentioned earlier, independent and interdependent self-construal have been associated with distinct information processing strategies (Choi et al., 2007; Lin & Han, 2009; Nisbett et al., 2001). Therefore, independence, which is linked to analytic thinking, could affect the ways in which people perceive the global patterns as reflected in overall accuracy performance following training. However, independence was not predictive of significantly slower learning rates. The difference in the findings might have been observed because overall accuracy and learning rates represent different learning indices where the latter considers performance fluctuations over time. For example, group differences in learning rates could perhaps be better explained by other cultural variables that were not measured in the present study (Morris et al., 2015). Nonetheless, the self-construal findings should not be neglected as it would discount potentially important cultural findings. Future studies could instead employ further individual level differentiations such as cognitive styles (Choi et al., 2007) that could be more representative of individual-level cultural differences that impact VPL processes.

Although clear patterns sometimes do not emerge in cross-cultural research, individual-level analyses in future research remain indispensable for examining the dynamic nature of cultural systems (Na et al., 2019). For example, although individuals usually have stronger inclinations towards a specific cultural orientation to guide behaviours and cognitions, these values can shift according to varying social contexts (Grossmann & Jowhari, 2018; Kühnen & Oyserman, 2002). Consequently, there may be discrepancies in cross-cultural studies due to the ambiguity of which processes are susceptible to cultural influences (e.g., Hakim et al., 2017). That is, an individual exposed to different host cultures may develop seemingly conflicting self-construal and cultural mental representations that can be activated through primes to influence attentional and perceptual processes (Morris et al., 2015). Indeed, priming self-construal has previously been used to make cultural inferences on behaviour and neural responses (e.g., Lin & Han, 2009). Therefore, priming methodologies could be used in future studies to attribute cultural values and VPL abilities (Morris et al., 2015).

Cultural differences in VPL remains a relatively unexplored domain despite the recognition of how exposure to different cultural beliefs and social milieus can shape behaviours, cognition, and the brain's functional organisation (e.g., Han, 2015; Hedden et al., 2008; Park & Huang, 2010). Our study adds to our knowledge of cultural diversity, and research seeking further knowledge and acceptance of cultural distinctiveness of cognition and behaviours promotes equal learning opportunities for all. Further research in this domain is essential to reveal the nature of socio-cultural influences on perceptual learning and brain plasticity.

Conclusion

To our knowledge, the present study provides the first compelling evidence of cross-cultural differences in VPL. Culture mediates information processing (Blais et al., 2021; Caparos et al., 2020; Davidoff et al., 2008); and extending these findings to the VPL research domain, our results demonstrate that cultural differences in global processing can indeed affect learning. Despite the perceptual uncertainties induced by noise in the global patterns, the collectivistic group (Asian sample) showed greater improvements in response accuracy in the perceptual learning task compared to the individualistic group (European sample). However, there was a lack of differences at the individual level as represented by independent and interdependent self-construal, suggesting that further research employing priming procedures, cognitive screening, and neural measures are needed to explore the dynamic multilevel influence of culture on VPL. Nonetheless, our research offers novel insights into the role of socio-cultural influences on our ability to improve our perceptual decisions through training.

Ethical Compliance

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Compliance with Ethical Standards

All procedures performed in studies involving human participants were in accordance with the ethical standards of the Birmingham City University Ethics Committee (Reference: PSY_BSc_OCT17_001) and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Conflicts of Interest

The authors declare they have no conflict of interest.

Informed Consent

Informed consent was obtained from all individual adult participants in the study.

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