A Search for an Affective Index of Inhibition in the Narrowing of Attention Reveals Interactive Effects of Congruence and Exposure on Stimulus Liking

by

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ABSTRACT

A SEARCH FOR AN AFFECTIVE INDEX OF INHIBITION IN THE NARROWING OF ATTENTION REVEALS INTERACTIVE EFFECTS OF CONGRUENCE AND EXPOSURE ON STIMULUS LIKING

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The narrowing of attention is critical for survival. We examined whether inhibition supports this ability by combining a global/local-perception task with an affective-evaluation task. Because inhibition results in negative stimulus evaluations, we assessed whether stimulus ratings were more negative following the narrowing of attention (local-trials) than after the broadening of attention (global-trials). We found no evidence that changes in attentional breadth impact stimulus liking (Exp. 1-3: total N=364). We did, however, consistently observe that stimuli whose outer border and internal elements were the same shape (congruent) received more positive ratings than stimuli whose border and elements were different shapes (incongruent). Moreover, ratings of congruent, but not incongruent, stimuli decreased significantly between their first (baseline) and second encounters (post-task). Efforts to characterize these interactive effects revealed that they are not a simple function of exposure-frequency (Exp. 3) nor modulated by changes in attentional breadth (Exp. 4), highlighting the need for additional research.

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LIST OF ABBREVIATIONS

ANOVA: Analysis of Variance

ms: miliseconds

M: mean

SD: standard deviation

1 Introduction

The selection and concentration of processing resources on a relatively narrow region of visual space has critical survival value. Narrowing attention to a specific region leads to increased perceptual sensitivity and precision needed to fulfil goals and avoid threats (Castiello & Umiltà, 1990; Eriksen & St. James, 1986). As suggested by the 'zoom lens' account of attention, this is due to an increase in processing efficiency that occurs as the spatial size of the attentional focus decreases (Eriksen & St. James, 1986). The corresponding concentration of processing resources, akin to a zoom lens, gradually drops off with increasing distance from the focal center (Eriksen & St. James, 1986; Eriksen & Yeh, 1985).

The use of attentional tasks such as the flanker paradigm (B. A. Eriksen & Eriksen, 1974) has consistently revealed effects of such changes in the breadth of attention through the level of interference that the flanking distractors have on the speed and accuracy of target detection (Ito et al., 1998). The speed of visual search has also been observed to vary as a function of attentional breadth, with faster search resulting from increased precision of target-location processing that occurs as the attentional focus is narrowed (Briand & Klein, 1987; Greenwood et al., 1997). Dynamic changes in the scale of attentional focus, induced by varying the size of location pre-cues have likewise been shown to facilitate processing efficiency for both search (Greenwood & Parasuraman, 1999) and non-search related tasks (Castiello & Umiltà, 1990). Thus, resolving the competition for processing resources demanded by a vast array of information in the visual environment can be accomplished by narrowing the focus of attention.

The capacity of the visual system to vary the spatial scope of the attended area may help to promote effective attentional selection without having to shift a limited attentional window between multiple objects (Facoetti & Molteni, 2000; LaBerge, 1983). However, while there is evidence of a gradual reduction in the concentration of processing resources as a function of the size of the attentional focus, early accounts of such effects were not clear about exactly how the breadth of attention can be varied.

The present research considers two hypotheses about the specific mechanism(s) underlying changes in the scope of attention. In the *amplification-only hypothesis*, the narrowing of attention is achieved solely through the selective amplification of the stimulus representations within the focus of attention. In contrast, the *amplification-plus-inhibition hypothesis* posits that the amplification of the stimulus representations within the focus of attention is accompanied by active suppression of stimulus representations outside the focus of attention, and that these mechanisms thereby work together to determine the spatial scope of attention. Indirect evidence from a varied range of attentional paradigms (Chen & Treisman, 2008; Kreitz et al., 2020; Most et al., 2000) and the center-surround model that posits contributions from both attentional-facilitation and -inhibition (Cutzu & Tsotsos, 2003) favour the attentional amplification-plus-inhibition hypothesis. On the other hand, other views that posit a purely facilitatory account (Egner & Hirsch, 2005; Hommel, 2004; MacLeod et al., 2003) favour the amplification-only hypothesis. To test between these two hypotheses, we used a novel approach based on growing evidence that there is a strong link between inhibition and negative affect. Previously ignored or otherwise-inhibited objects, for example, subsequently receive more negative affective ratings than previously-unseen objects or the targets of attention (Fenske & Raymond, 2006; Raymond et al., 2003). Thus, in line with other work that has used stimulus ratings to provide an affective index of inhibition to establish its involvement in a given cognitive task (e.g., Kihara et al. 2011; De Vito & Fenske, 2018), we combined a global/local perception task with an affective evaluation task to obtain affective ratings of stimuli that had previously been perceived under conditions of broad (global perception) or narrow (local perception) attention in a search for evidence about the potential involvement of inhibition in the narrowing of attention. Specifically, if inhibition plays a role in the narrowing of attention, stimuli perceived with narrowed attention should receive more negative ratings than those perceived with a broad attentional focus.

1.1 The Potential Role of Inhibition

According to the amplification-plus-inhibition hypothesis, attentional inhibition is critical for the ability to narrow the focus of attention. Specifically, the suppression of perceptual signals from peripheral locations may facilitate the ability to amplify the processing of information inside the focus of attention. Early evidence of this can be seen in the work of Cepeda et al. (1998) in a task which recorded the reaction times to probes presented after digit search displays. They interpreted their results as evidence that selection is accomplished in part through the inhibition of locations of distractor digits relative to the target and to the background (Cepeda et al., 1998). Similar to the probe task, flanker tasks in which the scope of attention is varied using different sizes of cue (e.g., Facoetti & Molteni, 2000), have shown that the interference from irrelevant distracting flanking letters in target-identification response times is greater in the larger size cue condition than in the smaller size cue condition. The reduced interference in the small-cue condition has been interpreted as being due the effective inhibition of the distracting flankers when attention is narrowed.

Such evidence of feature-based inhibition of distractors and distractor locations is consistent with Tipper et al.'s negative-priming effect, in which responses to a target object are slowed significantly if it has previously been ignored in a previous encounter (Tipper, 1985), which has also been explained in terms of 'attentional inhibition of distractor representations' (Houghton et al., 1996; Tipper, 1985). According to such accounts, dual mechanisms involving both facilitatory and inhibitory processes are adaptive for two reasons: (a) amplification of target signal along with suppression of distractor signal improves the rate at which the target processing can be separated from distractor processing and (b) it amplifies the target signal when the capacity to do so is limited, despite equally strong target and distractor signals (Houghton et al., 1996).

A critical role for inhibitory processes is likewise supported at the neural level with the existence of the size of receptive fields in the extrastriate areas (Desimone & Duncan, 1995). To resolve ambiguity/competition between stimuli falling within the receptive field, spatial selection in the ventral stream, a cortico-cortical pathway important for object recognition, involves attenuation of response to a distractor location along with enhancing the processing of the stimulus at the attended location. Similarly, in their ambiguity resolution theory, Luck et al.

(1996) propose that inhibition of objects near the target resolves ambiguity at higher levels of the visual system as well as aids in accurately coding and maybe binding the features of the attended object.

One of the earliest theories of attentional selection which accommodated inhibition in the manner that these previous attentional paradigms have found support for is the ‘neighbourhood inhibition theory’ (Mounts, 2000). This theory states that the area immediately outside of the attentional selection forms an inhibitory ring and performance on detection and identification becomes asymptotic as a function of the increasing distance between the target and distractors. This role of inhibition corresponds with the functioning of the prefrontal cortex (Miller & Cohen, 2001) and the biased competition accounts proposed by Desimone & Duncan (1995). Their model of visual attention proposes that neural competition takes place through mutually inhibitory interactions and that only the ‘winner’ neurons contribute to the higher levels of processing. Further, Cutzu & Tsotsos, (2003)’s Selective Tuning Model posits that these strongest inputs to neurons are selected by the top-down winner-take-all (WTA) processes which prune input connections around the winner to form a center-surround distribution. Thus, a Center-Surround distribution takes the form of a Mexican hat where the attentional focus is accompanied by a suppressive surround and any information falling within this zone is inhibited. The attentional performance takes a dip after the excitatory peak at the suppressive zones before becoming asymptotic, this is represented by a U-shaped curve (Cutzu & Tsotsos, 2003; Yoo et al., 2018). Direct neurophysiological evidence has been shown to support this profile of cortical responsiveness with an excitatory center and an inhibitory surround and reaffirms the potential coexistence of attentional amplification along with inhibition (Hopf et al., 2006).

1.2 Is Inhibition Really Needed?

These previous investigations provide evidence that is consistent with accounts of selective attention that involve simultaneous operation of amplification and inhibition. If inhibition actually works in concert with attentional amplification to narrow our selective focus, it is important to verify this by developing experiments that can test competing predictions that arise from accounts of attention that involve inhibition against accounts of attention that don't involve inhibition.

Among the theories advocating a purely 'Amplification-only view', is a non-inhibitory account of negative priming, which posits the effect occurs, not as a lingering effect of prior inhibition, but instead as a result of the incompatibility of the retrieved memory of the object appearing as a distractor with the current experience of the object appearing as a target (Neill & Mathis, 1998). A similar solely facilitatory account has been proposed by Hommel (2004) to explain how the degree of feature overlap between objects from one trial to another can either facilitate or interfere with performance. Specifically, concerning the sequential effect of reduced interference after consecutive incongruent trials, Hommel suggests that the relative ease of processing is not due to inhibition of the irrelevant stimulus on the previous conflict trial, but instead due to the level of match between event-files in memory. This account also closely relates to another retrieval-based account known as the feature mismatch theory (Park & Kanwisher, 1994). These non-inhibitory accounts draw an important distinction between interference that disrupts current attentional focus and inhibition and MacLeod et al. (2003) strongly emphasize against the synonymous use of the two terms. This non-inhibitory attentional amplification hypothesis also finds support in the cognitive control studies where conflict resolution is shown to take place through the biasing of perceptual processing toward task-relevant stimulus properties (Egner and Hirsh, 2005). In high control conditions, when the face stimuli were presented as targets, an increased functional coupling in the DLPFC and FFA in the was found, but not in the face-distractor condition (Egner & Hirsch, 2005), which they took as evidence that conflict adaptation was not mediated by selective inhibition of distractor processing, but through conflict-sensitive biased processing of target-feature. Thus, the attentional amplification-plus-inhibition view doesn't stand unopposed and is directly contradicted by the attentional amplification-only view as elucidated above.

Taken together, previous research presents us with two contrasting hypotheses of attentional selection that explain how we narrow our focus of attention: amplification-plus-inhibition versus amplification-only. Determining which of these two hypotheses best accounts for our ability to narrow the focus of attention requires a measure that is sensitive to attentional inhibition. This motivates the decision in the present research to consider growing evidence that inhibition has affective consequences for associated stimuli that can provide an index of its involvement in a given cognitive task (De Vito & Fenske, 2018; Kihara et al., 2011).

1.3 Affective Devaluation by Inhibition

There is growing evidence that the inhibition of distracting or otherwise-problematic stimulus representations elicits negative affect (Clancy et al., 2019) that leads such items to subsequently receive more negative ratings than novel items or the targets of attention (e.g., Raymond et al., 2003). Across a diverse range of attention-based paradigms, the stimuli encountered under experimental conditions thought to involve inhibition become affectively devalued compared to stimuli encountered under conditions in which inhibition is not thought to be required (for reviews, see Fenske & Raymond, 2006; Raymond, 2009; Gollwitzer et al., 2014). For instance, showing a subset of the distractors from a visual-search array before the rest of the distractors and the target leads to faster search times than when all items appear together, an effect attributed to the opportunity to inhibit the previewed distractors prior to the target onset (Watson & Humpreys, 1997; Allen & Humpreys, 2007). Fenske et al.'s (2004) discovery that the previewed distractors are subsequently rated more negatively than those that appear together with the target was taken as evidence that the relatively greater inhibition applied to the previewed distractors led to their relatively greater devaluation. This relative priority of inhibition in determining emotional responses was also noted given that—according to accounts of the mere exposure effect—the increased exposure of the previewed distractors should have resulted in more positive affective evaluations of them due to the enhanced fluency of processing that comes with increased exposure (Jacoby & Dallas, 1981; Zajonc, 1968). Instead, the stimulus ratings appeared to be determined more by the negative affective consequences of inhibition than any positive effect of increased exposure (Fenske et al., 2004). As more direct evidence of the link between inhibition and stimulus devaluation, De Vito et al. (2017) found that the Pd event-related-potential—an index of distractor inhibition— was larger during trials of an attention task whose distractors subsequently received the most negative affective evaluations than during trials whose distractors received less negative evaluations. In other words, trial-by-trial fluctuations in the electrocortical measure of distractor inhibition were predictive of how negatively the corresponding stimuli would be rated later on (De Vito et al., 2017). The rapid increase in observations of distractor devaluation effects across so many different attention-related paradigms (Griffiths & Mitchell, 2008; Raymond, 2009; Raymond et al., 2003; Veling et al., 2007), and the corresponding growth of evidence of the link between inhibition and stimulus devaluation prompted stimulus ratings to be used as an index of distractor inhibition in an investigation of its potential role in attentional blink tasks (Kihara et al., 2011) and to assess whether inhibition plays a role in maintaining representations in the accessory mode of working memory (De Vito & Fenske, 2018). These studies have therefore established the use of stimulus ratings as an acceptable way of testing for the potential involvement of inhibition in a given cognitive operation, such as that underlying the ability to narrow the focus of attention.

In light of the evidence that affective ratings of the stimuli encountered during a given task can provide evidence of the potential involvement of inhibition in that task, they may also provide a promising and effective measure to test between the two competing hypotheses about the mechanisms underlying our ability to narrow the focus of attention. According to the amplification-plus-inhibition hypothesis, stimuli perceived with a narrow focus of attention should subsequently receive more negative affective ratings than those perceived with a broad focus. In contrast, the amplification-only hypothesis provides no reason to expect any decreases in the ratings of stimuli perceived with a narrow focus of attention compared to ratings of previously-unseen items or those perceived with a broad focus of attention.

2 Experiment 1: Is Inhibition Involved in Narrowed Attention?

It is important to consider the nature of stimulus displays especially when relevant and irrelevant information are a part of the same object (Chen, 2003). We make use of a single stimulus object with both relevant and irrelevant characteristics and spatial attention is varied with verbal instructions to attend to one or the other prior to every trial. Thus, we manipulated attention by creating a set of hierarchical stimuli that each contain both a global outline and local elements whose shapes can be varied independently. These were inspired by the type of hierarchical stimuli commonly used in global/local attention tasks in which participants are instructed to identify either the outer global feature or the inner local feature (Navon, 1977). Our stimuli were each comprised of a large shape whose outer border was either a circle or square that was filled with smaller shapes that were either all circles or all squares. Each item could be ‘congruent’ in terms of having the same shape at both the levels, or it could be ‘incongruent’ by having different shapes at the different levels. Responses are typically slower for incongruent stimuli than for congruent stimuli when participants are asked to attend to and discriminate only the local dimension or only the global dimension due to the conflict between the target level and the other level (Kinchla et al., 1983). Thus, there is often a trade-off between the processing of one structural level (e.g., global) at the cost of another (e.g., local). Whether this trade-off involves the inhibition of the non-cued information is a key question of interest.

After the administration of this Global/Local Attention manipulation task, we measured how much participants like each of the stimulus images to provide an affective index of the potential involvement of attentional inhibition (De Vito & Fenske, 2018; Kihara et al., 2011). We were specifically interested in a comparison of the average affective ratings of stimuli perceived with broadened attention during global trials to those of stimuli perceived with narrowed attention during local trials. Baseline affective evaluations were obtained for all stimulus images at the beginning of the experiment before the introduction of the global/local attention-manipulation task. If the narrowing of attention involves inhibition, then the ratings of stimuli perceived with a narrow focus of attention should be more negative than the baseline ratings of those items, and more negative than the ratings of the stimuli perceived with a broad focus. If the narrowing of attention does not involve inhibition, then stimuli from both global and local trials should be liked more than baseline due to the affectively positive effect of repeated exposure in the absence of inhibition (Zajonc, 1968)

2.1 Methods

All materials and procedures used in this study were approved by The University of Guelph Research Ethics Board (REB: 17-10-013).

Participants

A total of 206 participants completed the study from start to end. Of the 206 total participants (Age M = 19.26, SD = 1.74), 151 identified as female, 54 identified as male, and 1 as other.

We used an approach to determine the smallest effect size that would have been significant in a previous study (Lakens et al., 2018) with the same measure (affective ratings) and which looked at the effects of attention as a function of visuospatial eccentricity (Raymond et al., 2005). d = 0.27 is the smallest sample d-value that would have been significant in Raymond et al. (2005) with n = 40, alpha=0.05, $t(39)$ = 1.68 for a repeated measures design. Thus, assuming d = 0.27 for a one-tailed alternative hypothesis and if we want a 90% chance of finding our effect if it exists, we would need at least 119 participants. Informed consent was obtained from every participant prior to the experiment.

This experiment was conducted online; participants accessed the study through Pavlovia, an online server to run experiments built in Psychopy (Peirce, 2007).

Stimuli

The hierarchical shape stimuli are in the form of Mondrian-like patterns. The Mondrian patterns were developed using a custom python code and uniform sized circular and square masks were applied using Pillow (PIL: Python Imaging Library) and adapted from a base code posted by an anonymous coder (https://note.nkmk.me/en/python-pillow-square-circle-thumbnail/). Opacity and Contrast were controlled across all images.

We generated Mondrian patterns by utilizing our custom python code to draw 150 elements of randomly generated sizes at random locations on the screen at a time. The colour for a single element was randomly selected from the following predetermined set of colours: red, blue, green, purple, pink, orange, yellow, brown, grey, turquoise and violet. Thus, within one global shape, there were either 150 overlapping circles or squares of varying sizes and colours. After the last shape was drawn, a screenshot of every unique pattern was saved. Next, we applied a circular mask of radius 2.64 centimetres or a square mask of side 2.64 centimetres to these patterns. We created a total of 128 Mondrian patterns, 64 are clusters of circles and 64 are clusters of squares. We applied the circular mask over 32 clusters of circles and 32 clusters of squares. Similarly, we applied the square mask over 32 clusters of circles and 32 clusters of squares to create a total of 128 unique images. The codes for generating the circle and square Mondrian patterns and the application of the circular and square mask are available on this project's OSF page [https://osf.io/9hsf4].

The Circles and Squares are the two main categories of global shapes which are made of smaller circles and squares. Hence, there are four types of images, namely (global-local, see Figure 1 below): Circle-circles, Circle-squares, Square-circles, Square-squares. Congruency is determined by the match between the global and local elements of a single image. In Figure 1, the 2 outermost figures are congruent images and the 2 innermost figures are incongruent images. There are 128 unique images with an equivalent number assigned to the global and local conditions, as well we have an equal number of congruent and incongruent images.

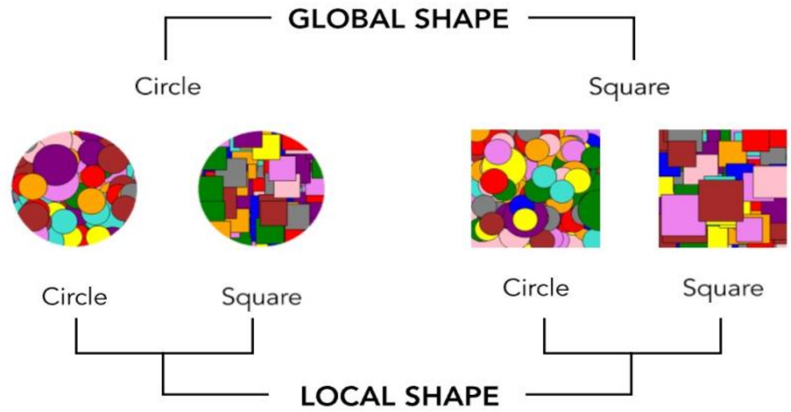

Figure 1. Examples of Mondrian-like patterns used as hierarchical stimuli in the Global/Local perception task. The outer border (global shape) of each pattern was either a circle or a square. The internal elements (local shape) of each pattern were either all circles or all squares.

Design

Participants were provided brief information about the experiment adequate to sign the declaration of consent. The study includes the following three phases: Baseline Affective Ratings, Practice Trials- Global/Local attention manipulation and Global/Local attention manipulation + Affective evaluation and the Main experimental trials. Block-wise self-paced breaks were provided to the participants, however the participants were asked to ensure that the breaks were not too long in duration.

Baseline affective ratings: The 128 unique stimulus images that were utilised in the main experiment were presented in the beginning of the study to obtain a baseline of the affective ratings for every individual. Along with the measurement of change in affective ratings after subsequent manipulations, this helped in controlling for any individual preferences for shapes. The images were of an appropriate size in relation to the screen to ensure high visibility and were presented for a duration of 200 miliseconds. A scale ranging from 1 to 100 appeared below all images, where 1 stands for ‘didn’t like it at all’ and 100 for ‘liked it a lot’ and remained on the screen even after the image disappeared until the participant provided a rating.

Practice trials: Participants were provided training on the two tasks that were performed in the main experiment. First the global/local attention manipulation task was presented. Upon reading the instructions, a different set of stimulus images from the main experimental set were shown and they were asked to either identify the global or the local element in separate global/local blocks. By not repeating the same images (from the main set) a second time, we are trying to control for the effects of familiarity as this form of perceptual fluency/mere exposure effect has been shown to bias towards a positive judgment of objects (Zajonc, 2001). Participants completed 2 blocks of 8 trials each and identified either the global shape (circle or square) or the local shapes (circle or square) as per the instructions provided before every block. The presentation duration of the stimulus image was increased to 300 milliseconds during the practice trials, giving participants adequate time to learn the task. The sequence of blocks were counterbalanced across participants to control for the interference effects (Navon, 1977). Feedback about the accuracy was given after every trial. After completion of the two blocks, feedback on percentage of accuracy across two blocks was presented. If the accuracy was <90 percent, they were asked to perform 2 additional blocks with 8 trials each. This phase ensured that the participant understood the task and can perform top-down regulation of attention.

The next phase of practice trials included the affective evaluation task in addition to the Global/Local task. Thus, 16 more trials across 2 blocks of global and local attention followed the first phase of practice trials. No feedback was provided for the global/local attention task in this phase. Thus, at this stage, participants got practice with the progression of a single trial in the main experiment.

Main experiment: Finally, in the main experiment participants performed both the tasks across a total of 128 trials. Global and Local trials were blocked twice with 32 trials per block. Instead of randomisation of global/local trials, we chose to block them to obtain a more effective measure of top-down regulation of the varying spatial focus of attention (Driscoll et al., 2021; Hanif et al., 2012). We similarly know from Global/Local processing studies about the Global Interference effect, where local trials preceded by global trials are more likely to experience slower processing as compared to global trials preceded by local trials (Navon, 1977). Thus, the sequence of the blocks were counterbalanced across the participants, such that half of the participants were presented the blocks in the following order: global, local, global, local, while the other half were presented in the order of local, global, local, and global. No two same condition blocks followed each other consecutively to control for the effect of adaptation.

Before every block and every trial, a text cue indicated whether they need to report the global or local elements of the image. Each stimulus image was presented on screen for 200 milliseconds, matching the baseline exposure time. This was followed by a screen prompting them to identify the global or local shape by choosing between circle and square. They were asked to make a mouse click on the correct shape shown on the screen (square or circle) to indicate their response. The location of the square and circle was also counterbalanced across participants such that for half of them, square appeared on the right hand side of the fixation cross and for the other half it appeared on the left hand side of the fixation. The location of the square and circle response shapes were consistent for a single participant throughout the experiment. Thus, considering this in addition to the sequence of blocks, participants were randomly assigned to any one of the four counterbalanced blocks:

Global-Local-Global-Local—Square on right

Global-Local-Global-Local—Square on left

Local-Global-Local-Global—Square on right

Local-Global-Local-Global—Square on left

A fixed duration for the presentation of every stimulus image instead of allowing them to disappear after response would control for the varying visual exposure times taken by different participants. That said the circle/square response shapes disappeared only after a response was made.

The presentation of the attention manipulation instruction before every block begins was retained on screen until participants indicated their readiness by clicking on the fixation cross in the centre of the screen. Further, every trial proceeded in the following manner: A Global/Local prompt was presented once before every block to alert the participants of the upcoming attention block, providing participants adequate time to prepare a broader or narrower focus. They indicated their readiness to begin the block by clicking on the fixation cross. Next, a Global/Local cue was presented before every trial and participants began the trial by clicking on the fixation cross. It was followed by the stimulus image on the screen and it remained there for 200 milliseconds. Upon its disappearance, participants were expected to identify whether the global shape or the local shapes were circles or squares. After this, a fixation cross was presented again for centring their mouse click and the same image that underwent the attentional manipulation was presented on screen for 200 milliseconds at the same location and occupying the same space. Lastly, they were asked to provide the affective evaluation rating in the form of liking on a scale of 1 to 100. A question mark remained on screen until a response was provided.

Individual difference measures: Individual differences in attention and cognitive-affective responses are known to be linked with an individual's attentional difficulties and emotional responses (Hunter and Eastwood, 2016; Malkovsky et al. 2012; Thomson et al. 2015). Thus, we included some individual differences measures to help us understand the potential link between attention and individual difference factors such as boredom. Boredom has been conceptualized as the inability to adequately engage attention on internal or external information (Eastwood et al., 2012). Boredom proneness has also been found to be correlated with another form of attentional failure, spontaneous mind-wandering (Isacescu et al., 2017). There could be differences in every individual's ability to control the expansion and contraction of spatial attention scope. If boredom and mind-wandering reflect poor attentional control, then individuals prone to boredom and mind-wandering should be less effective at applying inhibition than those with good attentional control. Thus, we employed measures of boredom and mind-wandering as measures of attention check for this study as well as included two questionnaires to assess these individual differences. Further, varying the focus of attention has been found to be associated with specific changes in mood (Hanif et al., 2012; Hanif & Fenske, 2020). Thus, we were interested in understanding if mood can be regulated by changes in attentional focus. To that end, we partially integrated Hanif and Fenske's design to understand changes in mood caused by Global and Local attention.

After every block, participants were asked to rate their current state of mind on the following three questions for measuring the possible effects of attentional manipulation on boredom, mind-wandering and mood:

(A) How bored were you right before these questions? – rating on a scale of 1 (not bored at all) to 100 (extremely bored)
(B) To what extent were your thoughts focused only on the experimental tasks just now? – rating on a scale of 1(not at all) to 100 (entirely)
(C) How would you rate your mood right before these questions? – rating on a scale of 1 to 100 (1- positive, 25- somewhat positive, 50- neutral, 75- somewhat negative, 100- negative)

We also added, the 'click cross to continue' prompts between each question just like in our main experiment to center the mouse click so as not to let the default mouse location from the previous trial bias the subsequent ratings they provide.

Post-task questionnaires: After the completion of the experiment, participants were asked to complete the following two questionnaires as measures of individual differences:

(A) State Boredom Proneness Scale (Struk et al., 2017)- 12 questions on a 7-point Likert scale.
(B) Spontaneous and Deliberate Mind-wandering scales (Carriere et al., 2013)-8 questions on a 7-point Likert scale.

Data Analysis

We pre-registered this study on the Open Science Framework (https://osf.io/9hsf4), including the criteria used to identify data that needed to be excluded prior to the final analysis. We excluded the data from 21 participants who failed to understand the task instructions, as reflected by their inability to correctly answers at least 3 of the 4 questions on the instruction-information quiz. We excluded the data from 13 additional participants who failed to follow the task instructions by repeatedly clicking on the same middle section of the affective rating scale (i.e., 75% or more of their rating scores in the 48-52 range of the 100-point scale). The data from 12 additional participants were excluded due to their inability to make correct responses on at least 90% of the practice or experimental attention-task trials. The 6 participants who reported in the post-task questionnaire being externally distracted for at least 40% of the experiment were also excluded. The data from the remaining 154 participants were included in our final data analysis.

When considering reaction times, any trial with a response that was 2.5 SDs slower or faster than the mean reaction time for that participant was considered an outlier and therefore excluded from further analysis (X% of trials). When considering affective ratings, we excluded ratings of stimuli from trials in which an error was made in the attention-task response due to the fact that errors are associated with their own negative affective consequences (Chetverikov, 2014).

2.2 Results and Discussion

Affective Ratings: Main hypothesis

To assess whether stimuli perceived under conditions of narrowed attention subsequently received more negative ratings than those perceived under conditions of broad attention, we calculated average stimulus ratings for each type of stimulus from each experimental condition at each point in the experiment and submitted the resulting values to a 2 (Attention: Global, Local) X 2 (Phase: Baseline, Post-attention) X 2 (Congruency: Congruent, Incongruent) repeated-measures ANOVA. Our analysis revealed that stimulus liking was not significantly affected by any attention-related differences during global versus local trials (Attention main effect: $F\ (1, 153)$ = 3.54, *MSE* = 60.24, p = .06, *generalized* η^2 = 0.0002). If Attention had influenced affective ratings for stimulus images, it would have emerged in the attention phase and been reflected in an Attention x Phase interaction. However, this interaction was also not significant ($F(1, 153)$ = 1.65, *MSE* = 20.39, p = .20, *generalized* $\eta 2$ = 0.005). Taken together, these results fail to support either the amplification-only or amplification-plus-inhibition hypothesis.

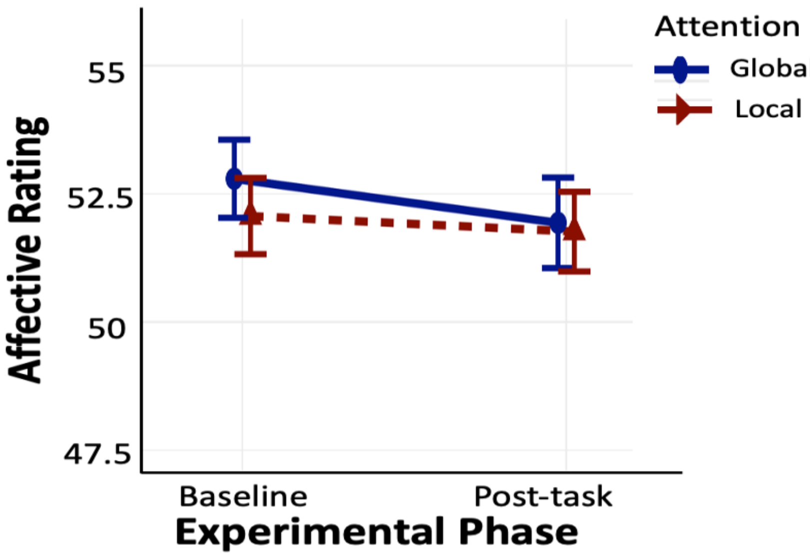

Figure 2. Average affective ratings of Mondrian-like patterns that appeared as stimuli on Global trials or Local trials of the Global/Local attention task in Experiment 1. Affective ratings were obtained for each stimulus both before the attention task (Baseline) and after the attention task (Post-task). The rating scale ranged from 1 to 100, with higher scores representing more affectively positive ratings. Error bars represent 95% confidence intervals.

While we found no evidence of any effect of attention, there was a significant effect of stimulus congruency ($F\ (1, 153)$ = 40.94, *MSE* = 22,215.22, $p < 0.001$, *generalized* $\eta 2$ = 0.1). As can be seen in Figure 3, congruent items—circle images whose internal elements were circles and square images whose internal elements were squares—were liked more, on average, (*M* = 56.38, *SD* = 14.32) than incongruent items whose outer shape and internal elements were different shapes (*M* = 47.89, *SD* = 12.60). Moreover, there was a significant interaction between Congruency and Phase (*F (1, 153)* = 6.69, *MSE* = 271.77, *p* = .02, *p*< 0.05, *generalized η2* = 0.001), whereby liking of congruent items decreased significantly from the first encounter (baseline ratings: *M* = 57.14, *SD* = 13.92) to the second encounter (post-task ratings: *M* = 55.62, *SD* = 14.70, *t (153)* = 2.22, *p* = .03, *Cohen's d* = 0.12) whereas there were no changes in liking for incongruent items between the first (baseline ratings: *M* = 47.48, *SD* = 12.54) and second encounters (post-task ratings: *M* = 47.71, *SD* = 12.63), *t (153)* = -0.48, *p* = 0.631, *Cohen's d* = -0.03). The use of stimulus congruency was intended as a tool for the manipulation of global and local attention, but surprisingly, it ended having the largest effect in the study. The decrease in liking for congruent images from first to second encounter is particularly interesting, given that we had predicted an increase in liking due to repeated exposures as established by the mere exposure effect (Zajonc, 1968).

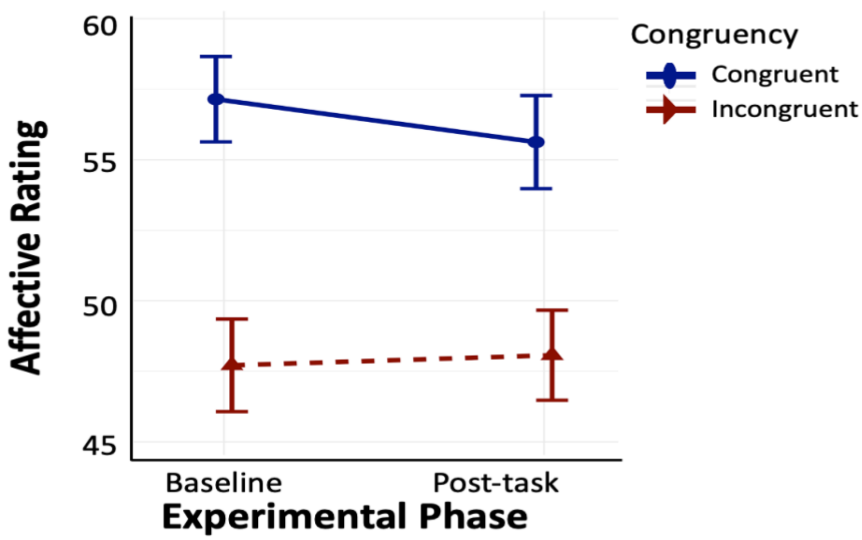

Figure 3. Average affective ratings of Mondrian-like patterns whose internal elements were the same shape as that of their outer border (congruent) and items whose local elements and global shape were different (incongruent) in Experiment 1. Affective ratings were obtained for each stimulus both before the attention task (Baseline) and after the attention task (Post-task). The rating scale ranged from 1 to 100, with higher scores representing more affectively positive ratings. Error bars represent 95% confidence intervals.

Affective Ratings: Individual differences.

To evaluate the role of individual differences in attentional difficulties, we considered whether individual differences had an influence on the affective ratings provided during the experiment. We filtered the affective ratings according to the attention condition to assess how people belonging to high versus low state or trait based individual differences rated images viewed with Global or Local attention. We found that there was no significant difference in the affective ratings between the high and low state boredom groups provided after the attention task for both the global ($t\ (152) = 0.093$, $p = .925$, *Mdiff* = 0.17, *95% CIs* = [-3.41, 3.75]) and local conditions ($t\ (152) = 0.16$, $p = .871$, *Mdiff* = 0.29, *95% CIs* = [-3.18, 3.75]). We find similar results for those grouped into high and low mind wandering and affective ratings after both global ($t\ (152) = -0.51$, $p = 0.611$, *Mdiff* = -0.92, *95% CIs* = [-4.50, 2.65]). and local attention ($t\ (152) = -0.87$, $p = 0.383$, *Mdiff* = -1.53, *95% CIs* = [-4.99, 1.93]). We also find no significant difference in affective ratings between groups who on an average provided more positive mood ratings versus those who provided more negative mood ratings after both the global ($t\ (152) = -0.81$, $p = .418$, *Mdiff* = -1.46, *95% CIs* = [-5.04, 2.10]). and local attention ($t\ (152) = -0.84$, $p = 0.399$, *Mdiff* = -2.95, *95% CIs* = [-4.94, 1.98]). This was surprising in the light of the significant positive correlations we find between the average mood ratings and affective ratings after both the global ($r = 0.22$, $p = 0.006$, $p < 0.01$, *95% CIs* = [0.06, 0.36]) the local attention condition ($r = 0.21$, $p = 0.010$, $p < 0.05$, *95% CIs* = [0.05, 0.35]). All the other correlations have been reported in Table 2. This may hint at some support for the Global attention-positive affect and Local attention-negative affect link that has been shown in some previous studies (Srinivasan and Hanif, 2010, Hanif et al. 2012).

Similar to the state-level measures, we find no significant differences between high and low groups formed based on the trait-level measures of Boredom Proneness and Spontaneous Mind-wandering. There was no significant difference in affective ratings between high and low Boredom Proneness groups after the global attention condition ($t\ (152) = -0.81$, $p = 0.418$, *Mdiff* = -1.46, *95% CIs* = [-5.04, 2.10]), but we found the difference to be significant after the local attention conditions (*t (152)* = 2.10, *p = 0.04*, *p < 0.05*, *Mdiff* = 3.63, *95% CIs* = [0.22, 7.05]). On the other hand, there was no significant difference in affective ratings between high and low Spontaneous Mind-wandering groups after both the global (*t (152)* = -0.32, *p = 0.747*, *Mdiff* = -0.59, *95% CIs* = [-4.16, 2.99]) and local attention conditions (*t (152)* = -0.21, *p = 0.836*, *Mdiff* = -0.37, *95% CIs* = [-3.83, 3.10]).

Manipulation checks: Cognitive-Behavioural Performance

While affective ratings of liking was our primary measure for this study, cognitive behavioural measures such as reaction times and accuracy for the attention task were important considerations as manipulation checks. Shorter reaction times and higher accuracy for Global stimuli have been shown to be good behavioural performance indicators for an effective manipulation of spatial attention when utilizing the Hierarchical Global-Local task (Hughes et al., 1984; Navon, 1981). We found no significant differences in reaction times (*t (153)* = 0.10, *p* = .32, Global: *M* = 0.92, *SD* = 0.20, Local: *M* = 0.91, *SD* = 0.19*)* for performing the global/local attention task. While there is a significant difference in accuracy (*t (164)* = -3.94, *p* = 0.00, *p* < 0.01, *Mdiff* = -0.014, *95% CIs* = [-0.02, -0.007]) on the attention task between images viewed with global and local attention, we found the accuracy to be higher for local attention (M = 0.98, SD = 0.13) as compared to global attention (M = 0.97, SD = 0.18). These manipulation checks further confirm that the task we employed for manipulating spatial attention did not produce patterns of performance that are typical of Global-Local hierarchical tasks.

To ensure that the lack of differences in reaction times for the attention task cannot be attributed to any individual difference factors, we analysed the differences in high and low groups for each of the three individual difference factors. Except the state boredom ratings for the local attention condition, we found the differences in reactions times between high and low groups between all other individual difference factors to be not significant. We found a significant difference in reaction times between high and low state-boredom and reaction times for the local attention condition (*t (152)* = 2.00, *p* = .046, *p < 0.05*, *Mdiff* = 0.05, *95% CIs* = [0.00, 0.11]). When we consider the average reaction times, we find a negative correlation between reaction times on the attention task and state boredom ratings (r =-0.16, p = 0.044, $p < 0.05$, *95% CIs* = [-0.31, -0.004]). Thus, the participants who were more prone to boredom had faster reaction times on the local attention trials. Boredom has been closely associated with mind wandering (Isacescu et al., 2017). According to the attention-resource account of mind-wandering (Smallwood and Schooler, 2006), a competition ensues between on and off task thoughts to draw on resources from the same limited attentional pool. Consequently a negative correlation in the form we have observed for boredom and reaction times has been shown to be a reflection of a low-attentionally demanding task (Thomson et al. 2014). Thus, lower attentional resources were required to complete the Global-Local hierarchical tasks, that we utilized to manipulate spatial attention in this study.

The overall results suggest that the most individual difference factors had no influence on the lack of differences in reaction times between global and local attention conditions and might not be able to account for why we did not produce the typical patterns seen in Global/Local hierarchical stimuli, i.e., faster reaction times for global in comparison to local attention trials.

Table 1. Descriptive Statistics and Correlation matrix for individual-difference factors, affective ratings of stimuli encountered and reaction times for the attention task on global or local trials in Experiment 1

		State Boredom (1-100)	State Mind-Wand-ering (1-100)	Mood (1-100)	Trait boredom (1-7)	Trait Mind-Wand-ering (1-7)	Global affective ratings (1-100)	Local affective ratings (1-100)	Global reaction times (in seconds)	Local reaction times (in seconds)
State Boredom	M	62.53								
	SD	21.44								
	r	1.00								
State Mind-Wand-ering	M	-	37.01							
	SD	-	22.76							
	r	0.23**	1.00							
Mood	M	-	-	40.90						
	SD	-	-	18.38						
	r	-0.54***	-0.31***	1.00						
Trait Boredom	M	-	-	-	3.78					
	SD	-	-	-	1.17					
	r	0.24**	-0.02	-0.14	1.00					
Trait Mind-Wand-ering	M	-	-	-	-	4.59				
	SD	-	-	-	-	1.19				
	r	0.09	-0.10	-0.03	0.43***	1.00				
Global affective ratings	M	-	-	-	-	-	52.36			
	SD	-	-	-	-	-	10.15			
	r	-0.02	-0.03	0.21**	-0.05	0.00	1.00			
Local affective ratings	M	-	-	-	-	-	-	51.91		
	SD	-	-	-	-	-	-	10.04		
	r	-0.04	0.02	0.21**	-0.02	0.02	0.90***	1.00		
	M	-	-	-	-	-	-	-	0.92	
	SD	-	-	-	-	-	-	-	0.20	

Global reaction times	r	-0.12	-0.03	0.03	-0.01	0.03	0.23**	0.22**	1.00	
Local reaction times	M	-	-	-	-	-	-	-	-	0.91
	SD	-	-	-	-	-	-	-	-	0.19
	r	-0.19*	0.00	0.05	-0.06	0.03	0.20*	0.20*	0.80***	1.00

$^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

3 Experiment 2: Does Stimulus Size Modulate the Extent of Inhibition Involved in Narrowing the Focus of Attention?

The online format of data collection for Experiment 1 was hugely beneficial to this study for easily obtaining a large number of participants in a short period of time. Employment of a number of different attention checks and associated pre-determined exclusion criteria helped us in getting a reliable dataset to be able to answer our primary research question. Controlling for stimulus size is particularly crucial in our study as the main experimental manipulation involves broadening and narrowing of attention across space on the screen. This might be one reason why, in Experiment 1, we failed to manipulate spatial attention in the form that requires. If the stimulus is not large enough, requiring the inhibition of one level over another, all stimulus images may have been perceived with narrowed attention. As illustrated in Figure 2, results from Experiment 1 show that affective ratings for images viewed with both global and local attention are trending towards devaluation from the baseline ratings. This might be attributed to the overall small size of the stimuli in proportion to the screen requiring participants to employ only local attention as opposed to switching between broad versus narrow attention. To ensure that our experimental manipulation is not rendered ineffective owing only to the small size of the stimulus images, we conducted Experiment 2, with an increase in the size of our stimuli that is twice as big as the size we used in Experiment 1.

Another possible source of unexplained variability in our data, as it relates to stimuli size, might be the lack of experimental control over the angular dimensions of stimuli that are affected by participants varying screen sizes and viewing distances. One immediate limitation of online administration of studies is our inability to keep such factors constant in a laboratory using the same monitor for every participant and a physical chinrest. In the current experiment, we incorporated the Virtual Chinrest to estimate participants viewing distances that allowed us to calibrate the size of the stimuli (Li et al., 2020), such that it always has the size of 10 * 10 centimetres. This novel method makes use of two procedures to make this estimation: the Card Task and the Blind Spot Task. This method was found to produce the best estimates of viewing distance in comparison to other methods based on body height or arm's length distance in online experiments (Brascamp, 2021).We adapted the tiered approach, proposed by Brascamp (2021) that makes use of the benefits of the blind spot based method, while also getting measures of body height and screen type to be prepared in the event of data loss associated with an unsuccessful performance of the blind spot task.

Similar to Experiment 1, we predict that if narrowing the focus of attention involves inhibition then stimuli perceived with a narrow focus of attention will receive more negative affective ratings than those perceived with a broad focus

3.1 Methods

Participants

A total of 136 participants completed the study from start to end. Of the 136 total participants (age *M* = 21.56, *SD* = 1.75), 92 identified as male, 42 identified as female and 2 as other.

As the current experiment is a replication of Experiment 1, in order to make them comparable, we utilised the same power analysis as Experiment 1. Thus, we aimed to collect data from at least 120 participants after exclusions. This experiment was also conducted online, and the participants were recruited using Prolific (www.prolific.co) [data collected on 2022/6/16 and 2022/6/23]. Also, we set the pre-screening criteria to match our participant demographic from the first experiment, i.e., they had to be between the ages of 18-25, students and must have normal or corrected to normal vision. Those who completed the study were compensated for their time with 10 CAD/hour and with a bonus payment of 5 CAD/half an hour for those who required more than 1 hour to complete the study. Informed consent was obtained from all participants prior to the experiment.

Stimuli

The same set of 128 stimulus images that were created for Experiment 1 were utilized for the current experiment, excepting the twice as much increase in their size to ensure that their attention was not defaulting to only narrowed attention on all trials.

Procedure

Experiment 2 followed the exact same procedure as Experiment 1 with the addition of the Virtual Chinrest routines in the beginning of the study. We added these routines before the instructions for the experiment started as the estimates of viewing distance obtained from the virtual chinrest procedures were subsequently used to calibrate the stimulus sizes during the rest of the experiment.

The Virtual Chinrest routines began with some questions to the participants about their body height (in feet, inches or centimetres) and screen type (laptop screen or external screen). After this the Card Task required participants to scale an on-screen picture against a real-world object that has a standard size everywhere in the world, a bank credit card. Participants had to simply press the card against the screen and adjust the size of the on-screen picture to be the same size as their card. Lastly, they completed the blind spot task which involved fixating on a static blue square in the centre of the screen with their left eye while their right eye is closed or covered with a hand. They must hold down the space key while they see a red dot moving away from the blue square, right to left and release the key as soon as they see the red dot disappear.

Data Analysis

The application of the same exclusion criteria as Experiment 1 resulted in the following participant level exclusions for the current Experiment:

Exclusion Criterion	Pre-criterion participants	Participants excluded
< 75 % accuracy on instructions quiz	136	5
< 90 % accuracy on practice rounds	131	2
≥ 75% ratings within 48-52 range	129	0
< 90 % attention-task accuracy	129	3
distracted ≥ 40% of experiment	126	4
high trait boredom (> 2.5 SDs)	122	0
high trait mind wandering (> 2.5 SDs)	122	0
N for Final Analysis	**122**	

All exclusions were conducted prior to data analysis. After all the exclusions, a total of 122 participants were included in our final data analysis. This satisfies the sample size calculation to obtain sufficient power.

3.2 Results and Discussion

Affective Ratings: Main hypothesis

To assess whether stimuli perceived under conditions of narrowed attention subsequently received more negative ratings than those perceived under conditions of broad attention, we calculated average stimulus ratings for each type of stimulus from each experimental condition at each point in the experiment and submitted the resulting values to a 2 (Attention: Global, Local) X 2 (Phase: Baseline, Post-attention) X 2 (Congruency: Congruent, Incongruent) repeated-measures ANOVA. Our analysis revealed that stimulus liking was not significantly affected by any attention-related differences during global versus local trials (Attention main effect: *F (1, 121)* = 0.465, *MSE* = 7.65, *p* = .496, *generalized η2* = 0.00). If Attention had influenced affective ratings for stimulus images, it would have emerged in the attention phase and been reflected in an Attention x Phase interaction. However, this interaction was also not significant (*F (1, 121)* = 0.05, *MSE* = 0.721, *p* = .819, *generalized η2*= 0.00). Taken together, these results fail to support either the amplification-only or amplification-plus-inhibition hypothesis.

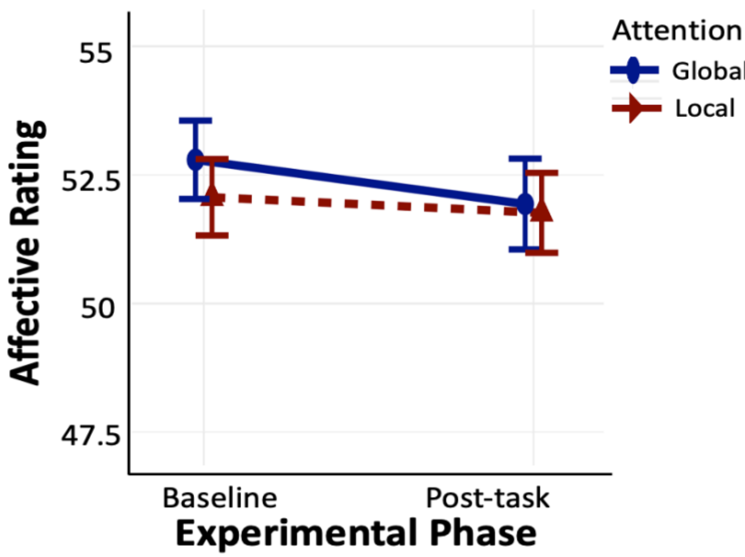

Figure 4. Average affective ratings of Mondrian-like patterns that appeared as stimuli on Global trials or Local trials of the Global/Local attention task in Experiment 2. Affective ratings were obtained for each stimulus both before the attention task (Baseline) and after the attention task (Post-task). The rating scale ranged from 1 to 100, with higher scores representing more affectively positive ratings. Error bars represent 95% confidence intervals.

While we found no evidence of any effect of attention, there was a significant effect of stimulus congruency (*F (1, 121)* = 47.67, *MSE* = 2670.68, *p* < 0.001, *generalized η2* = .10). As can be seen in Figure 5, congruent items—circle images whose internal elements were circles and square images whose internal elements were squares—were liked more, on average, (*M* =

58.01, *SD* = 16.58) than incongruent items whose outer shape and internal elements were different shapes (*M* = 47.55, *SD* = 15.29). Moreover, there was a significant interaction between Congruency and Phase ($F(1, 121) = 10.92$, *MSE* = 554.73, $p = 0.001$, $p < 0.01$, *generalized* $\eta 2 = 0.002$), whereby liking of congruent items decreased significantly from the first encounter (baseline ratings: *M* = 59.45, *SD* = 15.97) to the second encounter (post-task ratings: *M* = 56.58, *SD* = 17.09, $t(121) = 3.33$, $p = 0.001$, $p < 0.01$, *Cohen's d* = 0.17) whereas there were no changes in liking for incongruent items between the first (baseline ratings: *M* = 47.48, *SD* = 14.34) and second encounters (post-task ratings: *M* = 47.62, *SD* = 16.21), $t(121) = -0.15$, $p = .876$, *Cohen's d* = -0.01). The use of stimulus congruency was intended as a tool for the manipulation of global and local attention, but surprisingly, it ended having the largest effect in the study. The decrease in liking for congruent images from first to second encounter is particularly interesting, given that we had predicted an increase in liking due to repeated exposures as established by the mere exposure effect (Zajonc, 1968).

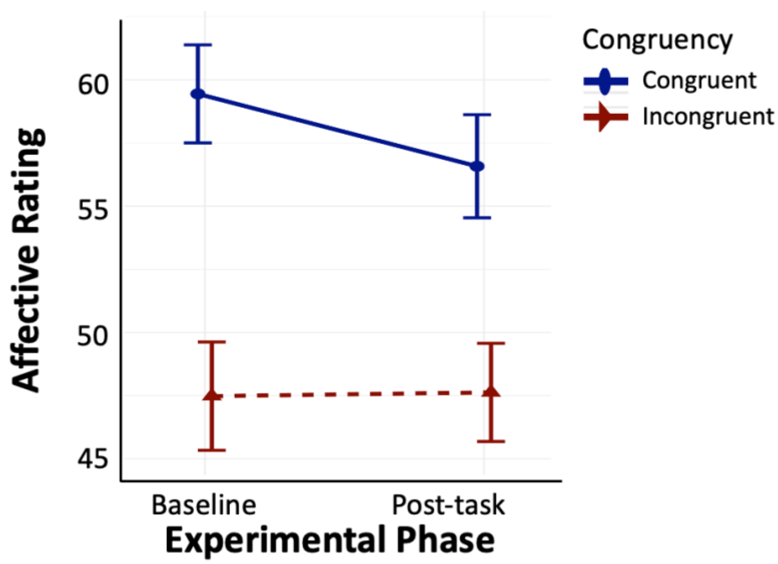

Figure 5. Average affective ratings of Mondrian-like patterns whose internal elements were the same shape as that of their outer border (congruent) and items whose local elements and global shape were different (incongruent) in Experiment 2. Affective ratings were obtained for each stimulus both before the attention

task (Baseline) and after the attention task (Post-task). The rating scale ranged from 1 to 100, with higher scores representing more affectively positive ratings. Error bars represent 95% confidence intervals.

Affective Ratings: Individual differences

To evaluate the role of individual differences in attentional difficulties, we considered whether individual differences had an influence on the affective ratings provided during the experiment. We filtered the affective ratings according to the attention condition to assess how people belonging to high versus low state or trait based individual differences rated images viewed with Global or Local attention. We found that there was no significant difference in the affective ratings between the high and low state boredom groups provided after the attention task for both the global ($t\ (120) = 0.82$, $p = .415$, *Mdiff* = 2.13, *95% CIs* = [-3.04, 7.30]) and local conditions ($t\ (120) = 0.64$, $p = .52$, *Mdiff* = 1.62, *95% CIs* = [-3.41, 6.65]). We find similar results for those grouped into high and low mind wandering and affective ratings after both global ($t\ (120) = 0.003$, $p = 0.998$, *Mdiff* = 0.01, *95% CIs* = [-5.18, 5.19]). and local attention ($t\ (120) = 0.43$, $p = 0.668$, *Mdiff* = 1.15, *95% CIs* = [-4.18, 6.47]). We also find no significant difference in affective ratings between groups who on an average provided more positive mood ratings versus those who provided more negative mood ratings after both the global ($t\ (120) = -1.28$, $p = .203$, *Mdiff* = -3.33 ,*95% CIs* = [-8.47, 1.82]). and local attention ($t\ (120) = -0.59$, $p = 0.115$, *Mdiff* = -4, *95% CIs* = [-9, 0.99]). This was surprising in the light of the significant positive correlations we find between average mood ratings with affective ratings after both the global ($r = 0.23$, $p = .012$, $p < 0.05$, *95% CIs* = [0.05, 0.39]) and local attention conditions ($r = 0.24$, $p = .007$, $p < 0.01$, *95% CIs* = [0.06, 0.40]). This may hint at some support for the Global attention-positive affect and Local attention-negative affect link that has been shown in some previous studies (Hanif and Srinivasan, 2010, Hanif et al. 2012).

Similar to the state-level measures, we find no significant differences between high and low groups formed based on the trait-level measures of Boredom Proneness and Spontaneous Mind-wandering. There was no significant difference in affective ratings between high and low

Boredom Proneness groups after both the global (t (120) = -1.15, p = 0.252, *Mdiff* = -2.99, *95% CIs* = [-8.15, 2.16]) and local attention conditions (t (120) = -1.38, p = 0.172, *Mdiff* = -3.48, *95% CIs* = [-8.49, 1.54]). There was also no significant difference in affective ratings between high and low Spontaneous Mind-wandering groups after both the global (t (120) = -0.41, p = 0.685, *Mdiff* = -1.60, *95% CIs* = [-6.24, 4.12]) and local attention conditions (t (120) = -0.54, p = 0.588, *Mdiff* = -1.38, *95% CIs* = [-6.43, 3.66]). Thus, the lack of differences in affective ratings as a function of the attention manipulation cannot be accounted for by any differences in the individual differences.

Manipulation checks: Cognitive-Behavioural Performance

While affective ratings of liking was our primary measure for this study, cognitive behavioural measures such as reaction times and accuracy for the attention task were important considerations as manipulation checks. Shorter reaction times and higher accuracy for Global stimuli have been shown to be good behavioural performance indicators for an effective manipulation of spatial attention when utilizing the Hierarchical Global-Local task (Hughes et al., 1984; Navon, 1981). We found no significant differences in reaction times (t (121) = 1.13, p = .261, Global: M = 0.86, SD = 0.32, Local: M = 0.85, SD = 0.35) for performing the global/local attention task. While there is a significant difference in accuracy (t (128) = -2.97, p = 0.003, $p < 0.01$, *Mdiff* = -0.013, *95% CIs* = [-0.02, -0.004]) on the attention task between images viewed with global and local attention, we found the accuracy to be higher for local attention (M = 0.97, SD = 0.16) as compared to global attention (M = 0.99, SD = 0.11). These manipulation checks further confirm that the task we employed for manipulating spatial attention did not produce patterns of performance that are typical of Global-Local hierarchical tasks.

To ensure that the lack of differences in reaction times for the attention task cannot be attributed to any individual difference factors, we analysed the differences in high and low groups for each of the three individual difference factors. Except the trait boredom ratings for the local attention condition, we found the differences in reactions times between high and low groups between all other individual difference factors to be not significant. We found a significant difference in reaction times between high and low trait-boredom and reaction times for the local attention condition (*t (120)* = -2.10, *p* = .038, $p < 0.05$, *Mdiff* = 0.10, *95% CIs* = [-0.006, 0.201]). Thus, The participants who were more prone to boredom had faster reaction times on the local attention trials. These results suggest that the most individual difference factors had no influence on the lack of differences in reaction times between global and local attention conditions and might not be able to account for why we did not produce the typical patterns seen in Global/Local hierarchical stimuli, i.e faster reaction times for global in comparison to local attention trials.

Table 2. Descriptive Statistics and Correlation matrix for individual-difference factors, affective ratings of stimuli encountered and reaction times for the attention task on global or local trials in Experiment 2

		State Boredom (1-100)	State Mind-Wand-ering (1-100)	Mood (1-100)	Trait boredom (1-7)	Trait Mind-Wand-ering (1-7)	Global affective ratings (1-100)	Local affective ratings (1-100)	Global reaction times (in seconds)	Local reaction times (in seconds)
State Boredom	M	53.49								
	SD	22.85								
	r	1.00								
State Mind-Wand-ering	M	-	24.99							
	SD	-	18.94							
	r	0.32***	1.00							
Mood	M	-	-	48.95						
	SD	-	-	20.02						
	r	-0.60***	-0.30***	1.00						
Trait Boredom	M	-	-	-	3.61					
	SD	-	-	-	1.14					
	r	0.24**	0.12	-0.27**	1.00					
Trait Mind-Wand-ering	M	-	-	-	-	4.45				
	SD	-	-	-	-	1.09				
	r	0.33***	0.25**	-0.24**	0.21*	1.00				

Global affective ratings	M	-	-	-	-	-	52.87			
	SD	-	-	-	-	-	12.54			
	r	-0.14	-0.05	0.23*	0.00	0.02	1.00			
Local affective ratings	M	-	-	-	-	-	-	52.69		
	SD	-	-	-	-	-	-	12.39		
	r	-0.12	-0.09	0.24**	0.01	0.06	0.94***	1.00		
Global reaction times	M	-	-	-	-	-	-	-	0.86	
	SD	-	-	-	-	-	-	-	0.32	
	r	-0.05	0.03	0.07	-0.18*	-0.06	0.13	0.11	1.00	
Local reaction times	M	-	-	-	-	-	-	-	-	0.85
	SD	-	-	-	-	-	-	-	-	0.35
	r	-0.01	-0.01	0.04	-0.23*	-0.07	0.17	0.17	0.89***	1.00

*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$*

4 The Mere Congruency Effect

The experiments so far have shown no support for either of our two hypotheses regarding the possibility that inhibition is involved in our ability to narrow the focus of attention. It is possible that either inhibition plays no role in varying the spatial scope of attention from broad to narrow or there are no affective consequences of spatial attentional manipulation. However, one affective consequence that we have consistently replicated across three experiments so far is 1) ‘congruent' stimuli are liked more than ‘incongruent’ stimuli, and 2) there is a significant decline in liking for congruent stimuli from baseline to post-task ratings, but no change in liking for incongruent stimuli from baseline to post-task ratings.

The decrease in liking for congruent stimuli from their first encounter to their second encounter is surprising because this change in stimulus liking goes in the opposite direction as the typical change in liking that occurs with repeated stimulus exposure. Indeed, mere exposure to an item across multiple encounters typically leads to enhanced liking (Bornstein, 1989; Zajonc, 1968). The fluency amplification model (Jacoby & Dallas, 1981; Jacoby & Whitehouse, 1989) proposes that this positive change in stimulus affect occurs because the increased processing ease, speed or “fluency” due to repeated exposures is misattributed as enhanced liking when participants are asked to evaluate the now-familiar objects. This closely relates to our predictions for the change in affective ratings that would have supported the “amplification-only” hypothesis if inhibition does not play any role in narrowing the focus of attention. We find no support for this hypothesis and even more surprisingly as opposed to repeated exposures leading to enhanced liking for stimulus objects, the liking for stimulus images in Experiments 1 and 2 either declines (congruent) or remains relatively stable (incongruent). Zajonc et al. (1974) reported this kind of decline in liking in the form of a U-shaped relationship between exposure and affective ratings in which liking initially increases with added exposures but eventually decreases following extreme number of exposures. The two-factor theory for the mere exposure effect attributes this form of decline in positive affect to stimulus satiation, which results from increases in boredom following extensive repeated exposures to the same stimulus (Berlyne, 1970; Stang, 1975). However, the very few exposures per image in the present experiments (2 per stimulus in total for Experiments 1 and 2) and the absence of any initial enhancement in liking for either category of stimuli make it challenging to see how these prior accounts could explain the specific decreases in liking for congruent (and only congruent) stimuli observed here.

The use of stimulus repetition in Experiments 1 and 2 was only intended to provide an initial baseline of affective ratings against which the affective consequences of our main experimental manipulation—broad versus narrow attention—could be assessed. Thus, we did not specifically vary the number of stimulus exposures to assess the potential role of exposure on stimulus liking. The results of Experiments 1 and 2, however, make clear that stimulus exposure may indeed be playing a critical role, along with stimulus congruency, in driving participants affective evaluations. To better understand the interaction between the effects of stimulus congruence and exposure in determining the liking ratings observed so far, we conducted follow-up experiments in which we specifically manipulated the frequency of exposures. If the decrease in liking for congruent items depends on stimulus exposure in the same way that increases in liking typically do in mere-exposure effects, then we would expect that the liking of congruent items would continue to decrease with each additional exposure. This provides a tentative first step in developing a better understanding of why specific stimulus characteristics, such as whether the internal elements of a pattern have the same shape as its outer border, cause a decline in liking following repeated encounters.

The addition of the manipulation of number of exposures in Experiment 3 also provides another set of experimental conditions under which changes in the breadth of attention can be assessed for the potential impact on subsequent stimulus ratings. We can thereby test whether repeatedly perceiving a stimulus with a narrowed focus of attention or a broadened focus of attention results in the differences in stimulus ratings predicted by the amplification-plus-inhibition hypothesis versus that predicted by the amplification-only hypothesis.

5 Experiment 3: Does the Liking for Congruent Stimuli Continue to Decrease with Each Added Exposure?

5.1 Methods

Participants

A total of 69 participants completed the study from start to end. Of the 69 participants (Age *M* = 18.22, *SD* = 1.30), 56 identified as female, 10 identified as male, 2 as non-binary and 1 as other.

This experiment was also conducted online, and the participants were recruited through the University of Guelph's undergraduate participant pool and they were compensated through course credit. Informed consent was obtained from every participant prior to the experiment. Participants accessed the study through Pavlovia, an online server to run experiments built in Psychopy (Peirce, 2007).

Stimuli

The same set of 128 stimulus images that were created for Experiment 1 were utilized for the current experiment. To manipulate their exposure frequency during the main experimental phase with attention-based trials, we split them, such that half of them were shown once and the other half three times. Thus, 64 stimulus images were only shown during the baseline trials and once during the main attention trials, whereas the rest 64 were shown once during the baseline trials and three times during the main attention trials. Affective ratings for the original image that was shown three times was only obtained after the third and last exposure. In addition to the 128 original stimulus images, we generated 128 novel images that were used as filler images during the affective ratings procedure after the first and second exposures of stimuli that were shown three times.

The mere exposure effect has been indirectly associated with recognition memory of the objects involved (Bornstein & D'Agostino, 1992; Seamon et al., 1983). For the recognition memory trials after the completion of all other experimental procedures, we generated 32 more novel stimulus images. These novel images were randomly interspersed with 32 original images to test recognition memory for Mondrian images that were seen and rated during the main experiment.

Procedure

The only experimental manipulation for the current experiment was the varying frequency of stimulus exposures. Keeping all other experimental conditions as close to the previous experiments as possible will allow us to compare the results and attribute any changes observed to that one manipulation in the experimental design. Thus, Experiment 3 followed the exact same procedure as Experiments 1 as well as 2 with the additional change in the frequency of exposures of the stimulus images. Since affective ratings for the images that were shown three times was obtained only after the third exposure and because we wanted to imitate the conditions of the previous experiments closely, after their first and second exposures, participants were shown novel images that they had never seen before and asked to provide affective ratings for them instead of the original images. The three exposures of any stimuli categorised to be seen three times were distributed semi-randomly within a single block. We ensured that the repetitions did not immediately follow each other and that there was a gap of at least 3 other unique images between any exposures of the same stimulus. This increased the number of trials per block from 32 to 64. Despite finding no effects of the state-based individual difference measures, we retained the state-based measures in the current experiment as they provided a good break in between two blocks and to prepare for the next block of trials.

Finally, we added recognition memory trials as a control to test whether the mere exposure effect disappears with recognition of objects and correct attribution of the source of affect (Jacoby & Dallas, 1981). There was a substantial increase in the total duration for completing the current experiment as compared to the previous experiments due to the increase in the total number of trials. Therefore, we decided to obtain confidence ratings on recognition memory for only 25% of the total original images shown in the study. The recognition memory trials had 64 images in total, 32 original images that were shown during the attention task and afterwards rated for their liking and 32 completely novel images that were never shown during any part during the study.

The procedure for the section on recognition memory proceeded in the following manner: Participants were asked to pay careful attention to the images as they will be tested on their ability to distinguish old images from the new ones. They were asked to click the fixation cross once they were ready to start the trial. The rating question and scale appeared first and remained on screen to avoid attentional capture away from the stimulus image shown in the centre. The Rating question displayed on the screen was, “How confident do you feel about seeing this before?” and they had to provide a rating on a scale ranging from ‘definitely not’ and ‘definitely yes’. We increased the presentation duration for the stimulus images to 500 milliseconds to ensure that the participants got a good look at the stimulus images to subsequently provide a rating that best represents their confidence in their recognition of the images. The trial ended once a rating was provided, and a new trial started. After every 16 images, participants were updated with the number of images left in the section. This is also where they could take short breaks to rest their eyes before continuing with the study by clicking on the cross in the centre of the screen.

We found no differences in affective ratings or on any other performance measures between the individual difference groups of high and low trait-based boredom proneness and spontaneous mind wandering in the previous two experiments. Thus, we decided to not include the associated post-task questionnaires at the end of the current experiment.

Data Analysis

The application of the same exclusion criteria as Experiment 1 resulted in the following participant level exclusions for the current Experiment:

Exclusion Criterion	Pre-criterion participants	Participants excluded
< 75 % accuracy on instructions quiz	69	4
< 90 % accuracy on practice rounds	65	1
≥ 75% ratings within 48-52 range	64	2
< 90 % attention-task accuracy	62	4
distracted ≥ 40% of experiment	58	11
N for Final Analysis	**47**	-

All exclusions were conducted prior to data analysis. After all the exclusions, a total of 47 participants were included in our final data analysis.

5.2 Results and Discussion

Affective Ratings: Main hypothesis

To assess whether stimuli perceived under conditions of narrowed attention subsequently received more negative ratings than those perceived under conditions of broad attention, we calculated average stimulus ratings for each type of stimulus from each experimental condition at each point in the experiment and submitted the resulting values to a 2 (Attention: Global, Local) X 2 (Phase: Baseline, Post-attention) X 2 (Congruency: Congruent, Incongruent) repeated-measures ANOVA. Our analysis revealed that stimulus liking was not significantly affected by any attention-related differences during global versus local trials (Attention main effect: $F(1, 46) = 0.85$, $MSE = 340.87$, $p = .362$, *generalised* $\eta 2 = 0.00$). If Attention had influenced affective ratings for stimulus images, it would have emerged in the attention phase and been reflected in an Attention x Phase interaction. However, this interaction was also not significant ($F(1, 46) = 0.80$, $MSE = 30.20$, $p = 0.373$, *generalized* $\eta 2 = 0.0003$). Taken together, these results fail to support either the amplification-only or amplification-plus-inhibition hypothesis.

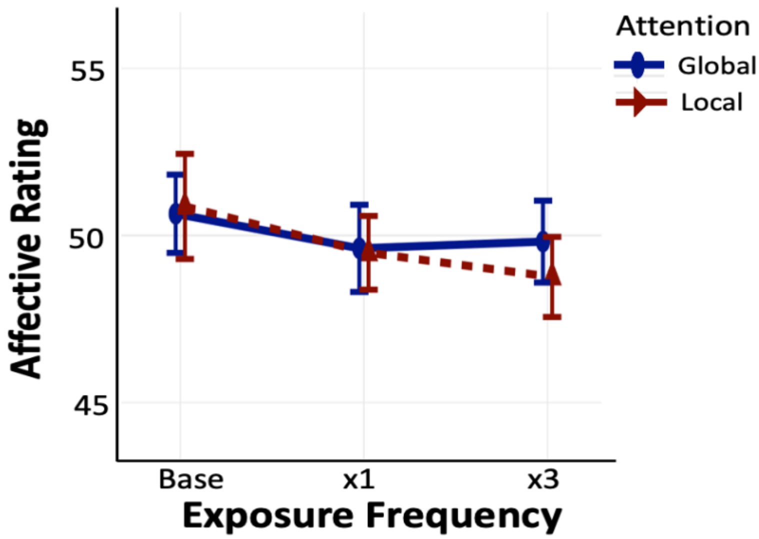

Figure 6. Average affective ratings of Mondrian-like patterns that appeared as stimuli on Global trials or Local trials of the Global/Local attention task in Experiment 3. Affective ratings were obtained for each stimulus both before the attention task (Baseline) and after the attention task (Post-task) where stimuli were repeated once or three times (exposure frequency). The rating scale ranged from 1 to 100, with higher scores representing more affectively positive ratings. Error bars represent 95% confidence intervals.

While we found no evidence of any effect of attention, there was a significant effect of stimulus congruency ($F(1, 46) = 29.66$, $MSE = 42260$, $p < 0.001$, *generalized* $\eta 2 = 0.31$). As can be seen in Figure 7, congruent items—circle images whose internal elements were circles and square images whose internal elements were squares—were liked more, on average, ($M = 57.57$, $SD = 14.50$) than incongruent items whose outer shape and internal elements were different shapes ($M = 42.58$, $SD = 13.31$). Moreover, there was a significant interaction between Congruency and Phase ($F(1, 46) = 12.69$, $MSE = 1849.37$, $p < 0.001$, *generalized* $\eta 2 = 0.01$), whereby liking of congruent items decreased significantly from the first encounter (baseline ratings: M = 59.81, SD = 20.12) to the second encounter (post-task ratings: M = 55.33, SD

=19.49, t (46) = 3.45, p = .001, p < 0.01) whereas there were no changes in liking for incongruent items between the first (baseline ratings: *M* = 41.68, *SD* =17.60) and second encounters (post-task ratings: *M* = 43.47, *SD* = 43.47), t (46) = -1.62, p = .111, Cohen's d = -0.14). The use of stimulus congruency was intended as a tool for the manipulation of global and local attention, but surprisingly, it ended having the largest effect in the study. The decrease in liking for congruent images from first to second encounter is particularly interesting, given that we had predicted an increase in liking due to repeated exposures as established by the mere exposure effect (Zajonc, 1968).

We had manipulated the frequency of stimulus exposures during the attention task to test whether the decrease in liking for congruent stimuli continues with each successive encounter in the same way that the increase in liking is observed in the mere exposure effect (Zajonc, 1968). That is we were interested in assessing whether similar to the continual increase in liking with the increase in the number of exposures (mere exposure effect), if the decrease in liking for congruent stimuli from the first to the second encounter, observed in the first two experiments, would persist with an increase in the number of times the stimulus images are repeated before they are finally rated. We found no significant effect of exposure manipulation on affective ratings (*F (1, 46)* = 1.01, *MSE* = 20.98, *p* = .320, *generalized η2* = 0.0002). The affective ratings obtained after 1 exposure of the stimulus image was not significantly different from the ratings obtained after an image was seen 3 times during the attention trials (1 exposure: *M* = 49.5, *SD* = 19.51, 3 exposures: *M* = 49.3, *SD* = 20.30, *t (46)* = 0.69, *p* = .490, *Mdiff* = 0.26, *95% CIs* = [-0.49, 1.01]). The decline in affective ratings from Baseline to post attention that we have been finding for congruent images disappears when images are considered as images that were seen once or three times during the attention trials (1 exposure: baseline *M* = 50.98, *SD* = 20.58, post attention *M* = 49.5, *SD* = 19.51, *t(46)* = 1.67, *p* = .101, *Mdiff* = 1.46, *95% CIs* = [-0.29, 3.21], *d* = 0.16, *95% CIs* = [-0.03, 0.36], 3 exposures: baseline *M* = 50.52, *SD* = 21.34, post attention *M* = 49.3, *SD* = 20.30 , *t(46)* = 1.41, *p* = .165, *Mdiff* = 1.24, *95% CIs* = [-0.53, 3.00], *d* = 0.14, *95% CIs* = [-0.06, 0.33]). Thus, the decrease in liking for the congruent stimuli does not continue with the increase in the number of repeated exposures of the images. On the other hand, the absence of the mere exposure effect for the incongruent stimuli continues even with the increase in the number of stimulus exposures. This may be attributed to the small sample size that we currently have, and we hope to update these analyses after our desired sample size for this experiment has been obtained.

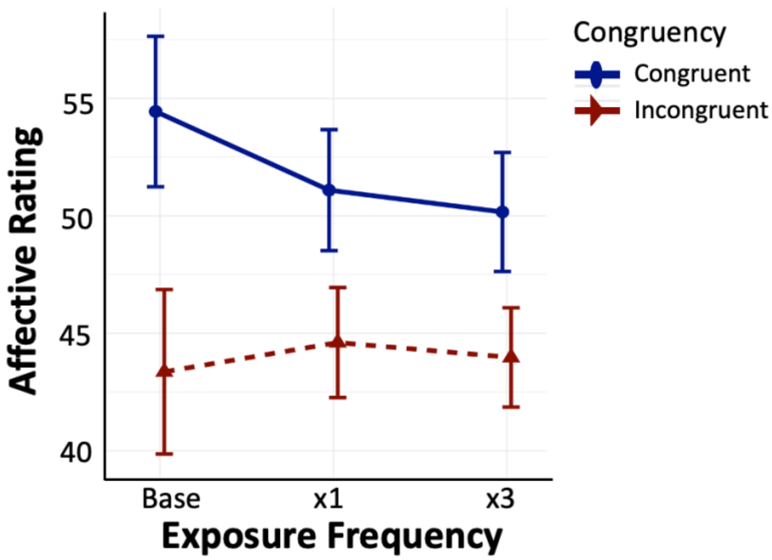

Figure 7. Average affective ratings of Mondrian-like patterns whose internal elements were the same shape as that of their outer border (congruent) and items whose local elements and global shape were different (incongruent) in Experiment 3. Affective ratings were obtained for each stimulus both before the attention task (Baseline) and after the attention task (Post-task) where stimuli were repeated once or three times (exposure frequency). The rating scale ranged from 1 to 100, with higher scores representing more affectively positive ratings. Error bars represent 95% confidence intervals.

Considering that conscious awareness and recognition has been found to be unnecessary for obtaining the mere exposure effect (Bornstein & D'Agostino, 1992; Seamon et al., 1983), we wanted to assess if we would find a negative correlation between confidence ratings for recognition memory judgments and the affective ratings for the same images obtained during baseline and after the attention task. We found that the confidence ratings for recognition memory judgments for the selected 32 images was above chance (M = 56.31, SD = 6.99). There was no significant difference in the mean confidence ratings for the recognition of stimuli viewed under either global (*M* = 57.05, *SD* = 7.12) or local attention trials (*M* = 55.57, *SD* = 6.89, *t (31)*= 0.85, *p* = 0.40). However, we find a positive correlation between affective ratings of stimulus images and subsequent confidence in their recognition judgment for both images viewed with global (*r* = 0.29, *p* = 0.11, *95% CIs* = [-0.07, 0.59]) and local attention (*r* = 0.21, *p* = 0.25, *95% CIs* = [-0.15, 0.52]). This suggests that stimulus images that were previously evaluated positively were also more confidently recognized to be previously seen during the experiment.

We also find that the confidence ratings for recognition judgments for the selected 16 congruent stimulus images and 16 incongruent stimulus images was above chance with the mean confidence ratings of 57.80 (*SD* = 4.81) and 54.65 (*SD* = 4.88) respectively. But there was no significant difference between the mean confidence ratings for recognition judgments for congruent versus incongruent stimuli (*t (30)* = 1.84, *p* = 0.08, *Mdiff* = 3.15, *95% CIs* = [-0.35, 6.64]). Moreover, we find a positive correlation (*r* = 0.40, *p* = 0.02, *p* < 0.05, *95% CIs* = [.06, 0.65]) between confidence in recognition judgments and the average affective ratings. When we filtered the images according to congruency, the significant positive correlation between confidence in recognition judgments and the average affective ratings disappears for both congruent (*r* = 0.26, *p* = 0.33, *95% CIs* = [-0.27, 0.67]) and incongruent stimuli (*r* = 0.25, *p* = 0.34, *95% CIs* = [-0.28, 0.67]). These results demonstrate that difference in recognition memory judgments may not explain the decline in liking for congruent images from 1st to 2nd encounter that we have been finding.

Manipulation checks: Cognitive-Behavioural Performance

Shorter reaction times and higher accuracy for Global stimuli have been shown to be good behavioural performance indicators for effective manipulation of spatial attention when utilizing the Hierarchical Global-Local task (Hughes et al., 1984; Navon, 1981). We found no significant differences in reaction times for performing the attention task between global and local conditions (global: *M* = 0.88 seconds, *SD* = 0.25, local: *M* = 0.85 seconds, *SD* =0.23, *t (46)*

= 1.86, *p* = 0.069, *Mdiff* = 0.03, *95% CIs* = [-0.002, 0.069]). We also found no significant difference in accuracy (*t (57)* = -0.20, *p* = 0.84, *Mdiff* = -0.001, *95% CIs* = [-0.01, -0.009]) on the attention task between images viewed with global (*M* = 0.971, *SD* = 0.17) as compared to local attention (*M* = 0.972, *SD* = 0.16). These manipulation checks further confirm that the task we employed for manipulating spatial attention was not effective.

To ensure that the lack of differences in affective ratings between our attention conditions is not due to any individual differences, we conducted some comparisons grouped by high and low state based Boredom, Mind-wandering. Since the ratings on the state based individual difference scales were obtained in between the four blocks during the attention trials, we compared the affective ratings only from this phase of the experiment. We created high versus low groups by applying a median split to each of the three state-based ratings. There was no significant difference between the high and low state-based boredom groups in the affective ratings during the global (*t (45)* = 0.04, *p* = 0.966, *Mdiff* = 0.12, *95% CIs* = [-5.44, 5.69]) and local attention trials (*t (45)* = 0.44, *p* = 0.661, *Mdiff* = 1.12, *95% CIs* = [-4.00, 6.25]). Similarly, there was no significant difference in the affective ratings between those who were categorised into either high or low state-based Mind-wandering after both the global (*t (45)* = -0.68, *p* = 0.502, *Mdiff* = -1.86, *95% CIs* = [-7.40, 3.68]) and local attention trials (*t (45)* = -0.32, *p* = 0.748, *Mdiff* = -0.82, *95% CIs* = [-5.95, 4.30]). Our last state-based individual difference measure of Mood also showed no significant differences in affective ratings between those who on an average reported a positive mood versus a negative mood while performing the attention task after both the global (*t (45*) = 0.67, *p* = .507, *Mdiff* = 1.83, *95% CIs* = [-3.70, 7.38]) and local conditions (*t (45)* = 0.19, *p* = 0.85, *Mdiff* = 0.49, *95% CIs* = [-4.65, 5.62]). These results suggest that most individual difference factors had no influence on the lack of differences in reaction times between global and local attention conditions and might not be able to account for why we did not produce the typical patterns seen in Global/Local hierarchical stimuli, i.e faster reaction times for global in comparison to local attention trials.

Table 3. Descriptive Statistics and Correlation matrix for individual-difference factors, affective ratings and reaction times for stimuli encountered on global or local trials in Experiment 3

		State Boredom (1-100)	State Mind-Wandering (1-100)	Mood (1-100)	Global affective ratings (1-100)	Local affective ratings (1-100)	Global reaction times (in seconds)	Local reaction times (in seconds)
State Boredom	M	63.48						
	SD	20.83						
	r	1.00						
State Mind-Wandering	M	-	47.99					
	SD	-	27.10					
	r	0.24	1.00					
Mood	M	-	-	36.64				
	SD	-	-	16.24				
	r	-0.51***	-0.33*	1.00				
Global affective ratings	M	-	-	-	50.18			
	SD	-	-	-	8.61			
	r	0.00	0.04	0.07	1.00			
Local affective ratings	M	-	-	-	-	49.99		
	SD	-	-	-	-	8.18		
	r	-0.09	-0.01	0.23	0.88***	1.00		
Global reaction times	M	-	-	-	-	-	0.88	
	SD	-	-	-	-	-	0.25	
	r	0.07	0.09	-0.10	0.02	0.03	1.00	
Local reaction times	M	-	-	-	-	-	-	0.85
	SD	-	-	-	-	-	-	0.23
	r	0.04	0.10	-0.19	-0.02	-0.07	0.77***	1.00

$*p < 0.05$, $**p < 0.01$, $***p<0.001$

6 Experiment 4: Is Decrease in Liking for Congruent Stimuli Due to the Global/Local Task?

We know from Experiment 3, that this congruency effect might not be conceptualized as a reversal of mere exposure effect as we found no effect of the manipulation of frequency of exposures on the affective ratings. One of the main pre-requisites of the mere exposure effect is a truly unencumbered repetition of stimuli and not just as a consequence of another task (Bornstein, 1989; Montoya et al., 2017), which has been the case for our Experiments 1-3. A change in the context of the stimulus exposure and ratings has been shown to contribute to a reversal of the mere exposure effect, where liking for a stimulus object was found to be specific to the exposure context (de Zilva et al., 2013) or depended on the consistency of processing between exposures and rating phases (Inoue et al., 2018). Excepting the baseline phase, the rest of the exposures involved the context of the attention task for processing stimulus images, which was not present when participants were finally asked to indicate their liking for the images during the rating phase. To confirm what we observed in Experiment 3, that this is not a reversal of the mere exposure effect, we need to ensure the similarity of the exposure and rating contexts. This will also allow us to test whether this congruency effect is modulated by the attention task.

While the attention task has not been effective in manipulating the spatial focus of attention, it has consistently been an essential task in the experiments whenever we have found the congruency effect. To more accurately capture the underlying mechanisms of this effect, we conducted the current experiment to test whether the attention task has been modulating the decline in ratings for congruent stimuli during the main experimental trials. We accomplish this by replacing the attention task with an inconsequential choice task that imitates the conditions of all the experiments so far but does not require processing of the stimuli at the global or local level. If we find effects in the same direction as all the experiments so far, it will be clear that the attention task has had no significant contribution to the congruency effect. On the other hand, if the effect disappears, we will be able to conclude that some part of the process of doing the attention task is responsible for the congruency effect.

6.1 Methods

Participants

A total of 55 participants completed the study from start to end. Of the 55 participants (Age M = 18.82 , SD = 2.56), 42 identified as female and 12 identified as male and 1 as non-binary.

The participants were recruited through the University of Guelph's undergraduate participant pool. They were compensated for their time and effort through course credit. Informed consent was obtained from every participant prior to the experiment. This experiment was administered online, participants accessed the study through Pavlovia, an online server to run experiments built in Psychopy (Peirce, 2007).

Stimuli

In the current experiment, we utilized the same set of 128 stimulus images that we have been consistently using in all our previous experiments.

Procedure

The procedures for the current experiment are nearly the same as Experiment 3, excepting the elimination of the attention task. To precisely imitate the conditions of all the previous experiments so far, we simply replaced the "Global"/ "Local" cue before every trial with a "Ready" instruction and the shape discrimination task within the attention task with an inconsequential choice task. Instead of selecting the correct shape (square or circle), participants were presented with a choice between two lines of 45 and 135 degrees each. Participants were asked to simply click on either one of them to proceed to the affective ratings task. They were free to choose between either of the two options, there was no right or wrong answer. Like the past 3 experiments, we counterbalanced the location of the lines on either side of the 'or' presented on the screen across the participants. The rest of the procedure including the manipulation of the frequency of exposures and the recognition memory trials in the very end of the experiment were retained the same as Experiment 3. Trials were still divided into four blocks. We also included the inter-block questions measuring state-based individual differences of boredom, mind-wandering, and mood.

Data Analysis

The application of the same exclusion criteria as Experiment 1 resulted in the following participant level exclusions for the current Experiment:

Exclusion Criterion	**Pre-criterion participants**	**Participants excluded**
≥ 75% ratings within 48-52 range	55	0
distracted ≥ 40% of experiment	55	14
high trait boredom (> 2.5 SDs)	41	0
high trait mindwandering (> 2.5 SDs)	41	0
N for Final Analyses	**41**	**-**

All exclusions were conducted prior to data analysis. After all the exclusions, a total of 41 participants were included in our final data analysis.

6.2 Results and Discussion

To assess whether congruent stimuli perceived under the baseline condition subsequently received more negative ratings than the those perceived after the choice task, we calculated average stimulus ratings for each type of stimulus at each point in the experiment for each exposure frequency and submitted the resulting values to a 2 (Phase: Baseline, Post-attention) X

2 (Congruency: Congruent, Incongruent) X 2 (Exposure Frequency: once, three times during the attention task) repeated-measures ANOVA.

In line with all the previous results, we found a significant effect of stimulus congruency ($F\ (1, 40)$ = 19.57, *MSE* = 6218.79, $p < 0.001$, *generalized* $\eta 2$ = 0.21). As can be seen in Figure 3, congruent items—circle images whose internal elements were circles and square images whose internal elements were squares—were liked more, on average, (*M* = 52.53, *SD* = 15.09) than incongruent items whose outer shape and internal elements were different shapes (*M* = 43.82, *SD* = 12.46). Moreover, there was a significant interaction between Congruency and Phase ($F\ (1, 40)$ = 8.65, *MSE* = 460.37, $p = .005$ that is $p < 0.01$, *generalized* $\eta 2$ = 0.02), whereby liking of congruent items decreased significantly from the first encounter (baseline ratings: *M* = 54.44, *SD* = 20.17) to the second encounter (post-task ratings: *M* = 50.63, *SD* = 20.11, $t\ (40)$ = 2.29, $p = .027$, $p < 0.05$, *Cohen's d* = 0.25) whereas there were no changes in liking for incongruent items between the first (baseline ratings: *M* = 43.36, *SD* = 18.95) and second encounters (post-task ratings: *M* = 44.29, *SD* = 18.01, $t\ (40)$ = - 0.62, $p = .538$). The decrease in liking for congruent images from first to second encounter persists without the attention processing task. Thus, the attention task has had no significant contribution to the congruency effect we have been finding throughout this study.

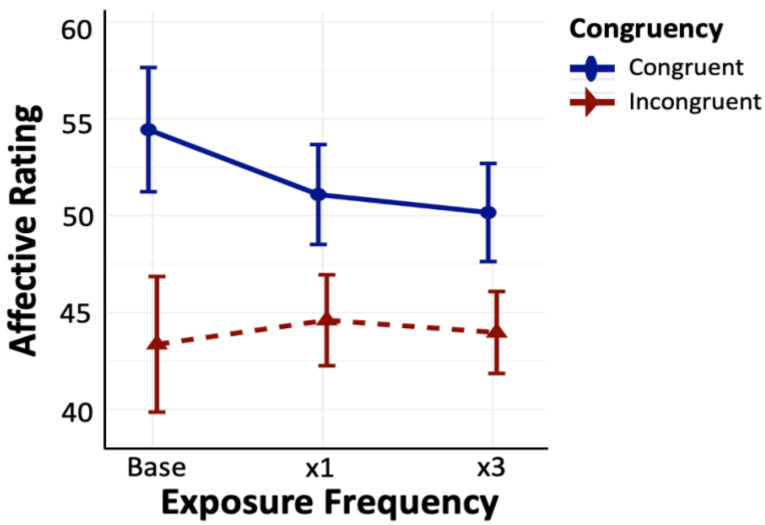

Figure 8. Average affective ratings of Mondrian-like patterns whose internal elements were the same shape as that of their outer border (congruent) and items whose local elements and global shape were different (incongruent) in Experiment 4. Affective ratings were obtained for each stimulus both before the attention task (Baseline) and after the choice task (Post-task) where stimuli were repeated once or three times (exposure frequency). The rating scale ranged from 1 to 100, with higher scores representing more affectively positive ratings. Error bars represent 95% confidence intervals.

We had manipulated the frequency of stimulus exposures to test whether this effect of congruency can be considered an effect opposite of the mere exposure effect (Zajonc, 1968). We were interested in seeing if the effect would still persist with an increase in the number of times the stimulus images are repeated before they are finally rated. There was no significant effect of exposure manipulation on affective ratings ($F (1, 40) = 0.045$, $MSE = 0.80$, $p = .831$, *generalized* $\eta 2 = 0.00003$). The affective ratings obtained after 1 exposure of the stimulus image was not significantly different from the ratings obtained after an image was seen 3 times during the attention trials (1 exposure: $M = 47.78$, $SD = 19.66$, 3 exposures: $M = 47.02$, $SD = 19.14$, $t (40) = 1.37$, $p = .18$, $Mdiff = 0.78$, *95% CIs* = [-0.37, 1.93]). The decline in affective ratings from Baseline to post attention that we have been finding for congruent images disappears when images are considered as images that were seen once or three times during the attention trials. They were not rated as significantly different than baseline (1 exposure: baseline $M = 48.41$, *SD*

= 20.48, post attention, *M* = 47.85, *SD* = 19.66, *t(40)* = 0.39, *p* = .695, *Mdiff* = 0.562, *95% CIs* = [-2.32, 3.44], 3 exposures: baseline *M* = 49.39, *SD* =20.19, post attention *M* = 47.07, *SD* =19.06, *t(40)* = 1.66, *p* = .10, *Mdiff* = 2.32, *95% CIs* = [-0.50, 5.14]). We find the complete absence of the mere exposure effect for the incongruent images here surprising. However, this manipulation makes it clear that the effect of congruency we have been observing does not change as a function of the number of exposures in the same way that the mere exposure effect does.

Considering that conscious awareness and recognition has been found to be unnecessary for obtaining the mere exposure effect (Bornstein & D'Agostino, 1992; Seamon et al., 1983), we wanted to assess if we would find a negative correlation between confidence ratings for recognition memory judgments and their respective affective ratings obtained during baseline and after the attention task. We find that the confidence ratings for recognition judgments for the selected 16 congruent stimulus images and 16 incongruent stimulus images was above chance with the Mean confidence ratings of 58.92 (*SD* = 3.88) and 55.98 (*SD* = 4.19) respectively. But there was no significant difference between the Mean confidence ratings for recognition judgments for congruent versus incongruent stimuli (*t (30)* = 2.06, *p* = 0.05, *Mdiff* = 2.94, *95% CI*s = [0.02, 5.86]). Thus, difference in recognition memory judgements may not explain the decline in liking for congruent ratings that we find. Moreover, contrary to previous findings, we find a positive correlation (*r* = 0.49, *95% CIs* = [0.17, 0.72]) between confidence in recognition judgements and the average affective ratings (*t (30)* = 3.08, *p* = 0.004, <0.01). When we filtered the images according to congruency, the significant positive correlation with average affective ratings disappears for both congruent (*r* = 0.35, *p* = 0.18, *95% CIs* = [-0.18, 0.72]) and incongruent stimuli (*r* = 0.40, *p* = 0.12, *95% CIs* = [-0.11, 0.75]).

Affective Ratings: Individual differences

To test whether the differences in affective ratings can also be explained by any individual difference factors, we conducted some comparisons grouped by high and low state based Boredom and Mind-wandering. Since the ratings on the state based individual difference scales were obtained in between the four blocks during the attention trials, we compared the affective ratings only from this phase of the experiment. We created high versus low state based Boredom groups by applying a median split to our ratings on the Boredom scale. There was no significant difference between the high and low state-based boredom groups in the affective ratings during the attention trials ($t\ (39) = 0.15$, $p = .878$, $Mdiff = 0.58$, *95% CIs* = [-6.98, 8.14]). Similarly, there was no significant difference in the affective ratings between those who were categorised into either high or low state-based Mind-wandering ($t\ (39) = 0.55$, $p = .587$, $Mdiff = 2.04$, *95% CIs* = [-5.50, 9.57]). Our last state based individual difference measure of Mood also showed no significant differences in affective ratings between those who on an average reported a positive mood versus a negative mood while performing the attention task ($t\ (39) = 0.39$, $p = .694$, $Mdiff = 1.47$, *95% CIs* = [-6.07, 9.02]).

Table 4. Descriptive Statistics and Correlation matrix for individual-difference factors and affective ratings for stimuli in Experiment 4

		Affective Ratings	State Boredom (1-100)	State Mind-Wandering (1-100)	Mood (1-100)
Affective Ratings	M	47.46			
	SD	11.82			
	r	1.00			
State Boredom	M	-	72.62		
	SD	-	18.02		
	r	-0.04	1.00		
State Mind-Wandering	M	-	-	51.53	
	SD	-	-	22.89	
	r	0.15	-0.12	1.00	
Mood	M	-	-	-	35.21
	SD	-	-	-	16.13
	r	-0.07	-0.45**	-0.44**	1.00

$*p < 0.05$, $**p < 0.01$, $***p < 0.001$

7 General Discussion

Our ability to narrow the focus of attention across visual space has critical importance in the concentration of processing resources on a target region (Castiello & Umilta, 1990). Varying the spatial scope of attention from a broader space to a narrowed region has been shown to facilitate processing efficiency by resolving competition from a vast array of information in the environment (Greenwood & Parasuraman, 1997; Briand & Klein, 1987). While there has been enough research about the indirect relationship between processing efficiency and the size of attention focus (Facoetti & Molteni, 2000; Couperus & Magnun, 2010), little is known about how narrowing the focus of attention is accomplished. In the present study, we sought to answer this question by trying to find support for either one of the two competing hypotheses: 'amplification-only' hypothesis which suggests the sole contribution of the enhancement of target information within attentional focus (Egner & Hirsh, 2005; Hommel, 2004; Neill & Matthias, 1998) and 'amplification-plus-inhibition' hypothesis which draws on inhibition of irrelevant information outside of the focus to amplify the information within the attentional focus (Cutzu and Tsotsos, 2003; Hopf et al. 2006). Growing support for the affective measure of stimulus devaluation by inhibition based on the strong link between inhibition and negative affect (Raymond et al. 2003; Fenske et al. 2004), prompted us to utilize this measure to test the role of inhibition underlying our ability to narrow the focus of attention and to contrast between the two hypotheses. We had hypothesized that if inhibition plays a role in the narrowing of attention, stimuli perceived with narrowed attention should receive more negative ratings than those perceived with a broad attentional focus. Accordingly for the amplification-plus-inhibition hypothesis to be supported, stimuli perceived with a narrow focus of attention should have subsequently received more negative affective ratings than those perceived with a broad focus. In contrast, the amplification-only hypothesis provided us with no reason to expect any decreases in the ratings of stimuli perceived with a narrow focus of attention compared to ratings of previously-unseen items or those perceived with a broad focus of attention. Thus, if the latter is supported, we expected stimuli from both broad and narrow scope of attention to be liked more than baseline due to the affectively positive effect of repeated exposure in the absence of inhibition (Zajonc, 1968).

Unfortunately, our study found no support for either the ‘amplification-plus-inhibition’ hypothesis or the ‘amplification-only’ hypothesis, making it difficult to conclude the role of inhibition underlying our ability to narrow the focus of attention. We suspect that two possibilities may explain these inconclusive results. One, it is very likely that our attention task has proven to be an ineffective manipulation for varying the scope of attention between broad and narrow. The average accuracy for the attention task is extremely high (at least 97% across the first three experiments), that is the difficulty level was not challenging enough to require inhibition of the global shape while processing the local elements during the local trials. We also found no significant differences in the reaction times between the global and local trials while performing the attention task. Previous studies that have employed the Navon’s hierarchical task to manipulate spatial attention into global versus local have consistently shown that reaction times are faster, and accuracy is higher for Global as compared to Local processing of objects, this is known as the Global precedence effect (Hughes et al., 1984; Navon, 1981). Thus, a more effective manipulation of spatial attention may still be useful in answering the question that we failed to answer in this study. If future experiments with other spatial attention manipulation paradigms find devaluation of stimuli perceived with a narrow focus of attention it would also add to the usefulness of affective ratings as an index of the potential involvement of inhibition in cognitive tasks (see also De Vito & Fenske, 2018; Kihara et al., 2011). And after ruling out the confounding effect of the ineffectiveness of the attention task, if we find no significant devaluation of stimuli, we would be able to more conclusively support our second suspicion, that inhibition is not involved or necessary for narrowing the focus of attention. This would in turn support the ‘amplification-only’ hypothesis.

With the amplification-only hypothesis, we had predicted that repeated exposures with the same stimulus images would lead to enhanced liking due to the mere exposure effect (Zajonc, 1968). Across the first two experiments, we found an effect in the opposite direction of this effect for the congruent stimuli and an absence of this effect for the incongruent stimuli, which suggested that our experimental procedure might not have been conducive to obtain the mere exposure effect. Despite our experimental manipulations in Experiments 3 and 4, that imitated the conditions under which the mere exposure effect is commonly found, the decline in liking ratings for congruent (only from the 1^{st} to 2^{nd} encounter) and relative stability in liking ratings for incongruent stimuli persisted. There are certain methodological differences between our experiments and the mere exposure studies that have shown the strongest effects. We make use of a combination of delay types in a single study, such as the 'immediate assessment' for the baseline phase and 'immediate assessment after final presentation with no delay' for the original images in the attention task phase. A meta-analysis by Montoya et al., (2017) found a positive slope and a negative quadratic term for the delay categories of assessment immediately after the final presentation of the exposure phase, or the assessment following the exposure phase and delay of any duration, but the negative quadratic term was not significant for immediate assessment after each stimulus exposure. While the studies involved a much higher number of exposures, our results from Experiments 3 and 4 are trending in a direction opposite to the above effects as our immediate assessment condition of delay type (baseline) consistently shows a decline after 2^{nd} encounter (especially across experiments 1 and 2) and the assessment immediately after the final presentation of the exposure phase show no significant difference in liking ratings.

Another methodological factor that may relate to the recognizability of our stimulus images. Expanding on the fluency model of the mere exposure effect (Jacoby & Dallas, 1981) other theorists have observed some independence in the processes of liking and recognition judgments for objects previously seen (Bornstein & Dagostino, 1992; Seamon et al., 1983). In fact, the effect of mere exposure is much stronger when the objects are presented subliminally than the effects obtained with clearly recognized stimuli (Bornstein, 1989; Montoya et al., 2017), presumably because conscious awareness of the stimulus eliminates the misattribution of processing fluency to its likability (Jacoby & Dallas, 1981). We had generated 128 unique Mondrian patterns which are difficult to categorise and distinguish from each other with numerous closely related elements and presentation durations as short as 200 milliseconds at a time. Considering the above research, this non-distinguishability may be beneficial and should have produced stronger effects of mere exposure. We find that the recognition memory for both congruent and incongruent stimuli are above chance level, but there was no significant correlation of recognition memory judgments with the average affective ratings. In fact, contrary to an expected negative relationship between recognition memory and liking for stimulus objects, we find a positive correlation between these variables. It is possible that the processing fluency likely associated with congruent stimuli produced an illusory sense of familiarity, leading to the decline in ratings upon seeing them again and a false positive attribution of liking to the sense of familiarity instead of an enhancement in liking. However, it is unclear why processing fluency used to make a judgment of familiarity is not consequently utilised to more confidently claim it to be a stimuli previously viewed during the experiment.

The absence of the mere exposure effect as reflected from the no significant differences in affective ratings between 1 and 3 exposures of the stimuli also inclines us to believe that this may not be entirely attributable to the methodological differences. It is possible that this congruency effect is not a mere variation of the mere exposure effect. We had expected a significant difference in affective evaluations between congruent and incongruent stimuli after the attention task, as congruency between shapes at the global and local level may facilitate the visual shape discrimination, whereas the conflict caused by the incongruence between global and local shapes may cause interference (Reeck & Egner, 2011). Surprisingly, we find that perceptual consistency between shapes at the global and local levels drive the affective evaluations even at baseline despite of the absence of any task-related competition between global and local levels. Thus, some form of mere congruency causes higher liking ratings for the congruent as compared to the incongruent stimuli at baseline and likely also drives the post-baseline decline only for congruent stimuli, which does not continue beyond the 2nd exposure.

The processes underlying this mere congruency effect are still mysterious. It is not clear what about the inherent properties of the congruent stimuli make them more likable than incongruent stimuli at baseline and not as likable after repeated exposures. Previous research on rapid affective evaluations based on low-level perceptual properties of objects suggests that curved contours are liked more than sharp contours, which may indicate a sense of threat and trigger a negative bias (Bar & Neta, 2006; Damiano et al., 2021). While we do find that circles made up of circles are liked the most among all the stimulus categories, the previous finding doesn't explain why the other objects classified as congruent and with sharp ends, Squares made up of squares are also liked more than both the incongruent stimuli. From the same evolutionary standpoint, it is possible that the perceptual continuities associated with congruent stimuli may signal safety and promote an initial positive bias. But the subsequent re-examination of the object afforded by the repeated exposures may trigger a more wholistic and analytical processing that dissociates participants from the experience of misattributed fluency and leads to reduced liking (Whittlesea & Price, 2001). Interaction of this kind of processing upon re-exposures with stimulus complexity has been shown to decrease liking for visually simple product designs and increased preferences for visually complex product designs (Cox & Cox, 2002). Thus, congruent stimuli may be perceived simpler in design as compared to incongruent and experience more wholistic processing upon re-exposure, resulting in the decline in liking from the first exposure to second exposure that we have replicated across four experiments in this study.

The effect of emotion on attention has received a lot attention in the literature (Fox et al. 2004; Eastwood et al. 2001; Fenske & Eastwood, 2003, Freidrickson and Branigan, 2005; Rowe at el. 2007). Unlike objects like emotional faces or pictures of events that evoke strong positive or negative emotional reactions, some objects don't inherently possess an affective value that consequently influences other cognitive processes. Some previous studies have found evidence to support that the broad attention-positive affect and narrow attention-negative affect associations share a bidirectional causal link (see Vuilleumier and Driver, 2007 for a review). Srinivasan & Hanif (2010), for instance, found that global and local processing facilitates the identification of positive and negative faces respectively. If our data had shown that attentional inhibition is associated with negative affective values, it would have not only characterised how we come to assign specific affective values to seemingly neutral objects in our environment, but it would also have further reinforced a reciprocity in the relationship between attention and emotion. As previously reiterated, significant contribution to this literature on the effects of attention on emotion would require the use of a more effective paradigm to manipulate attention and to find converging support for the potential usefulness of the measure of affective devaluation by inhibition. That said, our study still finds some form of affective evaluations of objects influenced by low-level perceptual properties instead of high-level cognitive processes such as attention.

Our results supporting the mere congruency effect has broad implications for evaluating the immediate affective values associated with basic object features commonly found in the environment. As opposed to a reciprocal relationship, the strong effects on affective evaluations at first rapid exposure and subsequent decline upon possible cognitive reappraisal may hint at the independence of affect and cognition (Zajonc, 1980; Zajonc, 2001) as well as at their respective temporal positions during object processing. The primacy of affect and the subsequent influence of cognition on affective judgements is especially interesting as it interacts with perceptual properties such as congruency. Better characterisation of this effect to further analyse the interaction of affect and cognition warrants future studies.

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