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Perceptual organization of line configurations: Is visual awareness necessary?

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ABSTRACT

We examined whether configuring, which determines the appearance of grouped elements as a global shape, requires visual awareness, using a priming paradigm and two invisibility-inducing methods, CFS and sandwich masking. The primes were organized into configurations based on closure, collinearity, and symmetry (collinear primes), or on closure and symmetry (noncollinear primes). The prime-target congruency could be in configuration or in elements. During CFS, no significant response-priming was observed for invisible primes. When masking induced invisibility, a significant configuration response-priming was found for collinear and noncollinear primes, visible and invisible, with larger magnitude for the former. An element response-priming of equal magnitude was evident for visible and invisible noncollinear primes. Our results suggest that configuring can be accomplished in the absence of visual awareness when stimuli are rendered invisible by sandwich masking, but it benefits from visual awareness. Our results also suggest sensitivity to the available grouping cues in unconscious processing.

1. Introduction

The visual system is known to construct objects and surfaces from cluttered pieces of visual input. Gestalt psychologists suggested that perceptual organization, including perceptual grouping and figure-ground organization, underlies our perception (Koffka, 1922; Wertheimer, 1923). Recent studies suggest that perceptual organization is a multiplicity of processes, which vary, for example, in time course, attentional demands, and developmental trajectory (e.g., Behrmann & Kimchi, 2003; Kimchi, 2003; Peterson & Kimchi, 2013). In addition, classic and modern researchers distinguish two kinds of perceptual organization processes: (1) a process of unit formation or clustering that determines which elements belong together; (2) a process of shape formation or configuring that determines the appearance of the grouped elements as a whole based on the interrelationships of the elements (Behrmann & Kimchi, 2003;Kimchi & Razpurker-Apfeld, 2004; Koffka, 1935; Rock, 1986; Trick & Enns, 1997, see also Wagemans, 2018).

One of the key questions in vision research is what kind of perceptual organization processes can be accomplished without conscious awareness of the stimulus and what kind of perceptual organization processes require awareness. In order to address this question, some studies used a masked priming paradigm (e.g. Breitmeyer, Ogmen, Ramon, & Chen, 2005; Kimchi, Devyatko, & Sabary, 2018; Jimenez, Montoro, & Luna, 2017; Montoro, Luna, & Ortells, 2014; Poscoliero, Marzi, & Girelli, 2013; Schwarzkopf &

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Rees, 2011), in which a masked prime is followed by a clearly visible target that can be congruent or incongruent with the prime in some attribute, for example, shape. Reaction times to a congruent target are compared to reaction times to an incongruent target, assuming that in a case of unconscious processing of the information contained in the prime, response-priming effect will be observed: RTs to the congruent target will be faster than those to the incongruent target. Different methods are used to suppress the stimulus from awareness (for a review, see Breitmeyer, 2015).

Recent findings demonstrated that under certain conditions, clustering can be accomplished without visual awareness. Particularly, Montoro et al. (2014), using sandwich masking – a combination of forward and backward masking – to render the prime invisible, showed that perceptual grouping of dot elements into columns or rows by Gestalt laws of luminance similarity or proximity (Wertheimer, 1923) does not require awareness. However, the picture appears to be more complicated when different invisibility inducing methods are used for the same perceptual grouping process. For example, in a recent study (Kimchi et al., 2018), dots organized into columns or rows by luminance similarity or by connectedness (Palmer & Rock, 1994) were suppressed from visual awareness either by sandwich masking or by continuous flash suppression (CFS; Tsuchiya & Koch, 2005). In CFS, a colored flashing Mondrian-like mask is presented to the participant's dominant eye, and a prime is presented to the suppressed eye. Kimchi and colleagues found response-priming effects for grouping by connectedness and by luminance similarity when the primes were invisible due to sandwich masking, but no priming effects were found for these grouping processes when the primes were rendered invisible by CFS. This difference in the results can hardly be explained by a sever interruption of information processing under CFS, since the authors obtained priming effects of both grouping principles for the same primes in the trials in which participants reported seeing the prime.

Results concerning the process of configuring or shape formation were obtained mainly in studies investigating whether the formation of an illusory figure can take place in the absence of visual awareness. In the study exploring unconscious processing of contextual illusions (Harris, Schwarzkopf, Song, Bahrami, & Rees, 2011), participants were asked to indicate whether an illusory Kanizsa triangle pointed to the left or to the right. Participants' performance was good for an unmasked illusory Kanizsa triangle; however, when the individual pacmen-inducers or the whole Kanizsa stimulus were suppressed from awareness by CFS, performance dropped to a chance level in both cases. Similar results were obtained in a follow-up masking study (Banica & Schwarzkopf, 2016). While these results provide evidence for certain limitations of unconscious formation of an illusory figures during CFS and masking, other findings coming from the breaking-CFS paradigm demonstrate that the illusory Kanizsa triangle emerged from suppression faster than ungrouped, misaligned pacmen-inducers (Moors, Wagemans, van Ee, & de-Wit, 2016; Wang, Weng, & He, 2012). Wang et al. (2012) attributed these findings to perceptual grouping. However, Moors et al. (2016) suggested that the advantage of illusory figure in breaking to awareness from CFS suppression should not be explained by figure-ground or illusory surface organization processes, but by low level features such as cardinal orientation of the aligned Kanizsa inducers. A recent study that explored the possible sources of an unconscious priming effect of illusory figures observed under metacontrast masking, demonstrated the role of salient region processing – the region of perceived brightness enhancement and depth stratification in illusory Kanizsa figure (Poscoliero et al., 2013). In another study, Jimenez et al. (2017) examined unconscious priming for two types of primes: pacmen-inducers that were aligned to produce illusory figure and misaligned pacmen that were grouped into a global geometric shape. Both types of primes were rendered invisible by sandwich masking. Significant priming effects for both types of organizations were observed when the prime was masked for 53 ms, but none were observed when the prime was masked for 23 ms.

Aside from organization of elements into an illusory Kanizsa shapes, the study of which yielded mixed results, only a handful of studies investigated whether the process of configuring or shape formation can be accomplished in the absence of visual awareness. One of these studies investigated unconscious integration of local features defined by position or orientation into a global shape, using counter-phase contrast flickering in order to render primes invisible (Schwarzkopf & Rees, 2011). It was found that neither position-defined primes nor orientation-defined primes produced priming effects without visual awareness when retinotopic effects were ruled out, indicating that neither primes were integrated into a representation of a global shape. Yet, somewhat different results were reported by Breitmeyer et al. (2005). They used metacontrast masking to investigate unconscious response-priming effects produced by whole forms – a diamond or a square made of solid lines – or by their parts – a diamond or a square configuration composed of disconnected edges (corners) or disconnected side-lines. The results showed significant response-priming effects for whole forms and for configuration composed of disconnected corners, with the former larger than the latter, but not for configuration composed of side-lines. These results suggest that the process of organization of side-lines into a configuration may require visual awareness, and that visual awareness can improve the organization of edges (corners) into a configuration.

Thus, the findings concerning unconscious configuring are far from being clear. The different studies used different stimuli and different methods to suppress the stimuli from awareness, which makes it difficult to disentangle the effects of stimuli from the effects of methods, and both these effects from the effect of the process under study.

In the current study, we examined whether organization of line configurations require visual awareness, using a masked priming paradigm, and two different methods to render the primes invisible, sandwich masking and CFS, with the same stimuli. The primes we used were square-like or diamond-like configuration composed of 'L' elements (i.e., "corners", Experiments 1, 2 and 4) or of lines (i.e., "side lines", Experiment 3). The clearly visible targets could be congruent or incongruent with the prime in configuration or in elements. This allowed us to examine the nature of the unconscious representation (elements, configuration, both, or none).

Awareness of the prime was assessed on each trial using a sensitive subjective visibility scale of four levels (e.g., Kimchi et al., 2018; Peremen & Lamy, 2014b; Ramsøy & Overgaard, 2004), which was found to be as sensitive as measures relying on objective discrimination performance, as long as the subjective measure employed is not dichotomous (Peremen & Lamy, 2014b; Ramsøy & Overgaard, 2004). The trial-by-trial measure of awareness allowed us to compare the influence of the prime on behavior when it is consciously perceived and when it is not, under identical stimulus conditions. Unconscious processing of the prime was measured as the performance difference between the congruent and incongruent conditions on trials in which visibility of the prime was null.

If organization of elements into a configuration does not require visual awareness, then response-priming effect of configuration should be observed regardless of prime visibility. If visual awareness is essential for configuring to occur, then response-priming of configuration would be observed only when the prime is reported visible. Dependency of the results on the method used to render the prime invisible (CFS vs. visual masking) may provide information about the level of processing of the configuring process.

2. Experiment 1: Grouping 'L' elements into a configuration during CFS

2.1. Method

2.1.1. Participants

Participants in all the experiments were students at the University of Haifa and were paid or granted with course credit for participation. All participants provided informed consent to a protocol approved by the Ethics Committee of the University of Haifa. All had normal vision, and none participated in more than one experiment. Twenty-six individuals (25 right-handed and 1 left-handed, 21 females, age range = 21–32 years (M = 24.6)) participated in Experiment 1.

2.1.2. Apparatus

Stimuli and experiment were generated using Matlab R2014a and Psychophysics Toolbox (http://psychtoolbox.org). All stimuli were presented on an LCD BenQ monitor (24-in, 100-Hz refresh rate, 1920 × 1080 resolution). Participants provided responses using a response-box (Psychology software tools, model 200A) and a computer keyboard. All stimuli were viewed through an adjustable mirror stereoscope attached to a chin rest at a distance of 57 cm. The testing room was dimly lit.

2.1.3. Stimuli

A black and grey mosaic frame (8.5° × 8.5°, with a thickness of 1.25°) was presented to both eyes throughout the trials to facilitate binocular fusion. All stimuli were presented centrally on a grey background (RGB: 70, 18.2 cd/m^2) within the frame (Fig. 2A). The prime was a square-like or a diamond-like configuration (Fig. 1A). The square-like prime subtended 4° × 4°, and consisted of four 'L' elements (RGB: 190, 58.9 cd/m^2). Each arm of the 'L' element subtended 1.5° in length and 6 pixels in width. The diamond-like prime was a 45° rotation of the square-like prime.

There were two types of targets, defined by the potential congruency between the prime and the target, administered in separate blocks. In the configuration block, prime-target congruency was at the level of configuration. The target was a square-like or a diamond-like configuration consisted of four lines (RGB: 190). The square target subtended 3.8° × 3.8°; the diamond target was a 45° rotation of the square target. Each line of the target subtended 2.85° in length and 3 pixels in width (Fig. 1A). In the element block, prime-target congruency was at the level of elements. One target, the cross-like target subtending 3.8° × 3.8°, was made of four 'L' elements (RGB: 190), each of which subtended 1.43° in length and 3 pixels in width (Fig. 1A). The other target, the X-like target, was composed of 45° rotation of the L elements. For each target type, prime and target were equally likely to be congruent or incongruent.

The CFS mask was a high-contrast, Mondrian-like pattern (Fig. 2A; 5.74° × 5.74°), which consisted of 300 colored and randomly positioned triangles (0.4–2.2% of the mask size). The refresh rate of the CFS mask was set at 10 Hz. During the experiment, each particular mask was randomly chosen from a pool of 1000 masks and appeared just once.

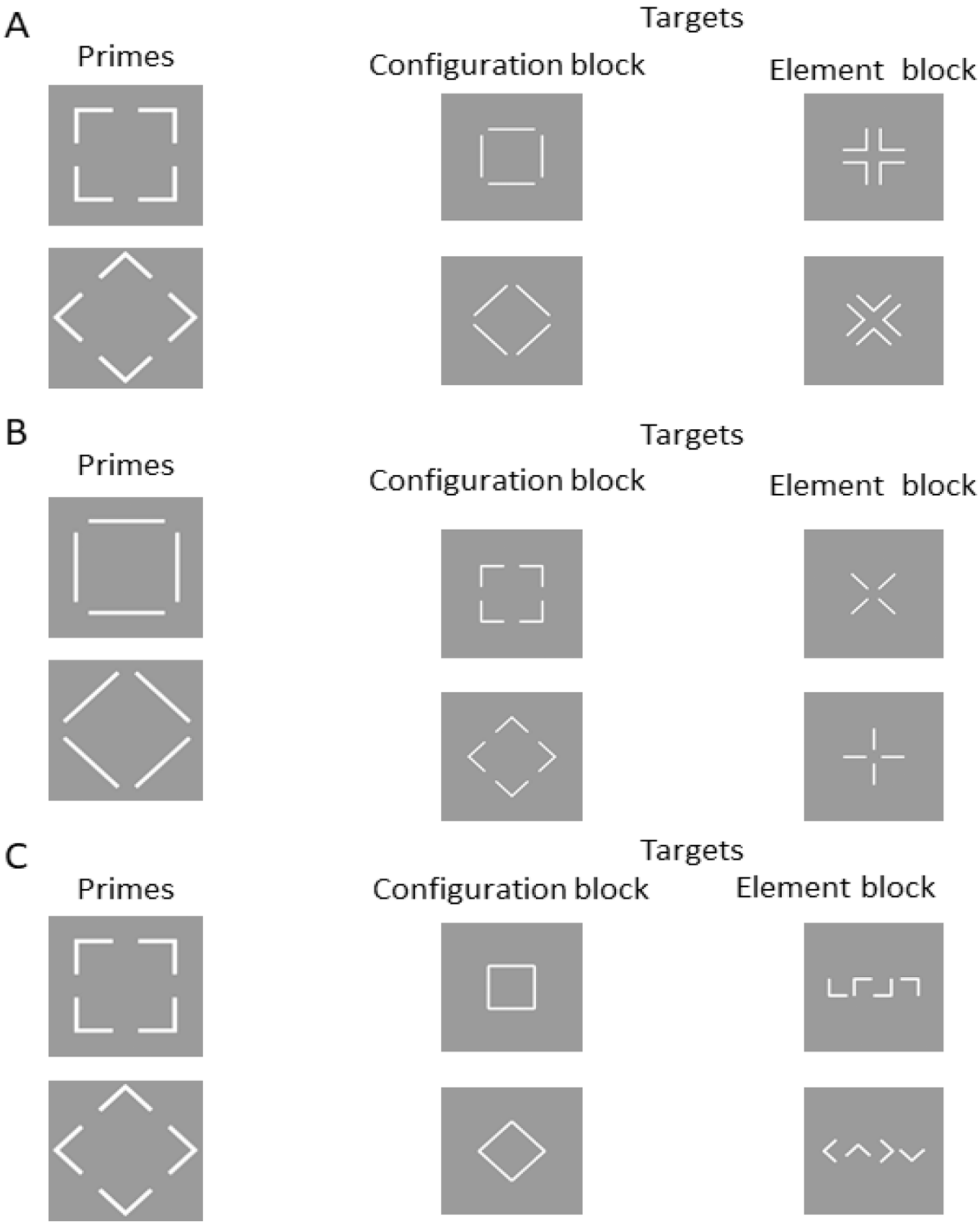

Fig. 1. Primes and targets in (A) Experiment 1 and 2, (B) Experiment 3, and (C) Experiment 4. In all experiments, prime-target congruency was at the level of the configuration in the configuration block, and at the level of the elements in the element block (see text for details).

2.1.4. Procedure and design

Before each experiment, we checked the dominant eye and calibrated the stereoscope for each participant using a custom program created in Matlab.

The sequence of events in a trial is shown in Fig. 2A. Each trial started with a fixation mark (a 0.5° × 0.5° light grey cross, RGB 200) presented at the center of the screen for 1000 ms. Then a prime was presented to the suppressed eye, gradually increasing its contrast from 0 to 100% during first 100 ms. A CFS mask (full contrast) was simultaneously presented to the dominant eye. The prime and mask remained on the screen for 400 ms until the target appeared in the dominant eye. The target remained present until the participant responded or 2000 ms had elapsed. Participants had to discriminate between the targets in each block by pressing one of two keys on the response-box with their right hand as fast as possible while avoiding making mistakes. In the instructions, the targets were presented as two possible images shown on the display, to be discriminated by pressing the appropriate response key. Thus,

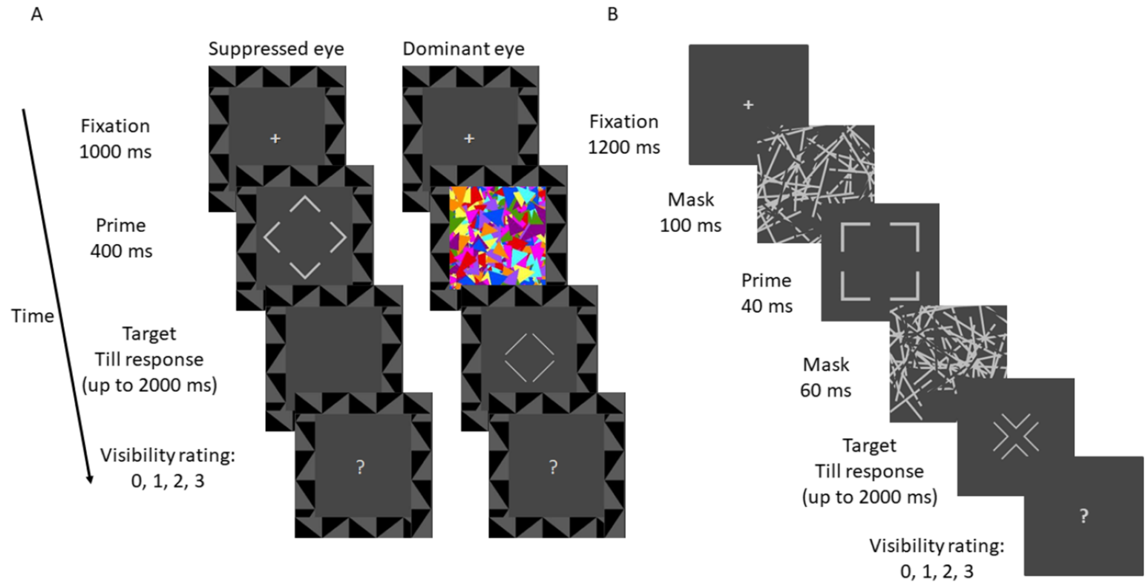

Fig. 2. Sequence of events in a trial. (A) Experiments 1: The prime was gradually introduced and presented to the suppressed eye, while the dynamic Mondrian was presented to the dominant eye, followed by the target. Participants were required to make a speeded response to the target and then rate subjective visibility of the prime. The example depicts a congruent trial in the configuration block. (B) Experiments 2–4: The prime was masked by forward and backward masks. The example depicts an incongruent trial in Experiment 2, element block.

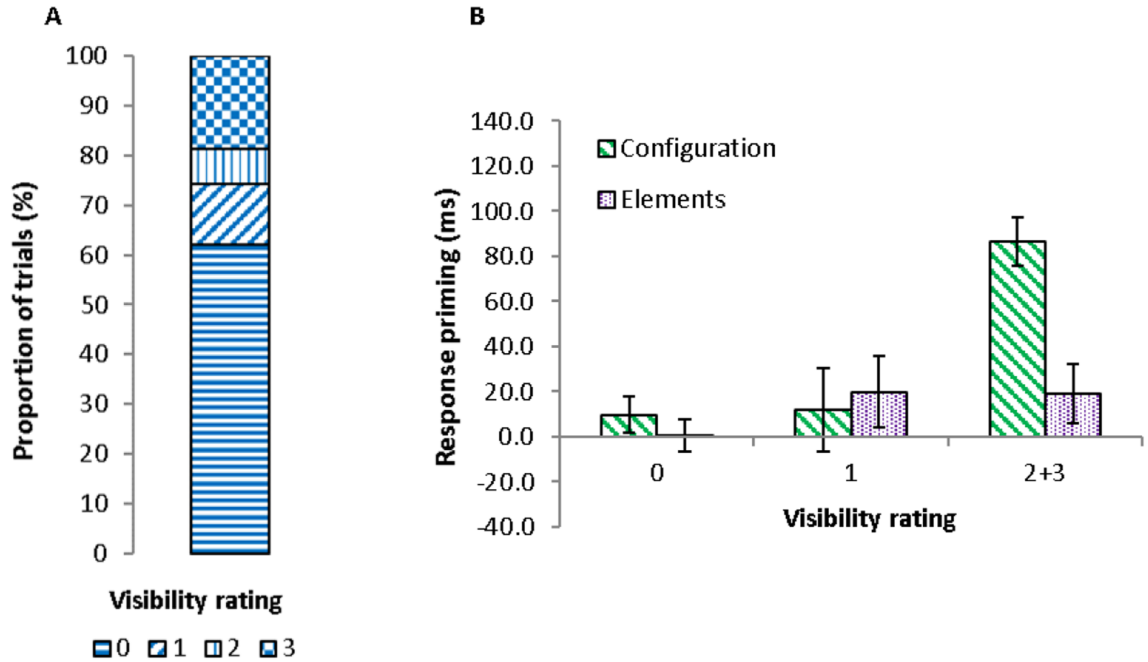

Fig. 3. Prime visibility ratings and response-priming in Experiment 1. (A) Mean proportions of trials in each level of prime visibility. (B) Mean response-priming effects for configuration and elements as a function of visibility rating. Error bars represent standard error.

participants were not given any verbal description of the targets and were not directed to discriminate between the targets at the level of configuration or elements. The participants' response to a target was followed by a question mark in the center of the screen (both eyes), prompting the participants to provide subjective report of prime visibility. Participants rated the prime visibility using a scale ranging from 0 ("I saw nothing") to 3 ("I clearly saw another figure") by pressing the "C", "V", "B" and "N" keys on the keyboard, which were covered by labels 0, 1, 2, and 3, respectively, using their left hand. For the visibility rating 1 or 2, participants were told verbally that if they thought they had barely seen something they should press 1, and if there had been something almost visible they should press 2.

The experiment consisted of two blocks: a configuration block and an elements block, as described above (see Fig. 1A). The order of the blocks was counterbalanced across participants. Each block consisted of 264 trials and included 24 catch trials in which no prime was presented. There were 3 breaks in each block, and one inter-block break, during which participants were instructed regarding their task in the next block of the experiment. The experimental trials were preceded by 48 practice trials in each block. During the practice, an auditory tone provided immediate feedback after an incorrect response or when 2000 ms had elapsed with no response.

2.2. Results and discussion

Four participants were excluded from the analysis because they gave visibility rating 3 in more than 30% of catch trials, in which no prime was present. Two participants were excluded as they had low accuracy (54% and 49% correct responses), and additional two participants were excluded as they did not experience suppression typical for CFS (reported seeing a prime in more than 80% of the trials). The remaining 18 participants rated 77.55% of all the catch trials with visibility rating 0, and 4.98% with visibility rating 3. Catch trials were excluded from all analyses, in all experiments.

Proportions of trials in each visibility are presented in Fig. 3A. The prime was rated invisible on 62% of the trials; proportions of trials with almost visible (visibility rating 2, 6.9%) and fully visible prime (visibility rating 3, 18.8%) were relatively low.

Several participants in this experiment, as well as in the following experiments, did not use all the possible visibility ratings, resulting in an unbalanced data structure. Therefore, we used a linear mixed-effects model in all analyses involving visibility as a factor.

In all reaction time (RT) analyses, trials in which responses to the target were incorrect (4.47% of trials) were excluded from the analysis. In addition, trials with RTs more than 2 SD from condition mean for each participant were trimmed (5.21% of correct trials). Mean RTs and accuracy for congruent and incongruent conditions in each visibility are presented in Table 1.

As can be seen in Fig. 3A, there were not enough trials with visibility ratings of 2 and 3 to allow meaningful analysis of each visibility level. We therefore combined trials on which visibility was rated 2 or 3. The same holds for the following experiments. A linear mixed-effects model for repeated measures with visibility (0, 1, 2 + 3), congruency (congruent, incongruent) and block (configuration or element) as within-subject factors was performed on the RT data. The analysis showed a significant effect of congruency, $F(1,17) = 22.01$, $p < .0002$, indicating that overall RTs were faster on the congruent than incongruent trials. The main effect of visibility was also significant, $F(2,29) = 136.84$, $p < .0001$, indicating that responses were faster on trials on which visibility was rated 0 than on the other trials, and a significant effect of block, $F(1,17) = 14.83$, $p = .0013$, with faster RTs in the elements than the configuration block. There were also significant two-way interactions between visibility and block, $F(2,17) = 16.29$, $p = .0001$, congruency and block, $F(1,17) = 4.76$, $p = .0434$, and congruency and visibility $F(2,26) = 11.23$, $p < .0003$. Finally, and most importantly, there was a significant three-way interaction between block, visibility and congruency, $F(2,15) = 5.02$, $p = .0214$, indicating that congruency effects differed for configuration and elements and varied with visibility. Mean response-priming effects of configuration and elements for the three visibility conditions are presented in Fig. 3B. Follow-up analyses for the configuration revealed a significant congruency effect, $F(1,17) = 22.71$, $p = .0002$, which interacted significantly with visibility, $F(2,22) = 17.28$, $p < .0001$. As can be seen in Fig. 3B, a significant response-priming effect of configuration was found for visibility level 2 + 3, averaged 86.3 ms, $F(1,15) = 65.51$, $p < .0001$; no significant congruency effect of configuration was observed for visibility rating 0, $F(1,15) = 1.55$, $p = .2317$, and visibility rating 1, $F < 1$. The analyses for the elements showed a significant effect of congruency, $F(1,17) = 5.37$, $p = .0333$, which did not interact with visibility, $F(2,19) = 2.47$, $p = .1117$. Examination of the

Table 1
Mean[1] (M) and standard error (SE) for RTs (ms) and accuracy (%) in congruent and incongruent conditions for each level of visibility in Experiment 1.

Visibility	RT				Accuracy			
	Congruent		Incongruent		Congruent		Incongruent	
	Configuration block							
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
0	653.1	28.5	663.1	28.5	93.6	3.8	94.6	3.8
1	783.0	30.8	794.6	30.8	93.3	3.8	91.8	3.8
2	777.1	32.1	859.5	32.2	94.8	3.9	95.3	4.0
3	715.3	29.4	803.2	29.4	94.3	4.1	94.9	4.1
	Element block							
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
0	672.2	28.4	672.7	28.4	96.0	3.7	97.2	3.7
1	733.5	30.2	753.0	30.2	95.9	4.0	93.4	4.0
2	809.7	32.9	828.3	32.4	90.0	4.1	88.9	4.1
3	696.3	30.5	713.4	30.4	97.5	4.7	85.3	4.5

[1] All means reported in the article are least square means from the linear mixed model.

response-priming of the elements showed no statistically significant effects at any of the visibility ratings. However, a more conservative examination of the congruency effect of elements in the aware (visibility rating 1, 2, and 3) and unaware (visibility rating 0) conditions, revealed a significant response-priming for the aware condition, $F(1,12) = 6.48$, $p = .0257$, averaged 24 ms; no statistically significant response-priming effect was observed for the unaware condition, $F < 1$. To evaluate evidence in favor of the null effects of congruency under visibility rating 0 (which is not allowed in the classic significance tests), we computed Bayesian paired T-test statistics, using JASP statistical software (www.jasp-stats.org). The evidence in favor of the null hypothesis for congruency effects for visibility rating 0 was moderate, Bayes Factor (BF01) = 3.903 and (BF01) = 4.076, for configuration and elements, respectively.

Similar analysis was conducted on the accuracy data. It showed similar trends as the RT data, suggesting no speed-accuracy trade-off, but none of the main effects or interactions reached statistical significance. Since this holds for the following experiments as well, there is no further discussion of accuracy data.

The finding of no significant response-priming effects of elements or configuration when visibility was null is seen to suggest no unconscious representation of neither the elements nor organization into a configuration during CFS. This finding is ocnsistent with previous findings suggesting that processing during CFS is rather limited (e.g., Harris et al., 2011; Hesselmann, Darcy, Sterzer, & Knops, 2015; Kimchi et al., 2018; Peremen & Lamy, 2014a).

The significant response-priming effect of the configuration when the prime was visibile, is similar to previous findings suggesting grouping of elements into configuration in the presence of visual awarness (Kimchi, 2000). The finding of no significant response-priming of the elements may be due to preemption of the elements by the configuration (e.g., Rensink & Enns, 1995), or alterantively, by prime-target dissimilarity in configuration that diminished the facilitation due to prime-target congruency in elements, resulting in a null effect (Kimchi, 2000).

3. Experiment 2: Grouping 'L' elements into a configuration under sandwich masking

3.1. Method

3.1.1. Participants

Twenty-four individuals (22 right-handed, 17 females, age range = 20–35 years (M = 23.79)) participated in Experiment 2.

3.1.2. Apparatus

The apparatus was the same as in Experiments 1, except that no stereoscope was attached to the chin rest. Experiments 2–4 were designed and stimulus presentation was controlled by E-Prime 2 software (Psychology Software Tools, Pittsburgh, PA)

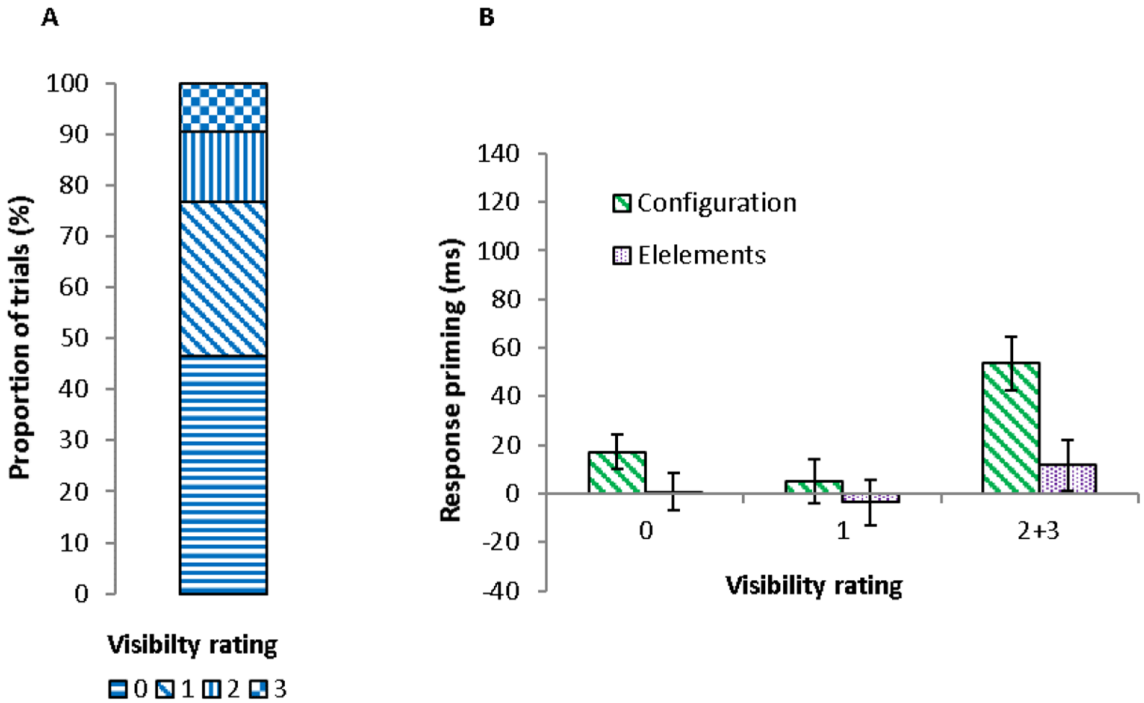

Fig. 4. Prime visibility ratings and response-priming in Experiment 2. (A) Mean proportions of trials in each level of prime visibility. (B) Mean response-priming effects for configuration and elements as a function of visibility rating. Error bars represent standard error.

3.1.3. Stimuli

Primes were identical to the ones in Experiment 1 (Fig. 1A). The targets were same as in Experiment 1, but smaller in size in order to avoid retinotopic effects. The square-like target subtended 2.66° × 2.66°, and each line in the target was 2° in length and 3 pixels in width. The cross-like target subtended 2.66° × 2.66° and each arm of the 'L' element subtended 1° in length and 3 pixels in width. The diamond-like and 'X-like targets were 45° rotation of square-like and cross-like targets, respectively. The forward and backward masks were patterns consisting of 50 grey (RGB 70) and light grey (RGB 190) lines randomly placed inside a square area subtended 5.85° × 5.85° (Fig. 2B). Each line subtended 3° in length and 4 pixels in width. The orientations of the lines were also random, but excluded orientations of 45° and its multiplications. During the experiment, each particular mask was randomly chosen from a pool of 50 masks and appeared just once in a trial. Participants viewed the screen through a circular aperture (16 cm in diameter) of a matte black cardboard sheet.

3.1.4. Procedure and design

The sequence of events in each trial is shown in Fig. 2B. Each trial started with a fixation mark (a 1° × 1° grey cross, RGB 210) presented at the center of the screen for 1200 ms. A forward mask then appeared for 100 ms, followed by a prime that appeared for 40 ms, which was followed by a backward mask presented for 60 ms. Then the target appeared and remained on the screen until the participant responded or 2000 ms had elapsed. Response to the target was followed by a question mark in the center of the screen, prompting the participants to provide subjective report of prime visibility.

All other aspects of the design and procedure were the same as in Experiment1.

3.2. Results and discussion

The participants rated 49.83% of all the catch trials with visibility rating 0 and 5.99% with visibility rating 3.

Proportions of trials in each visibility are presented in Fig. 4A. The prime was rated invisible on 46.49% of the trials; proportions of trials with almost visible (visibility rating 2, 13.71%) and fully visible prime (visibility rating 3, 9.47%) were relatively low.

In all RT analyses, trials in which responses to the target were incorrect (4.21% of trials) were excluded from the analysis, as were trials with RTs more than 2 SD from the condition mean for each participant (5.14% of correct trials). Mean RTs and accuracy for congruent and incongruent trials in each level of visibility are presented in Table 2.

A linear mixed-effects model for repeated measures with visibility (0, 1, 2 + 3), congruency (congruent, incongruent) and block (configuration, element) as within-subject factors was performed on the RT data. The analysis showed significant main effects of congruency, $F(1,23) = 14.11$, $p = .001$, indicating that overall RTs were faster in the congruent than incongruent trials; visibility, $F(2,39) = 37.18$, $p < .0001$, indicating that responses were faster on trials on which visibility was rated 0 than on the other trials; and block, $F(1,23) = 147.64$, $p < .0001$, showing that overall RTs in the configuration block were shorter than in the element block. The interaction between visibility and block did not reach statistical significance, $F(2,38) = 1.73$, $p = .1908$, nor did the interaction between block, visibility and congruency, $F(2,34) = 1.5$, $p = .2379$. Critically, congruency interacted with block, $F(1,23) = 8.87$, $p = .0067$, indicating that the congruency effects differed for configuration and elements, and with visibility, $F(2,38) = 5.43$, $p = .0084$, suggesting that the congruency effects varied with visibility. Mean response-priming effects for configuration and elements as a function of visibility conditions are presented in Fig. 4B. Follow-up analyses indicated significant response-priming effects of configuration for visibility rating 0 (17.18 ms), $F(1,34) = 5.53$, $p = .0247$, and for visibility 2 + 3 (53.56 ms), $F(1,34) = 24.14$, $p < .0001$; the magnitude of the configuration response-priming effect was significantly larger for the latter than for the former, F

Table 2
Mean (M) and standard error (SE) for RTs (ms) and accuracy (%) in congruent and incongruent conditions for each level of visibility in Experiment 2.

Visibility	RT				Accuracy			
	Congruent		Incongruent		Congruent		Incongruent	
	Configuration block							
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
0	629.8	24.3	647.0	24.3	97.2	2.8	92.9	2.8
1	669.0	24.6	674.2	24.6	95.6	2.9	97.6	2.9
2	691.3	25.6	722.8	25.6	97.7	3.1	96.3	3.1
3	628.4	27.3	722.1	27.0	99.3	3.6	84.0	3.7
	Element block							
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
0	692.7	24.3	693.4	24.3	94.9	2.8	91.8	2.8
1	716.9	24.6	713.3	24.6	95.3	2.9	94.6	2.9
2	738.1	25.7	743.1	25.7	91.2	3.2	93.4	3.0
3	717.6	26.2	736.7	26.3	90.2	3.7	84.3	3.7

(1,16) = 10.22, p = .0056. The congruency effect of configuration for visibility level 1 was not significant, $F < 1$. No significant congruency effects of elements were observed, regardless of visibility, $F < 1$, $F < 1$ and F(1,34) = 1.28, p = .266, for visibility level 0, 1, and 2 + 3, respectively. The evidence in favor of the null hypothesis for congruency effects for visibility rating 0 was close to strong, Bayes Factor (BF01) = 4.572.

The significant response-priming of configuration, observed in visibility 0, is in a clear contrast to the results of Experiment 1, in which no significant response priming was observed when visibility was null. The present finding suggests that grouping element into a configuration can occur in the absence of visual awareness when the stimulus is rendered invisible by masking. The finding of a larger congruency effect of configuration when the prime was reported visible (visibility rating 2 + 3) than when it was reported invisible (visibility rating 0) indicates that visual awareness improves the process of configuring, strengthening the representation of the configuration.

No significant response-priming effects were observed for the elements. As noted earlier, it may be due to preemption of the elements by the configuration (e.g., Rensink & Enns, 1995), or by prime-target dissimilarity in configuration that diminished the facilitation due to prime-target congruency in elements, resulting in a null effect (Kimchi, 2000).

4. Experiment 3: Grouping of line elements into a configuration under sandwich masking

This experiment was designed to examine to what extent unconscious configuring is sensitive to the available grouping cues, which were found to influence configuring under awareness conditions. In particular, good continuation (collinearity) has an important role in grouping and configuring. Previous research, for example, demonstrated the advantage of the combination of closure and collinearity over closure alone for grouping into a configuration (e.g., Hadad & Kimchi, 2008; Kimchi, 2000; Spehar, 2002). Thus, the primes employed in this experiment, which was otherwise similar to Experiment 2, were a square-like and a diamond-like configuration made of lines rather than of L elements. Consequently, whereas grouping in Experiment 2 was based on collinearity, closure, and symmetry, grouping in Experiment 3 was based mainly on closure and symmetry. Henceforth, we refer to the primes of Experiment 2 as collinear primes and to the primes of Experiment 3 as noncollinear primes.

4.1. Method

4.1.1. Participants

Thirty individuals (26 right-handed, 21 females, age range = 19–37 years (M = 25.6)) participated in Experiment 3.

4.1.2. Apparatus, stimuli, procedure and design

The apparatus and procedure (Fig. 2B) were the same as in Experiment 2. The square-like prime subtended 4° × 4° and each line in the prime subtended 3° in length and 6 pixels in width (see Fig. 1B). The diamond-like prime was a 45° rotation of the square-like prime. The square-like target subtended 2.66° × 2.66°, and each line in 'L' element was 1° in length and 3 pixels in width. The cross-like target subtended 2.66° × 2.66° and the lines subtended 1° in length and 3 pixels in width. The diamond-like and X-like targets were 45° rotation of square-like and cross-like targets, respectively. The masks were the same as in Experiment 2 except that there were 100 lines of both colors and the length of each line was 1°.

All other aspects of the procedure and design were the same as in Experiment 2.

4.2. Results and discussion

Five participants were excluded from the analysis because of visibility rating of 3 in more than 30% of catch trials. The remaining 25 participants rated 58.17% of all the catch trials with visibility rating 0 and 4% with visibility rating 3.

Proportions of trials in each visibility are presented in Fig. 5A. The prime was rated invisible on 46.55% of the trials; proportions of trials with almost visible (visibility rating 2, 15.39%) and fully visible prime (visibility rating 3, 8.18%) were relatively low.

In all RT analyses, trials in which responses to the target were incorrect (5.37% of trials) were excluded from the analysis, as were trials with RTs more than 2 SD from the condition mean for each participant (4.93% of correct trials). Mean RTs and accuracy for congruent and incongruent trials in each level of visibility are presented in Table 3.

A linear mixed-effects model for repeated measures with visibility (0, 1, 2 + 3), congruency (congruent, incongruent) and block (configuration, element) as within-subject factors was performed on the RT data. The analysis showed significant main effects of all three factors: congruency, F(1,24) = 50.29, $p < .0001$, indicating that overall RTs were faster in the congruent trials; visibility, F(2,46) = 285.75, $p < .0001$, indicating that responses were faster on trials on which visibility was rated 0 than on the other trials; and block, F(1,24) = 153.78, $p < .0001$, showing faster RTs in the configuration block than in the element block. Congruency interacted with block, F(1,24) = 17.81, p = .0003, and with visibility F(2,43) = 15.83, $p < .0001$. There was no significant interaction between visibility and block, $F < 1$. Importantly, there was a significant interaction between block, visibility and congruency, F(2,34) = 6.92, p = .003, suggesting that the response-priming effects differed for configuration and elements and varied as a function of visibility. Mean response-priming effects for configuration and elements as a function of visibility conditions are presented in Fig. 5B. Follow-up analyses for the configuration revealed a significant effect of congruency, F(1,24) = 65.48, $p < .0001$, and a significant interaction between congruency and visibility , F(2,39) = 15.27, $p < .0001$. As can be seen in Fig. 5B, a significant response-priming of configuration was found for visibility rating 0 (17.92 ms), F(1,34) = 4.78, p = .0358, visibility rating 1 (25 ms), F(1,34) = 5.45, p = .0256, and for visibility rating 2 + 3 (99.7 ms), F(1,34) = 73.82, $p < .0001$; the magnitude of the latter priming

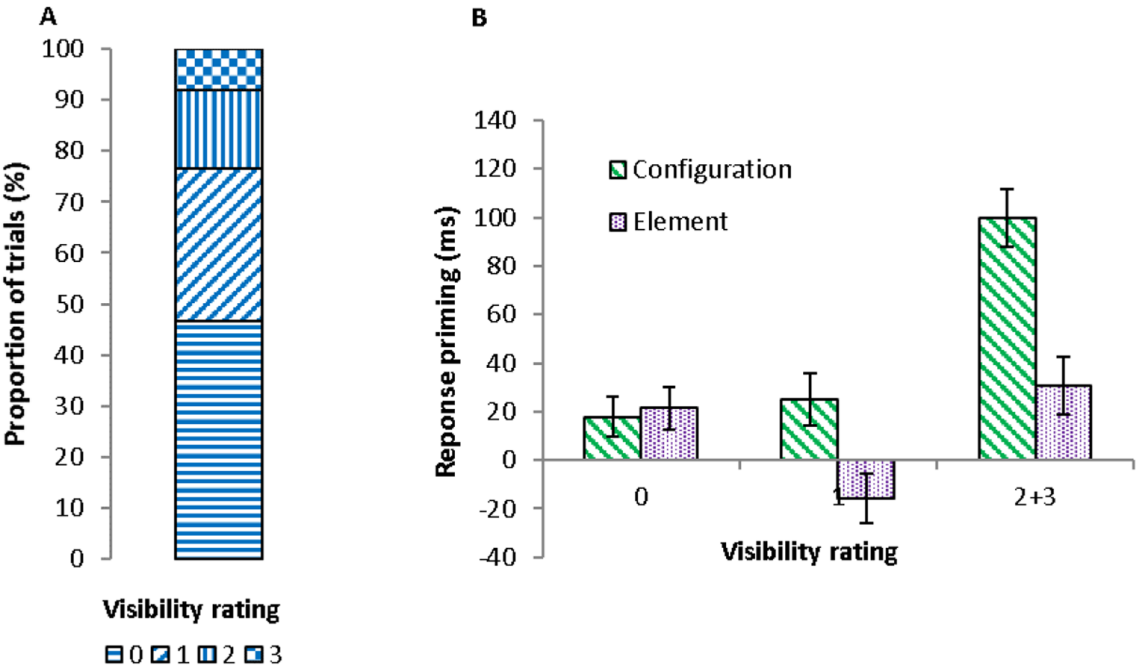

Fig. 5. Prime visibility ratings and response-priming in Experiment 3. (A) Mean proportions of trials in each level of prime visibility. (B) Mean response-priming effects of configuration and elements as a function of visibility rating. Error bars represent standard error.

was significantly greater than priming for visibility level 0, $F(1,16) = 27.1$, $p < .0001$. The congruency effect for elements did not reach statistical significance, $F(1,24) = 3.91$, $p = .0597$, but the interaction between congruency and visibility was significant, $F(2,38) = 7.24$, $p = .0022$. As can be seen in Fig. 5B, a significant congruency effect of elements was found for visibility rating 0 (21 ms), $F(1,34) = 6.26$, $p = .0173$, and visibility rating 2 + 3 (30.7 ms), $F(1,34) = 6.63$, $p = .0146$, with no difference in their magnitude, $F < 1$. No significant congruency effect of elements was observed for visibility level 1, $F(1,34) = 2.37$, $p = .1329$.

The results concerning priming of configuration converge with the results of Experiment 2, suggesting that configuring can take place in the absence of visual awareness when the stimulus is suppressed from awareness by visual masking. Yet, configuring benefits from the presence of visual awareness, as indicated by the greater magnitude of the configuration response-priming when the prime was visible (visibility level 2 + 3) than when visibility was null (visibility level 0). Further support for the role of visual awareness in the process of configuring comes from comparing priming effects of configuration versus elements separately for visibility rating 0 and visibility rating 2 + 3. No difference between the two priming effects was found for visibility level 0, $F < 1$, but response-

Table 3
Mean (M) and standard error (SE) for RTs (ms) and accuracy (%) in congruent and incongruent conditions for each level of visibility in Experiment 3.

Visibility	RT				Accuracy			
	Congruent		Incongruent		Congruent		Incongruent	
	Configuration block							
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
0	644.1	29.2	662.1	29.2	97.1	3.2	92.6	3.2
1	744.3	29.6	769.3	29.6	95.8	3.2	93.8	3.2
2	739.7	30.4	841.5	30.2	90.9	3.5	89.1	3.3
3	734.2	32.2	828.0	32.6	98.4	4.1	93.1	4.0
	Element block							
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
0	698.8	29.2	720.1	29.2	92.9	3.2	89.5	3.2
1	809.5	29.5	793.6	29.5	93.2	3.2	93.3	3.2
2	809.7	30.6	848.2	30.6	87.7	3.5	93.3	3.6
3	858.7	31.8	876.4	31.7	95.3	4.0	86.3	4.1

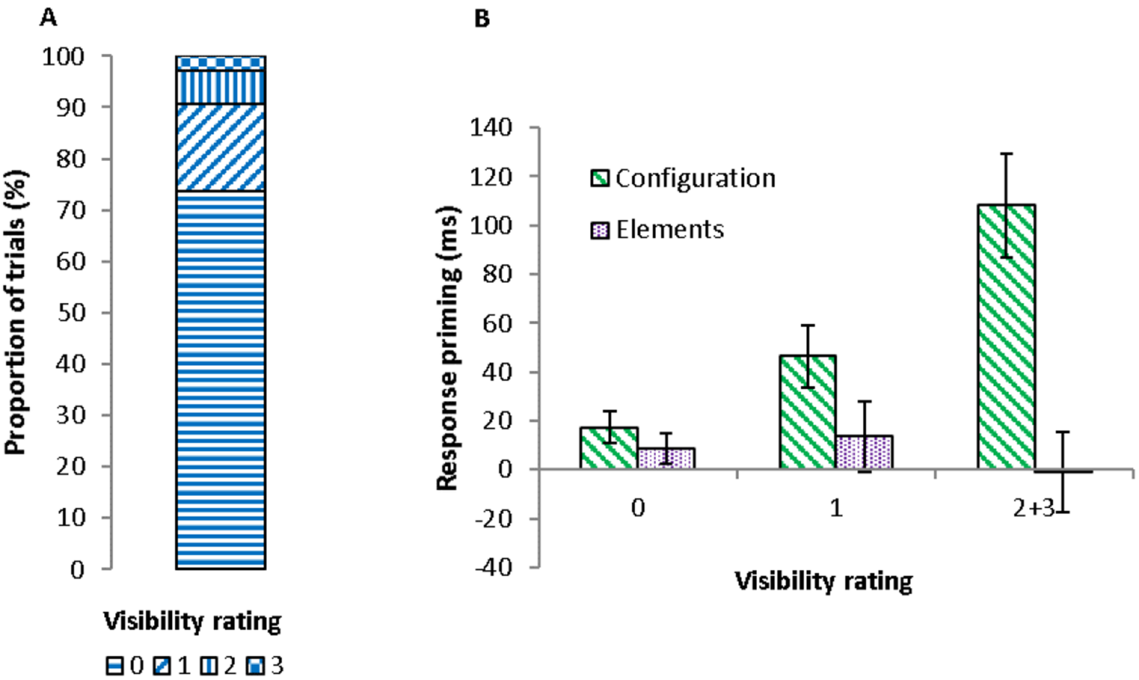

Fig. 6. Prime visibility ratings and response-priming in Experiment 4. (A) Mean proportions of trials in each level of prime visibility. (B) Mean response-priming effects for configuration and elements as a function of visibility rating. Error bars represent standard.

priming effect of configuration was significantly larger than response-priming effect of elements for visibility level 2 + 3, $F(1,13) = 11.93$, $p = .0043$.

In contrast to the results of Experiment 2, the present results showed significant response-priming effect also of the elements, both when the prime was invisible and when it was visible. Thus, in the absence of collinearity, configuring takes place, but the elements were represented as well. These results suggest sensitivity to grouping cues not only in the presence of awareness, but also in its absence.

The finding of elements priming with the noncollinear primes also suggests that the absence of elements priming in the presence of collinearity, as in Experiment 2, is more likely a result of preemption of the elements by the configuration (e.g., Rensink & Enns, 1995), rather than a result of prime-target dissimilarity in configuration in the element block. Presumably, the presence of collinearity may lead to preemption of the elements by the configuration, which in turn results in no elements priming effect.

One may argue that the strong response-priming observed for the configuration versus the absence (Experiment 2) or weaker response-priming (Experiment 3) for the elements is due to a configuration bias, which resulted from the way we created our target stimuli. In the element block, we designed that target stimuli such that prime-target congruency was in elements. Yet, as can be seen in Fig. 1A-B, the target stimuli differed from one another not only in elements, but also in configuration, such that the discrimination task could be based on the configuration rather than on the elements. Thus, it is possible that the target-discrimination task in Experiments 2–3 was always based on configuration, regardless of whether it was the configuration block or the element blocks, creating a configuration bias. To rule out this alternative account of the configuration priming, we conducted the following control experiment, making sure that target discrimination in the element block could be based only on elements.

5. Experiment 4: Control experiment

This experiment was exactly the same as Experiment 2, except for the target stimuli, which could be discriminated either at the level of configuration only (configuration block), or at the level of elements only (element block).

5.1. Method

5.1.1. Participants

Twenty-two individuals (20 right-handed, 18 females, age range = 19–29 years (M = 22.9)) participated in Experiment 4.

5.1.2. Apparatus, stimuli, procedure and design

The apparatus and procedure (Fig. 2B) were the same as in Experiment 2. The primes were the same as in Experiment 2. The square target subtended 2° by 2° with line width of 3.8 pixels (Fig. 1C). The diamond target was 45° rotation of the square target. The L-elements had orientation of 90° or 45° and subtended 0.81° or 0.76°, respectively (Fig. 1C). The line width of any L-element was 4 pixels. The array of L-elements with 90° orientation subtended 3.96° horizontally; the gaps between the elements from left to right were 0.29°, 0.06° and 0.37°, respectively. The array of L-elements with 45° orientation subtended 4.09° horizontally; the gaps between the elements from left to right were 0.21°, 0.25° and 0.59°, respectively.

5.2. Results and discussion

The participants rated 78.98% of all the catch trials with visibility rating 0 and 1.61% with visibility rating 3.

Proportions of trials in each visibility are presented in Fig. 6A. The prime was rated invisible on the majority of the trials (73.74%); proportions of trials with almost visible (visibility rating 2, 6.39%) and fully visible prime (visibility rating 3, 2.95%) were very low.

In all RT analyses, trials in which responses to the target were incorrect (5.16% of trials) were excluded from the analysis, as were trials with RTs more than 2 SD from the condition mean for each participant (5.59% of correct trials). Mean RTs and accuracy for congruent and incongruent trials in each level of visibility are presented in Table 4.

A linear mixed-effects model for repeated measures with visibility (0, 1, 2 + 3), congruency (congruent, incongruent) and block (configuration, element) as within-subject factors was performed on the RT data. The analysis showed significant main effects of congruency, $F(1,21) = 32.15$, $p < .0001$, indicating that overall RTs were faster in the congruent trials; visibility, $F(2,28) = 86.35$, $p < .0001$, indicating that responses were faster on trials on which visibility was rated 0 than on the other trials; and block, $F(1,21) = 10.56$, $p = .0038$, showing that overall RTs in the configuration block were faster than RTs in the element block. There were significant two-way interactions between visibility and block, $F(2,22) = 10$, $p = .0008$, congruency and block, $F(1,21) = 19.55$, $p = .0002$, and congruency and visibility, $F(2,24) = 4.87$, $p = .0167$. Critically, there was a significant interaction between block, visibility and congruency, $F(2,18) = 6.52$, $p = .0074$, suggesting that the response-priming effects differed for configuration and elements and varied as a function of visibility. Mean response-priming effects for configuration and elements at each visibility condition are presented in Fig. 6B. A follow-up analysis for the configuration showed a significant effect of congruency, $F(1,21) = 43.57$, $p < .0001$, which interacted significantly with visibility, $F(2,22) = 8.76$, $p = .0016$. As can be seen in Fig. 6B, significant priming effects of configuration were found for visibility level 0 (17.45 ms), $F(1,18) = 7.49$, $p = .0136$, visibility level 1 (46.37 ms), $F(1,18) = 13.71$, $p = .0016$, and visibility level 2 + 3 (108.2 ms), $F(1,18) = 26.15$, $p < .0001$, and the magnitude of the latter priming was significantly greater than the priming for visibility 0, $F(1,6) = 18.75$, $p = .0049$. The analysis for the elements showed no significant effect of congruency, and no significant interaction between congruency and visibility, $Fs < 1$. As can be seen in Fig. 6B, no significant congruency effect of elements was found at any of the visibility conditions: $F(1,18) = 1.87$, $p = .1879$, $F < 1$, and $F < 1$, for visibility rating 0, 1 and 2 + 3, respectively. The evidence in favor of the null hypothesis for congruency effects for visibility rating 0 was close to moderate, Bayes Factor (BF01) = 1.354.

The present findings of significant response-priming of configuration, and no significant response-priming of elements, rule out the suggestion that the configuration priming observed in Experiments 2 and 3 was a result of a configuration bias in these experiments. Rather, the replication of a significant response-priming of configuration, observed in visibility 0, provides additional support for the suggestion that grouping elements into a configuration based on Gestalt cues of closure, collinearity, and symmetry, can occur in the absence of visual awareness. The finding of a larger magnitude of configuration priming when the prime was reported visible than when it was reported invisible, though should be taken with caution due to the small proportion of trials in visibility rating 2 + 3, further converge with the results of Experiments 2 and 3, suggesting that visual awareness can improve the configuring process.

Table 4
Mean (M) and standard error (SE) for RTs (ms) and accuracy (%) in congruent and incongruent conditions for each level of visibility in Experiment 4.

Visibility	RT				Accuracy			
	Congruent		Incongruent		Congruent		Incongruent	
	Configuration block							
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
0	623.3	19.6	640.9	19.6	93.4	3.1	93.0	3.1
1	688.3	21.2	733.3	21.1	92.9	3.4	92.0	3.4
2	768.4	27.5	775.7	27.5	86.9	4.2	95.1	4.6
3	513.0	32.8	776.8	30.8	94.2	6.4	93.0	5.5
	Element block							
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
0	631.5	19.6	639.7	19.6	96.0	3.1	95.6	3.1
1	707.0	21.6	718.3	21.7	94.3	3.5	95.9	3.6
2	694.4	23.6	684.6	24.5	96.9	4.4	80.5	4.2
3	588.9	30.6	641.0	29.7	97.7	7.2	83.1	5.1

6. General discussion

We examined whether organization of line configuration can occur in the absence of visual consciousness. To this end, we conducted a series of masked priming experiments in which the primes were rendered invisible either by CFS (Experiment 1) or by sandwich masking (Experiments 2–4). We used two types of primes: collinear primes composed of 'L' elements grouped into a square-like or a diamond-like configuration by closure, good continuation and symmetry (Experiments 1, 2 and 4), and noncollinear primes, in which line elements were grouped into configuration mainly by closure and symmetry (Experiment 3). The targets in all experiments could be congruent with the primes either at the level of configuration or at the level of elements, which allowed us to test for response-priming effects of configuration and elements.

The results showed no evidence for grouping into a configuration during CFS. When the prime was rendered invisible by CFS and participants reported not seeing the prime, neither significant response-priming of configuration nor significant response-priming of elements were observed; significant response-priming of the configuration was observed for the visible primes (Experiment 1). In a clear contrast, when the same collinear primes were rendered invisible by sandwich masking (Experiment 2 and 4), a significant response-priming effect of configuration was observed both when the prime was reported invisible and when it was reported visible, with a larger priming for the latter than for the former. Similar response-priming effects of configuration were found with the noncollinear prime, which was also rendered invisible by sandwich masking (Experiment 3). We ruled out a configuration bias account for our findings (Experiment 4). Thus, taken together, our results suggest that grouping line elements into a configuration can occur in the absence of visual awareness, when the stimulus is suppressed from awareness by visual masking; yet, the presence of visual awareness benefits the configuring process, strengthening the configural representation. This benefit from visual awareness is also observed for other types of grouping stimuli (Breitmeyer et al., 2005; Jimenez et al., 2017), and numeric stimuli (Avneon & Lamy, 2018). Interestingly, an effect of visual awareness is also observed in a masked Eriksen flanker task, in which response interference was larger when the flankers were reported as being more visible (Maniscalco, Bang, Iravani, Camps-Febrer, & Lau, 2012).

An interesting difference was observed between the collinear and noncollinear primes: whereas response-priming of configuration was observed for both primes, response-priming of elements was observed only for the noncollinear primes, both when the prime was invisible and when it was visible. Unlike the priming of configuration, the priming of elements did not increase with visual awareness, and was significantly weaker than the configuration priming under prime visibility. These findings are somewhat reminiscent of Kimchi (2000) findings. Using primed-matching with unmasked primes, Kimchi showed that configural organization of line segments outweighed any effect of the line components for both collinear and non-collinear primes when the distance between the line components was small, but only for the collinear primes when the distance was larger, presumably due to the availability of collinearity. Our results suggest that sensitivity to the available grouping cues is evident also in the absence of visual awareness: unconscious priming of elements was observed for the noncollinear prime, but not for the collinear prime.

Note that we suggest that the lack of elements priming (Experiments 2 and 4) is due to the presence of collinearity, which presumably leads to preemption of the elements by the configuration. The finding of elements priming when collinearity is absent (Experiment 3) supports this suggestion. Nonetheless, one may argue that the slower RTs in the element than in the configuration block, observed in Experiments 2–4, play a role in the lack of elements priming. Indeed, Avneon and Lamy (2018) have recently found priming effects for shorter and longer RTs for conscious primes and only for short RTs for unconscious primes. To examine whether the lack of elements priming can be accounted for by the slower RTs we followed the vincentization procedure used by Avneon and Lamy (2018) for the trials with visibility rating 0 in the elements block in each experiment, and conducted a repeated measures ANOVA with congruency (congruent vs. incongruent) and RT-distribution half (fast vs. slow RTs) as within-subject factors. The results of Experiments 2 and 4 showed no significant interaction between the two factors, indicating no difference in the congruency effect between fast and slow RTs. Only in Experiment 3, in which the elements priming was observed, the interaction was significant, but the results showed larger priming effect for the slower than for the faster RTs (see Appendix A). Thus, the results of these analyses, and the finding of the elements priming in Experiment 3 (in contrast to its absence in Experiments 2 and 4), rule out the slower RTs account for the lack of the elements priming.

The unconscious priming effect of configuration obtained for collinear primes in the sandwich masking experiments is in agreement with previous findings (Breitmeyer et al., 2005; Jimenez et al., 2017) and supports the hypothesis that perceptual organization of elements into a configuration can be accomplished without visual awareness in certain masking conditions. However, our finding of unconscious configuration priming effects with noncollinear primes appear to disagree with the results of Breitmeyer et al. (2005). They found no evidence of priming effect of configuration for noncollinear "side" primes, which were rendered invisible by metacontrast masking. This difference may be explained by stronger proximity between the line elements in our primes: the gaps between the line elements in our noncollinear primes constituted 25% of the prime's side, while in Breitmeyer et al. (2005) study the corresponding gaps constituted 50% of the prime's side. Previous research has suggested that grouping of line fragments into a configuration depends on the proximity between the fragments and on the presence or absence of collinearity, such that collinearity facilitates the grouping of spatially distant fragments (Hadad & Kimchi, 2008; Kimchi, 2000). Therefore, in the absence of collinearity, spatially distant fragments may not configure, as presumably ocuured in Breitmeyer et al. (2005).

As noted earlier, we observed unconscious configuring with sandwich masking, but not during CFS. These results are in line with previous findings demonstrating unconscious priming in masking experiments and a lack of or a less pronounced priming in CFS experiments for the same set of stimuli (Almeida, Pajtas, Mahon, Nakayama, & Caramazza, 2013; Izatt, Dubois, Faivre, & Koch, 2014; Kimchi et al., 2018; Peremen & Lamy, 2014a). Some findings suggest that during CFS the processing of information is limited to early visual areas (Hesselmann & Malach, 2011; Sterzer, Stein, Ludwig, Rothkirch, & Hesselmann, 2014; Yuval-Greenberg & Heeger, 2013, see also Cohen, Nakayama, Konkle, Stantić, & Alvarez, 2015; Moors, Hesselmann, Wagemans, & van Ee, 2017; Watanabe et al., 2011). Thus, the presence of unconscious configuring priming with sandwich masking and its absence with CFS, suggest the involvement of higher-level areas in perceptual organization processes in general and in the process of configuring in particular (see also Kimchi et al., 2018).

The influence of the invisibility inducing method on unconscious processing is also observed in several studies reported in the literature. For example, in contrast to our results, Schwarzkopf and Rees (2011) showed no unconscious priming of both position-defined configurations and orientation-defined configurations in the absence of visual awareness when retinotopic effects were ruled out. The difference between Schwarzkopf and Rees's results and ours could have emerged from the difference in stimuli, the difference in the method used to render the prime invisible, or both. The stimuli in Schwarzkopf and Rees' study were somewhat simpler configurations than ours, and they used counter-phase flickering whereas we used masking to suppress the prime from awareness. The use of counter-phase flickering versus metacontrast and sandwich masking yielded different results also in the study of unconscious formation of illusory figures: Banica and Schwarzkopf (2016), using counter-phase flickering to render the stimulus invisible, failed to find perception of illusory Kanizsa figures, whereas Jimenez et al. (2017), using sandwich masking, and Poscoliero et al. (2013), using metacontrast, observed formation of illusory figures without visual awareness. Presumably, the suppression induced by counter-phase flickering occurs at earlier levels of processing than masking (see, Schwarzkopf & Rees, 2011).

A somewhat different view is presented by Persuh, Emmanouil, and Ro (2016). They suggested that findings pertaining to absence of unconscious processing may result from restricted visual input (e.g., very short stimulus duration in masking), rather than from limitations in unconscious perception. They invented a new invisibility-inducing method – perceptual overloading technique, in which a stimulus followed by a mask is repeatedly presented to both eyes (Persuh et al., 2016), and demonstrated formation of illusory contours in the absence of visual awareness, in agreement with other studies (Jimenez et al., 2017; Poscoliero et al., 2013). Note however, that in counter-phase flickering a masked stimulus is also repeatedly presented for several times, yet the results clearly dissociate (Banica & Schwarzkopf, 2016). Furthermore, unconscious formation of illusory contours was also observed with masking procedures with short presentation time (e.g., Jimenez et al., 2017; Poscoliero et al., 2013).

7. Conclusions

To conclude, our findings demonstrate that organization into a configuration, based on Gestalt cues of collinearity, closure, and symmetry, can occur without visual awareness when the stimulus is rendered invisible by sandwich masking. Yet, visual awareness appears to strengthen configural representations. Our results also suggest sensitivity to the available grouping cues in unconscious processing. The finding of unconscious configuring under sandwich masking but not during CFS (observed in our study) and counter-phase flickering (e.g., Schwarzkopf & Rees, 2011), may suggest the involvement of higher-level areas in configural processing.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://data.mendeley.com/datasets/phbnrsvjys/drafta=0462cf83-1a80-4a57-afe3-db03329571b Reserved DOI: https://doi.org/10.17632/phbnrsvjys.1.

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