Intuitive Theories of Attention Shape Perceptions of Others' Attentiveness

by

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Author's Declaration

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Statement of Contributions

Yuanze Huang is the primary author of this thesis and was responsible for developing the research ideas and methodology, recruiting participants, analyzing the data, and writing the thesis. The research was conducted under the supervision of Dr. Clara Colombatto, who provided guidance on the conceptual development and methodology of the research, reviewed the experimental paradigm, code, data analyses, and thesis, and provided funding for the project.

Abstract

People routinely draw on expectations about how attention operates, yet relatively little is known about the content of these intuitions—that is, how people think attention works. Across two preregistered experiments, we used judgments of others' attentiveness to investigate these intuitive theories, examining how observers infer attentiveness from observable behaviour (e.g., how quickly someone responds to external stimuli) and situational context (e.g., how distracting the environment is). Participants completed a spatial cueing task and observed an agent performing the same task, rating the agent's attentiveness on each trial. In Experiment 1 ($N = 50$), faster observed response times were associated with higher attentiveness ratings, suggesting that observers treated response speed as a cue to attentional engagement. Participants also rated agents as more attentive following invalid than valid cues, indicating sensitivity to the surrounding context. Experiment 2 ($N = 35$) introduced a neutral-cue condition to determine whether this difference reflected facilitation from valid cues, the attentional demands imposed by invalid cues, or both. Ratings were higher following invalid than neutral cues but did not differ between valid and neutral cues, suggesting that observers were particularly sensitive to the demands imposed by invalid cues. Response speed was also less informative following valid cues, suggesting that observers interpreted behaviour in light of context. Together, these findings suggest that people associate greater attentiveness with relatively rapid responding while also evaluating behaviour in relation to situational context. In this way, judgments of attentiveness therefore reveal people's broader expectations about how attention operates—their intuitive theories of attention.

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Introduction

In everyday life, people routinely rely on intuitive assumptions about how attention works. A student writing an essay may move their phone out of reach to avoid distraction. A tired driver may start a conversation with a passenger to stay alert. A teacher regularly reminds students to pay attention or stay focused at the end of class. These everyday examples suggest that people draw on expectations about how attention operates. In this sense, people appear to possess an intuitive theory of attention: a lay understanding of what attention is, how it is expressed, and how it shapes behavior. Such theories may provide a framework for interpreting cues associated with attentiveness in everyday life.

Research on meta-attention provides one way to examine these intuitive theories, focusing on how people understand and monitor their own attentional states. This work has explored whether people can monitor changes in their attention, recognize distraction, understand the limits of multitasking, and judge how much visual information they can attend to at once (Chidharom et al., 2025; Finley et al., 2014; Kawahara, 2010; Bell et al., 2022). However, more recent work suggests that intuitive theories of attention may extend beyond the self. People may also hold beliefs about others' attention, including which situational and behavioral cues signal that someone is more or less attentive.

Consistent with this idea, research on attention and social cognition suggests that people are sensitive to a range of cues related to others' attentional states. For example, observers can distinguish natural gaze trajectories from altered ones, suggesting sensitivity to the temporal structure of gaze (Ziman et al., 2023). They can also predict others' reaching actions more quickly when those actions are guided by internally rather than externally

driven attention, suggesting that observers are sensitive to whether another person's actions are driven by internal goals or external cues (Pesquita et al., 2016). These inferences may also emerge early in development: 14-month-old infants use another person's attentional cues, but not emotional cues, to predict that person's subsequent actions, suggesting that attentional information can guide expectations about others' behavior from infancy (Vaish & Woodward, 2010). Together, these findings suggest that observers use attentional information to anticipate others' subsequent gaze and actions.

Among these sources of information, the face may be particularly relevant, as gaze, eye movements, and facial muscle activity have been associated with people's attentiveness. Some cues signal where attention is likely directed. Eye gaze, for instance, is closely linked to attention, as people often look toward objects, locations, or individuals that are relevant to their current goals (Land & Hayhoe, 2001; Hayhoe & Ballard, 2005). Other cues may reflect the degree of attentional engagement. Pupil dilation, for example, has been linked to attentional demand (Kahneman & Beatty, 1966). Consistent with this idea, recent studies show that observers can also perceive others' attentional states from these features. Colombatto and Scholl (2025) found that faces with direct gaze toward the observer and larger pupils were perceived as more attentive. They further showed that judgments of attentiveness were shaped by additional facial features, including subtler cues such as flared nostrils and mouth curvature. Moreover, observers can also extract gaze information across multiple faces: Sweeny and Whitney (2014) showed that observers can rapidly extract a summary representation of a crowd's gaze direction, suggesting that people can perceive

group-level cues to where others may be attending without tracking each individual's gaze separately.

Faces provide important information about whether someone is attentive, but facial cues are not always available or reliable. In many everyday situations, observers may not have a clear view of another person's face, and even when facial information is available, it may be ambiguous or misleading. For example, people can direct their attention to one location while looking elsewhere (Colombatto et al., 2020), meaning that gaze direction does not always reveal the true focus of attention. In addition, people may sometimes attempt to conceal their attentional state, such as when a student tries to appear engaged despite mind-wandering, or when someone masks their lack of interest during a conversation. In such cases, judgments of attentiveness may rely on multiple, complementary sources of information rather than facial cues alone. Building on this idea, the present studies move beyond the face to examine whether people infer others' attentional states from behavior, particularly how quickly someone responds to events in the environment. For instance, someone may appear attentive, but if they fail to respond after their name is called several times, observers may infer that their attention has drifted.

Previous research suggests that observers use response time as a cue when making inferences about others' mental states. For example, response time can shape judgments of preference: quick choices are often interpreted as reflecting stronger preferences, whereas longer choice times may suggest weaker or more uncertain preferences (Gates et al., 2021). Relatedly, by observing only how long people took to choose between different divisions of

money, observers could infer whether those individuals generally favored more selfish or more prosocial allocations (Bavard et al., 2024). In addition, faster responses can lead observers to infer greater confidence during a task (Colombatto & Fleming, 2026), and they can also shape judgments of moral character, with quick moral decisions often viewed as more virtuous and quick immoral decisions judged more harshly (Critcher et al., 2013). Across these domains, response time appears to provide observers with information about the internal states guiding a person's actions. Extending this idea to attentional states, faster responses to task-relevant events may be interpreted as evidence of greater attentiveness, whereas slower responses may suggest reduced engagement or a lapse of attention.

However, behavioural cues may not be interpreted in isolation; their meaning may depend on the broader context in which a response occurs. For example, how quickly a pedestrian begins crossing after the walk signal appears may be interpreted in light of the surrounding traffic conditions. A rapid response may suggest attentiveness when the path is clear, but insufficient monitoring when a vehicle is approaching the crosswalk. Conversely, a slower response may reflect either distraction or the deliberate monitoring of traffic signals, approaching vehicles, and other pedestrians. More broadly, an attentional ecology perspective suggests that attentional states depend on the fit between a person's goals, the task they are performing, and the environment in which the task occurs (Pham & Sanocki, 2024). Empirical work similarly shows that situational distractions can affect attentional behaviour. For example, task-irrelevant auditory stimulation disrupts performance on externally directed visual tasks by interfering with attention to task-relevant information

(Ziegler et al., 2018). Together, this work suggests that attentional performance is shaped by situational demands and distractions, raising the possibility that observers interpret response time in relation to these factors. A delayed response may suggest inattention during a simple task with few distractions, whereas the same delay in a more demanding situation may be attributed to the need to process competing information rather than to reduced attentiveness. The present studies therefore examined whether observers integrate response time with situational context when inferring another person's attentiveness.

Another factor that may shape attentiveness judgments is observers' own experience with the task. People often draw on their own experiences when inferring about what others are likely to perceive or notice. For example, Ortega and colleagues (2018) used magic tricks involving unexpected visual changes to show that people's own visual awareness can bias their judgments about others' awareness. Participants who noticed the change judged that others would be more likely to notice it as well, whereas those who missed the change gave lower estimates of others' detection. In the context of attention, observers' own task experience may help them understand which situations are more difficult, distracting, or effortful. This experience may then shape how they interpret another person's behavior in the same task.

Across two preregistered experiments, we used a spatial cueing paradigm to examine the separate and joint effects of response time and cue validity on perceived attentiveness. Cue validity referred to whether the target appeared at the cued location or at the opposite location. This paradigm provides a useful framework for examining how people infer

attentiveness from both observed behaviour and contextual information. In a typical Posner cueing task, people respond faster when a cue correctly indicates where a target will appear and more slowly when the cue directs attention to the opposite location (Posner, 1980). The paradigm is well suited to the present research because it allows response time to be interpreted in relation to cue validity. Response time provides an observable behavioural cue, whereas cue validity provides information about the attentional context in which that behaviour occurs. Similar judgments may occur in everyday life, where the same response speed can carry different implications depending on the surrounding circumstances. For example, a driver who responds quickly to a hazard despite difficult road conditions may be perceived as more attentive than a driver responding equally quickly under clear conditions. Thus, the same response time may be judged differently depending on whether it follows a valid or invalid cue.

In Experiment 1, participants watched previous participants complete a spatial cueing task and rated how attentive they appeared on each trial. Based on prior work showing that observers use response time to infer others' internal states, we predicted that judgments of attentiveness would be related to observed response time. Specifically, faster responses were expected to be associated with higher attentiveness ratings than slower responses. This prediction follows from the idea that observers may treat response time as a cue to how effectively attention is directed toward the task: faster responses may suggest that the relevant stimulus was detected and acted on efficiently, whereas slower responses may suggest that attention was less focused or had to be redirected. We also predicted that

judgments would be shaped by cue validity, such that participants would rate others as more attentive following invalid cues than valid cues. This prediction does not assume that invalid cues make a person more attentive. Rather, it follows from the idea that responding under greater attentional demands may provide stronger evidence of attentional engagement. Because invalid cues direct attention away from the target location, responding requires the person to overcome misleading spatial information and redirect attention toward the target. Observers may therefore treat the invalid-cue context itself as evidence that the person was attentively engaged with the task. By contrast, responses following valid cues may provide weaker evidence because the cue already directs attention toward the correct location.

We also predicted an interaction between response time and cue validity. Whereas the main-effect prediction concerned whether cue context independently influenced attentiveness judgments, the interaction prediction concerned whether cue context changed how observers interpreted response speed. Specifically, Slower responses were expected to be more strongly associated with lower attentiveness ratings following valid cues than following invalid cues. Because valid cues facilitate responding by directing attention toward the target location, a slow response in this context may suggest that the person was not fully attentive. By contrast, a slow response following an invalid cue may be judged less negatively because the misleading cue provides an external explanation for the delay.

Finally, participants also completed the spatial cueing task themselves, with the order of performing the task and judging others counterbalanced. This allowed us to examine whether firsthand task experience shaped how observers interpreted response time in relation

to cue validity. We predicted a three-way interaction among task order, response time, and cue validity, such that the difference in the relationship between response time and attentiveness judgments across valid and invalid trials would be larger among participants who completed the spatial cueing task before judging others. Firsthand experience may make observers more aware of how valid cues facilitate responses and how invalid cues delay responses by requiring attentional reorientation. Participants with this experience may therefore be more likely to interpret response time in relation to the demands of each cue condition, whereas those who judged others before completing the task may rely more similarly on response speed across conditions.

In Experiment 2, we added a neutral cue to further examine how cue context shapes attentiveness judgments. The neutral condition allowed us to test whether the valid and invalid difference was driven by observers' expectations about valid cues, invalid cues, or both. If observers expect valid cues to facilitate performance by directing attention toward the target, then responses following valid cues may be rated as less attentive than responses following neutral cues. In this case, the cue itself may explain the person's efficient performance, making the response less diagnostic of attentional engagement. By contrast, if observers expect invalid cues to slow down performance by directing attention away from the target, then responses following invalid cues may be rated as more attentive than responses following neutral cues. In this case, responding after an invalid cue may be seen as stronger evidence that the person overcame misleading spatial information and redirected attention to the target.

In addition to the primary hypotheses, we also explored whether individual differences in participants' own attentional performance and self-awareness were related to how they judged others. For example, we examined whether participants' awareness of their own response speed was associated with the expectations they used to evaluate another person's attentiveness. Greater awareness of one's own attentional behaviour may shape how behavioural cues such as response speed are interpreted when judging others.

Together, the present studies were designed to examine not only whether observers can infer others' attentiveness, but also the underlying intuitions that shape how these judgments are made. If observers use response time and cue validity to infer attentiveness, this would suggest that they expect attention to leave systematic traces in behavior, and that these traces are interpreted in relation to the surrounding context. In this way, the present studies speak to a broader question about attention and social cognition: how observers use behavior and context to infer hidden attentional states, revealing intuitive theories about how attention shapes action and is expressed across different situations.

Experiment 1

Methods

Participants

Fifty-eight participants were recruited through the University of Waterloo participant pool and received 0.75 course credits for completing a 45-minute study session. The study was approved by the University of Waterloo Research Ethics Board (protocol no. 47124) and preregistered on AsPredicted (https://aspredicted.org/sz7n65.pdf) before data collection began. A power analysis based on pilot data from 13 participants indicated that a sample of 25 participants would provide at least 95% power to detect the observed interaction between cue validity and response time in attentiveness judgments, $b = -0.51$, $SE = 0.17$, $t(2065.5) = -2.91$, $p = .004$. The preregistered target was increased to a post-exclusion sample of 50 participants to provide sufficient data for the preregistered secondary analyses. Participants were excluded if they (1) reported experiencing problems during the experiment (N = 3), (2) provided the same rating on more than 80% of trials in the Observer Task (N = 4), or (3) failed to achieve an accuracy rate above 85% in the Action Task (N = 1). All participants reported having normal or corrected-to-normal vision, no history of attention-related impairments (e.g., ADHD), fluency in English, and no prior participation in similar attention studies conducted in our lab. After exclusions, the final sample consisted of 50 participants who took part in the study (8 men, 36 women, and 6 non-binary participants; mean age = 19.98 years, range = 18–34).

Apparatus

Stimuli were presented on a 24-inch Dell monitor with resolution 1920 × 1080 pixels and 60-Hz refresh rate. The experimental task was programmed in Python using the PsychoPy libraries (Peirce et al., 2019). Participants were seated approximately 50 cm from the monitor and viewed the experiment in full-screen mode.

Procedure

After providing informed consent, participants completed two tasks in a counterbalanced order: the Action Task, in which they responded to targets themselves and rated their own attentiveness, and the Observer Task, in which they observed another participant's responses and judged that participant's attentiveness. Participants first received instructions for the task they were assigned to complete first. Upon completing the first task, they received instructions for the second task. At the start of each task, participants were provided with a definition of attentiveness along with the task instructions. Specifically, they were told: "By 'attentive,' we mean that you (or the participant) were engaged in the task (i.e., keeping your/their focus on the screen), as opposed to being distracted (e.g., being lost in thought)."

Action Task. Participants completed a spatial cueing task adapted from Posner (1980). On each trial, two black square outlines were displayed bilaterally on a white screen. Each square measured approximately 3.95° × 3.95°. The squares were positioned symmetrically, 7.88° to the left and right of the screen center and 6.47° above the center and remained visible throughout the trial. A black fixation cross, presented with a text height of

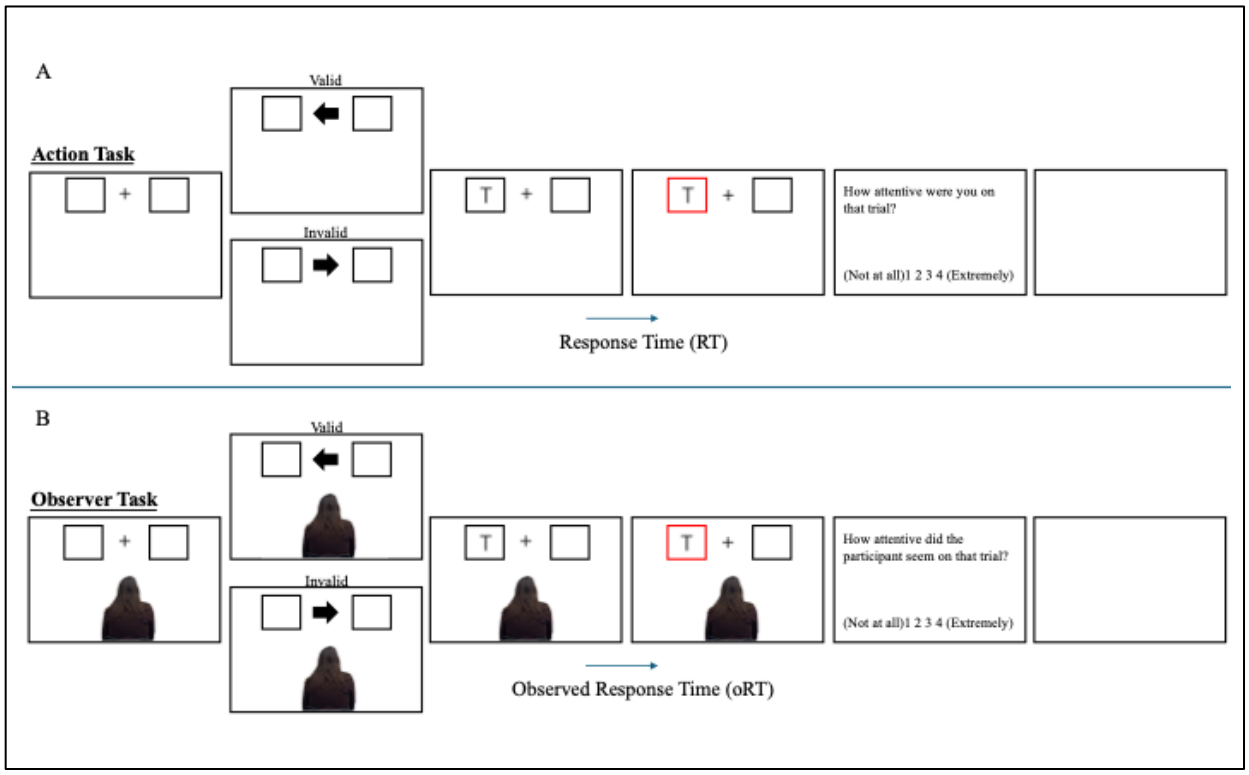
approximately 1.58° and positioned 6.30° above the screen center, appeared simultaneously with the square outlines and was displayed for 500 ms (see Figure 1A). Then, a directional arrow cue pointing toward either the left or right box was presented for 200 ms. The cue was positioned in the upper central area of the display, 6.47° above the screen center, and measured approximately 4.25° × 2.72°. This was followed by a 100-ms inter-stimulus interval, after which a target letter ("T"), presented with a text height of approximately 1.58°, appeared in one of the boxes (see Figure 1A). This timing resulted in a 300-ms stimulus onset asynchrony between cue onset and target onset. Participants were instructed that the arrow would sometimes point toward the box in which the target would appear and would sometimes point toward the opposite box. The target then remained on the screen until participants responded. Participants were asked to indicate the target location by pressing the left arrow key if the target appeared on the left side of the screen and the right arrow key if it appeared on the right side. After the response, the selected box was highlighted in red for 500 ms to indicate the response, followed by a blank screen for 500 ms. Participants then rated how attentive they had been on that trial using a scale from 1 (Not at all) to 4 (Extremely), as shown in Figure 1. The rating screen remained on the screen until the participants responded. Finally, a 500-ms blank-screen inter-trial interval preceded the next trial. (see Figure 1A).

Observer Task. The Observer Task was identical to the Action Task in terms of procedure and stimulus presentation, except that participants were told they would observe video recordings of previous participants completing the spatial cueing task.

On each trial, participants saw the same two boxes, along with a video clip of an agent viewed from behind and presented below the boxes, as shown in Figure 1B. The trial sequence was the same as in the Action Task. A fixation cross was presented for 500 ms, followed by a directional cue for 200 ms and a 100-ms inter-stimulus interval, resulting in a 300-ms cue-target stimulus onset asynchrony. The target then appeared in one of the boxes and remained on the screen until the observed response occurred. The observed response was indicated by highlighting the selected box in red for 500 ms (see Figure 1B). Participants were then asked to rate how attentive the agent seemed during that trial on a scale from 1 (Not at all) to 4 (Extremely), with the rating scale remaining on the screen until a response was made. Finally, a 500-ms inter-trial interval was presented before the next trial began (see Figure 2).

At the end of both tasks, participants provided demographic information and answered questions about their experience during the study. They were fully debriefed and informed that the observed task performance had not actually been produced by the participants shown in the videos but had instead been generated based on data from previous participants (see the Design section for more details).

Figure 1. The Action and Observer Tasks



Note. Panel A shows the Action Task, in which participants completed each trial themselves, whereas Panel B shows the Observer Task, in which participants viewed a video clip of an agent completing the trial. In both tasks, the trial began with two square outlines and a fixation cross, followed by a directional arrow cue pointing toward either the target location (valid cue; 80 trials) or the opposite location (invalid cue; 80 trials). The target then appeared and remained on the screen until a response was made, after which the selected box was highlighted in red. In the Action Task, participants rated their own attentiveness from 1 (Not at all) to 4 (Extremely). In the Observer Task, participants rated how attentive the agent seemed using the same scale.

Design

Action Task. Participants also completed the same spatial cueing task themselves, consisting of 160 trials in total: 80 valid trials and 80 invalid trials.

Observer Task. Each participant observed two agents in total, one male and one female. The agents were volunteers from the University of Waterloo School of Psychology and were recorded before the study. Each agent sat in a chair facing a white wall approximately 90 cm away and was recorded from behind for 2 minutes using an iPhone 11 camera while sitting naturally and not performing any specific task. On each trial, a video segment was randomly selected from the corresponding 2-minute recording and matched to the duration of that trial.

Before the main study, 10 pilot participants completed a spatial cueing task identical to the Action Task, consisting of 80 valid trials and 80 invalid trials. Reaction time data from these pilot participants were used to create two Gaussian response-time distributions: one for valid trials and one for invalid trials. The mean and standard deviation were estimated separately for each cue condition by fitting a Gaussian distribution to the corresponding reaction time data. Mean reaction times were faster for the valid RT distribution (M = 350 ms) than for the invalid RT distribution (M = 440 ms). These distributions were then used to generate the observed response times (oRTs) presented in the Observer Task.

Each participant completed 160 trials in the Observer Task, divided equally across four conditions: valid cues with observed RTs generated from the valid distribution, valid cues with observed RTs generated from the invalid distribution, invalid cues with observed RTs generated from the valid distribution, and invalid cues with observed RTs generated

from the invalid distribution. This created a 2 × 2 design crossing cue validity with RT distribution type. Trials were presented in a random order. Agent gender was balanced across trials, such that the male agent appeared on 80 trials and the female agent appeared on 80 trials, with the agent shown on each trial randomized.

Results

Main Analysis

All statistical analyses were conducted in R (version 4.5.1). Linear mixed-effects models were fitted using the lme4 package, with statistical significance assessed using the lmerTest package. Estimated marginal means and follow-up contrasts were obtained using the emmeans package.

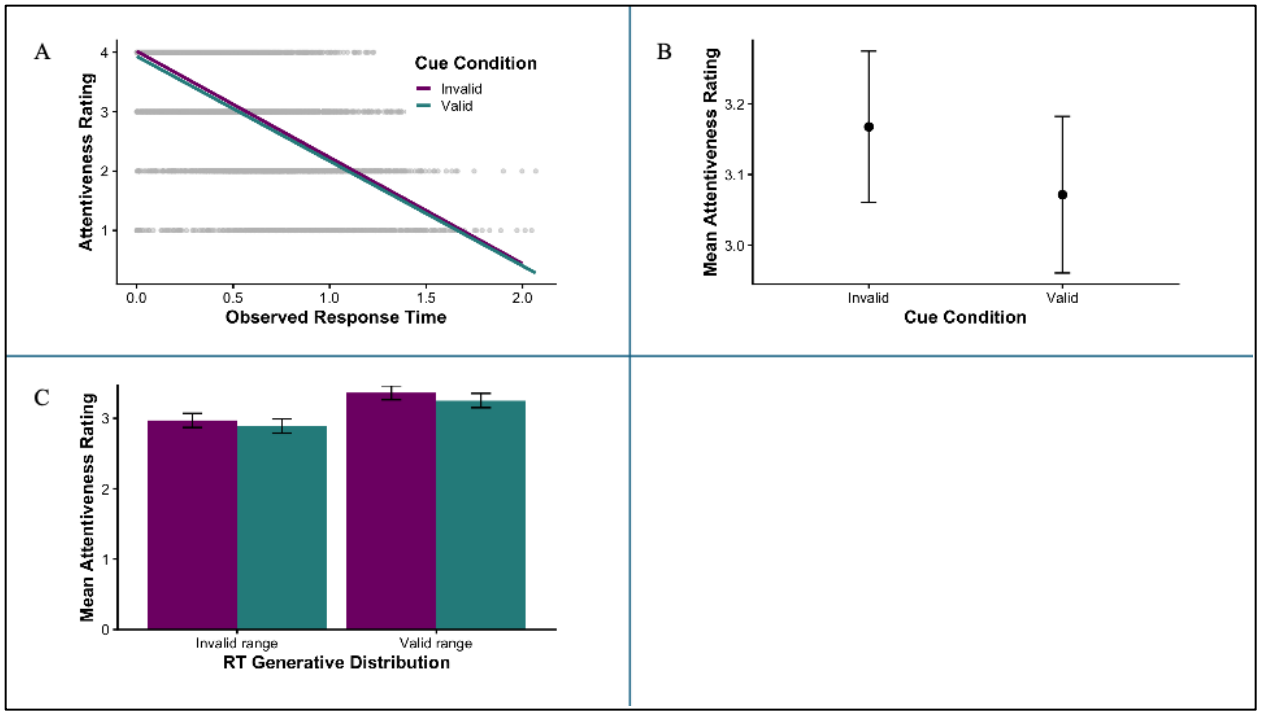
To examine how observed response times (oRTs) and cue condition influenced perceived attentiveness, we conducted a preregistered linear mixed-effect model with attentiveness ratings as the dependent variable and oRT, cue condition (valid vs. invalid), and their interaction as fixed effects, and participant as a random intercept. Consistent with our prediction that faster observed responses would be associated with higher attentiveness ratings, there was a significant main effect of oRT, $b = -0.55$, $SE = 0.03$, $t = -52.96$, $p < .001$. Participants judged others as more attentive when they responded faster and less attentive when they responded more slowly (see Figure 3A). Consistent with our prediction regarding cue validity, there was also a significant main effect of cue condition, $b = -0.07$, $SE = 0.03$, $t = -3.62$, $p < .001$. Specifically, participants rated others as more attentive following invalid cues than valid cues (see Figure 3B). However, contrary to our prediction

that cue validity would shape how response time was interpreted, the oRT × cue condition interaction was not significant, $p = .295$. This suggests that the relationship between observed response time and perceived attentiveness was similar across valid and invalid trials. In other words, although both oRT and cue condition independently influenced attentiveness judgments, cue condition did not significantly change the extent to which oRT influenced judgments of others' attentiveness.

In addition, we conducted a preregistered linear mixed-effects model in which oRT was treated as a categorical variable rather than a continuous predictor. Specifically, trials were categorized according to the RT distribution from which the oRT was generated: the valid RT distribution or the invalid RT distribution. Others' attentiveness ratings were entered as the dependent variable, with RT distribution type, cue condition, and their interaction included as fixed effects, and participant included as a random intercept. Consistent with the previous continuous model, there was a significant main effect of RT distribution type, $b = 0.40$, $SE = 0.03$, $t = 15.14$, $p < .001$. Participants rated others as more attentive when the observed RT was generated from the valid RT distribution, which was generally faster, than from the invalid RT distribution, which was generally slower (see Figure 3C). There was also a significant main effect of cue condition, $b = -0.08$, $SE = 0.03$, $t = -3.07$, $p = .002$, indicating that participants rated others as more attentive following invalid cues than valid cues (see Figure 3C). As in the previous continuous model, the RT distribution type × cue condition interaction was not significant, $p = .390$, suggesting that the

effect of RT distribution type on perceived attentiveness did not differ significantly between valid- and invalid-cue trials.

Figure 2. Results of Experiment 1



Note. Panel A shows the relationship between observed response time (oRT) and attentiveness ratings by cue condition; attentiveness ratings decreased as oRT increased, $p < .001$. Panel B shows model-predicted attentiveness ratings by cue condition; agents were rated as more attentive on invalid-cue trials than on valid-cue trials, $p < .001$. Panel C shows model-predicted attentiveness ratings with RT generative distribution treated as a categorical predictor; ratings were higher for trials with RTs generated from the valid distribution than for those generated from the invalid distribution, $p < .001$, and were also higher on invalid-

cue than valid-cue trials, $p = .002$. Error bars represent 95% confidence intervals, and the y-axis displays a restricted range of the full 1–4 attentiveness rating scale.

Finally, we examined whether prior task experience influenced participants' attentiveness judgments. Specifically, we tested whether having completed the Action Task before the Observer Task affected how participants evaluated others' attentiveness. To do so, we conducted an additional linear mixed-effects model with the same structure as the previous continuous model, but with task order included as an additional fixed effect. We continued to observe significant main effects of oRT, $b = -0.57$, $SE = 0.01$, $t = -39.20$, $p < .001$, and cue condition, $b = -0.05$, $SE = 0.02$, $t = -2.67$, $p = .008$. A significant main effect of task order was also observed, $b = -0.23$, $SE = 0.09$, $t = -2.57$, $p = .013$, indicating that participants who completed the Observer Task first gave lower overall attentiveness ratings than those who completed the Action Task first. However, task order did not significantly interact with oRT, $b = 0.04$, $SE = 0.02$, $t = 1.70$, $p = .090$, or cue condition, $b = -0.04$, $SE = 0.03$, $t = -1.38$, $p = .168$. The three-way interaction among task order, cue condition, and oRT was also not significant, $b = -0.009$, $SE = 0.029$, $t = -0.31$, $p = .760$, suggesting that the interaction between oRT and cue condition did not differ significantly across task order.

Secondary Analyses

In addition to the main analyses, we conducted several preregistered secondary analyses to further characterize attentiveness judgments and examine observers' awareness of their own attentional performance and potential individual differences in how they judged others.

To begin, we conducted a preregistered secondary analysis to examine whether the relationship between observed response time (oRT) and attentiveness ratings was nonlinear. Specifically, we tested whether attentiveness ratings changed linearly across the full range of oRTs or showed evidence of curvature. We added a quadratic oRT term and its interaction with cue validity to the primary linear mixed-effects model. A likelihood-ratio test indicated that the quadratic model provided a significantly better fit than the linear model, $\chi^2(2) = 21.23$, $p < .001$. Within the quadratic model, the linear effect of oRT was significant, $b = -0.52$, $SE = 0.03$, $t(7946.54) = -16.70$, $p < .001$. The main effect of cue validity was also significant, $b = -0.20$, $SE = 0.04$, $t(7946.42) = -5.53$, $p < .001$, as were the interaction between oRT and cue validity, $b = -0.14$, $SE = 0.04$, $t(7946.51) = -3.28$, $p = .001$, and the interaction between quadratic oRT and cue validity, $b = 0.39$, $SE = 0.10$, $t(7946.69) = 3.81$, $p < .001$. The main quadratic effect of oRT was not significant, $b = -0.09$, $SE = 0.08$, $t(7946.85) = -1.15$, $p = .252$. However, the generated oRT distributions contained a small number of extreme values in the upper tail that may have disproportionately influenced the estimated curvature. The quadratic results were therefore interpreted with caution, and the linear model was retained as the primary basis for interpretation.

Secondly, we conducted a preregistered Pearson correlation between participants' mean RTs in the Action Task and their mean attentiveness ratings in the Observer Task. This analysis examined whether participants' own response time was associated with how attentive they perceived others to be. Specifically, if participants used their own performance as a reference point when evaluating others, those who responded relatively faster or slower

themselves might differ systematically in the overall attentiveness ratings they assigned to others. However, the correlation was not significant, $r(48) = .09$, $p = .512$, providing no evidence of an association between participants' own mean RTs and their mean judgments of others' attentiveness.

In addition, we conducted a preregistered Pearson correlation to examine the relationship between each participant's cueing effect in the Action Task (i.e., mean RT on invalid-cue trials minus mean RT on valid-cue trials) and their cue-related difference in attentiveness ratings in the Observer Task (i.e., mean attentiveness ratings on invalid-cue trials minus those on valid-cue trials). Specifically, we examined whether participants who exhibited larger cueing effects in their own responses also perceived a larger cue-related difference in others' attentiveness, such that they rated agents as relatively more attentive on invalid-cue than valid-cue trials. The correlation was negative but did not reach statistical significance, $r(48) = -.26$, $p = .070$.

In addition, we conducted a preregistered paired-samples *t* test comparing participants' mean ratings of their own attentiveness in the Action Task with their mean ratings of others' attentiveness in the Observer Task. This analysis examined whether attentiveness judgments differed between self and others. The results showed that participants rated their own attentiveness significantly higher than others' attentiveness, $t(49) = 6.72$, $p < .001$.

Before starting the tasks and again after completing both tasks, participants indicated whether they believed their RTs were faster or slower than those of the average person.

Responses were provided on a scale ranging from 1 (*much slower than average*) to 100 (*much faster than average*). This allowed us to examine whether performing the task themselves and observing others perform the task changed participants' perceptions of their own response speed. A preregistered paired-samples *t* test indicated that self-judgments did not significantly differ from before to after completing both tasks, $t(49) = -1.84$, $p = .072$, suggesting no significant overall shift in participants' perceived response speed. We then conducted preregistered Pearson correlations between participants' self-judgments and their mean RTs in the Action Task to examine the accuracy of these metacognitive judgments. Pre-task judgments were not significantly associated with participants' mean RTs, $r(48) = .21$, $p = .140$, providing no evidence that participants' initial perceptions of their response speed corresponded to their actual performance. In contrast, post-task judgments were significantly associated with mean RTs, $r(48) = .45$, $p < .001$. Because higher self-judgment scores indicated that participants perceived themselves as faster than average, this positive association suggested that participants with slower actual RTs tended to perceive themselves as relatively faster. Thus, participants' self-assessments after completing both tasks were even less aligned with their actual response speed, suggesting greater miscalibration.

Discussion

Experiment 1 examined how people infer another person's attentional state from observable behaviour and situational context, providing insight into the expectations that may form people's intuitive theories of attention. Although response time provides an observable cue to attentional engagement, the same response speed may be interpreted differently

depending on the demands of the situation in which it occurs. We therefore used a spatial cueing paradigm to examine whether participants relied on observed response time and cue validity, both independently and in combination, when judging another person's attentiveness.

The results indicate that participants judged others as more attentive when they responded more quickly. This finding suggests that participants treated response speed as a behavioral cue to attentional state, interpreting faster responses as reflecting greater attentional engagement. Participants also rated others as more attentive following invalid cues than valid cues, suggesting that their judgments were shaped not only by observed behavior but also by the surrounding context in which that behavior occurred. Specifically, participants may have recognized that responses made under more distracting or challenging conditions, such as following invalid cues, could still reflect high attentiveness, and they used this contextual information when evaluating others. However, the interaction between oRT and cue condition was not significant, indicating that although both factors independently influenced attentiveness judgments, there was no evidence that cue condition altered the extent to which oRT influenced these judgments, or vice versa.

In addition, task order did not significantly moderate the effects of response time, cue validity, or their interaction, suggesting that participants' judgments of others' attentiveness did not differ depending on whether they completed the actual task before or after observing others. This pattern provides no evidence that first-hand experience with the spatial cueing

task changed how participants inferred others' attentiveness, raising the possibility that these judgments were guided by pre-existing beliefs about how attention is shaped.

Together, these findings suggest that participants treated behavioural and situational information as separate indicators of attentiveness rather than integrating them in the specific way we predicted. Response speed appeared to provide a general cue to attentional engagement, while the demands that may have been associated with a misleading cue provided an additional and independent basis for judging attentiveness. This pattern offers insight into an intuitive theory in which both quick responding and responding within a more challenging attentional context signal that a person is attentively engaged.

Finally, an interesting finding from our secondary analyses concerned participants' judgments of their own response speed. Although participants' self-judgments did not significantly change from pre-task to post-task, their post-task judgments were more misaligned with their actual performance. In particular, participants with slower actual RTs showed a greater tendency to perceive themselves as faster than average. This pattern emerged after participants had both performed the task themselves and observed others performing it, raising the possibility that task experience may influence self-evaluations of response speed in unexpected ways. Further research is needed to determine why this miscalibration occurs.

Experiment 2

Experiment 1 showed that participants rated others as more attentive following invalid cues than valid cues. However, the difference in attentiveness ratings between valid and invalid trials could be explained in at least two ways. One possibility is that participants may have recognized, as discussed previously, that invalid cues create a more demanding situation because attention must be redirected away from the misleadingly cued location. From this perspective, responding following an invalid cue may be viewed as requiring greater attentional engagement, leading to higher attentiveness ratings. Alternatively, participants may have understood that valid cues facilitate performance by automatically directing attention toward the target location. Because valid cues make responding easier, participants may have viewed responses on valid trials as requiring less active attentional engagement and therefore assigned them lower attentiveness ratings. Experiment 2 was primarily designed to distinguish between these possibilities. It also provided an opportunity to examine whether the effects of response time and cue validity observed in Experiment 1 would be replicated in a new sample.

To distinguish between these possibilities, Experiment 2 introduced a neutral-cue condition that provided no predictive spatial information about the target location, thereby providing a baseline against which the valid and invalid conditions could be compared. If participants primarily believe that valid cues facilitate responding and reduce the amount of attention required, they should rate people as less attentive following valid cues than neutral cues. In contrast, if participants primarily believe that invalid cues create greater attentional

demands and require more active reorientation or inhibition, they should rate people as more attentive following invalid cues than neutral cues. It is also possible that both expectations contribute to attentiveness judgments, in which case ratings should be lowest following valid cues, intermediate following neutral cues, and highest following invalid cues.

Methods

Participants

Thirty-eight participants have been recruited through the University of Waterloo participant pool and received 1 course credit for completing a 60-minute study session. The study was approved by the University of Waterloo Research Ethics Board (protocol no. 47124) and preregistered on AsPredicted (https://aspredicted.org/sz7n65.pdf) before data collection began. Recruitment is ongoing and will continue until a post-exclusion sample of 50 participants is achieved, consistent with Experiment 1. Participants were excluded if they (1) reported experiencing problems during the experiment (n = 2), (2) provided the same rating on more than 80% of trials in the Observer Task (n = 1), or (3) failed to achieve an accuracy rate above 85% in the Action Task (n = 0). All participants reported having normal or corrected-to-normal vision, no history of attention-related impairments (e.g., ADHD), fluency in English, no prior participation in similar attention studies conducted in our laboratory. At the time of this analysis, the post-exclusion sample consisted of 35 participants (10 men and 25 women; mean age = 21.15 years, range = 19–33).

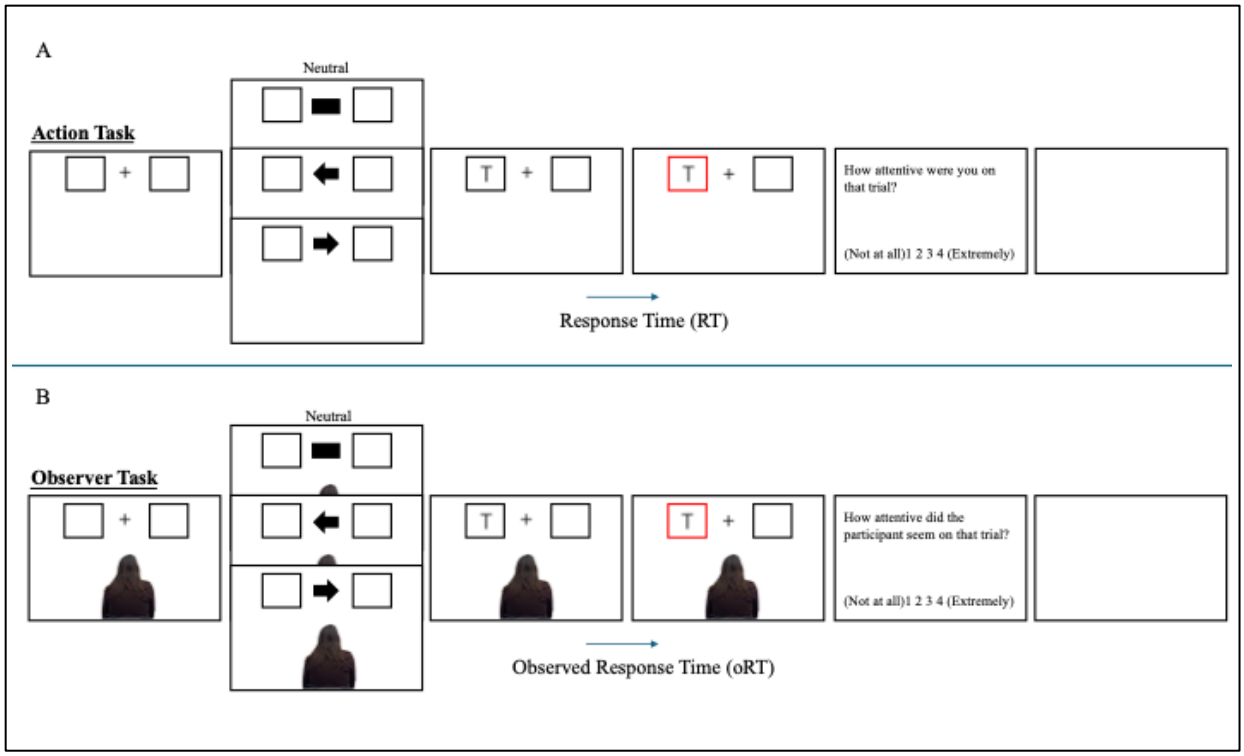
Procedure and Design

Experiment 2 was identical to Experiment 1, except that a neutral-cue condition was added to both the Action Task and the Observer Task. On neutral trials, a rectangle was presented instead of a directional arrow (see Figure 3). The rectangle appeared in the same position as the arrow cue and had approximately the same overall dimensions, measuring 4.25° in width and 2.72° in height and appearing 6.47° above the centre of the screen, and the rectangle provided no information about the location of the upcoming target.

After each response, participants rated either their own attentiveness in the Action Task or the agent's attentiveness in the Observer Task (see Figure 3). In each task, participants completed 80 neutral-cue trials in addition to 80 valid-cue trials and 80 invalid-cue trials, for a total of 240 trials. All trials were presented in a random order. In the Observer Task, observed RTs were generated from the same Gaussian distributions fitted to data collected from the 10 pilot participants used in Experiment 1. Each participant completed 240 trials, divided equally across six conditions: valid cues with observed RTs generated from the valid distribution, valid cues with observed RTs generated from the invalid distribution, invalid cues with observed RTs generated from the valid distribution, invalid cues with observed RTs generated from the invalid distribution, neutral cues with observed RTs generated from the valid distribution, and neutral cues with observed RTs generated from the invalid distribution. This created a 3 × 2 design crossing cue condition with RT distribution type. Each condition contained 40 trials, and trials were presented in a random order. Agent gender was balanced across trials, such that the male agent appeared on

120 trials and the female agent appeared on 120 trials, with the agent shown on each trial randomized.

Figure 3. The Action and Observer Tasks with the Neutral Condition



Note. This figure illustrates an example neutral-cue trial in each task. In both tasks, a non-directional rectangular cue appeared in place of the directional cue, after which the target appeared randomly in either the left or right location. In the Action Task (see Panel A), the target remained on the screen until the participant responded, after which participants rated their own attentiveness. In the Observer Task (see Panel B), the target remained on the screen until the agent responded, after which participants rated the agent's attentiveness. Each task included 80 valid-cue trials, 80 invalid-cue trials, and an additional 80 neutral-cue trials.

Results

Main Analysis

All statistical analyses for Experiment 2 were conducted using the same R version and packages described for Experiment 1.

To examine how oRT and cue condition influenced perceived attentiveness, we conducted a preregistered linear mixed-effects model with attentiveness ratings as the dependent variable; standardized oRT, cue condition (valid, neutral, or invalid), and their interaction as fixed effects; and participant as a random intercept. Consistent with Experiment 1 and with our prediction, participants judged others as more attentive when they responded faster and less attentive when they responded more slowly, $b = -0.50$, $SE = 0.01$, $t = -42.97$, $p < .001$ (see Figure 4A). As shown in Figure 4B, attentiveness ratings were significantly higher following invalid cues than valid cues, $b = 0.04$, $SE = 0.02$, $t = 2.53$, $p = .011$, and following invalid cues than neutral cues, $b = 0.05$, $SE = 0.02$, $t = 3.19$, $p = .001$. In contrast, attentiveness ratings did not significantly differ between valid and neutral cues, $b = 0.01$, $SE = 0.02$, $t = 0.66$, $p = .507$.

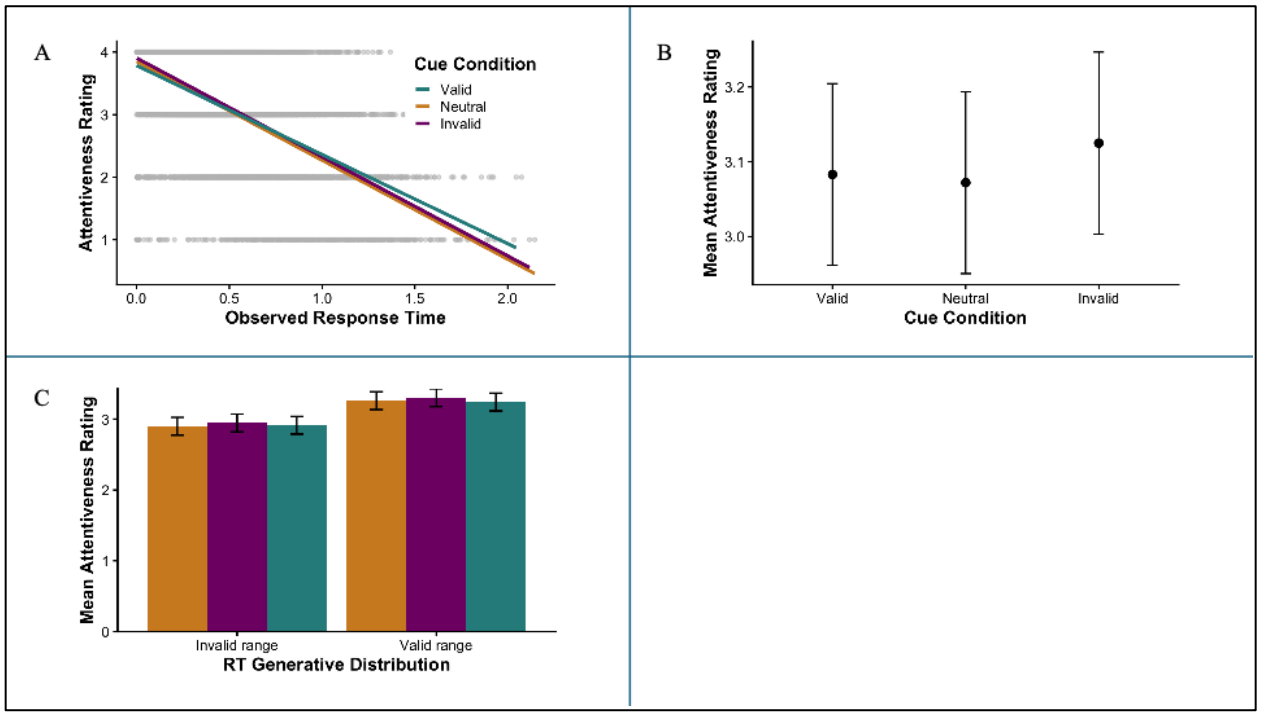
In addition, the relationship between oRT and perceived attentiveness differed across cue conditions. Although faster responses were associated with higher attentiveness ratings and slower responses with lower ratings, this relationship was significantly weaker following valid cues than following neutral cues, $b = 0.050$, $SE = 0.017$, $t = 2.98$, $p = .003$, and invalid cues, $b = 0.053$, $SE = 0.017$, $t = 3.19$, $p = .001$ (see Figure 4A). In contrast, the oRT slopes did not significantly differ between the invalid and neutral conditions, $b = -0.003$, $SE =$

0.017, $t = -0.21$, $p = .834$. Thus, participants' attentiveness judgments were more strongly influenced by response speed following neutral and invalid cues than following valid cues.

We also conducted a preregistered linear mixed-effects model in which oRT was treated as a categorical rather than continuous predictor. As in Experiment 1, trials were categorized according to the RT distribution from which the oRT was generated: the valid RT distribution or the invalid RT distribution. Others' attentiveness ratings were entered as the dependent variable, with RT distribution type, cue condition, and their interaction included as fixed effects and participant included as a random intercept. Consistent with the continuous model, there was a significant effect of RT distribution type, $b = 0.36$, $SE = 0.03$, $t = 12.39$, $p < .001$, such that participants rated others as more attentive when the observed RT was generated from the valid RT distribution, which was generally faster, than when it was generated from the invalid RT distribution, which was generally slower (see Figure 5C). However, attentiveness ratings did not significantly differ between invalid and valid cues, $b = 0.03$, $SE = 0.03$, $t = 1.10$, $p = .271$, between invalid and neutral cues, $b = 0.05$, $SE = 0.03$, $t = 1.62$, $p = .106$, or between valid and neutral cues, $b = 0.02$, $SE = 0.03$, $t = 0.51$, $p = .607$. The effect of RT distribution type also did not significantly differ across cue conditions, as the RT distribution type × cue condition interaction was not significant when comparing valid with invalid cues, $b = -0.03$, $SE = 0.04$, $t = -0.68$, $p = .500$, invalid with neutral cues, $b = -0.01$, $SE = 0.04$, $t = -0.14$, $p = .890$, or valid with neutral cues, $b = -0.03$, $SE = 0.04$, $t = -0.81$, $p = .416$. Thus, although participants gave higher attentiveness

ratings to responses generated from the faster valid RT distribution, this effect was similar across valid-, neutral-, and invalid-cue trials.

Figure 4. Results of Experiment 2



Note. Panel A shows the relationship between observed response time (oRT) and attentiveness ratings across cue conditions. Attentiveness ratings decreased as oRT increased, $p < .001$, although this relationship was weaker following valid cues than following neutral cues, $p = .003$, and invalid cues, $p = .001$. Panel B shows model-predicted attentiveness ratings by cue condition. Ratings were higher following invalid cues than valid cues, $p = .011$, and neutral cues, $p = .001$, whereas ratings following valid and neutral cues did not significantly differ, $p = .507$. Panel C shows model-predicted attentiveness ratings

with RT generative distribution treated as a categorical predictor. Ratings were higher for responses generated from the generally faster valid RT distribution than for those generated from the generally slower invalid RT distribution, $p < .001$; however, neither the effect of cue condition nor its interaction with RT distribution was significant. Error bars represent 95% confidence intervals, and the y-axis in Panel B displays a restricted range of the full 1–4 attentiveness rating scale.

Finally, we examined whether prior task experience influenced participants' attentiveness judgments when the neutral condition was included. To do so, we conducted an additional linear mixed-effects model with the same structure as the previous continuous model, but with task order included as an additional fixed effect and in interactions with oRT and cue condition. The previously observed main effects of oRT and cue condition remained significant. Specifically, there was a significant main effect of oRT, $b = -0.49$, $SE = 0.02$, $t = -29.83$, $p < .001$. Participants also gave significantly higher ratings following invalid cues than neutral cues, $b = 0.07$, $SE = 0.02$, $t = 3.06$, $p = .002$, and valid cues, $b = 0.04$, $SE = 0.02$, $t = 1.99$, $p = .046$, whereas ratings did not significantly differ between valid and neutral cues, $b = 0.02$, $SE = 0.02$, $t = 1.06$, $p = .287$. The previously observed interaction between oRT and cue condition also remained significant: the effect of oRT was significantly weaker following valid cues than following invalid cues, $b = 0.052$, $SE = 0.023$, $t = 2.29$, $p = .022$, and neutral cues, $b = 0.060$, $SE = 0.022$, $t = 2.70$, $p = .007$, whereas the effect of oRT did not significantly differ between invalid and neutral cues, $b = 0.008$, $SE = 0.023$, $t = 0.37$, $p = .715$. These findings provide no evidence that prior experience with the Action Task

influenced participants' attentiveness judgments or moderated the effects of oRT and cue condition

However, the main effect of task order was not significant, $b = -0.11$, $SE = 0.13$, $t = -0.87$, $p = .393$. The interactions between task order and cue condition were not significant, $ps \geq .308$, nor was the interaction between task order and oRT, $p = .056$. None of the three-way interactions among task order, cue condition, and oRT were significant, $ps \geq .436$. These findings provide no evidence that prior experience with the Action Task influenced participants' attentiveness judgments or moderated the effects of oRT and cue condition.

Secondary Analyses

As in Experiment 1, we conducted several preregistered secondary analyses examining observers' awareness of their own performance and individual differences in attentiveness judgments.

First, we conducted a preregistered Pearson correlations to examine the relationship between participants' RT differences across conditions in the Action Task and their attentiveness-rating differences across conditions in the Observer Task. Specifically, we examined whether participants who themselves showed larger differences between cue conditions also perceived larger corresponding differences in others' attentiveness. Participants' cueing effects in the Action Task, calculated as invalid minus valid RTs, were not significantly correlated with their cueing effects in the Observer Task, calculated as

invalid minus valid attentiveness ratings, $r(33) = .22$, $p = .214$. Similarly, attentional facilitation in the Action Task, calculated as neutral minus valid RTs, was not significantly correlated with attentional facilitation in the Observer Task, calculated as neutral minus valid attentiveness ratings, $r(33) = .16$, $p = .354$. Attentional costs in the Action Task, calculated as invalid minus neutral RTs, were also not significantly correlated with attentional costs in the Observer Task, calculated as invalid minus neutral attentiveness ratings, $r(33) = -.20$, $p = .247$. Together, these findings provide no evidence that participants' condition-related differences in their own RTs were associated with the corresponding differences in how they rated others' attentiveness.

In addition, as in Experiment 1, we conducted a preregistered paired-samples *t* test comparing participants' mean ratings of their own attentiveness in the Action Task with their mean ratings of others' attentiveness in the Observer Task to examine whether attentiveness judgments differed between self and others. Replicating the findings of Experiment 1, participants rated their own attentiveness significantly higher than others' attentiveness, $t(34) = 5.01$, $p < .001$.

Finally, as in Experiment 1, participants indicated before starting the tasks and again after completing both tasks whether they believed their RTs were faster or slower than those of the average person. Responses were provided on a scale ranging from 1 (much slower than average) to 100 (much faster than average), allowing us to examine whether performing the task themselves and observing others perform it changed participants' perceptions of their own response speed. A preregistered paired-samples *t* test indicated that these self-judgments

did not significantly differ before and after completing both tasks, $t(34) = -0.56$, $p = .577$, suggesting no significant overall shift in participants' perceived response speed. We then conducted preregistered Pearson correlations between participants' self-judgments and their mean RTs in the Action Task to examine the accuracy of these metacognitive judgments. Pre-task judgments were not significantly associated with participants' mean RTs, $r(33) = .14$, $p = .408$, providing no evidence that participants' initial perceptions of their response speed corresponded to their actual performance. However, unlike in Experiment 1, post-task judgments were also not significantly associated with mean RTs, $r(33) = .04$, $p = .841$, providing no evidence that completing both tasks changed the correspondence between participants' perceived and actual response speed.

Discussion

Experiment 2 had two main aims. First, by introducing a neutral-cue condition, we sought to determine whether the higher attentiveness ratings following invalid cues than valid cues reflected the facilitation provided by valid cues, the additional attentional demands imposed by invalid cues, or both. Second, we sought to replicate the central findings of Experiment 1 and further examine whether observers used both behavioural cues (e.g., response time) and situational cues (e.g., cue validity) when judging another person's attentiveness.

The results of Experiment 2 provided further evidence that observers use both behavioural and situational information when judging others' attentiveness and offered

additional insight into people's intuitive theories of attention. Replicating Experiment 1, participants judged faster responses as indicating greater attentiveness and rated agents as more attentive following invalid cues than valid cues. Furthermore, the comparisons involving the neutral condition helped clarify the difference between valid and invalid cues observed in Experiment 1. Participants gave higher attentiveness ratings following invalid cues than neutral cues, whereas ratings did not differ between valid and neutral cues. This pattern suggests that participants recognized the additional attentional demands created by invalid cues, which direct attention toward an incorrect location and require attention to be redirected when the target appears elsewhere. Responses made under this misleading context may therefore have been viewed as stronger evidence of attentional engagement. In contrast, the facilitation provided by valid cues may have been less salient or less relevant to participants' judgments. Thus, the cue-validity effect observed in Experiment 1 appears to have been driven primarily by elevated ratings following invalid cues rather than reduced ratings following valid cues.

Unlike in Experiment 1, when the neutral condition was introduced in Experiment 2, oRT interacted with cue condition, such that response speed had a weaker influence on attentiveness ratings following valid cues than following neutral or invalid cues. One possibility is that introducing the neutral condition made the different functions of the cues more salient, highlighting that fast responses following valid cues were partly facilitated by accurate spatial information and therefore provided less additional evidence of attentiveness. Response speed may instead have appeared more informative when the cue provided no

directional information or directed attention toward the incorrect location. In addition, unlike in Experiment 1, the effect of cue condition was not significant when oRT was treated as a categorical predictor. One possible explanation is that categorizing oRT reduced sensitivity by collapsing partially overlapping RT distributions, making small differences between cue conditions more difficult to detect. Because the present findings are based on an incomplete sample of 35 participants, these interpretations remain tentative. The effects will be reassessed once the planned sample size has been reached.

Consistent with Experiment 1, task order did not significantly moderate the effects of response time, cue validity, or their interaction. Participants' judgments of others' attentiveness therefore did not differ depending on whether they completed the Action Task before or after the Observer Task. This replicated pattern provides further evidence that first-hand experience with the spatial cueing task did not change how participants inferred others' attentiveness, suggesting that these judgments may instead have been guided by pre-existing beliefs about how attention is shaped.

Finally, the secondary analyses examined participants' judgments of their own response speed. Consistent with Experiment 1, these judgments did not change significantly after participants completed the tasks. However, unlike in Experiment 1, participants' perceived response speed was not significantly related to their actual RTs either before or after the tasks. This pattern suggests that participants' beliefs about their own response speed were relatively stable but did not necessarily reflect their actual performance. Completing the

task and observing others therefore did not appear to change participants' metacognitive awareness of how quickly they responded.

Together, these findings provide further evidence that participants used both behavioural and situational information when judging attentiveness. Response speed served as a general behavioural cue, with faster responses indicating greater attentiveness, whereas cue validity informed how participants understood the attentional demands of the situation. In particular, the higher ratings following invalid cues than neutral cues suggest that participants treated the attentional costs imposed by misleading spatial information as additional evidence of attentional engagement. By contrast, the absence of a difference between valid and neutral cues provides little evidence that participants based their judgments on the facilitation provided by valid cues. This pattern therefore speaks to an intuitive theory in which attentiveness is inferred partly from the effort required to overcome attentional demands, rather than from the extent to which the situation makes responding easier.

General Discussion

The present research examined people's intuitions about others' attention by investigating how they interpreted another person's performance in a visual attention task. Specifically, we investigated whether people use both observable behaviour and the context in which that behaviour occurs to infer another person's attentional state. Across two experiments, participants completed a spatial cueing task themselves and observed an agent completing the same task, with task order counterbalanced.

In Experiment 1, faster responses were consistently associated with higher attentiveness ratings, supporting our hypothesis that participants would treat response speed as a behavioural cue to attentional engagement. Agents were also judged as more attentive following invalid cues than following valid cues, suggesting that participants' judgments were influenced by the cueing context in addition to the agent's response speed. However, contrary to our hypothesis, the interaction between response time and cue validity was not significant, providing no evidence that participants interpreted response speed differently across the two cue conditions.

Experiment 2 was designed both to examine whether the pattern observed in Experiment 1 would also emerge in a new sample and to further elucidate whether the difference between the conditions reflected an expectation that invalid cues impose an attentional cost, an expectation that valid cues facilitate responding, or both. We therefore introduced a neutral-cue condition that directed attention neither toward nor away from the target location. The Experiment 2 findings should be considered preliminary, as data

collection is ongoing and the preregistered sample size has not yet been reached. These findings will need to be reevaluated once the full sample has been collected. Nevertheless, consistent with Experiment 1 and with our hypothesis, faster responses again predicted higher attentiveness ratings. Agents were also judged as more attentive following invalid cues than following valid cues. Interestingly, participants judged others as more attentive in the invalid condition than in the neutral condition, whereas attentiveness ratings did not differ between the valid and neutral conditions. This pattern suggests the possibility that participants recognized the attentional cost imposed by invalid cues but provides little evidence that they similarly incorporated the facilitation provided by valid cues into their overall attentiveness ratings. In addition, Experiment 2 revealed a significant interaction between response time and cue condition. The negative association between response time and attentiveness ratings was weaker following valid cues than following neutral or invalid cues, whereas it did not differ between the neutral and invalid conditions. Finally, task order did not significantly moderate the effects of response time or cue condition in either experiment, providing no evidence that completing the task before observing the agent changed how participants used these factors to judge attentiveness.

Within this broader pattern, the preliminary findings from Experiment 2 suggest that participants' attentiveness judgments more clearly reflected the cost associated with invalid cues than the facilitation provided by valid cues. Classic spatial-cueing research distinguishes the benefit produced by valid cues from the cost produced by invalid cues relative to a neutral baseline (Posner et al., 1980). In the original paradigm, these effects were

approximately symmetrical, such that the reduction in response time following valid cues was similar in magnitude to the increase following invalid cues. Subsequent research, however, suggests that attentional benefits and costs may not always be equivalent or arise from the same underlying processes. For example, Chen and Wyble (2018) proposed that cueing benefits and costs may reflect partly distinct mechanisms, while recent large-scale evidence found that valid-cue benefits were relatively robust, whereas invalid-cue costs varied with the spatial distance between stimuli (Luzardo & Yeshurun, 2025). Interestingly, the emerging pattern in the present study differs from this objective performance pattern: observers' attentiveness judgments more clearly reflected invalid-cue costs than valid-cue benefits. This contrast suggests that people's intuitive understanding of attention may not precisely mirror the objective effects of spatial cueing. One possible explanation for this divergence is that observers relied on the effort heuristic when judging attentiveness. According to this heuristic, people may evaluate an outcome more positively when they believe that greater effort was required to produce it (Kruger et al., 2004). Because invalid trials require an agent to disengage from the incorrectly cued location and reorient attention toward the target, responding in this condition may have been interpreted as evidence of greater attentional effort and engagement. By contrast, responding following a valid cue may have appeared relatively easy or typical, making the cue's facilitative contribution less apparent to observers.

Experiment 2 also revealed an interaction between response time and cue condition: the association between response time and attentiveness ratings was weaker following valid

cues than following neutral or invalid cues. In Experiment 1, we had predicted a stronger association following valid than invalid cues, reasoning that a slow response despite the assistance provided by accurate spatial information might be interpreted as particularly strong evidence of inattention; however, this interaction was not significant. The Experiment 2 results instead suggest that participants may have placed less weight on response time when the cue had already directed attention toward the target. Thus, introducing the neutral condition may have made the distinct functions of the cues more salient by providing a baseline against which the assistance provided by valid cues and the attentional demands imposed by invalid cues could be evaluated.

The weaker association in the valid condition may have reflected differences in how participants interpreted responses at both ends of the response-time distribution. Fast responses may have provided less direct evidence of attentiveness because they could be attributed partly to the situational support provided by the cue. At the same time, particularly slow responses may have been interpreted as reflecting a departure from the rapid, relatively automatic responding facilitated by the valid cue, rather than solely as evidence of inattention. This ambiguity may have led participants to judge very slow responses less harshly in the valid condition than in the neutral or invalid conditions. Together, these interpretations may have weakened the overall association between response time and attentiveness ratings following valid cues. By contrast, response time following neutral or invalid cues could be attributed more directly to the agent's attentional engagement because

the context either provided no directional assistance or initially directed attention away from the target.

Thus, rather than placing greater weight on slow responses following valid cues, as we had predicted in Experiment, participants may have interpreted response time differently when accurate spatial information was available, thereby treating it as less diagnostic of attentiveness. This finding suggests that context can shape not only attentiveness judgments directly, but also the diagnostic value assigned to observable behaviour. A given response time may therefore not carry a fixed meaning across situations; instead, people may adjust how much it reveals about attentiveness according to the circumstances in which the response was produced.

Beyond the effects of response time and cue condition, we also examined whether firsthand task experience shaped participants' judgments of attentiveness. One possible explanation for the absence of a task-order effect is that the spatial cueing task was sufficiently simple for participants to infer the consequences of valid and invalid cues without completing the task themselves. Future research could examine whether firsthand experience becomes more influential when task demands cannot be readily inferred through observation alone. A visual search paradigm may be particularly useful for this purpose because search difficulty can be manipulated through factors such as target–distractor similarity, search type, and set size. Participants who first perform searches of varying difficulty may develop a more calibrated understanding of how these conditions affect

response time and accuracy, which may subsequently influence their judgments of an agent's attentiveness.

In summary, people appear to hold a general belief that greater attentiveness is expressed through relatively rapid responding, while also evaluating this behaviour in relation to the attentional demands of the surrounding context. Performance following a misleading cue was treated as stronger evidence of attentional engagement than comparable performance under neutral or facilitating conditions. Moreover, the interaction observed in Experiment 2 suggests that context may shape not only overall attentiveness judgments, but also the diagnostic value assigned to response time. Together, these findings suggest that intuitive theories of attention involve more than a simple association between rapid responding and attentiveness. They also include expectations about how attention is expressed, what different situations demand, and how observable behaviour should be interpreted in light of its context when inferring another person's attentional state.

These findings contribute to our understanding of intuitive theories of attention by revealing the everyday expectations people use to infer attentiveness from observable behaviour and situational context. Such inferences are an important aspect of social cognition, helping people determine whether others are engaged, distracted, or responding appropriately to a situation. The present approach provides a foundation for examining how individuals with social anxiety or autism spectrum conditions use non-gaze information to interpret others' attentional states. This approach may be especially useful when gaze information is unavailable or difficult to use, such as when others' gaze is anxiety-provoking

(Boll et al., 2016; Schulze et al., 2013) or gaze cues are processed differently (Griffin & Scherf, 2020). By focusing on cues such as response speed and situational context, future research could examine how these populations use and weight additional sources of information when judging attentiveness. Understanding how different cues contribute to these judgments may ultimately inform strategies that support the interpretation of others' attentional states in everyday social interactions. These findings are also relevant to the growing interest in collaboration between humans and artificial intelligence technologies. Some current approaches use facial expressions, eye gaze, and other visual behaviours to recognize attentiveness (Chatterjee et al., 2023; Gupta et al., 2023; Kotseruba & Tsotsos, 2022). However, relying primarily on facial information may be insufficient when the face is not fully visible or when facial behaviour does not clearly reflect a person's attentional state. Incorporating non-facial cues, such as response speed and task context, could allow AI systems to evaluate attentiveness using multiple sources of information. This approach may support more context-sensitive systems, such as driver-monitoring systems that detect attentional lapses, educational technologies that adapt to students' engagement, and collaborative AI systems that respond to changes in a user's attentional state.

Limitations

Despite these contributions, several limitations of the present research should be considered and addressed in future studies. First, response time may not have served as an unambiguous indicator of attentiveness on invalid trials. A fast response could have been interpreted as reflecting efficient disengagement and reorienting, although an unusually fast

response might also have raised the possibility that the agent had responded without fully processing the cue. Although faster responses were generally associated with higher attentiveness ratings, indicating that participants tended to interpret response speed positively, the ratings alone could not reveal the specific explanation participants assigned to each response. Future research could examine these competing interpretations by providing observers with additional information about the agent's performance. For example, varying accuracy alongside response time could help determine whether observers interpret a fast response as efficient attentional processing when it is correct but as rushed or careless responding when it is accompanied by an error.

Second, the agent videos were created from brief two-minute recordings of a volunteer viewed from behind, with segments randomly selected for individual trials. Because the Observer Task contained many trials but was based on a limited amount of recorded footage, some video segments may have been presented more than once. Repeated movements could reduce the naturalism of the stimuli or become noticeable to participants. Future studies could use longer and more varied recordings to reduce repetition and improve the ecological validity of the Observer Task.

Finally, the relatively simple nature of the spatial cueing task may limit the generalizability of the findings. The task required only a brief shift of spatial attention followed by a straightforward response, capturing a limited aspect of attentional performance. In more complex or naturalistic situations, attentiveness may involve sustained concentration, monitoring multiple sources of information, resisting distractions, and

adjusting behaviour following errors. In such situations, slower responses may sometimes reflect more careful and attentive processing rather than inattention. Future research should therefore examine whether the present findings generalize to more complex and demanding tasks.

Conclusion

Together, these findings provide insight not only into whether observers can infer another person's attentiveness, but also into the underlying intuitions that shape how such judgments are made. In everyday life, a coworker who puts away their phone while working may be perceived as more attentive, while a driver who responds promptly to changing road conditions may be judged as more alert. The present research moves beyond these broad everyday assumptions by identifying some of the specific cognitive principles that may underlie such judgments. In particular, the findings suggest that people expect attention to leave systematic traces in observable behaviour, such as response speed, while also interpreting those traces in relation to the circumstances in which they occur. By teasing apart these underlying expectations, the present studies help clarify the intuitive theories people rely on when reasoning about how attention shapes action and is expressed across different situations. More broadly, this research contributes to our understanding of attention and social cognition by showing how behavioural and contextual information are combined when people infer others' hidden attentional states.

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