# Do You See That I See? Effects of Perceived Visibility on Awareness Checking Behavior

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## ABSTRACT
Informal interactions are a key element of group work, and many theoretical frameworks and systems have been developed to understand and support these conversations in distributed workgroups. In particular, systems used in several recent experiments provided information about others' current activities so that their availability for conversation could be assessed, and interruptions could be timed strategically. One issue with these experimental systems, though, is that many do not notify the observed party that these observations are taking place. There is reason to believe that such notification could be valuable to users, and that it could alter observers' behavior. Moreover, factors such as the perceived urgency of the interruption could affect willingness to violate social norms in gathering information. We report on an experiment assessing the impact of perceived visibility and task urgency on awareness checking behavior. Results suggest that people check more often when they believe their partners do not know they are checking, and more often when the task is time-constrained than when it is not.

### Author Keywords
Awareness; attention; interaction; CMC; CSCW

### ACM Classification Keywords
H.5.3. [Group and Organization Interfaces]: Computer-supported cooperative work;

## INTRODUCTION
Informal interaction has repeatedly been shown by CSCW researchers to be a key attribute of modern work [1, 29, 39]. Significant efforts over the past 20 years have focused on supporting these interactions via improved awareness of others' presence and activities [22], by improving people's ability to interrupt at appropriate times [16], and by limiting notification of impending interruptions to specific times or to unobtrusive display techniques (e.g., [27, 31]). While this work has yielded many research prototypes, the most common tools used in everyday, real-world collaboration still offer only rudimentary support for easily initiating and concluding informal interactions [5, 37].

In particular, these systems do not effectively support the initiation of interaction or gathering of information about colleagues. One reason for this is that prior theories and systems have largely not considered the initiation of interaction as a collaborative or joint process. Clark [13] uses the phrase *joint action* to describe instances of two or more people acting individually toward achievement of a shared goal, in which individual acts are in response to those by others.

In initiating conversation, we can think of individual actions in terms of *gathering* information about others' availability and signaling, or *displaying*, interest in interaction. In face to face interactions, this often occurs via awareness of the proximity and gaze of others [2, 12, 19, 35]. Suppose Alex and Bob work across the room from each other. If Alex moves closer to Bob to *gather* information about whether or not Bob is available to talk, Bob may notice Alex's presence and glance up at him. Alex may then notice Bob's glance and return it, or, if Bob seems busy when he looks up, Alex may decide to come back another time. In this way, Alex's approach simultaneously serves to gather information about Bob and *display* Alex's interest in talking to Bob. Closer proximity means that Alex can gather more information, and makes Alex's presence more noticeable to Bob. This triggers Bob's glance, which allows Bob to see that Alex is approaching, and *display* via a glance at Alex that Bob has noticed Alex's approach.

In contrast, most systems for online awareness and interaction make it much harder to act jointly in this way, because acts of gathering often do not function simultaneously as acts of display. With instant messaging (IM), for example, it is not possible for Bob to know when Alex is getting information about his status or considering talking to him. This is because most existing research and commercial systems and theoretical frameworks have focused *either* on gathering (e.g., the timing of interruptions [16, 32] *or* display (e.g., providing appropriate notification [9, 31]). This separation makes it hard to understand or support the ways in which people may wish to act in anticipation of or in response to the actions of others when they initiate conversation. Moreover, there is reason to believe that people may behave differently – gather more or less awareness information, for example – if they know other people are being made aware of their behavior [6], or if there is pressure to act quickly [12]. It is not enough simply to know how people use awareness information (e.g., [15]). We must also understand how they use it in a context where others know it is being gathered and when there is time pressure to act.

In this paper, we describe an experiment that illustrates the effects of both task urgency and the perceived visibility of one's behavior on the frequency with which they gather and use available awareness information. Results suggest that these factors affect both the frequency of awareness checking, and the way in which tasks are performed.

## BACKGROUND

We argue that gathering and display behaviors, introduced above, comprise what Clark [13] refers to as component moves in joint action. Joint action occurs when people act in the belief that they are part of a collective activity, in which their actions occur in response to coordination signals from another party.

Consider the example of Alex and Bob again. One key attribute of Alex's approach is the relationship between gathering and display. Alex's movement toward Bob to gather information necessarily functions simultaneously as an act of display, because Bob can see him approaching. We therefore say that these instances of gathering and display are coupled. In face-to-face interactions, people's ability to notice others (e.g., [33]) relies on this coupling. We perceive others' gathering because it is visible in ways that we can attend to [19], and our acts of display are typically cognizant of the fact that they will be gathered by others [36].

| | | Alex Gathers | |
|---|---|---|---|
| | | **Displayed** | **Not Displayed** |
| **Bob Gathers** | **Displayed** | Face-to-Face Approach | Some IM conversations |
| | **Not Displayed** | Some IM conversations | Spying, covert looking |

**Table 1. Coupling of Gathering and Display**

Table 1 illustrates possible coupling relationships between gathering and display. In face-to-face approaches (top left cell), physical proximity and eye gaze are effective ways to display attention because gathering and display are coupled [6]. In contrast, many behaviors that are coupled in face-to-face interactions have different relationships online [3], as illustrated in the three remaining cells of Table 1. If Alex and Bob are spying covertly on each other via webcam, for example, gathering and display may be completely uncoupled (bottom right cell). Alex's gathering is not displayed at all, and vice versa.

The remaining cells describe asymmetric coupling relationships. That is, Alex can gather information about Bob without Bob knowing that such gathering is underway, but the reverse is not true. One example of this is the "appear offline" (or invisible) option on instant messaging (IM) clients that is used by those wishing to avoid interruptions [5]. People using this option can gather information about others on their contact list without those others even knowing that such gathering is possible (because they do not know that the gatherer is online). In this way, asymmetric coupling can be exploited for personal gain (i.e., protecting oneself from interruptions while retaining the ability to interrupt others). This runs counter to the joint action approach that we advocate.

One important but unanswered question in this area is how perceptions of coupling affect people's behavior online.

### Coupling and Awareness

One problem with early CSCW awareness systems and media spaces was that gathering and display were not coupled. The first systems used cameras to provide video views of others in their offices [17, 18, 20, 22]. Cameras, however, were thought by some to be invasive [10, 14] and the systems did not support the subtleties of negotiating interaction [25]. These problems reflect an uncoupling of gathering and display in that one user could view video of another (i.e., gathering), without a clear display that this was taking place.

These early video experiences led many to experiment with the notion of a "virtual approach" (reviewed in [37] and discussed by Buxton [11]). In our terms, this work can be characterized as an attempt to increase coupling between gathering and display by replicating the sequence of actions typically involved in initiating a conversation. The approach would facilitate interaction more naturally by allowing for multiple levels of information gathering, and also for displaying these activities to the observed parties.

Several systems allowed users to, for example, "glance" at others to discern their availability [28], and then follow a series of progressively more informative steps eventually resulting in conversation. At each step, the observed party would have to respond in kind (e.g., with a "glance" of their own) to proceed with the interaction. This restricts users to this lockstep sequence, which may not always be appropriate. In urgent situations, for example, users may wish to bypass these steps and initiate interaction more quickly.

One key issue in considering this literature is that the factors such as the coupling of gathering and display, and task urgency may convey attention, but also act as constraints on awareness checking behavior. That is, users may alter their awareness checking behavior if they perceive that others will know about it or if they are time constrained. Studies of awareness systems to date, however, have not considered these potential influences.

The OpenMessenger system [8] provides an architecture for coupling gathering and display behaviors, but the effects of these factors have not been empirically tested.

### Coupling, Urgency and Awareness Checking

Coupling of gathering and display should affect people's awareness checking behavior for two primary reasons. First, Goffman [21] argues that human behavior around others is performative; it is often intended to convey information or impressions to others. Sudnow [36] discusses the importance glances in assessing others' behavior and availability. He notes that people in public settings know that others may glance at them and act accordingly, such as by putting on headphones or adjusting posture to appear busy [6]. Sudnow [36] refers to these as "glanceable states," in that information can be discerned via a glance.

Moreover, people notice when others glance at or look at them, and this is one of the ways that mutual attention can be negotiated [2, 19] . That is, gathering information about a collaborator's presence or availability is not necessarily just a passive act of information retrieval. In face-to-face contexts people describe the clear ways that the visibility of their actions affects their behavior [6]. Namely, they realize that walking by a colleague to see if she is available will often result in being noticed by that colleague.

Second, visibility of actions can create social costs. People behave differently when they know others are present [40]. This can be particularly true with awareness information because people do not want to bother others or be perceived as spying or invasive [6, 14]. Thus, making people's gathering of awareness information visible (by coupling gathering to display) should affect the frequency with which awareness information is gathered.

At the same time, however, the urgency of the task should also affect the gathering of awareness information. From Birnholtz et al's [6] work and other observational studies of informal interactions, we know that people may violate certain social norms around interaction when they believe it is important or urgent to do so [24, 12]. That is, people were observed to interrupt others more readily or try more frantically to get their attention when the interruption was urgent. Thus, when participants need to act quickly, they may be more likely to check awareness information, even when gathering and display are coupled.

Most controlled laboratory studies of urgency in interruptions, however, has been about the urgency of the information being presented to the person being interrupted (e.g., [4]), and not how perceived urgency for the interrupter affects behavior. This is the second question we asked in this study.

## THE PRESENT STUDY

We ran a laboratory experiment to explore the answers to these questions via a series of specific hypotheses. In this section we describe these hypotheses and the methodological details of the experiment.

### Hypotheses

Our first hypothesis was about the frequency of awareness information gathering and the coupling of gathering and display behaviors. We believed that gathering would occur less frequently when gathering and display are coupled; that is, when people believe their interaction partner will know that gathering is taking place. This is because the awareness check could distract their partner or be perceived as the first move in an interaction. We therefore hypothesized that:

*H1: Participants will gather awareness information more frequently when gathering and display are uncoupled than when they are coupled.*

Next, we were interested in the effects of task urgency on gathering behavior. If people have limited time available to complete a task, they should be more likely to gather information about a collaborator's status–assuming that collaborator's status is related to their time-sensitive task–even when there is some social cost to doing so, in the form of coupling between gathering and display. We therefore hypothesized that:

*H2: Participants will gather awareness information more frequently when the task is of high urgency than when it is of low urgency.*

Third, we were interested in the possible effects of coupling and urgency on the performance of the task. With regard to coupling, two outcomes were possible. On the one hand, it could be (if we assume H1 is correct) that participants gather more information in the uncoupled condition simply because it is easy and has few social costs, and that this extra checking will actually detract from their task performance. On the other hand, however, it is also possible that participants in the coupled condition gather less information even when it would be helpful for them to do so, and that this will detract from their performance. We therefore asked:

*RQ1: What is the effect of coupling on task performance?*

Next, we were interested in the perceived task load as it related to the coupling of gathering and display. We believed that the social cost of knowing somebody is aware of one's actions would increase the cognitive load of the task:

*H3: Participants will rate the task load as higher when gathering and display are coupled than when they are uncoupled.*

Finally, we were interested in how the coupling of gathering and display behaviors affected people's perceptions of their performance, both as a team and individually. Based on prior work suggesting that shared awareness of a workspace can improve perceptions of performance [34], we believed that:

*H4: Participants will perceive their performance and collaboration to be stronger when gathering and display are coupled than when they are uncoupled.*

### Design

We used a 2 x 2 within-participants design with a single participant and a confederate. Both the relationship between gathering and display (coupled vs. uncoupled) and the task urgency (low vs. high) were varied within participants. In a task intended to approximate loosely coupled collaboration with a partner while also working on one's own projects, participants played two games as detailed below: a jigsaw puzzle game played with their partner and a shape identification game played on their own.

In the coupled condition, the confederate's information gathering behavior about the participant was displayed to the participant via peripherally projected images of avatars that appeared to approach the participant (using a technique previously tested and found to be effective by [7], see Figure 5), and an alert sound was heard. They were told that their partner saw a similar display, though this was not actually the case. In the uncoupled condition, no information was displayed when one user gathered information about another.

In the high urgency condition, described in detail below, participants were given a short time to complete the individual (shape game, see below) component of the task. In the low urgency condition, they had more time. The two urgency conditions were presented alternately within each coupling condition (coupled or uncoupled), with the initial coupling condition varied randomly.

### Participants

Participants consisted of 40 undergraduate students at a large university in the northeastern United States (22.5% male). Each participant received $10 for their participation.

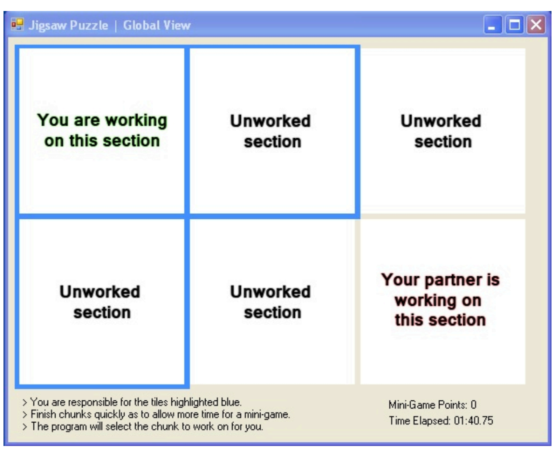


**Figure 1. The division of a puzzle as displayed to participants, along with their score and elapsed time (bottom).**

### Task and Materials

The jigsaw puzzle component of the task is shown in Figures 1 and 2. Figure 1 shows the entire puzzle, a photo (not shown) that has been divided into six sections, with each person responsible for three of these. Individual sections were solved in a separate puzzle window, divided into puzzle and pieces areas (Figure 2). Pieces were dragged from the pieces area to the puzzle area, and snapped into the grid. Participants believed that their partner (the confederate) was using the same interface to solve the puzzles, but the confederate actually had a special interface that enabled them to appear to be making progress on the puzzle in the awareness information available to the participant (see C and D in Figure 4) by clicking a button.

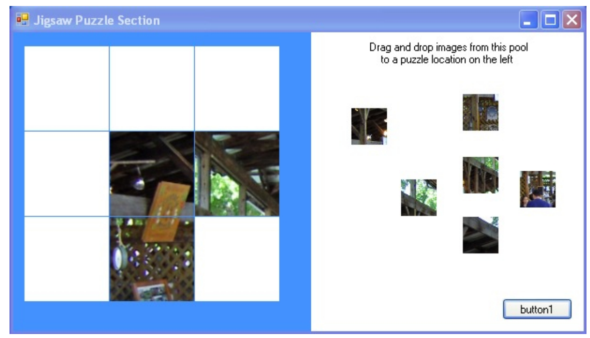


**Figure 2. The puzzle interface, with the pieces area on the right and the puzzle itself on the left**

The shape games (see Figure 3) were played individually and consisted of images of ordinary objects that appeared in specific sequences. Participants had to memorize these in 5 seconds and then identify the displayed sequence from four similar choices after the original images disappeared.

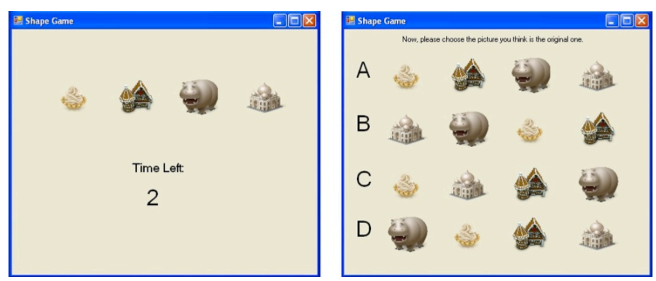


**Figure 3. Shape game windows, with the initial sequence (left) and the set of choices (right).**

Four web-based questionnaires were administered. A *pre-experiment questionnaire* collected participants' experience in IM usage. A *task questionnaire* administered after each of the two coupling conditions required the participants to rate their individual and team performance regarding the task they had just finished. A *post-experiment questionnaire* asked about the participants' impression of their "partner" and demographic information.

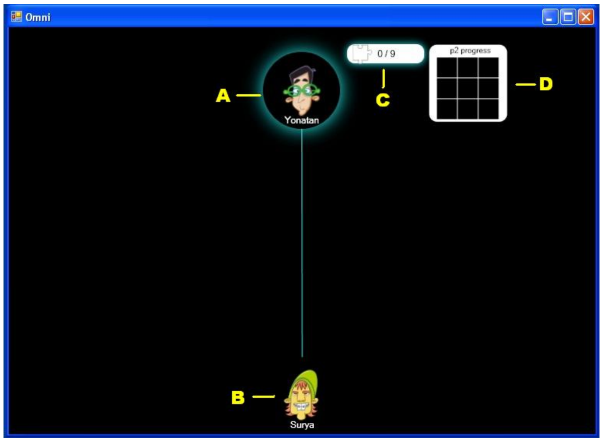


**Figure 4 The projected awareness window including: (A) the partner's avatar, (B) the participant's avatar, (C) the number of correctly placed puzzle pieces (displayed after 1 second) and (D) the location of correctly placed puzzle pieces (displayed after 1 additional second). This figure shows the participant checking on the partner's progress and finding that no pieces have been correctly placed.**

## Procedure

Participants came to the lab alone and were told they had been paired with a partner who had arrived separately and was in another room. In actuality, they were all paired with the same trained confederate.

To communicate with their partner, they were briefly introduced to the chat function of the OpenMessenger system [8], and encouraged to chat via text with their partner (the confederate). They were told to briefly introduce themselves and greet each other, and that they could use this chat function during the experiment.

### *Task Instructions*

After the introduction, participants watched a short instructional video in which they were introduced to the puzzle and shape game tasks, which were designed to present them with both individual and group incentives. Their overall goal was to earn as many points as possible, which they could do in two ways.

As a pair, they collaborated with their partner in the completion of puzzles. Each puzzle was divided into six sections (with nine pieces in each). Three of these assigned were to the participant, and three to the confederate (see Figure 1). To create interdependency in the task, participants could not move on to their next puzzle section until their partner's current section was completed. Participants were told to finish the puzzles as a team as fast as they could, and they earned points together based on how quickly each set of puzzle sections was solved. Both the participant and the partner (the confederate) received 30 points for solving the puzzles in < 5 minutes; 20 points for 5-8 minutes; and 10 points for times > 8 minutes.

Individually, participants could earn additional points by playing shape games, which were available only when participants had completed their own puzzle section, and were waiting for their partner to finish, so they could move on. Whenever this occurred, participants were presented with a Yes/No dialog box asking if they wanted to play a shape game. Participants were also asked every time they finished a shape game; but if they chose "No", they would not be able to access the shape games again until the next puzzle section was complete. For each correctly solved shape game, participants would get 1 point. For wrong answers, they lost 1 point. If their partner finished the puzzle while they were playing a shape game, however, participants lost 5 points.

The scoring scheme provided an incentive to gather awareness information about their partner's progress on the puzzle, to assess whether or not they had time to play a shape game. They did this by hovering the mouse cursor over their partner's avatar on the projected awareness display (see Figures 4 & 5). When they did so, the number of puzzle pieces correctly placed by their partner was shown next to the avatar (see Figure 4). They could use this information to estimate how much time they had left.

Unknown to the participant, the amount of time available for these games was manipulated via the urgency independent variable. The confederate partner always timed her puzzle solving such that the same amount of time available for playing shape games was either 30 seconds (high urgency) or 120 seconds (low urgency).

### *Coupling Manipulation*

After the instructional video, participants were told either that their information gathering behavior would be visible to their partner (if they experienced the coupled condition first) or that it would not be visible (in the uncoupled condition). The order of these conditions was randomized among participants.

This was demonstrated via a separate short video, shown at the start of each condition. In the coupled condition participants were shown that their "partner" would be notified each time the participant gathered information via their own projected awareness display. Their "partner" would see the participant's avatar approaching and would also hear an alert sound. The same was true for the participants. In the uncoupled condition, they were shown that the avatars did not move and no alert sound was made.

In testing the experiment task, we found it was necessary to reinforce to the participant that visible notification was occurring in the coupled condition. As such, the confederate briefly made reference to the notifications via chat at scripted intervals, saying they were distracting or annoying. To discount these messages themselves as a cause of the observed effects, the confederate sent similar messages in the uncoupled condition at similar intervals, though the wording of these messages did not reference the display.

### *Practice Session and Questionnaires*

After the instructions, participants completed a practice task session in which they familiarized themselves with the game rules and the OpenMessenger system, and then moved through all of the conditions.

Upon completion of the coupled and uncoupled conditions, participants completed the task questionnaire. After the second task questionnaire, they also completed the post-experiment questionnaire.

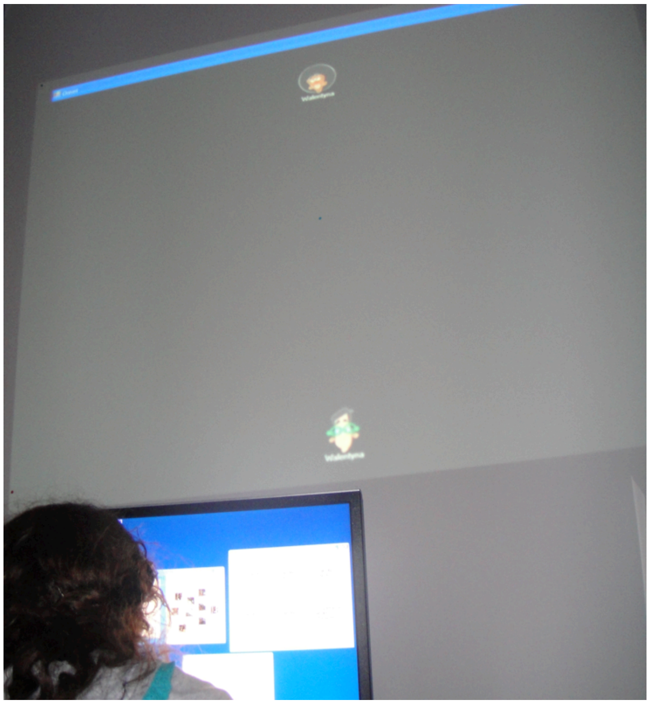

**Figure 5. The experimental setup, with game display directly in front of participants and the awareness display projected on the wall behind the monitor.**

### Measures

Data gathered during the experiment consisted of log data from the system, which included both the puzzle and shape game interfaces and the awareness checking and chatting. From this data we extracted the number of awareness checks per puzzle section.

*Awareness checks*. Counts of awareness checks per puzzle section were extracted from the log files. Because the raw number of checks was correlated with the amount of time available to participants for these checks, we used a rate measure, awareness checks per minute, as our dependent variable.

*Shape Game Activity*. The number of shape games played in each puzzle section was likewise extracted from the logs. Because the time available for playing shape games varied between puzzle sections, we used a rate measure, shape games per minute available for games, as our dependent measure.

*Shape Game Score.* Each attempt at a shape game was scored, and total score per puzzle section were extracted from the logs. To correct for the amount of time available for playing shape games, we divided people's total shape game score by the number of games played.

*Task Load*. TLX [23] questions were asked separately for the puzzle and shape games in both the coupled and uncoupled conditions. In both cases, five of the six questions factored together (the exception was success on the task). These five questions were averaged to create two TLX factors, one for puzzles ($\alpha$= .80) and one for shape games ($\alpha$= .73). Both measures were normally distributed, and correlated with each other r = .59 ($p < .001$).

*Subjective Performance*. All performance questions were factored together and resulted in three dimensions. The first dimension included the three group collaboration questions and the partner effectiveness question, which did not fit with the other 3 conceptually. Cronbach's $\alpha$ showed that the partner communication question did not fit well with the other two collaboration questions, probably because there was little actual collaboration. With that removed, the $\alpha$ for the remaining 2 questions = .80. The four self performance questions factored together reliably ($\alpha$ = .71).

## RESULTS

In this section we describe the results from the experiment, in terms of awareness checks, shape game performance and subjective questionnaire measures.

### Awareness Checks

Hypothesis 1 stated that people would perform more frequent awareness checks when their behavior was uncoupled; that is, when their partners did not know they were checking. Hypothesis 2 stated that people would perform more frequent awareness checks when the task was more urgent. We tested both hypotheses using a mixed model ANOVA in which participants served as a random factor, puzzle and section number were repeated factors, and coupling condition (coupled, uncoupled) and urgency (high, low) were fixed factors. As our dependent measure, we used awareness checks per minute. (Note that in mixed models, when tests of fixed effects involve variances at different levels of the model, non-integer degrees of freedom can result [30].)

As shown in Figure 6, both H1 and H2 were supported. People performed more awareness checks per minute when they believed their behavior was uncoupled (M = 3.42, SEM=.18) than when it was coupled (M = 2.28, SEM=.18), ($F [1, 236.76] = 25.04$, $p < .0001$). People also performed more awareness checks when the task was of high urgency (M=3.00, SEM = .18) than when it was of low urgency (M=2.76, SEM = .18), ($F [1, 259.85] = 4.29$, p. < .05). There was no interaction between coupling condition and urgency condition ($F < 1$, n.s.).

### Shape Game Performance

Research Question 1 asked about the effects of coupling and task urgency on participants' task performance. To answer this question, we used two measures of performance: number of shape games attempted, and number of shape games won. These were selected as opposed to the overall score because they were indicators of how effectively participants used the awareness information (games won) and because shape games were the only behavior affected by the urgency manipulation (puzzle time was not affected by this).

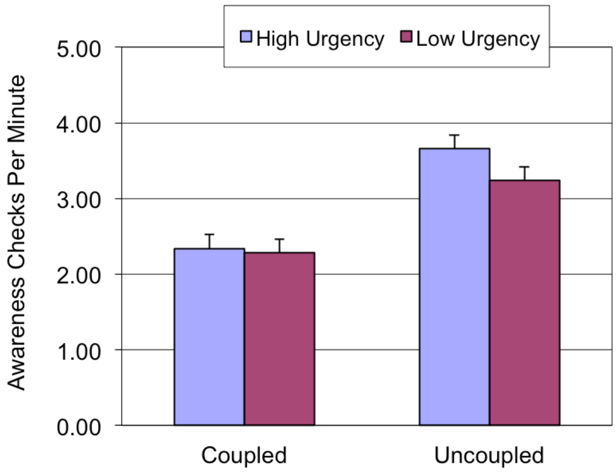


**Figure 6. Awareness Checks Per Minute.**

In addressing Research Question 1, we first explored the effects of coupling and task urgency on the number of shape games participants attempted (per minute, of the time allotted for this), using a Mixed Model ANOVA of the same form as that in the previous section. We found no significant effect of coupling condition ($F [1, 214.20] = 2.25$, $p = .15$) but a significant effect of task urgency ($F [1, 149.85] = 7.29$, $p < .01$). As shown in Figure 7, even when corrected for the amount of time available, people attempted fewer shape games when the task felt highly urgent ($M = 2.29$, $SEM = .12$) than when it was not ($M = 2.82$, $SEM = .12$). There was no interaction between coupling condition and urgency condition ($F [1, 200.96] < 1$, n.s.).

This is interesting for two reasons. First, it implies that participants were using the awareness information and thus detected the difference between the high and low urgency conditions. Second, it suggests that the awareness information they gathered affected their perception of the task and how much time they had available.

As a manipulation check, we also examined people's performance on the shape games using their scores divided by number of games played, to correct for time, using a Mixed Models ANOVA of the same form as in the previous section. We found a strong effect of urgency on shape game scores ($F [1, 165.26] = 25.67$, $p < .0001$) but no effect of coupling condition and no interaction between urgency and coupling ($Fs < 1$, n.s.). Confirming the effect of our urgency manipulation, participants performed significantly worse ($M = .29$, $SEM = .05$) in the high urgency condition than in the low urgency condition ($M = .66$, $SEM = .05$), reflecting the fact that they were more likely to be cut off when time for shape games was short.

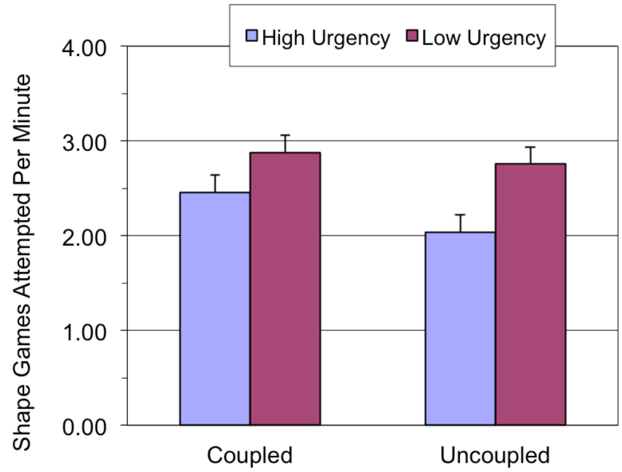


**Figure 7. Shape Games Attempted Per Minute.**

Finally, we looked at the relationships between awareness checks, shape games played, and shape games won. There was a small but significant correlation between awareness checks per unit of time and the number of games played in that same time period ($r = .11$, $p = .02$, $N = 433$). However, there were no correlations between either of these variables and shape game performance. This suggests that participants were using the awareness information at least some of the time when playing shape games, but may have been using a single awareness check to assess available time for multiple games in a row (i.e., not checking in between games).

From the standpoint of the relationship between coupling and performance, all of this suggests that neither of the explanations presented above was correct. There did not seem to be a relationship between participants' performance in the shape games and the coupling of gathering and display. At the same time, participants' perception of the urgency of the task did affect both the number of games they attempted (even when corrected for time) and their performance in these games. We discuss this further below.

### Task Load

Task load in our study was measured using the NASA TLX scale, administered after the coupled and the uncoupled phases of the study for both the puzzle and shape game tasks. Hypothesis 3 stated that participants would rate task load higher when gathering and display were coupled rather than uncoupled. We tested this hypothesis using Mixed Model ANOVAs in which TLX score was the dependent measure, participant was a random factor, and coupled vs. uncoupled was a fixed factor. Contrary to our hypothesis, there were no significant differences between coupling conditions in terms of task load for either the puzzle task ($F [1, 39] = 1.85$, $p > .10$) or the shape games ($F [1, 39] = < 1$, n.s.).

### Subjective Collaboration and Performance

We tested these hypotheses using Mixed Models ANOVAS of the same form as in the previous section. There were no significant effects of coupling condition on perceived collaboration (F [1, 39] < 1, n.s.) or perceived personal contributions to the collaboration (F [1, 39) < 1, n.s.). Thus, Hypothesis 4 was not supported.

## DISCUSSION

### Theoretical implications

We began with a discussion of informal workplace interaction and the role of awareness checking in this process. While our study involved very little conversational interaction, we argue that checking on somebody's availability is the first step in starting such an interaction. This is particularly true when the observed party is notified that checking is taking place. We present theoretical and design implications for systems supporting these initial steps of initiating interaction.

From a theoretical standpoint, the first implication is that the coupling of gathering and display did affect the frequency with which participants gathered information about their partner. By merely manipulating participants' beliefs about the visibility of their behavior, we saw a significant decrease in the amount of information gathering that took place. We hypothesized that this was due to visibility increasing the perceived social cost of checking awareness information, and results were consistent with this hypothesis. This is consistent with theoretical views of behavior as performative when in the presence of others, in that our participants modified their behavior when they believed it was visible by their partner.

This is important to consider as we interpret results from prior studies about both how awareness information is provided and used (e.g., [15]), and the possible utility of approach metaphors to the initiation of interaction (e.g., [37]). Our results suggest that notification when others are approaching (or gathering information, in our case) can affect not just the approached party's response and the initiation of interaction, but also the likelihood that gathering of awareness information will take place at all.

It also bears mentioning that display of one's behavior is necessarily conflated with possible distraction of one's partner in this design, as any visual or audible notification has the potential to distract. It is therefore difficult to reliably discern if participants altered their behavior because of concern about the behavior being displayed or to avoid distracting their partner. Given that these factors are also conflated in the real world, however, this limitation should not affect the interpretation of these results.

By a smaller (but still significant) margin, we also saw participants gather more awareness information when the task was of high urgency than when it was not. This suggests that participants also considered the urgency or time sensitivity of a task when deciding whether or not to gather information about – and possibly distract – a collaborator, whether that gathering behavior was visible to the collaborator or not. This finding reinforces prior field studies of interruption (e.g., [12]), showing in a controlled setting that perceived urgency influences gathering behavior even when there is a social cost to gathering.

We also saw that participants attempted fewer shape games per minute in the high urgency condition. Combined with the awareness check findings, this suggests that a greater feeling of urgency made participants feel a need to check more frequently to see if they had time to play shape games. This implies that the availability of the awareness information in the high-urgency condition could have been a distraction. Had they not gathered awareness information as often, they could possibly have attempted more shape games and earned more points. Thus, there may be times when the availability of awareness information is helpful in that it is known that time is scarce, but can also distract – by occupying some of that scarce time.

While we believed that considering the visibility of the behavior would give participants one additional thing to keep track of and consider, this did not appear to appreciably increase the perceived cognitive load of the task or the perceived quality of their collaboration. This could, however, also be because coupling affected aspects of participant experience not captured by the TLX scales. Future research could explore other measures of this.

Taken together, all of this offers preliminary support for a joint action approach to awareness and interaction. We saw that people modified their gathering behavior when they believed it to be visible to others. While we cannot confirm their intent, existing theory suggests that this was likely because they were concerned about how this behavior would be perceived and interpreted by others. Additional research is needed to understand how this would play out in a dyadic or group setting.

### Implications for design

From a design standpoint, these results have several implications. First, we saw that people's perceptions of the coupling of gathering and display behaviors affected whether and how they gathered information about others. This implies first that this distinction should be made clear to users of systems; that is, they should know which behaviors are visible to others and which are not. Beyond that, however, this also suggests that designers carefully consider how coupling might affect behavior in a system. In settings, for example, where it is desirable for people to regularly and quickly gather information about others (and this information is unlikely to pose a threat to privacy), it may be useful to not make these gathering behaviors visible to other users. This could result in greater use of the system.

There are also likely settings, however, in which coupling can be useful in facilitating action and response in a joint activity, such as when negotiating the start of an interaction, as discussed above. In these settings, these results suggest that the coupling of gathering and display behaviors will cause people to be more deliberate in their use of this information. More research is needed to explore how coupling works through multiple steps of the process, but this study shows a clear effect of coupling on an initial move to gather information about somebody else.

On the other hand, there may be settings in which coupling is a useful method to reduce unnecessary information-gathering behaviors and improve efficiency. For example, considering the social cost of gathering behaviors, users may reexamine the necessity (e.g.: task urgency,) of initiating an interaction before they do it.

These results also suggest that task urgency may reduce the extent to which people are concerned about how others perceive their behaviors, and that using coupling as a means to alter behavior – such as by reducing awareness checking or improving interaction – may be less effective when urgent interruptions are likely to be the norm.

### Limitations and Future Work

It is possible that some of the observed reduction in gathering behavior stemmed from a lack of relationship context. That is, people working with known partners and in a more familiar setting might be affected by coupling differently. Given the wide range of relationships and contexts in which people use awareness information, however, it would be difficult in a laboratory study to control for these effects. This does, however, point to a ripe potential area for future field studies.

Another possible limitation stems from our use of an essentially contrived task in a laboratory setting. We note that we took steps to develop this task in a way that made it similar in reward structure to real-world tasks, in that it involved an interdependent loosely coupled collaborative task, alongside individual tasks that could be done while waiting for collaborators when time was available, but resulted in a penalty when the timing was poor. We also used an interface for notification that is not common, though it has been demonstrated to be effective when compared with primary-screen notifications [7]. The main purpose of this study, moreover, is not to examine how information was displayed, but rather how behavior changes when participants believed it was being displayed at all. Thus, these findings should hold with multiple possible notification interfaces. Moreover, these limitations – contrived laboratory tasks and unique task interfaces -- are common to all laboratory studies of this nature.

This study opens a range of rich areas for future work. Two immediate directions we plan to pursue include studies of the role of coupling in familiar vs. unfamiliar dyads, and of a task involving more interaction and active use of the awareness information gathered.

Our study has shown that task urgency may cause people to alter their awareness checking behavior, whether it is visible or not. This raises a series of other questions about relationships between awareness checking behavior and other workplace dynamics such as power relationships (e.g., [26]) and different modes of interdependence and coordination (e.g., [38]). It is also possible that reductions in awareness information gathering seen here due to coupling could have an adverse effect on performance or relationships, and this merits further exploration.

## CONCLUSION

We have presented a theoretical rationale for a joint action approach to interpersonal attention management in supporting awareness and informal interaction. In our approach, actions are assumed to occur in anticipation of or in response to acts by others. To support this approach, we presented the OpenMessenger framework. This framework provides operational solutions for the problems of: 1) discerning the user's focus of attention, and treating this differently when the focus is on another person; 2) allowing for easy joint action both during and prior to conversational interaction; and 3) allowing for easy and natural awareness of other users' presence and behavior.

## ACKNOWLEDGEMENTS

We thank the National Science Foundation (OCI #0942658) for support. This material is based in part on work supported by the National Science Foundation, while Susan Fussell was working at the Foundation. Any opinion, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. We thank Allie Miller, Ben Jacoby, Danny Sullivan, John Schultz and Matt Lepage for their assistance with this work.

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