Potential social interactions are important to social attention

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Edited by Dale Purves, Duke University Medical Center, Durham, NC, and approved February 23, 2011 (received for review November 14, 2010)

Social attention, or how spatial attention is allocated to biologically relevant stimuli, has typically been studied using simplistic paradigms that do not provide any opportunity for social interaction. To study social attention in a complex setting that affords social interaction, we measured participants' looking behavior as they were sitting in a waiting room, either in the presence of a confederate posing as another research participant, or in the presence of a videotape of the same confederate. Thus, the potential for social interaction existed only when the confederate was physically present. Although participants frequently looked at the videotaped confederate, they seldom turned toward or looked at the live confederate. Ratings of participants' social skills correlated with head turns to the live, but not videotaped, confederate. Our results demonstrate the importance of studying social attention within a social context, and suggest that the mere opportunity for social interaction can alter social attention.

eye movements | overt visual attention | visual cognition | autism

Interest in understanding how our visual attention is influenced by social stimuli has grown substantially in recent years (1–5). Everyday experience tells us that the social content of a scene, such as the people or faces in it, can "grab" our attention, leading us to focus in on these social stimuli, often at the expense of attending to other features in our environment. Empirical support for this bias toward social stimuli is abundant. When presented with a picture of a human face, observers will look most to the socially informative features of the face, showing a strong preference to look at the eyes (6–12). Similarly, when instructed to examine a scene containing several individuals, participants tend to spend much of their time looking back and forth between the figures (1, 2, 12), and people will preferentially look at social rather than nonsocial scenes if given a choice (13).

Although it may be the case that we have a preference to attend to social stimuli during laboratory-based experiments, caution has been raised about the generalizability of laboratory-based results to the complex behavior observed in everyday situations (e.g., refs. 2 and 14). One common criticism of traditional laboratory-based research concerns the simplicity of the stimuli used to investigate social attention. For example, studies of face perception frequently have participants look at a series of schematic or photographed faces presented in isolation of any other stimuli (e.g., refs. 8, 10 and 11). Although the simplicity of the tasks enables a high degree of experimental control, excluding extraneous information from the stimuli also serves to preselect what "should be" important for the participant. In these situations, participants often look at the eyes, arguably because they communicate social information (e.g., refs. 15 and 16). However, showing relatively simple stimuli to participants may drive them to attend to the most complex or salient component of an image, which in the case of faces may often be the eyes. To properly establish that people preferentially select for social stimuli within their environment, Birmingham and colleagues (1–3) reasoned that one needs to provide participants with complex and natural scenes, within which social stimuli are embedded. Their research demonstrates that even when social figures are embedded within a complex scene, they are selected more often than would be expected based on low-level features (e.g., salience, size) alone. Research using complex, dynamic stimuli has also shown that people, especially their heads and eyes, are preferentially attended. When viewing a series of images that collectively tell a story, for example, participants will fixate on an actor's face earlier and for longer than nonsocial control objects (17). In a study by Kuhn et al. (18) in which participants watched a video of a magic trick, the proportion of fixations on the head and eyes was nearly 70%. Likewise, when participants were asked to watch videos of other students engaging in conversation, 77% of fixations were directed to the people in the clips (19).

Thus, our preference to attend to others appears to generalize to more complex stimuli. Even so, one cannot conclude that what is being measured in the laboratory corresponds to what occurs in everyday situations. There is more to everyday experience than heightened visual complexity. If our aim is to understand social attention, then one often overlooked factor must also be incorporated: the introduction of a social interaction, or at least the possibility of a social interaction, in which the participant is actively involved. With all computer-based studies, be they static or dynamic scene-viewing tasks, it may be difficult for participants to interpret these situations as realistically social, because although persons within the scenes may be interacting among themselves (e.g., refs. 1, 2 and 20), the participant is nevertheless unable to join in on the observed interaction. Indeed, in some ways, a typical experimental task is exemplary of an antisocial situation in which the participant is forced to remain an outsider because the people being observed are incapable of looking back and as such, there is no potential for a social interaction to emerge. Because of this phenomenon, a participant may attend to these scenes in a very different manner than if they were actively involved within the scenario. For example, although participants may fixate the eyes of a forward-staring stranger during a computer-based face-viewing task (e.g., refs. 8 and 9), participants will also show avoidance strategies when a stranger stares at them in a public space (21; see also ref. 22 for a discussion of gaze-avoidance during unfocused interactions). Although the stimulus (a stranger facing the participant) is superficially similar in both cases, when the stranger is physically present and is capable of interacting with the participant, the behavior of the participant changes. In other words, the potential (or lack thereof) for a social interaction to emerge may cause both an increase in looking behavior when one knows that the other person cannot return their gaze (i.e., during traditional computer-based tasks), and a decrease in looking behavior when mutual gaze is possible (i.e., in real life, where this gaze may signal a desire to communicate).

A failure to create opportunities for social interactions within the context of an experiment may be a particular problem for researchers studying social abilities of certain special populations, such as those with Autism Spectrum Disorder (ASD). Although social impairments in everyday life are characteristic of

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Author contributions: K.E.W.L., T.F., G.K., and A.K. designed research; K.E.W.L. and T.F. performed research; K.E.W.L. and T.F. analyzed data; T.F. made the video-coding program; and K.E.W.L., T.F., G.K., and A.K. wrote the paper.

The authors declare no conflict of interest.

This article is a PNAS Direct Submission.

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 www.pnas.org/cgi/doi/10.1073/pnas.1017022108

those with ASD, experimental evidence for these impairments, especially those relating to social attention, have been notoriously mixed within the ASD literature (see ref. 23 for a review). That many laboratory-based paradigms do not involve any possibility for social interaction may be partly responsible for this laboratory versus life behavioral distinction. Of course, a social interaction need not be one in which the participant is engaged in direct communication with another. A social interaction may be interpreted in a more general sense, such that a situation in which two individuals can send and receive verbal or nonverbal information to one another may be considered, on some level, social. Simply put, to truly study social attention as it operates in everyday social situations, one may need to first create and embed a person in a social situation.

The goal of the present study was to examine social attention in a situation that is free of several of the limitations of more traditional, computer-based tasks. We were interested in investigating how participants look at another individual when they are outside the restrictions of an unrealistic experimental paradigm. Furthermore, we aimed to compare looking behavior under conditions where the potential for social interaction was experimentally manipulated. To accomplish this, half our participants completed the study when a confederate was physically present with them, and half completed the study when a videotape of the same confederate played on a computer screen nearby. The latter condition, which is devoid of any potential for social interaction between the participant and the confederate, more closely mirrors what previous studies have used to gauge participants' preferences toward social stimuli. In contrast, the former condition most closely approximates what one might experience in everyday life, in that there exists the opportunity for an interaction to emerge between individuals. To achieve as naturalistic an environment as possible to record looking behavior, we recorded participants' behavior using a mobile eye tracker. The mobile eye tracker is a head-mounted camera that enables recording of both the participants' head orientation and the location of their eye fixations within the camera's field of view. Gaze behavior was recorded as they waited for an experimenter to return with instructions for an unrelated real-world visual-search task. Thus, during the time in which the participants' looking behavior was recorded, the participants were unaware that the study had commenced, and were given no instructions beyond being asked to sit and wait for the experimenter's return. In both conditions, a confederate sat quietly and completed a questionnaire; the only difference was whether or not the confederate was physically present in the room with the participant, and thus whether there was the possibility of a social interaction to take place. As evidence for abnormal social attention in persons with ASD has been mixed, possibly because of the artificial nature of the tasks being used in the laboratory, we additionally assessed whether looking behavior to the confederate would correlate with our participants' subjective social skills, as measured by the Autism Spectrum Quotient (AQ) (24), and whether differences in this relationship would be observed across conditions.

Results

Data Handling. The following analyses were concerned with participants' overt attention to, or looks and head turns towards, the confederate and were completed on each participant's eye-tracking video that was recorded as they waited for the experimenter in the waiting room. Each clip began when the participant sat down in the waiting room. The time in which the participant waited for the experimenter to return was coded (duration mean: 134.5 s; SD: 13.45 s). Although small variations in wait time occurred across participants, there was no significant difference in wait time across live-versus videotaped-confederate conditions [$t(24) = 0.18$, $P = 0.86$].

Videos were recorded and displayed at a rate of 30 frames per second. Videos were coded using a custom applescript video coder program developed by one of the authors (T.F.). The application works alongside QuickTime to allow the coders to control the speed of the video and permits logging of predefined events on a frame-by-frame basis.

Videos were coded to determine how often and for how long participants in each condition looked at the confederate. Three categories of events were coded and are detailed in Table 1 and exemplified in Fig. 1. Head turns toward the confederate, such that the confederate was visible in the participants' recorded video, were coded in one of two ways. A "head turn, fixation on confederate" event was coded when the participant turned toward and fixated on the confederate (Fig. 1*A*), and represents times in which the participant overtly attended to the confederate. Otherwise, when the participant turned toward, but did not fixate on the confederate, a "head turn, no fixation on confederate" event was coded (Fig. 1*B*). These events could reasonably represent acts of both overt and covert social attention to the confederate, as the participant would have overtly turned toward the confederate, but would have only been able to visually attend to the confederate covertly using peripheral vision. To avoid including frames in which only a small portion of the confederate was visible (e.g., only her foot), we additionally required that the confederate's torso or higher be in the frame for any event coding involving a head turn toward the confederate. The third coding category consisted of "fixation on baseline object" events, where the fixation cursor was overlaid anywhere on the baseline object (Fig. 1*C*). In the videotaped-confederate group, the empty chair in which the live confederate sat during the live-confederate sessions was considered the baseline object. For the live-confederate group, the blank screen upon which participants in the videotaped-confederate group viewed the taped confederate videos was considered the baseline object. Through comparison of gaze behavior directed toward these two baseline objects, it can be determined whether either location was looked at more often or for longer when no confederate was present.

For each event, the start and end time was recorded, and the duration of the event was determined from these time points, which was then summed to provide a measure of total event time. To determine the number of events, any consecutive events of the same category that were separated by 100 ms or less of uncoded frames or frames in which the gaze cursor was temporarily missing were collapsed into one event. This process ensured that any frames in which the fixation cursor was missing because of blinks or saccades would not artificially inflate the measure of how often each event occurred. Longer events in which the gaze cursor was temporarily missing from the video (e.g., because of fixations far in the periphery, and so forth) were not included in the analyses, except when calculating proportions, as detailed below (see *Fixation Analysis*).

Coder Reliability. Videos were coded by one of the authors (K.E.W.L.) and one of two research assistants who were unfamiliar with the specific hypotheses of the study. To calculate interrater reliability, Pearson's correlations were run on the fixation durations and counts from each coder pair for each event category and subcategory ("head turn, fixation on confederate," "head turn, no fixation on confederate," and "fixation on baseline object"). Correlations ranged between $R = 0.86$ and 1.00 (mean = 0.94; SD = 0.06). Remaining analyses were performed on the average value generated from the two coders.

Fixation Analysis. Where appropriate, if Levene's test of equality of variances was significant (with a $P < 0.25$), then the relevant degrees of freedom and P values were adjusted accordingly. Critically, it was first determined that looking behavior to the baseline object did not differ based on group, based on either overall fixation duration [$t(24) = 1.08$, $P = 0.29$] or total number of fixations [$t(24) = 1.66$, $P = 0.11$]. Participants thus did not show a preference to look at either location at which a confederate was positioned for the study. Any differences in looking behavior to

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Table 1. Event and coding criteria

Event	Coding Criteria
1 Head turn toward confederate	Confederate was in the line-of-sight (i.e., participant turned head to look toward confederate). Includes events 1a, 1b.
1a Head turn, fixation on confederate	Fixation cursor on confederate.
1b Head turn, no fixation on confederate	Confederate was in line-of-sight video recording but fixation cursor was not on the confederate.
2 Fixation on baseline object	Fixation cursor on baseline object (i.e., participant turned head toward and fixated baseline object).

that location based on condition can therefore be attributed to the difference imposed by a live or videotaped confederate.

When "head turn, fixation on confederate" events were compared, it was found that participants in the videotaped-confederate group fixated on the confederate more times, [$t(12.39) = 3.24, P = 0.01$], and spent more time overall fixating on the confederate [$t(12.21) = 2.97, P = 0.01$], than did participants in the live-confederate group. Based on "head turn, no fixation on confederate" events, participants in the videotaped-confederate group also turned their heads toward (but did not fixate on) the confederate significantly more often, [$t(12.66) = 5.66, P < 0.001$], and for a longer overall duration [$t(12.72) = 5.67, P < 0.001$], than participants in the live-confederate group. Participants in the videotaped-confederate condition fixated on the confederate significantly more often [$t(12) = 2.93, P = 0.01$] and for longer [$t(12) = 2.98, P = 0.01$] than they fixated on the baseline object. In contrast, participants in the live-confederate condition actually fixated on the confederate less often than they fixated on the baseline object, [fixation count: $t(12) = 2.22, P = 0.05$; fixation duration: $t(12) = 0.61, P = 0.55$]. Fig. 2 displays the mean overall durations that occurred for each coded event.

It is clear that participants in the videotaped condition turned toward and fixated on the confederate to a greater extent than did participants in the live-confederate condition. In this way, our findings imply that computer-based tasks of social attention may generally overestimate participants' willingness to attend to others in realistic situations, as measured here by head turns and fixations. Although computer-based tasks may overestimate the magnitude of social attention effects, it is nevertheless possible that these tasks may accurately capture behavior after the other person's image has been acquired within the participants' line-of-sight (i.e., in our case, after the participant has turned their head toward the confederate). To examine how participants distributed their attention once they had turned their head toward the confederate, we calculated the proportion of fixations that were directed to the confederate given that the confederate was in the participants' line-of-sight. Of the 13 participants in the live-confederate condition, the videos for two participants did not have the confederate in a single frame, and thus they were excluded from the following analysis. When calculated as a proportion of the time the confederate was in the participants' line-of-sight (including instances where the gaze cursor was missing), the relative frequency of fixations [$t(22) = 0.17, P = 0.87$] and the fixation duration [$t(22) = 0.19, P = 0.85$] on the confederate were not significantly different between groups. Although participants in the videotaped-confederate condition turned toward the confederate overall more frequently than did those in the live-confederate condition, once the confederate was in their line-of-sight, the distribution of gaze behavior to the confederate or elsewhere did not differ across conditions. This finding implies that manipulating the potential for a social interaction by introducing a live or videotaped person primarily influenced their willingness to attend to another, as indicated by how often participants turned their head toward the confederate, but it did not alter their general looking behavior after they had acquired the other person within their line-of-sight.

Autism Quotient Questionnaire Correlations. Although all participants completed the full AQ questionnaire, we focused our analysis on only the Social Skills subscale, as it was theorized that gaze behavior differences caused by our manipulation of the social presence of the confederate would best correlate with the social skills of our participants. Of interest was whether the participants' score on the Social Skills subscale would correlate with the number or overall duration of fixations and head turns made to the confederate. Note that higher scores on the Social Skills subscale are related to lower self-reported social skills.

For participants in the videotaped-confederate condition, no correlations reached significance (all, $P > 0.10$). For participants in the live-confederate condition, scores on the Social Skills subscale did not significantly correlate with fixations toward the confederate, (duration: $R = 0.30, P = 0.32$; number: $R = 0.47, P = 0.11$), but intriguingly, as seen in Fig. 3, a significant positive correlation was found between Social Skills scores and "head turn, no fixation on confederate" events, (duration: $R = 0.66, P = 0.02$; number: $R = 0.58, P = 0.04$). That there was only a relationship between social skills and head turns without fixation on the confederate, but not when the confederate was fixated, is suggestive of an effect that may be related to covert attentional behavior. It should be noted that these effects, although highly suggestive, should be treated with a degree of caution. For example, although it appears to be driven largely by an individual who had poor self-reported social skills (i.e., a higher Social Skills subscale score of 6) and frequently looked toward the confederate (mean number of head turns: 17.5; mean head-turn duration: 11,447.5 ms), this individual also reported a suspicion that the confederate was part of the study. As such, there is the possibility that the greater number of head turns toward the confederate related to this suspicion. Arguing against this possibility is the fact that the only other participant in the live condition who expressed similar suspicions looked toward the confederate very infrequently (mean number of head turns: two; mean head-turn duration: 366.7 ms). In addition, because "head turn, no fixation on confederate" events may also be considered measures of overt attention, no conclusions can be made about

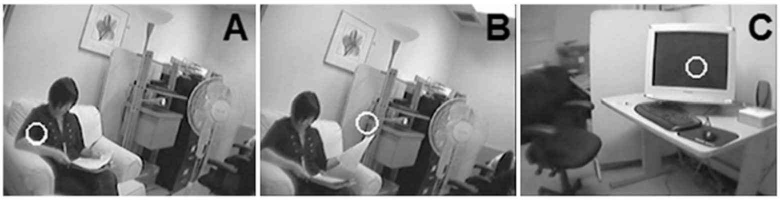

Fig. 1. Video frames exemplifying each coding event. (*A*) The participant turned their head toward and fixated (shown by the white circle) on the confederate. (*B*) The participant turned their head toward the confederate but did not fixate on the confederate. (*C*) The participant fixated on the baseline object (blank computer screen in this example).

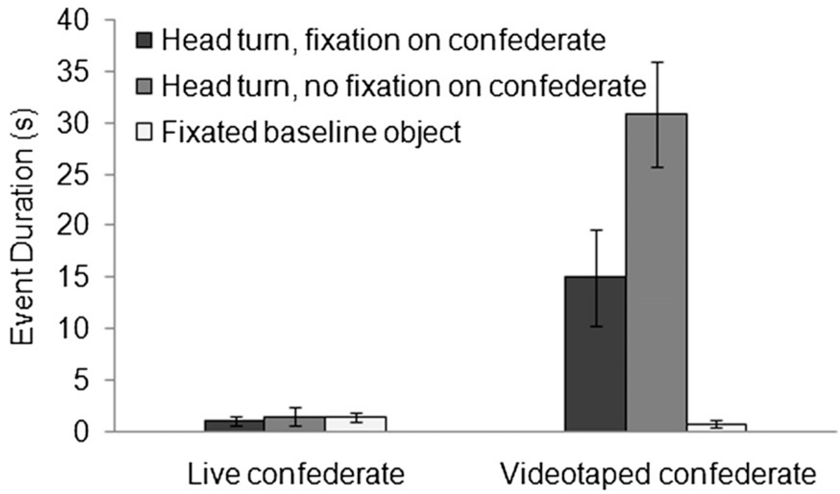

Fig. 2. Mean overall duration of fixations to the confederate, head turns toward the confederate, and fixations on the condition's baseline object (n = 13 for each confederate-type group). Error bars denote SE. The overall pattern was similar for the mean fixation number.

the relationship between social skills and purely covert social attention. Thus, although the reported correlations are suggestive of a relation between social skills and social attention if the other person is physically present, it is clear that additional investigations are required.

Discussion

Although there is a wealth of information suggesting that we show a bias to look toward social stimuli, such as people and faces, the majority of this research has measured looking behavior using computer-based tasks that are simplistic and do not involve the participant in any social situation (e.g., refs. 1–3 and 8–10). The goal of the present study was to investigate how one's visual attention to other people within a naturalistic situation is influenced by the possibility of a social interaction emerging. To accomplish this, we recorded participants' head and eye movements as they waited to begin an unrelated study, during which time a confederate, acting as another participant, quietly completed a questionnaire nearby. In the live-confederate condition, the confederate was physically present in the room, but in the videotaped condition, the confederate was shown on a video on a nearby monitor. Our results demonstrate that the willingness of our participants to look at another individual is strongly influenced by whether or not that individual is physically present, and as such, whether the confederate is capable of looking back and engaging in a social interaction with the participant. Participants looked at the videotaped confederate significantly more often and for an overall longer duration than other participants did toward the same confederate that was physically in the room. This result was primarily because of the participants' far greater willingness to turn their heads toward the videotaped confederate. Additionally, we found that the number and duration of head turns toward the live confederate was positively correlated with poorer subjective social skills, as measured by the Social Skills subscale of the AQ. Fixation behavior and head turns to the videotaped confederate did not significantly correlate with Social Skills scores. Our results exemplify an important difference between the results normally observed using traditional, computer-based tasks to study social attention, and the natural behavior that we argue is more typical in everyday situations.

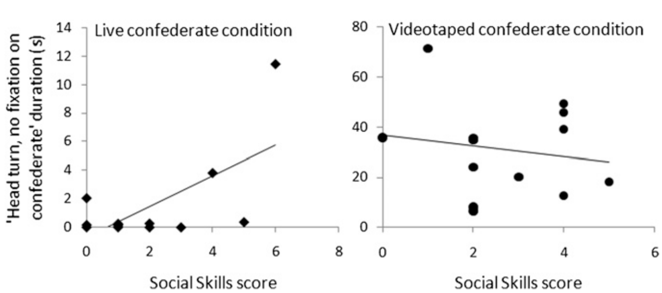

Fig. 3. Scatterplot of participants' scores on the AQ's Social Skills subscale in relation to the overall duration of "head turn, no fixation on confederate" events for participants in the live- (n = 11) and videotaped- (n = 13) confederate groups. Note different scales on both axes of the scatterplots. Overall fixation number showed a similar pattern.

By creating a natural situation in which to measure visual behavior, our study addressed two common limitations of current social attention research, and in so doing, arguably provides a more appropriate measure of how social attention functions in everyday settings. Unlike other paradigms that rely heavily on simplistic, computer-based stimuli and tasks that may not elicit natural behavior (see refs. 14 and 25 for an extended discussion on this point), our task measured behavior as participants engaged in a familiar and realistic task: sitting in a waiting room. In an attempt to capture spontaneous participant behavior, we provided no task instructions and recorded all eye movements before participants believed the study had commenced. Furthermore, both the stimuli and the context surrounding our task were created to be as realistic as possible. For example, in the videotaped-confederate condition, although the confederate was presented via a prerecorded video, this may not have seemed out of the ordinary given the fact that it was played at one of several workstations within a room designated as both a coding and waiting room. The second potential limitation, that social attention should be measured by eliciting a social setting, was also addressed through our manipulation of the physical presence of the confederate. Although the videotaped-confederate condition more closely resembles previous computer-based tasks measuring social attention, it was only in the live-confederate condition in which the opportunity for social interaction was possible. Interestingly, despite the differences in the complexity and realism of the scenarios, the results from our videotaped-confederate condition nicely compliment previous findings that demonstrate a bias to look at other people. Critically however, this result was not replicated in our live-confederate condition. Participants did not show a bias to fixate on the confederate, and in fact looked significantly less often to the confederate than to the baseline object (a blank computer monitor). Through the simple act of introducing the potential for a social interaction, visual behavior changed dramatically.

The mere presence of another person has been shown to influence many measurable behaviors (e.g., refs. 26 and 27), although to our knowledge this study is unique in showing that it can influence how we look at that person. Similar factors that have been theorized to drive mere-presence effects may have

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also affected our participants' social attention. For example, the physical presence of another may have been sufficient to cause participants to interpret the scenario socially, which in turn may have activated particular social rules and norms (e.g., ref. 26). Passively observing images or video of other people may be insufficient to activate these norms. Mutual eye contact may serve as a signal to initiate interaction (28), which could have been undesirable to our participants. Thus, participants looked away from the live confederate, avoiding the potential for eye contact; those in the videotaped-confederate condition did not need to initiate avoidance behavior as it was clear that the confederate in the videotape could not look back. Gaze-avoidance behavior has also been observed during situations in which direct communication is not initiated, but there nevertheless exists the potential for verbal or nonverbal interaction, for example when in an elevator with a stranger (29) or when passing near another individual when walking (30). Thus, the dramatic difference in looking behaviors across conditions likely reflects two processes: an increased likeliness to look and turn toward the videotaped confederate because the confederate cannot initiate an unwanted social interaction, and a decreased willingness to look at or turn toward the live confederate precisely because this possibility of an interaction exists.

If future studies support the hypothesis that participants with poorer reported social skills will look longer or more often toward another if that other person is physically present, as our correlational analysis suggests may be true, then it is possible that these results may also be attributable to participants' understanding or willingness to follow social norms. If these participants are less aware of any rules governing social situations with strangers, then they may find it more challenging to avoid looking at the confederate. In contrast, when the situation is not interpreted socially, as in the videotaped-confederate condition where the confederate could not initiate any interaction, then social skills should not relate to looking behavior, as was observed in the present investigation. Investigation of how social competency influences social attention is an interesting avenue for future research and may be able to shed light on why many measures of social attention within the ASD literature produce inconsistent results. For example, an impairment in social interaction is considered a hallmark of the disorder (31), is often observed in face-to-face interactions early on (e.g., ref. 32), and is the focus of many training programs throughout development (33–35), all of which suggest a real impairment in everyday situations. However, when shown side-by-side social and nonsocial images, participants with ASD show a similar preference to look at the social stimuli, as do their non-ASD counterparts (13). Only a subtle difference emerges, such that those with ASD show a reduced preference to initially fixate social information (36). Many other laboratory-based tasks have also failed to find robust differences in social attention and gaze following across those with and without ASD (23). One reason for the inconsistency in ASD social attention research may be because of the laboratory-based studies not eliciting truly social behavior because the social meaning of the scenario is diluted when the possibility of social interaction is removed. Indeed, our correlation between looking behavior and the AQ Social Skills subscale might be strengthened in the future by employing a design that not only has the potential for social interaction but institutes a social interaction.

In addition to further investigations concerning how social attention is related to social competency, the results of this study pose many interesting related questions. For example, there is evidence to suggest that eye contact with another is in part mediated by the display rules of one's culture (37, 38). It would be of interest to determine whether results similar to those obtained here would generalize when participants with different cultural values were recruited. An additional line of inquiry directly related to the present study involves better understanding what factors present during our live-confederate condition served to influence the looking behavior of our participants. One possibility is that participants looked less at the confederate when they were physically present because the participants were aware that the confederate could see them looking. This theory predicts that a very different result might be obtained if participants could camouflage their looking behavior (e.g., by wearing sunglasses). Finally, although we have shown that participants look less at live versus videotaped others, it is likely that variations of the present study, such as using two well-acquainted participants or introducing social-status discrepancies (19) between participants could have powerful mediating influences on observed behavior.

It is important to note that our results do not imply that humans do not possess a bias in real life to attend to other people, as the videotaped-confederate condition clearly demonstrates that we do. However, our live-confederate condition provides strong evidence that this behavior is malleable, and can be influenced by the opportunity for an interaction with the other individual. Although more traditional, controlled, computer-based tasks may be important in examining the intricacies of why this preference exists, more naturalistic tasks are crucial if we want to understand how social attention operates outside of the laboratory.

Methods

Twenty-six University of British Columbia students (19 female) with a mean age 21.92 y (SD = 4.15) took part in exchange for course credit or monetary remuneration. All provided informed written consent before participating and were fully debriefed upon study completion. The study was approved by the University of British Columbia's Ethics Board.

Eye gaze and line-of-sight video was recorded using an Applied Science Laboratory Mobile eye-tracking device, whereby a head-mounted optics system records gaze direction as a small color camera records the participant's line-of-sight (40° vertical × 50° horizontal) at 30 Hz, which can be used to infer head (and body) orientation. Before each use, and again at the end of the study, the eye tracker was calibrated by having participants fixate on nine circular targets (roughly 1° in diameter) on one of the laboratory walls. This process allowed gaze location to be mapped to positions within the field-of-view. The eye-tracker has an instrumental resolution of 0.1° and our setup yielded gaze accuracy within 1°.

Participants were informed that they would complete a real-word search task as their eye movements were being recorded. The task, which was unrelated to the present study, involved having the participants navigate through the building in search for a specific room. Participants were fitted and calibrated with the eye-tracker, then led to a waiting room. The experimenter then asked the participant to sit and wait as an instruction sheet was retrieved. The experimenter left the room and waited approximately 2 min before returning. The experimenter then returned, gave the instructions to the participant, and waited for them to complete the navigation task. The present investigation was concerned with the participant's behavior during the waiting period. Thus, although participants were informed that the mobile eye-tracker was on and recording for the duration of the study,

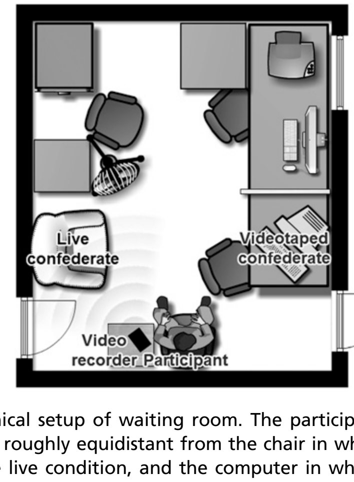

Fig. 4. Graphical setup of waiting room. The participant (pictured) sat in a chair placed roughly equidistant from the chair in which the confederate sat during the live condition, and the computer in which the video of the confederate was played during the video condition. Because of the location of the participant relative to the confederate, the participant was required to make a head or body movement to orient toward the confederate.

including the wait period, all data pertinent to the study at hand was recorded before participants believed they had started the experiment proper.

Two groups of participants ($n = 13$ per group) completed the task. Half of the participants were run through the live-confederate condition, in which a female confederate (age: 24 y) acting as another study participant sat in a chair ∼50 inches to the left and 40 inches in front of the participant and quietly completed a questionnaire. Fig. 4 graphically depicts the setup of the waiting room. The confederate was present when the participant entered the room and left once the experimenter returned (the experimenter informed the confederate that they were needed in another testing room; at no other point did the experimenter interact with the confederate). The confederate kept her attention on the questionnaire at all times, with the exception of five predetermined points. Embedded within the questionnaire were prompts for the confederate to look up, such that the confederate's timing of looks was roughly consistent across all trials and not elicited in response to the participant's actions. Three times during the 2-min interval, the confederate looked directly at the participant with a neutral facial expression; once the confederate looked up as if in thought; and once the confederate looked just above the participant. (Although our intention was to examine the frequency of direct gaze on the confederate as a function of the two confederate conditions, the quality of the recorded video was too poor, and as we show, the actual looks at the live confederate were so infrequent that a reliable analysis was not viable.) All looks were brief but untimed. No attempts were made to engage the participant in any type of social interaction. Thus, the live-confederate condition consisted of the participant waiting in the presence of another person, introducing the potential for social interaction into the situation.

The remaining 13 participants took part in the videotaped-confederate condition. Each participant entered the waiting room to a video playing on a 20-inch CRT monitor, ∼50 inches to the right and 40 inches in front of the participant. The video that each participant was shown was taken from a recording made during a live-confederate session with a different participant. A hidden camera located in a storage box directly to the left of the participant recorded the confederate completing the questionnaire. The video was edited so that it began just before the participant walked past the camera and continued until the confederate was called out of the waiting room. Each video was then played for the next participant in the videotaped-confederate group on the computer of a nearby workstation, and was started just before the participant entered the room. It is important to note that the laboratory in which participants were tested works with a lot of video data, and the waiting room also doubles as a coding room. As such, a video left momentarily unattended at a workstation should not have appeared out of the ordinary for the participant. Each video was shown once. In so doing, any variations in the confederate's appearance across testing days or sessions was controlled across conditions. Furthermore, the use of multiple videos derived from the live-confederate sessions ensured that any difference between live and videotaped-confederate groups was not because of subtle, uncontrolled differences in the confederate's behavior. The visual and behavioral aspects of the stimulus were very similar in each case, such that the only critical difference across groups was whether the confederate was actually present.

The participants then completed the search task, and returned to the laboratory. At this point, each participant completed another camera calibration. Finally, participants completed the AQ (24), which consists of 50 statements that are designed to measure the degree to which adults report having traits associated with the autistic spectrum. Of particular interest to the current study was the participants' score on the Social Skills subscale of the AQ. As noted in the introduction, we anticipated that participants who scored higher on this subscale, indicating lower subjective social skills, may show atypical gaze behavior toward the confederate, especially in the live condition, where the confederate was physically present and behavior should have most closely resembled how participants would have looked at strangers in everyday situations. Finally, all participants were debriefed and provided with a written description of the study's purpose and hypotheses.

ACKNOWLEDGMENTS. The authors thank the two anonymous reviewers for their helpful comments and suggestions, Nicola Anderson and Michael Smith for helping with coding, and James Farley for help conducting the study. Funding for this project was provided by a National Sciences and Engineering Research Council of Canada (NSERC) Discovery Grant (to A.K.), a Commonwealth/Government of Canada Fellowship (to T.F.), and an NSERC postgraduate scholarship (to K.E.W.L.).

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