



Original Articles

Hidden intentions: Visual awareness prioritizes perceived attention even without eyes or faces

Clara Colombatto^{a,*}, Benjamin van Buren^{b,*}, Brian J. Scholl^{a,*}

^a Yale University, USA

^b The New School, USA



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ABSTRACT

Eye contact is a powerful social signal, and it readily captures attention. Recent work has suggested that direct gaze is prioritized even unconsciously: faces rendered invisible via interocular suppression enter awareness faster when they look directly at (vs. away from) you. Such effects may be driven in a relatively low level way by the special visual properties of eyes, per se, but here we asked whether they might instead arise from the perception of a deeper property: being the focus of another agent's attention and/or intentions. We report five experiments which collectively explore whether visual awareness also prioritizes distinctly non-eye-like stimuli that nevertheless convey directedness. We first showed that directed (vs. averted) 'mouth' shapes also break through into awareness faster, after being rendered invisible by continuous flash suppression — a direct 'gaze' effect without any eyes. But such effects could still be specific to faces (if not eyes), so we next asked whether the prioritization of directed intentions would still occur even for stimuli that have no faces at all. In fact, even simple geometric shapes can be seen as intentional, as when numerous randomly scattered cones are all consistently pointing at you. And indeed, even such directed (vs. averted) cones entered awareness faster — a direct 'gaze' effect without any facial cues. Additional control experiments ruled out effects of both symmetry and response biases. We conclude that the perception of directed intentions is sufficient to boost objects into awareness, and that putative eye-contact effects might instead reflect more general phenomena of 'mind contact'.

1. Introduction

Of all the objects we can perceive, arguably the most important are other agents, and accordingly visual processing is highly efficient at detecting other people and extracting their properties (from race and gender to emotional states and personality traits). Other agents are important because their actions may have immediate consequences for our own fitness, and so it is especially informative to perceive where and how their attention and intentions are directed — as signaled by cues such as gaze direction. Eye gaze, in particular, is a highly reliable cue to the location of an agent's desires (e.g. King, Rowe, & Leonards, 2011), and their future actions (e.g. Land & Hayhoe, 2001). And indeed, eye gaze cues — and especially direct eye contact — are prioritized in visual processing in many ways, even from birth (Farroni, Csibra, Simion, & Johnson, 2002). For example, faces that are looking at us capture attention (e.g. Böckler, van der Wel, & Welsh, 2014; Yokoyama, Ishibashi, Hongoh, & Kita, 2011), are found faster during visual search (e.g. Senju, Hasegawa, & Tojo, 2005; von Grünau & Anston, 1995), and are

harder to disengage from (e.g. Dalmaso, Castelli, & Galfano, 2017; Senju & Hasegawa, 2005). And beyond controlling our attention, direct gaze also has powerful downstream consequences on our mental lives, as when faces looking at us are remembered better (Hood, Macrae, Cole-Davies, & Dias, 2003), or are rated as more likeable (Mason, Tatkov, & Macrae, 2005).

In fact, gaze is so powerful that it even impacts us when it is not consciously perceived. This has been especially apparent in a series of recent studies that explored eye gaze using continuous flash suppression (CFS) — a form of binocular rivalry in which a rapid stream of flashing masks shown to one eye temporarily renders invisible stimuli presented to the other eye (Tsuchiya & Koch, 2005; for a review, see Stein, 2019). In this work, faces looking directly at the observer break into awareness (escaping the interocular suppression from the flashing masks) faster than faces looking away (Chen & Yeh, 2012; Stein, Senju, Peelen, & Sterzer, 2011). This prioritization seems especially robust, as such effects are revealed both with multiple measures (e.g. unconscious fixation patterns, as in Rothkirch, Madipakkam, Rehn, & Sterzer, 2015;

* Corresponding authors at: Department of Psychology, Yale University, Box 208205, New Haven, CT 06520-8205, USA.

E-mail addresses: clara.colombatto@yale.edu (C. Colombatto), vanburen@newschool.edu (B. van Buren), brian.scholl@yale.edu (B.J. Scholl).

adaptation aftereffects, as in Stein, Peelen, & Sterzer, 2012; or neural responses, as in Burra et al., 2013; Madipakkam, Rothkirch, Guggenmos, Heinz, & Sterzer, 2015; Yokoyama, Noguchi, & Kita, 2013), and with multiple suppression methods (e.g. masking, as in Sato, Okada, & Toichi, 2007; or when observers are simply actively attending elsewhere, as in Yokoyama, Sakai, Noguchi, & Kita, 2014).

1.1. From ‘eye contact’ to ‘mind contact’

Unconscious prioritization of eye contact may be driven in a relatively low level way by the eyes, per se — and indeed a great deal of work has suggested that gaze perception is driven by various eye-specific properties (e.g. Kingstone, Kachkovski, Vasilyev, Kuk, & Welsh, 2019), such as the stark contrast between the dark iris and the surrounding light sclera (e.g. Ando, 2002, 2004). But of course, direct eye gaze is not important in and of itself, but rather in virtue of what it signals — namely, the attention and intentions of other agents (i.e. of the *mind* behind the eyes). So might the prioritization of direct gaze in visual awareness then be driven not simply by superficial features (e.g. faces and eyes) themselves, but rather by the deeper perception of *directed intentions*?

This possibility is supported by recent work demonstrating that computations of gaze direction rely not just on the brute properties of the eyes themselves (e.g. the position of the pupils within the sclerae), but also on the integration of multiple cues including head orientation (Palmer & Clifford, 2018) and the surrounding context (Lobmaier, Fischer, & Schwaninger, 2006; for a review, see Langton, Watt, & Bruce, 2000). Similarly, the perception of a gaze as direct can be modulated by numerous factors including perceptual uncertainty (Clifford, Mareschal, Otsuka, & Watson, 2015; Mareschal, Calder, & Clifford, 2013), the faces’ emotional expressions (Ewbank, Jennings, & Calder, 2009; Harbort, Witthöft, Spiegel, Nick, & Hecht, 2013; Lobmaier & Perrett, 2011), and observer characteristics (Gamer, Hecht, Seipp, & Hiller, 2011; Jun, Mareschal, Clifford, & Dadds, 2013; Rimmele & Lobmaier, 2012; Schulze, Renneberg, & Lobmaier, 2013).

Higher-level properties (beyond mere physical cues) have been shown to play a role not just in the computation of gaze direction in the first place, but also in the powerful downstream effects of perceiving others’ gaze. This has been especially apparent in studies of “eyes without minds”, in which gaze effects are greatly reduced when the very same visual cues (of eyes) are dissociated from the perceived direction of attention (i.e. from the “mind behind the eyes”). For example, gaze cues fail to draw observers’ attention when they are not seen to signal underlying intentions (as in the phenomenon of ‘gaze deflection’; Colombatto, Chen, & Scholl, 2020). And effects of gaze can be modulated by our beliefs about whether others can see, such that they are reduced in face stimuli with closed eyes (Nuku & Bekkering, 2008), with opaque sunglasses (Hazem, George, Baltazar, & Conty, 2017; Morgan, Freeth, & Smith, 2018; Teufel, Alexis, Clayton, & Davis, 2010), or with their line of sight obstructed in other ways (e.g. Kawai, 2011; Myllyneva & Hietanen, 2015; cf. Cole, Smith, & Atkinson, 2015; Kingstone et al., 2019). This work has suggested that the power of eye contact may reside not in any particular visual cue, but rather in a more abstract ‘feeling of being watched’ (Conty, George, & Hietanen, 2016; de Hamilton, 2016) — and indeed the effects of eye contact are boosted when social information is made relevant (for a review, see Burra, Mares, & Senju, 2019), and eye contact can in turn boost affiliative behaviors (e.g. mimicry; Wang & de Hamilton, 2012), positive affect (Hietanen, 2018), and self-awareness (Hietanen & Hietanen, 2017; Isomura & Watanabe, 2020).

1.2. The current study: unconscious prioritization of gaze without eyes?

While past work has explored the relative contributions of physical cues (of eyes) vs. more abstract properties (of minds) by exploring “eyes without minds”, here we adopt a novel complementary approach, asking about “minds without eyes”. If the essence of gaze is the perception of

attention and intentions, might ‘gaze’ effects arise even in stimuli that do not look like eyes (or faces) but are nonetheless perceived as intentional? In other words, might perceived intentions (beyond the eyes themselves) be not only *necessary*, but also *sufficient* for gaze effects?

Of course, we typically associate agents with their superficial appearances (e.g. with their faces and eyes), but agency can also be communicated via other means. For example, consider a display containing many simple oriented geometric ‘dart’ shapes that are moving around the screen in an entirely random fashion, but are nevertheless always pointing towards a disc. When viewing such displays, observers have the distinct impression that the darts are actively pursuing the disc (the ‘wolfpack effect’; Gao, McCarthy, & Scholl, 2010), and such impressions appear to reflect involuntary mechanisms of visual processing (e.g. van Buren, Uddenberg, & Scholl, 2016; for a review, see Scholl & Gao, 2013).

Might then the prioritization in visual awareness observed for direct gaze using eyes also occur for stimuli that have no eyes (and perhaps even no faces), as long as they are still seen to reflect directed intentions? To find out, we replicated a previous study of direct gaze driving faster breakthrough times in CFS (Stein, Senju, et al., 2011, Experiment 1a), now with stimuli that were still readily perceived as signaling directed attention despite being eyeless (as in the ‘directed mouths’ stimuli employed in Experiments 1a and 1b) and even faceless (as in the ‘directed cones’ stimuli employed in Experiments 2, 3a, and 3b).

2. Experiment 1a: prioritizing ‘directed mouths’ (without eyes)

Observers viewed displays featuring ‘mouths’ that were directed either towards or away from them (as depicted in Fig. 1a and b). Following Stein, Senju, et al. (2011), Experiment 1a), we used CFS to render these displays invisible, and measured the time they took to break through interocular suppression (Fig. 1c).

2.1. Method

2.1.1. Observers

Fourteen observers (with normal or corrected-to-normal acuity; 9 females; average age = 20.79 years) participated for course credit or monetary compensation, after giving their informed consent. This sample size was chosen before data collection began to match that of Stein, Senju, et al. (2011), and was held constant across all experiments reported here.¹

2.1.2. Apparatus

Stimuli were presented on a Dell 2208WFPT monitor with a 60 Hz refresh rate, using custom software written in Python with the PsychoPy libraries (Peirce et al., 2019). Observers placed their head in a chinrest and viewed the display through a custom-made mirror haploscope. The display was 90 cm away, and subtended approximately $29.50^\circ \times 18.68^\circ$ (with all extents below reported based on this distance).

2.1.3. Stimuli

The mouths (generated using Blender, version 2.76) each consisted of a green sphere ($0.57^\circ \times 0.50^\circ$), with a red cutout (centered 0.31° from the top) containing a realistic 3D model of white human teeth. On Directed trials (Fig. 1a), the cutout ($0.40^\circ \times 0.32^\circ$) was horizontally centered, and on Averted trials (Fig. 1b) it was rotated leftward or rightward. (When rotated leftward, the new center was 0.43° from the sphere’s right border, the rightmost border was 0.27° from the sphere’s right border, and the cutout subtended $0.29^\circ \times 0.32^\circ$ due to foreshortening — mutatis mutandis for rightward rotations.) Eighty

¹ A power analysis also confirmed that this sample size was sufficient to detect the effect size from Experiment 1 of Stein, Senju, et al., 2011 ($d_z = 1.89$) with 99.99% power.

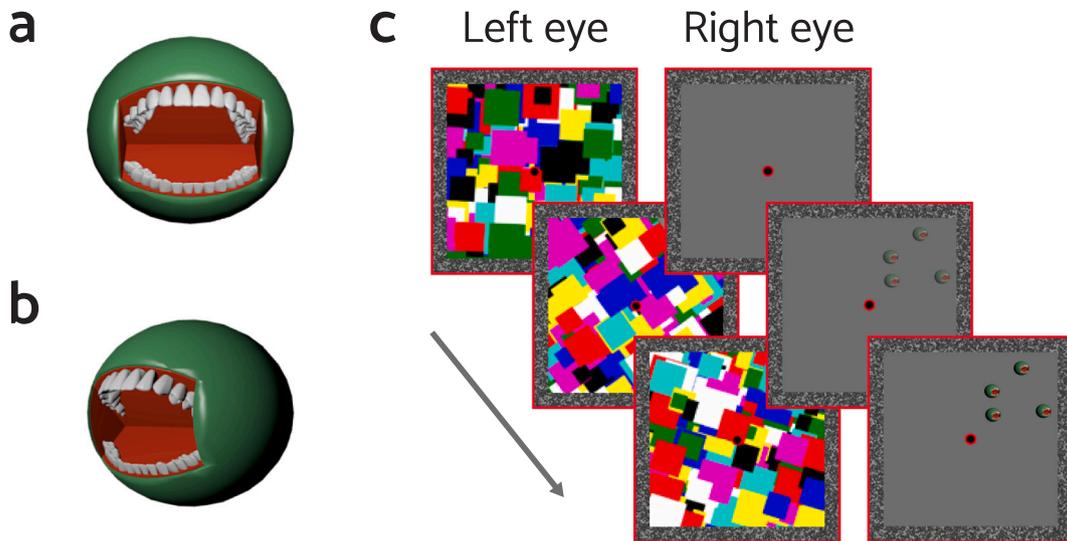


Fig. 1. (a) Averted and (b) Directed ‘mouths’ employed in Experiments 1a and 1b. (c) Depiction of the Continuous Flash Suppression paradigm.

$3.27^\circ \times 3.27^\circ$ images (40 Directed and 40 Averted, as depicted in Fig. 2a) were created by placing either 4 Directed or 4 Averted mouths in random non-overlapping locations on a gray (#6F6F6F) background (each at least 0.18° from the nearest image border).

The functional part of the display consisted of two $6.38^\circ \times 6.38^\circ$ vertically centered regions centered 7.01° to the left and right of the screen center. As depicted in Fig. 1c, each had a gray (#6F6F6F) background and a central fixation dot (radius = 0.14°) with a black (#000000) inside and a red (#FE0303) outline (stroke width = 0.07°), and each region was surrounded by a frame filled with static noise to support binocular alignment (0.54° stroke), and an outer red frame (#FE0303; 0.07° stroke).

Eighty Mondrian masks were created, each consisting of 500 squares — with different sizes (randomly selected from 0.45° to 1.35°), different colors (randomly selected between white [FFFFFF], yellow [FFFF00], fuchsia [FF00FF], red [FF0000], green [#008000], turquoise [#40E0D0], blue [#0000FF], and black [#000000]), but the same orientation (randomly selected for each mask).

2.1.4. Procedure

At the beginning of each trial, observers saw the frames and fixation dots, and (if necessary) adjusted the haploscope mirrors until the left and right regions were binocularly fused. After they pressed a key to start the trial, the Mondrian masks immediately began flashing at 10 Hz on a randomly selected side. The ‘mouths’ image was shown on the other side (horizontally centered 1.56° to either the left or right of fixation, and vertically positioned with the center randomly placed from -1.56° to 1.56° of fixation), with its opacity linearly increased from 0% to its maximum opacity over the course of the first second. As soon as observers saw any part of the image, they immediately indicated its position with respect to the fixation dot by pressing either the left or right arrow key. The trial ended after a response, or after 8 s had elapsed — at which point the next trial immediately began.

2.1.5. Design

Observers completed 40 trials in each of the 2 conditions (Directed/Averted; with the 40 trials in each condition differing only in the random placements of the mouths), in a different random order for each observer, and with a self-paced break halfway through. On half of the trials (evenly distributed across each condition, and presented in a randomized order), the image appeared to the left of fixation; on the other half it appeared to the right. The mouths were averted leftward for

half of observers and rightward for the other half. The experimental trials were preceded by 16 trials featuring different stimuli (license plates). The first 4 were practice trials (the results of which were not recorded), and the remaining 12 functioned as a pre-test: observers were excluded from moving on to the experimental trials if their accuracy was below 75% or their average response time on accurate trials was below 1 s.

2.2. Results and discussion

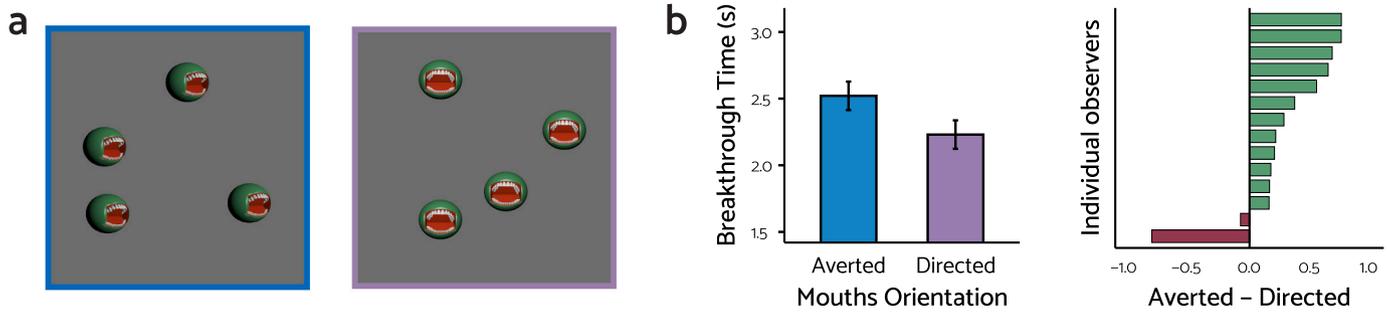
Trials in which observers failed to respond (4.50/80 on average) were assigned breakthrough times of 8 s (i.e. the maximum trial length), and trials in which observers responded inaccurately (1.93 on average) were discarded (with these criteria adopted directly from Stein, Senju, et al., 2011). As depicted in the left panel of Fig. 2b, breakthrough times were faster for displays containing Directed compared to Averted mouths (2.23 vs. 2.52 s, $t(13) = 2.67$, $p = .019$, $d = 0.27$).² This difference was also highly robust nonparametrically: as depicted in the right panel of Fig. 2b, for 12 of the 14 participants breakthrough times were faster for displays containing Directed compared to Averted mouths. This initial result suggests that objects directed at the observer are prioritized in visual awareness even without visible eyes.

3. Experiment 1b: direct replication and conscious control

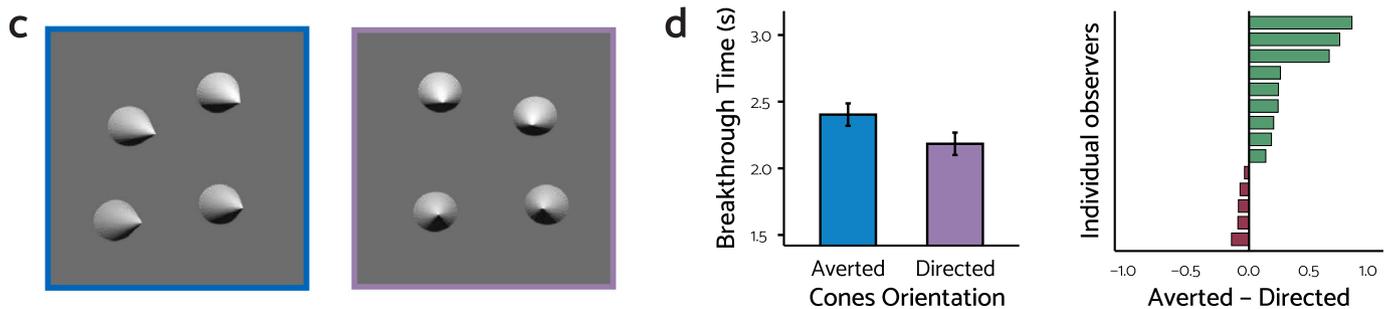
To ensure that these results were due to unconscious processing of the stimuli rather than a response bias in conscious detection (Balsdon & Clifford, 2018; Moors et al., 2019), we directly replicated Experiment 1a, adding a between-subjects factor: for half of observers, the mouth displays were never suppressed from visual awareness. We reasoned that if the difference obtained in Experiment 1a stemmed from a bias occurring after conscious detection of the suppressed stimuli — such as changes in response criterion or detection thresholds (rather than from processing differences during interocular suppression itself) — then it should also occur when the stimuli are never suppressed in the first place. But if the differences in breakthrough times truly reflect differences in unconscious processing, then they should now vanish when the

² This same qualitative pattern of results was also obtained when trials in which observers failed to respond were simply discarded — and this was also true for all subsequent experiments reported here.

Experiment 1



Experiment 2



Experiment 3

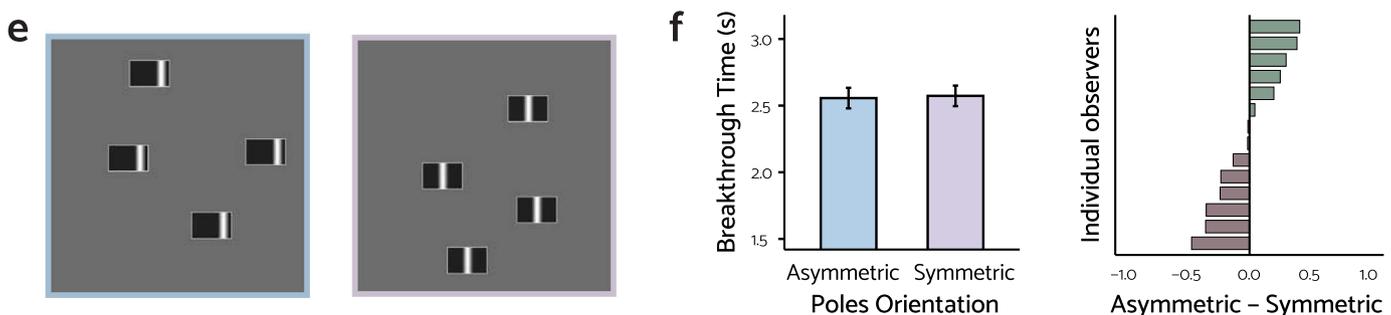


Fig. 2. Sample Averted (left) and Directed (right) displays employed in Experiments 1a and 1b (a), 2 (c), and 3a and 3b (e). Results from Experiments 1a (b), 2 (d), and 3a (f), depicted both as the average breakthrough times for Averted vs. Directed displays (left) and the average difference in breakthrough times for Averted – Directed displays separately for each observer (right). Error bars reflect 95% confidence intervals, subtracting out the shared variance.

displays are presented consciously. We thus added a new condition where the masks and mouth displays were presented not to different eyes (a ‘binocular’ setup, as in Experiment 1a), but rather to the same eye, while a blank frame was presented in the other eye (a ‘monocular’ control; Gayet, Van der Stigchel, & Paffen, 2014). We thus predicted that the results of Experiment 1a would replicate in the binocular fade-in condition, but not in this additional monocular fade-in condition.

3.1. Method

This experiment was identical to Experiment 1a, except as noted here. The sample size was doubled (to 28 naïve observers; 15 females; average age = 22.14 years) to match the number of observers tested in each (between-subjects) condition of both Experiment 1a and Stein, Senju, et al. (2011). Half of observers completed a direct replication of Experiment 1a, and the other half completed a modified replication in

which the mouth images faded in on top of the Mondrian masks. Opacity was again linearly increased over the course of 1 s, but starting at 2 s (instead of 0 s), to match the subjective experience of binocular fade-in.

3.2. Results and discussion

We again assigned breakthrough times of 8 s to missed trials (3.32 on average) and discarded inaccurate trials (0.96 on average). Breakthrough times were faster for Directed vs. Averted mouths in the binocular fade-in condition (2.33 vs. 3.19 s, $t(13) = 4.51$, $p = .001$, $d = 0.67$), but not in the monocular fade-in condition (3.00 vs. 3.00 s, $t(13) = 0.43$, $p = .674$, $d = 0.03$), with a significant interaction (mean difference between Directed and Averted mouths in binocular vs. monocular conditions: 0.86 vs. 0.00 s, $t(26) = 4.49$, $p < .001$, $d = 1.70$). These results thus fully replicated Experiment 1a, while also ensuring that the advantage for Directed mouths was due to unconscious

processing per se, rather than to a response bias (which would have been operative in the monocular fade-in condition too; see Gayet et al., 2014).³

4. Experiment 2: prioritizing ‘directed cones’ (without faces)

The novel ‘mouth’ stimuli employed in Experiments 1a and 1b had no eyes, but they still very explicitly conveyed another salient facial feature, and might thus still be perceived as cues to facial orientation (which can indicate the direction of attention even in the absence of eyes; e.g. Perrett & Emery, 1994). So might these results still rely on some sort of face-specific directedness? To find out, we developed new ‘cone’ stimuli, which are as different as can be from mouths (and eyes) in their surface properties, but which are nonetheless also readily perceived as being directed towards or away from the observer.

Of course, a single cone can be perceived as having an orientation without any concomitant attribution of intentionality (since after all one can easily tell from a cone’s shape that it is not a biological agent). Nevertheless, certain groups of such stimuli can still signal the presence of agentic directedness in a deeper way. Consider, for example, a field of cones that all have different orientations but are all systematically directed at the same point (e.g. Gao et al., 2010). This consistency can hardly be interpreted as the outcome of a coincidence, especially when stimuli positioned in different locations are all pointing at you; instead, this arrangement strongly suggests the presence of agentic directedness. Might such face-less shapes thus also be prioritized in visual awareness when directed at the observer?

4.1. Method

This experiment was identical to Experiment 1b, except as noted here. Twenty-eight new observers participated (19 females; average age = 22.25 years). Eighty $3.27^\circ \times 3.27^\circ$ images (40 Directed and 40 Averted) were created by placing either 4 Directed or 4 Averted $0.57^\circ \times 0.52^\circ$ grayscale cones on the background. These cone stimuli were created by placing actual volumetric cones in a 3D scene using Blender (with a ratio of 0.53 between the ‘base’ diameter and the long perpendicular axis), with simulated light from above (as depicted in Fig. 2c).

4.2. Results and discussion

We again assigned breakthrough times of 8 s to missed trials (1.64 on average), and discarded inaccurate trials (1.89 on average). As depicted in the left panel of Fig. 2d, breakthrough times were faster for Directed vs. Averted cones in the binocular fade-in condition (2.18 vs. 2.40 s, $t(13) = 2.55$, $p = .024$, $d = 0.21$), and this difference was again also robust across observers (as depicted in the right panel of Fig. 2d). As predicted, this advantage for Directed vs. Averted cones vanished in the monocular fade-in condition (3.11 vs. 3.12 s, $t(13) = 0.39$, $p = .699$, $d = 0.04$), with a significant interaction (mean difference between Directed and Averted cones in binocular vs. monocular conditions: 0.22 vs. 0.01 s, $t(26) = 2.45$, $p = .021$, $d = 0.93$). These results thus demonstrate that objects seen to be directed at the observer are prioritized in visual awareness, even when they lack any and all facial features.

³ This ‘monocular’ control demonstrates that when the stimuli are presented consciously, the prioritization effects vanish, but note that this control also differs from the ‘binocular’ condition in a few other respects — such as the relative contrast between the mask and the stimulus contour (Stein & Peelen, 2021), the precise response time distributions, and the temporal uncertainty with respect to stimulus presentation (see Stein, Hebart, & Sterzer, 2011; Stein & Sterzer, 2014; Yang, Brascamp, Kang, & Blake, 2014).

5. Experiment 3a: symmetry control

The ‘cone’ stimuli employed in Experiment 2 are visually very different from the ‘mouths’ employed in Experiments 1a and 1b, but they make salient a possible confound that is present in all of these stimuli: the Directed stimuli are more symmetric compared to the Averted stimuli in terms of brute image metrics. Might the prioritization in visual awareness have been due to this lower-level property? To find out, we tested for such a symmetry effect directly, in symmetric vs. asymmetric ‘pole’ stimuli, which did not convey directedness in either symmetric or asymmetric configurations.

5.1. Method

This experiment was identical to Experiment 1a, except as noted here. Fourteen new observers participated (7 females; average age = 18.71 years). As depicted in Fig. 2e, each individual pole consisted of a dark-gray rectangle ($0.47^\circ \times 0.29^\circ$, #202020, with a 0.04° white border), with a white inset vertical line (0.11° wide) and a light-dark gradient on either side. (These gradients mimicked the gradual shading and 3D appearance of the cones, and their extreme shades exactly matched the cones’ lightest and darkest regions.) For Symmetric stimuli, the vertical bar was horizontally centered in the rectangle; for Asymmetric stimuli, it was shifted (either leftward or rightward) by 0.14° . Eighty $3.27^\circ \times 3.27^\circ$ images (40 Symmetric and 40 Asymmetric, as depicted in Fig. 2e) were created by randomly placing either 4 Symmetric or 4 Asymmetric poles on the background.

5.2. Results and discussion

We again assigned breakthrough times of 8 s to missed trials (3.14 on average) and discarded inaccurate trials (1.14 on average). As depicted in the left panel of Fig. 2f, breakthrough times for Symmetric poles did not differ from those for Asymmetric poles (2.57 vs. 2.56 s, $t(13) = 0.21$, $p = .835$, $d = 0.02$). This null effect was significantly different (or in one case marginally so) from the Directed/Averted difference as measured in Experiment 1a (mean difference between Directed and Averted mouths vs. Symmetric and Asymmetric poles: 0.29 vs. -0.02 s, $t(26) = 2.29$, $p = .030$, $d = 0.87$), the binocular fade-in condition in Experiment 1b (mean difference between Directed and Averted mouths vs. Symmetric and Asymmetric poles: 0.86 vs. -0.02 s, $t(26) = 4.24$, $p < .001$, $d = 1.60$), and the binocular fade-in condition in Experiment 2 (mean difference between Directed and Averted cones vs. Symmetric and Asymmetric poles: 0.22 vs. -0.02 s, $t(26) = 2.03$, $p = .053$, $d = 0.77$). These results suggest that the advantage for Directed mouths and cones in the previous experiments was not based on a more general prioritization of visual symmetry.

6. Experiment 3b: symmetry control, direct replication

We also directly replicated Experiment 3a on 14 new observers (8 females; average age = 19.14 years). We again assigned breakthrough times of 8 s to missed trials (2.64 on average) and discarded inaccurate trials (3.21 on average). Breakthrough times for Symmetric poles did not differ from those for Asymmetric poles (2.26 vs. 2.18 s, $t(13) = 1.03$, $p = .324$, $d = 0.07$). And this null effect was again significantly different from the Directed/Averted difference as measured in Experiment 1a (mean difference between Directed and Averted mouths vs. Symmetric and Asymmetric poles: 0.29 vs. -0.08 s, $t(26) = 2.77$, $p = .010$, $d = 1.05$), the binocular fade-in condition in Experiment 1b (mean difference between Directed and Averted mouths vs. Symmetric and Asymmetric poles: 0.86 vs. -0.08 s, $t(26) = 4.55$, $p < .001$, $d = 1.72$), and the binocular fade-in condition in Experiment 2 (mean difference between Directed and Averted cones vs. Symmetric and Asymmetric poles: 0.22 vs. -0.08 s, $t(26) = 2.57$, $p = .016$, $d = 0.97$).

7. General discussion

The five experiments reported here collectively demonstrate a clear result: the perception of directed “gaze” boosts objects into visual awareness — even without eyes (as in the ‘mouth’ stimuli in Experiments 1a and 1b) or indeed any facial cues (as in the ‘cone’ stimuli in Experiment 2). This core result was replicated 3 separate times (including in a direct replication), and could not be explained by either response biases (as tested in Experiments 1b and 2), or differential symmetry (as tested in Experiments 3a and 3b).

This study explored the nature of the powerful effects that eye contact has on us: are they driven by the eyes per se as salient visual stimuli, or might they instead reflect the perception of deeper properties such as the attention and intentions of the mind behind the eyes? But while past work has approached this question by asking whether the effects of eye gaze might vanish in the absence of these deeper properties (i.e. in “eyes without minds”), here we adopted a complementary approach by asking whether they might instead arise from stimuli that superficially do not resemble agents at all, while nonetheless signaling these deeper properties (i.e. in “minds without eyes”; Colombatto, van Buren, & Scholl, 2019). Indeed, the stimuli employed in the current study are radically different from eyes (and in the case of cones, from faces altogether) at the level of superficial visual features, but they nevertheless still convey a sense of directed attention and intention. This proved sufficient to modulate unconscious processing, suggesting that these sorts of deeper properties may be extracted in visual processing itself (Scholl & Gao, 2013).

These sorts of ‘minds without eyes’ were implemented in the current stimuli via the coordinated orientation of items in each display (as depicted in Fig. 2a and c) — a particular type of systematicity which is unlikely to arise by chance, and which instead strongly suggests an agentic presence (Colombatto, van Buren, & Scholl, 2020). Of course, this leaves open the question of whether a *single* mouth or dart might also be sufficient to drive such effects. We did not pursue such questions in the current study (in part because such singletons often may not reliably trigger impressions of agency, especially with the cones), but this could be explored in followup studies. In addition, future work could also explore whether such non-eye-like stimuli are also sufficient to trigger other downstream effects of ‘gaze’ such as self-referential processing (Conty et al., 2016) or even positive affect (Hietanen, 2018).

The perception of directed intentions in ‘minds without eyes’ proved sufficient in the current experiments to trigger prioritized access to visual awareness, suggesting that past work on unconscious processing of eyes directed at the observer might not be unique to eyes after all. In this way, previous effects of eye contact might have been mischaracterized as arising from the salience of the eyes per se, when in fact they arise from a deeper property that the eyes (but not only the eyes) signify — the direction of others’ attention and intentions. As such, eye contact might be a special case of a more general phenomenon of perceived intentionality that we call ‘mind contact’.

Author note

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