MCHALE, MICHAEL W. M.A. The Effects of Attention Contagion on Task-Unrelated Thought and Learning in a Virtual Lecture. (2023)
Directed by Dr. Michael Kane. 75 pp.

Social contagion has been extensively explored within educational contexts, showing that behaviors spread between students in a classroom. Until recently, however, the cognitive aspects of social contagion (e.g., attention and mind-wandering) have been unstudied. Like other constructs, attention appears to be contagious: Students in the presence of visibly inattentive students also rate themselves as less attentive. These explorations into attention contagion, however, have left open questions regarding the spread of mind-wandering, or task-unrelated thought (TUT), within virtual settings. The current study answers the following questions. First, does TUT spread among students within virtual lectures? Second, do students' attention states impact virtual classmates' learning? To address these questions, I conducted a between-subjects online experiment in which 352 participants watched a simulated virtual lecture with either attentive or inattentive confederates on-screen. During the lecture, participants responded to interspersed thought probes to measure TUTs. To create a knowledge baseline, participants completed a pretest assessing general and specific lecture-topic knowledge. Following the lecture, participants completed a postlecture test to assess learning of the lecture material. Results indicated a significant between-condition difference in overall TUT rates, as well as in recalculated TUT rates to exclude environmental distraction or to isolate environmental distraction, with participants in the inattentive condition having a significantly higher TUT rate. In contrast, via a one-way ANCOVA (attentive versus inattentive conditions posttest scores; covariate = pretest scores) participants show no main effect of attention contagion on learning, with both conditions having equivalent posttest performance.

Keywords: Attention contagion, mind-wandering, task-unrelated thought, learning

THE EFFECTS OF ATTENTION CONTAGION ON TASK-UNRELATED THOUGHT AND LEARNING IN A VIRTUAL LECTURE

by

Michael W. McHale

A Thesis
Submitted to
the Faculty of The Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Master of Arts

Greensboro

2023

Approved by

Dr. Michael Kane
Committee Chair

APPROVAL PAGE

This thesis written by Michael W. McHale has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

Committee Chair

Dr. Michael Kane

Committee Members

Dr. Levi Baker

Dr. Peter Delaney

November 20, 2023

Date of Acceptance by Committee

November 20, 2023

Date of Final Oral Examination

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I: INTRODUCTION

Every educator has observed with frustration the spread of restlessness and inattention throughout a classroom, such as the chain reaction caused by a student zipping up their backpack near the end of a lecture that precipitates bag zipping and general restlessness among their peers. With the increase in online lectures during the COVID-19 pandemic, similar scenarios play out within virtual classrooms: inattentive behavior (e.g., fidgeting, inattentive affect, yawning) or camera muting spreading among students after one or two students initiate it (Kalsi et al., 2023). This spread shows that classrooms are collaborative and social environments where each student can influence their environment with their behaviors (attentive or inattentive), emotions, and engagement within the lecture (Jones et al., 2010; Rambaran et al., 2017; Ware & Williams, 1975). The current research explores the construct of "attention contagion" (Forrin et al., 2021) within virtual lectures, examining the spread of task-unrelated thoughts (TUTs) and the impact on learning among students.

The idea of contagion in classrooms—"the spread of affect, attitude, or behavior from Person A (the "initiator") to Person B (the "recipient"), where the recipient does not perceive an intentional influence attempt on the part of the initiator," (Levy & Nail, 1993, p. 266)—is not new. Numerous studies have examined the contagious influence of peer behaviors on academic performance in peer groups due to engagement and truancy (Rambaran et al., 2017), the spread of emotions and non-verbal emotional behaviors within an educational environment (Mottet & Beebe, 2000), the association of a teacher's behavior on student achievement and motivation (Radel et al., 2010; Ware & Williams, 1975), and the perception of self-regulated learning on effort regulation among peers (Jones et al., 2010). These studies reinforce the notion that

students are not isolated from one another during lectures; rather, individual actions from one student may yield implications for the entire group.

Models of Social Contagion

Social contagion is a multifaceted process that is moderated by its environment, the cognitive biases of individuals involved in the exchange, and the hierarchical social structure in which it exists. The Independent Cascade Model takes an infection-based view of social contagion (Hodas & Lerman, 2014). Each exposure between Person A ("infected initiator") and Person B ("recipient") has an equal chance of social contagion between the individuals (Hodas & Lerman, 2014). As exposures between "non-infected" and "infected" individuals increase, so does the probability that spread will occur. This one-to-one interaction model is an example of a simple contagion view.

Though this abstraction explains some exchanges, not all behaviors are spread within a one-to-one framework. Complex contagion was therefore introduced to increase the applications of social contagion to situations outside of a one-to-one framework (Hodas & Lerman, 2014). Complex contagion acknowledges that individuals can be sequentially exposed to numerous "infected" individuals, potentially increasing the likelihood of contagion—the more infected individuals that are encountered, the higher the likelihood that the behavior is adopted due to the compounding effects of numerous exposures (Campbell & Salathé, 2013; Hodas & Lerman, 2014; Iacopini et al., 2019). Instead of each interaction having an equal likelihood, the compounding effect of multiple interactions increases the likelihood of contagion.

Simple and complex contagion involve direct interactions between individuals (Person A talks to Person B, Person C. . . Person N); they do not, however, account for simultaneous hierarchical group interactions or contagion through links within a network (Person A, B, and C

concurrently talk to person D in a group setting). Thus, Iacopini et al. (2019), proposed a "simplicial" model of contagion, which allows contagion via simultaneous interactions within higher-order groups of varying sizes to be considered (Iacopini et al., 2019). In a lecture context, the application of the simplicial model would be a student adopting a behavior or cognitive state that is being exhibited by numerous other students in their classroom due to social reinforcement. Like complex contagion, this model involves numerous exposures; however, simplicial contagion involves concurrent exposures to the behavior (e.g., numerous students exhibiting off-task behavior at the same time).

Although these models describe the structure of how social contagion spreads, they do not explain the mechanisms behind contagious spread. A few explanations have been proposed as the catalyst of social contagion, mainly goal contagion and social influence.

Behavior within groups is tightly governed by social norms and group belonging, enabling individuals to discriminate appropriate from inappropriate behavior (Cialdini et al., 1990). One way these social norms are identified, both consciously and unconsciously, is via goal contagion. Goal contagion influences individuals to adopt the goal-directed behavior of those around them (Loersch et al., 2008). This process occurs at multiple levels, from one-to-one interactions (simple contagion) to group interactions (simplicial contagion) and is driven by the unconscious adoption of others' behaviors during interactions.

Perceiving these overt behaviors may also enable individuals to infer other peoples' goals, allowing them to make the connection between the observed behaviors (e.g., fidgeting) and their abstracted causes (e.g., they are fidgeting because they do not care about what is being presented; Loersch et al., 2008). During the perception of these behaviors, individual's may additionally connect their classmate's current behavior with what they believe is their

overarching goal that drives their behavior (e.g., “my classmate is acting attentively because their goal is to perform well in the class”). After inferring their classmate’s overarching goal, an individual may embody a group’s or an individual’s goal directed behavior as their own (Loersch et al., 2008). The embodying of another person’s goal by an individual happens as a function of how valuable the individual finds the goal. Therefore, when an individual appraises a goal as more valuable, they are more likely to embody the goal themselves (Aarts et al., 2004; Kalsi et al., 2023). This explains the transference of goal directed behavior, but it does not address the additional impact that social norms or social pressure can have on behavior.

As previously mentioned, behavior within groups is tightly controlled by social norms and individuals’ interest in gaining, and maintaining, belonging within a group (Cialdini et al., 2004). This primarily occurs due to social compliance with, and conformity to, group norms (Cialdini, 2004). Group members work together to create and agree upon the behaviors that are appropriate for that group’s context. To effectively abide by these social rules, an individual must both comply with the norms of the group (actively avoiding behaviors that blatantly break the group’s norms) and they must conform to the accepted behaviors of the group (adopting behaviors that are in line with the group’s behavioral norms). Doing so allows group members to maintain a positive affiliation with the group and foster a positive view of their own self-concept (Cialdini et al., 2004). Violating group norms and expectations can result in having group affiliation revoked or having their perception of their self-concept tarnished. Fear of ostracization can thus effectively encourage an individual to modify their behavior. For example, if a student is attending a lecture and their fellow classmates are taking notes and are engaged with the lecture, then to abide by the perceived social rules of the group, the student would be incentivized to follow the group norms exhibited (e.g., being on-task and engaged with the

lecture) and avoid the consequences associated with violating those norms. Both social influence and goal contagion therefore appear to guide the spread of behaviors described as social contagion, modifying the behaviors, actions, and possibly the mental states of individuals.

Attention Contagion in Learning Contexts

A new line of inquiry into social contagion—"attention contagion"—has focused on the cognitive aspects of contagion (i.e., the spread of inattention). Forrin et al. (2021), measured mind-wandering during an in-person laboratory experiment in which subjects viewed a video lecture using interspersed thought probes. These thought probes required participants to indicate the content of their immediately preceding thoughts among three options: On-task/On the lecture, TUTs unrelated to the environment (mind-wandering), or TUTs about the current environment (external distraction). Each participant was seated at a 2 × 2 grid of desks, always behind and diagonally opposite a research confederate. In the attentive-confederate condition (n = 80), the confederate maintained a forward-leaning position, their gaze was focused on the lecture, and they frequently took notes. The inattentive-confederate condition (n = 87) consisted of the confederate slouching in their chair, shifting their gaze from the lecture, and taking minimal notes.

Forrin et al. (2021) found that participants paired with an attentive confederate showed and self-reported significantly higher attentiveness, and performed better in a post-lecture assessment, when compared to those with an inattentive confederate. Attentiveness was measured via the rate of "On Task" thought probe responses and video-coded ratings of participants during the experiment for "attentive behaviors" (e.g., lower fidgeting and more engagement). Surprisingly, researchers did not find significant between-group differences in

either of the TUT categories analyzed separately, although the means for each were in the predicted direction (*p*s < .14).

Kalsi et al. (2023) followed up these findings by exploring attention contagion in virtual lectures. Participants watched a virtual lecture synchronously with four live confederates onscreen. In the attentive condition (*n* = 29), confederates acted attentively (frequent head nodding, upright posture, frequent note-taking, and no phone use), and in the inattentive condition (*n* = 32), confederates acted inattentively (bored facial expressions, slouching, diverting eye gaze, fidgeting, and frequent phone checking).

After the lecture, Kalsi et al. (2023) used a self-report survey to measure inattentiveness. Participants responded to the question, "How attentive to the lecture were you?" via a 0 ("Not at All") to 10 ("Extremely") scale. This measure has some notable limitations: Unlike embedded thought probes that each ask about immediately preceding experience, such retrospective ratings do not distinguish mind-wandering from external distraction experiences and they may not faithfully capture participants' momentary in-lecture experiences. Retrospective ratings may fail to capture participants' in-lecture experience for several reasons. First, a participant's memory of their thought content might be biased by their performance on the task (e.g., if they perform well, they may inflate their appraisal of their attentiveness). Second, a single post-task probe only provides a cumulative snapshot of their attentiveness, disregarding the fluctuations in thought content that constantly occur. Third, since people are frequently unaware that they are mind-wandering unless they are interrupted by a thought probe, they may struggle to retroactively report TUTs or other dimensions of inattention with high accuracy (Sayette, et al., 2009).

Following the attention rating, the Kalsi et al. (2023) participants answered two additional questions that were used to measure attentiveness indirectly, "During the lecture

approximately how many minutes did you spend on other websites on your computer?" and "During the lecture approximately how many minutes did you spend on your phone?" via a 0–30 min scale. On the self-report post-task probe, participants in the inattentive condition (M = 6.68, SD = 1.68) rated themselves as significantly less attentive than participants in the attentive condition (M = 7.45, SD = 1.76). Additionally, participants in the inattentive (M = 1.75, SD = 3.65) condition reported spending significantly more time on their phone during the lecture than attentive (M = 0.21, SD = 0.49) participants. However, participants in the attentive (M = 0.31, SD = 0.81) condition spent nonsignificantly less time browsing other websites than participants in the inattentive (M = 1.25, SD = 2.99) condition. These findings provide initial evidence that attention states spread within a virtual lecture context but provide no insight into the spread of TUT, specifically.

Behavioral Correlates of (In)Attention and Mind-Wandering

TUTs are associated with fidgeting behavior (Smallwood & Schooler, 2006; Carriere et al., 2013), and during in-person and virtual lectures, these behaviors can be easily observed by classmates. Changes in seating posture or position, adjusting clothing, looking around, twirling hair, yawning, or touching one's face can therefore serve as a metric for classmates to make inferences about other students' states of attention (Chisholm et al., 2013; Mehrabian, 1969).

Seli et al. (2014, Experiment 1) examined mind-wandering and fidgeting in a laboratory setting while subjects completed a computerized sustained attention task (Metronome Response Task). TUTs were assessed via thought probes during the task, which paused for each probe. To examine fidgeting, they collected movement data via a Wii balance board on which subjects were seated during the task. Additionally, at the beginning of the study, subjects perceived trait-level fidgeting behavior was reported via a questionnaire. The researchers compared fidgeting

behavior in the moments before each report type, on- versus off-task thinking, and found significantly more fidgeting preceding TUT reports than on-task reports (effect size: r = .36).

Given the findings that inattentive behaviors, like fidgeting, can spread from Student A (the "initiator") to Student B (the "recipient") within lectures, and given the link between fidgeting and mind-wandering, it is important to explore attention contagion's effects on TUTs (Forrin et al., 2021; Kalsi et al., 2023; Levy & Nail, 1993). TUTs are covert experiences, but behavioral cues (e.g., fidgeting, affect, or facial presentation) may allow students within a class to make inferences about others' attentiveness, potentially cueing them to engage in similar inattentive behaviors or TUTs (Lee et al., 2022; McVay et al., 2013; Risko et al., 2012; Smallwood & Schooler, 2006). Via perception of these behaviors, goal contagion or social conformity may be the mechanism which causes these behaviors to spread. After a student perceives their classmates' inattentive behaviors and makes inferences about why they are acting in such a way, a student may embody the assumed goals of their classmates or they may begin acting in a way that conform with the norms of the class (Forrin et al., 2021; Kalsi et al., 2023).

Potential Effects of TUTs on Educational Performance

Mind-wandering during educational activities has been studied in both laboratory and authentic classroom environments. Most laboratory-based studies have used video lectures that don't align with the archetype of "zoom" video lectures that are common in authentic contexts, but rather asynchronous and pre-recorded lectures (that usually cannot be paused or reviewed). Overall, regardless of the environment, the data consistently indicate that TUT rates during lectures correlate negatively with measures of lecture learning, including test, quiz, and comprehension scores (e.g., Hollis & Was, 2016; Kane et al., 2021; Lindquist & McLean, 2011; Risko et al., 2012).

In one of the first laboratory-based video-lecture studies, Risko et al. (2012) showed participants one of three 60 min video lectures in a simulated lecture setting. TUT rates, measured with thought probes presented during the video, increased from the first (35%) to the second half of the lecture (52%). Moreover, as individuals mind-wandered more, they also remembered less, $r = -.32$, $p < .05$, but the sample size was small for correlational analyses (N = 60). Kane et al. (2017) provided additional support for the negative relationship between mind-wandering and learning, using a combined experimental and correlational design. Participants (N = 182) watched a pre-recorded video lecture interspersed with thought probes, were assigned to a note-taking or no-note-taking condition, and were tested on the material. As TUT rate increased, overall learning decreased, $\beta = -.34$, $t(163)$, $p < .001$, indicating that mind-wandering uniquely predicted test performance beyond the other predictor variables in the regression model (including topic knowledge and prior interest).

Goals and Hypotheses

The present study investigated attention contagion, TUTs, and their effects on learning from virtual lectures. To extend the findings of Forrin et al. (2021) and Kalsi et al. (2023), the present study implemented a lecture-content pretest to assess prior knowledge, improved ecological validity by increasing the number of confederates within the virtual lecture, controlled confederate behaviors across participants by using prerecordings (rather than live acting), and explored how attention contagion might affect students' in-the-moment TUT reports via interspersed thought probes.

Specifically, I investigated whether participants' TUT rates are influenced by the attentive or inattentive behaviors exhibited by confederate "participants" during virtual lectures. Online participants viewed a virtual lecture with six ostensible other participants (research

confederates; see Appendix A). The study design featured one between-subject manipulation: attentive confederates (i.e., prerecorded confederates trained to appear on-task and engaged in the lecture) versus inattentive confederates (i.e., prerecorded confederates trained to appear visually distracted and not engaged). Learning from the lecture was measured via a postlecture test (with a pretest covariate). To measure TUTs, thought probes were interspersed throughout the virtual lecture; when answering each probe, participants were instructed to indicate their thought content immediately preceding the thought-probe cue.

Given findings about the cognitive and social influences on TUT rates (Forrin et al., 2021; Hodas & Lerman, 2014; Kalsi et al., 2023; Kane et al., 2021; Szpunar et al., 2013), I hypothesized that a state of inattention demonstrated by confederate lecture viewers (e.g., fidgeting, shifting of seating position, psychomotor agitation) would significantly increase participants' TUT rates compared to the attentive-confederates condition. For example, due to normative social influence, a student may observe their classmates' behaviors to ensure that they are abiding by the classroom norms. If a student observes classmates acting in an inattentive manner, this may cause the student to modify their behavior to abide by the group norm, engaging in off-task behaviors and thoughts (Nolan et al., 2008). Given the finding from Forrin et al. (2021), that attentive and inattentive conditions do not show a significant difference in either mind-wandering or external distraction assessed separately, it should be informative to examine the impacts of environmental distraction (e.g., attending to confederate behavior) on participant TUT rate—including environmental distractions as an option to report on thought probes. Specifically, in addition to examining TUT rates overall, I also analyzed them separately, distinguishing TUTs that reflect external/environmental distraction from more internally directed

TUTs. I did this because condition differences on TUTs might be limited to externally oriented thoughts that are related to viewing the inattentive behavior of confederates.

Furthermore, given the association between TUT rate and academic performance, I hypothesized that participants in the inattentive-confederate condition, who should have increased TUT rates, would also perform worse on the post-lecture test. Increased TUT rates have been linked to lower semester grades, exam scores, and quiz performance (e.g., Kane et al., 2021; Wammes, Boucher, et al., 2016; Wammes, Seli, et al., 2016). When a student is engaged in a cognitively demanding task, such as a lecture, TUTs should inhibit the encoding of incoming information and thus impede learning.

In addition to the two primary hypotheses above, I had six secondary hypotheses:

- Removing external distraction reports from TUT rates would result in the condition differences in TUT rates between the attentive and inattentive conditions being eliminated. This hypothesis was inspired by the importance of the perception-behavior link in social contagion. Presumably, when inattentive confederates are exhibiting outwardly distracting (e.g., fidgeting) behaviors, these behaviors should capture a participant's attention. After participants initially have their attention captured by the distracting behavior, the confederate behavior should then implicitly signal information about the importance of the lecture material. Due to the consistency and placement of the distracting behaviors within their visual field, participants should have their attention momentarily captured by these behaviors via an ongoing basis. Since these signals are rooted in the external behaviors of confederates, they would yield in an external distraction response when participants are probed. Thus, when the external distraction

reports are removed, these TUT responses should be accounted for and condition differences in TUT should no longer continue.

- Participants in the inattentive-confederates condition should show significantly higher rates of external distraction reports than participants in the attentive condition because the inattentive confederate behaviors should cause participants attention to be directed on the external environment.
- Conceptually replicating the finding reported by Kalsi et al. (2023), when controlling for participants' prelecture motivation to learn score, the adjusted mean TUT rate between conditions still should differ, with the inattentive condition yielding higher TUT rate than the attentive condition. This result would imply that attention contagion influences behavior above and beyond any effect of preexisting motivation to learn a topic, signaling that even highly motivated individuals are susceptible to attention contagion.
- Participants in the inattentive condition should show significantly lower scores on a goal contagion questionnaire when compared with the attentive condition, with participants showing a significant negative association between goal contagion score and TUT rate. Participants paired with inattentive confederates should score lower on the goal contagion questionnaire because the inattentive behaviors of the confederates should convey that the confederates appraise the lecture material as unimportant. After observing the confederates' inattentive behavior and constructing a perceived goal based on the confederate behavior (i.e., "the other participants' believe the lecture is unimportant"), participants in the inattentive condition should have this goal negatively influence their own view of the lecture importance, resulting in participants rating the lecture as unimportant (Kalsi et al., 2023). As a participant finds the lecture as less important, their

TUT rate should increase. If supported, this finding would indicate that goal contagion may be one mechanism of attention contagion.

- Participants in the attentive condition should show significantly higher scores on a social influence questionnaire than those in the inattentive condition, also showing a negative association between and TUT rate. That is, participants who are paired with attentive confederates might experience social pressure from their fellow participants, encouraging them to modify their behavior to align with group norms. Oppositely, participants who are paired with inattentive confederates might not experience social pressure from their fellow participants to regulate their behavior because on-task behavior is not exhibited as the group norm. Thus, due to this lack of a positive social influence, participants should report an increased TUT rate when compared to the attentive condition. If supported, this finding would indicate that social influence may be one mechanism of attention contagion.
- Participants in the inattentive condition should report significantly lower self-reported attentiveness ratings compared to their attentive condition counterparts, replicating Kalsi et al. (2023).

CHAPTER II: METHODOLOGY

Below I report how I determined my sample size and all data exclusion decisions, experimental manipulations, and measures for this study (Simmons et al., 2012). The study received ethics approval from the Institutional Review Board of the University of North Carolina at Greensboro (protocol FY23-285). The preregistration for this study is available on the Open Science Framework at the following URL: https://osf.io/wz92x.

Participants

I recruited participants from the online participant hosting site, Prolific (www.prolific.co), between June 5th, 2023 and July 17th, 2023. Per the preregistration, I screened participants for an allowable age range of 18–35 years old, a minimum Prolific approval rating of 95%, a minimum of a high school degree (or equivalent), English as a first language, access to a webcam, and residence in the United States, Canada, or the United Kingdom.

Participants were recruited via Prolific's sign-up interface. Following successful completion of the study, they were compensated with $9 credited to their account (pay rate = $12/hr). All participants were pseudorandomly assigned to either the attentive-confederates or inattentive-confederates condition via self-selection of sign-up appointments within Prolific. To do this, two separate and identical experiment postings were presented concurrently on Prolific, one for each condition. Prolific would then notify eligible participants about the experiment by sending the study(s) to their website homepage, among other studies. From here, participants would enroll in the study, being assigned to the corresponding condition. Participants data were recorded only for their initial submission (both experiment descriptions indicated that participants would not be paid for completing the other version of the study).

To ensure that the study was sufficiently powered, I conducted an a priori power analysis using G*Power (3.1.9.7; Faul et al., 2007) for a *t*-test for two independent means—the main analysis of this study—seeking an effect size of $d = .30$ with 80% power and $\alpha = .05$ (two-tailed). To achieve the above parameters, $n = 176$ subjects per group were needed ($N = 352$ total). I decided that an effect size of $d \leq .40$ was theoretically interesting for three reasons (see Brysbaert, 2019): (1) Numerous large replications and meta-analyses report $d = .40$ as the average effect size for psychological studies; (2) An effect size of $d = .40$ is sufficient to provide clear results; with this effect size from a between-subjects design, a randomly selected participant from the inattentive condition, for example, would have a 61% probability of showing a higher TUT rate than a randomly selected participant from the attentive condition—providing a compelling argument for a meaningful difference between the groups; (3) The current effect size target ($d = .30$) is more conservative than the Kalsi et al. (2023) reported effect size ($d = .44$).

Videorecorded Research Confederates

Six research confederates with acting experience were recruited from the UNCG School of Theatre and filmed to create the study stimuli. Using prerecorded confederate videos ensured that confederate behaviors were consistent across participants. Each video was overlaid on a template to create a video call grid (Appendix A). The confederates watched the pre-recorded video lecture and had their reactions (including responding to thought probes) recorded twice; during each session, they were recorded from a seated position in a room chosen to mimic the environment of a typical online participant via a computer webcam. Before the recording sessions, the confederates were asked to review the behavioral guidelines to ensure clarity, and following this they had the opportunity to have questions answered. Confederates were

instructed to move the same amount in each condition because movement momentarily attracts attention (Pratt et al., 2010). During the first viewing, participants acted per attentive behavioral guidelines. Following a short break, they then watched the lecture again, acting per the inattentive guidelines. Guidelines for both conditions are described in the Design section below.

Prior to filming either video, each confederate was randomly assigned a number 2–7; this number told each confederate how long (in min) should elapse between switching behaviors in both conditions. For example, the confederate assigned 4 switched between condition-specific behaviors in 4-min intervals. They were provided with a stopwatch on their computer screen and those who exhibited non-consecutive repeated behaviors (e.g., adjusting clothing) were instructed to engage in this behavior every 30–40 s during their assigned interval. Additionally, the number they were assigned indicated the time that they would begin exhibiting their attentive or inattentive behavior after the lecture began. For example, the confederate (in the inattentive condition) who was assigned the number 2 began exhibiting their initial inattentive behavior after 2 min elapsed following the start of the lecture, switching to a separate behavior every subsequent 2 min.

Prior to launching the study, four undergraduate research assistants were randomly presented (in both actor order and experimental condition) a 30 s excerpt from each of the actors' attentive and inattentive recordings. Following each video excerpt, each research assistant completed a Likert scale rating for the actor's attentiveness from 1 "inattentive" to 7 "attentive". Attentive segments were consistently rated as more attentive than were inattentive segments.[1]

[1] Mean rating of each actor by condition: Actor #1; attentive condition (M = 6.75, SD = 0.50) inattentive condition (M = 2.50, SD = 0.58), Actor #2; attentive condition (M = 6.25 , SD = 0.50) inattentive condition (M = 5.25, SD = 0.50), Actor #3; attentive condition (M = 6.50, SD =

Design

In this between-subjects (combined with a pretest-posttest) design, participants were assigned to either the attentive-confederates or inattentive-confederates condition; they also completed a pretest to assess their preexisting knowledge on the lecture subject (this was used as a covariate when analyzing between-group posttest scores) and a prelecture motivation to learn scale (this was used as a covariate in a secondary analysis of between-group TUT rate differences, following Kalsi et al., 2023).

Procedure

Before testing, participants provided informed consent; if they selected *no*, they were automatically exited from the study before data were collected. Consenting participants were then informed that compensation was not dependent on post-lecture performance and that they should not use external resources during the experiment. Following this, participants completed two bot-screening questions: "Which of these digits is an odd number: 2, 6, 7, or 8" and, "Which of the following word ends in the same letter as the word KEY: House, Indigent, Nephrology, or Squared?" Participants who incorrectly answered both questions had their participation terminated before data were collected.

After consenting and correctly answering the bot questions, participants indicated the number of hours that they slept the night before the study. Some studies show that participants who experience less than four hours of sleep prior to a cognitive task show increased inattentive behavior and poorer test performance (Fallone et al., 2001). Thus, the data from participants with

---

1.00) inattentive condition (M = 3.00, SD = 1.63), Actor #4; attentive condition (M = 7.00, SD = 0.00) inattentive condition (M = 2.25, SD = 0.96), Actor #5; attentive condition (M = 5.00 , SD = 1.63) inattentive condition (M = 4.00, SD = 1.83), Actor #6; attentive condition (M = 5.25 , SD = 0.50) inattentive condition (M = 4.25, SD = 1.23).

abnormal sleep quality (less than 4 hrs of sleep the previous night) were excluded from the study and replaced, as preregistered (see the *Measures* section below for more information; Carciofo et al., 2014). Participants then completed the prelecture measures. They were first pretested on lecture-relevant material, completing a test on general topic knowledge and lecture-specific information, then they completed a prelecture motivation to learn scale (regarding the upcoming lecture material). They then watched a 30 min lecture, responding to thought probes interspersed throughout the video, and then they completed a postlecture learning assessment.

The experiment instructions informed participants that they would be viewing a prerecorded lecture concurrently with a group of other research participants (actually videorecorded confederates). Prior to beginning the lecture, participants were informed of three constraints that they must follow. First, they were not to take any notes during the lecture. Second, they should carefully attend to the information to prepare them for a posttest on the lecture content. Third, they should not use any external electronic devices (other than viewing the lecture on their computer) during the lecture.

Prior to starting the lecture, participants received instructions on the importance of indicating the content of their thoughts immediately preceding each thought probe:

> At certain times during the lecture the video square will turn grey and you will be prompted to indicate the content of your thoughts directly preceding the grey screen. At this time, you will indicate the content of your thoughts by typing the corresponding keyboard key (1-8) that most closely aligns with your thought content. During this experiment, you may begin thinking about things other than the task at hand. When asked, via a thought probe, what you were just thinking about, please try your best to honestly assess the content of your thoughts directly preceding the probe. After clicking the "click to continue" button below, you will be presented with a sample thought probe to familiarize you with the process.

Following the thought probe instructions, participants were presented with a trial thought probe. After completing this probe participants then completed an instruction quiz, "When responding to questions about your thoughts, what time frame should you report your thoughts

from?" Participants chose one of three response options: since the very beginning of the task, the moment before the thought probe appeared, or over the last 30 to 60 seconds. Participants who chose the second option received the following message, "Correct", and participants who chose any other option received the following message, "Incorrect, Remember, when we ask you what you were just thinking about, please report on your thoughts from the instant before you were asked." After this message, the lecture started. To assess TUT experiences during the lecture, 12 thought probes were interspersed in the video at the same predetermined times for all participants (and at the same times for the confederates during their recordings). For each probe, the lecture paused and a notification (which was overlaid on the lecture video feed) appeared, prompting the participant to report their immediately preceding thoughts. All probes stayed onscreen for 10 s regardless of response.

The lecture phase of the research then began with a 7 s title screen, "Welcome, the host will let you in soon" (see Appendix B). After this, the title screen automatically transitioned to a 2 s screen that presented a loading screen with a spinning loading icon. This screen then automatically transitioned to the 30 min video lecture and the pre-recorded confederate videos. The pre-recorded confederate videos populated in the lecture environment at staggered times (7, 17, 25, 27 s during the 30 s prior to the start of the lecture) with two confederates being present when the subject entered the lecture to simulate the realism of an online lecture. During the entirety of the lecture, participants saw a livestream of themselves; this live-feed was

superimposed onto the videocall grid, making it seem that the participant was in a live video call with the confederates.[2]

Following the lecture, participants completed the lecture posttest, manipulation check, suspicion check, demographic questionnaire, and an inclusion questionnaire that included questions about their environment and external device usage (all described below).

Equipment and Experimental Environment

Participants were tested via the website, Prolific.co, and the experiment was hosted on the experiment hosting sight, Pavlovia.com. For inclusion in the research, each participant was required to use a laptop or personal computer equipped with a participant-facing webcam. The video lecture was saved and presented in an MP4 format, allowing seamless playback; each condition had an MP4 file edited to condition specifications. To create the prerecorded lecture for each condition, confederate reactions to the video lecture were recorded separately and edited into a video grid format via Hitfilm Express 16 video editing software. The experiment was created with PsychoPy3 and PsychoJS (Peirce et al., 2019). Using PsychoPy3, the thought probes were embedded within the lecture.

Stimuli

Participants watched a 30-min excerpt of a video lecture from environmental scientist Jesse Ausubel titled, "Nature is Rebounding: Land and Ocean Sparing through Concentrating Human Activities." This lecture discussed patterns of hydrological, agricultural, and ecological resurgence and growth within the United States. The video was presented via MP4 with 980 ×

[2] Participant videos were not recorded, so I cannot ensure that all subjects were visible to themselves (e.g., covering webcam or experiencing a technical issue) for the entirety of the experiment. See "Limitations" section of Discussion.

1080p quality and, as of July 27th, 2023, could be found here (with the lecture starting at the 8:50 mark): https://www.youtube.com/watch?v=0U3z6QYZOIM; I have also stored a copy here: https://osf.io/uczqw/.

Participants then viewed a virtual lecture, stylistically like the Zoom video platform. The video lecture appeared in the upper left portion of the screen, the research participant and six confederates appeared along the bottom and right edges of the lecture (see Appendix A). The six confederates in the attentive-confederates condition demonstrated the following: eye-gaze frequently focused on the screen, affirmative non-verbal behaviors exhibited in response to the presentation (e.g., affirmative head-nods and occasional "aha" moments; appropriate surprise responses to presented information), upright posture, and unobstructed facial presentation (not supporting their head with an arm bracing position).

The inattentive confederates exhibited the following behaviors: fidgeting (e.g., shifting seat position, wringing hands, and adjusting glasses or articles of clothing), eye gaze frequently averted from the screen, sitting in a slouched posture, obstructing their face by hand position (supporting their head with an arm bracing position), and engaging in no affirmative non-verbal communication (head-nods). These behaviors did not occur simultaneously, rather, they were distributed across the 30-min lecture. For example, a confederate could exhibit fidgeting behaviors and then begin obstructing their face, but they were not to do both behaviors simultaneously.

Measures

All measures used in this study were presented and collected via a computer, with the program hosted on Pavlovia.com.

Sleep Assessment

Participants completed a 10-point scale to indicate how many hours of sleep they had the night before the experiment, ranging from 0 to 10+ hrs.

Content Pretest

Before the lecture, participants completed a content-area pretest (Appendix C). Participants had a maximum of 15 s to complete each question; if left unanswered, the question was counted as incorrect and the program then progressed to the next question. The 20 multiple-choice questions began with broad questions about the lecture content area and progressed in specificity and domain knowledge required to answer the questions. For example, participants began with a broad content question, “All of the organisms of one species living in one area are known as a(n): a. community, b. population, c. species, d. ecotype.” The 12 broad domain questions were drawn from a College Board SAT Biology E/M Subject Test (*Real SAT Subject Tests*, 2002). Following this, they transitioned to 8 lecture-specific content questions (Appendix D), such as, “What is the most important ecological phenomenon on land today?"; these 8 questions later appeared on the lecture posttest (amid additional, new questions). Subjects’ pretest scores (used in some analyses as a covariate) were calculated from all 20 questions.

Prelecture Motivation to Learn

Following the pretest, participants completed a measure assessing their motivation to learn the lecture material (Forrin et al., 2021; Kalsi et al., 2023). This 11-point Likert scale ranged from 0 (“Not Motivated”) to 10 (“Extremely Motivated”). After completing this measure, participants began the lecture phase of the study.

Thought Probes

To measure participants' TUT rates, 12 thought probes were interspersed in the lecture at predetermined times, with an average distance of 2.5 min between each probe (*Min* = 1 min, *Max* = 4 min). The first probe did not occur until 5 min into the lecture. Participants were cued via an onscreen notification message, "please indicate what you were thinking about just before this message by typing the corresponding number on your keyboard" to complete each thought probe. This message appeared in the top-left corner of the screen, the same location as the lecture video (which was paused during the probe). When cued, participants indicated the content of their thoughts *just* before the cue—this occurred via a multiple-choice window on the video screen.

The thought probe window presented the following options (adapted from Kane et al., 2017): (1) *On-task on the lecture* - on task and thinking about the current content being discussed in the video, (2) *Lecture-related ideas* - thinking about an aspect of the lecture topic that is not currently being presented in the video, (3) *How well I'm understanding the lecture* - actively evaluating their comprehension of the lecture material, (4) *Everyday personal concerns* - thoughts about everyday tasks, goals, concerns, or personal worries, (5) *Daydreams* - thoughts about fantasies or unrealistic events, (6) *Current state of being* - thoughts about one's current physical, emotional, or psychological state, (7) *External environment* - thoughts about something lecture-unrelated in the immediate environment, or (8) *Other* – any thoughts that don't fit the other categories. Thought probes like this, which assess the contents of participants' immediately preceding thoughts, have strong evidence of reliability and construct validity (e.g., Kane et al. 2016, 2017, 2021).

Participants' TUT rates were scored as the proportion of the total probes to which they responded before the 10 s deadline (max = 12) with responses 3–8 coded as TUT; participants who failed to respond to a given thought probe within the time limit had that probe dropped from the denominator for calculating TUT rate (participants had to respond to at least 8 probes for their data to be used in the study). For additional analyses, since participants may have become distracted by confederate behavior, external distraction (response option 7) was broken out from the other TUT probe options and TUT rate was recalculated without the proportion of TUT responses attributed to external distraction (and external distraction rates were also analyzed separately).

Lecture Posttest

Following the lecture, participants completed a 20-item multiple-choice posttest to gauge their learning (see Appendix D). The information tested was specific to the lecture content (e.g., "Given the recent trends of the global plant biosphere, how has nitrogen gas concentration been impacted?"). Eight of the questions were identical to the lecture-specific pretest questions (marked in Appendix D). Posttest scores reflected the percentage of correct answers.

Self-Reported Attentiveness

Following the posttest, participants rated their own attentiveness during the lecture from 0 ("Not at All Attentive") to 11 ("Extremely Attentive"), as in prior attention contagion studies (Forrin et al., 2021; Kalsi et al., 2023).

Manipulation and Suspicion Checks

Participants then completed a set of Likert scales rating confederate attentiveness and a suspicion measure. The manipulation check is of primary interest: As in prior attention contagion

studies (Forrin et al., 2021; Kalsi et al., 2023), participants rated confederates' attentiveness during the lecture from 0 (*"Not at All Attentive"*) to 11 ("*Extremely Attentive"*).

Participants next answered several suspicion check questions, asking whether they had high levels of suspicion about the experiment's purpose while it was ongoing. The first question was, "What do you believe are the purposes of the present research?" Participants responded via a text box (these responses were qualitatively coded to see if the response aligned with the actual research purpose—if the response alluded to "other participants' impacts on behavior, the spread of attention, or suspicion for other participants acting" their data were conditionally retained, depending on the next question. The second question was, "When did you become aware of the purpose of the research?" and participants had three response options: (1) during the lecture, (2) during the post-lecture questionnaires or test, or (3) not applicable. If participants correctly determined the purpose of the research and it was during the lecture, their data were excluded from analyses and replaced.

Goal Contagion and Social Influence

Participants first responded to two questions relevant to goal contagion: "How important was the lecture material to you?" and "On average how motivated to learn did the other subjects appear to be?" with both on a 0 ("Not at All") to 11 ("Extremely") scale. These measures were chosen because they capture participants' perception of the confederate's overall motivation during the lecture, which ultimately is a metric that participants can use to infer the confederates' goals. In addition to inferences about the participant perception of confederate motivation, the first question allows insight into the participants' judgment of the lecture material. Together, these questions allow measurement of the association between each participants perception of the importance of the lecture and the perceived motivation of the confederates, under the assumption

that as participants judge their condition confederates to be more motivated, they should indicate the lecture material to be more important. If this is the case, each condition should have a difference in the goal contagion composite score. To measure social influence, subjects responded to three subscales with either “strongly disagree”, “disagree”, “agree”, or “strongly agree”: “Sometimes I thought about the fact that other subjects could see me", "I paid more attention because other subjects could see me", and "I paid more attention because I know the researcher will be able to see me” (see Appendix E)[3].

Demographics and Data Inclusion Questions

Participants completed a demographics and inclusion questionnaire after the manipulation and suspicion checks. Demographics questions asked for age, gender, race/ethnicity, and education level. The data inclusion portion consisted of Likert-scale questions pertaining to their environment and behavior during the experiment: *“While completing the experiment how noisy (people, TV, movies) was your immediate environment?”* and “*During the experiment how distracted were you by your immediate environment?”* They answered these questions via a four-item Likert scale. The first question had the following options: not at all noisy, somewhat noisy, moderately noisy, or extremely noisy. The second scale had the following options: not at all distracted, slightly distracted, moderately distracted, or extremely

[3] The current study measured goal contagion differently than did Kalsi et al. (2023), who measured only participants’ motivation to learn, at three points: prelecture, during the lecture, and post-lecture; they also used ratings of confederates’ motivation as manipulation check rather than as a measure of goal contagion. Also in the current study, social influence was measured via normative social influence measures, which were like the normative social influence measures from Kalsi et al. (2023). However, in addition to normative social influence measures, Kalsi et al. (2023) also measured informational social influence by asking participants to rate the importance of the lecture and via the number of participants (by condition) who asked to be emailed additional information about the lecture topic after the experiment.

distracted. Participants then completed two questions about their media multitasking behaviors during the experiment, "*During the experiment, how often did you interact with: (1) phone (calls or texts), email, or social media; (2) video games."* Both questions used the same scale: never, some of the time, most of the time, or all of the time. Lastly, a yes/no question asked if they used any outside resources during the post-lecture test (e.g., a search engine). Following the preregistration, participants' data were excluded if they indicated their environment was extremely noisy, or they were extremely distracted, or they responded to any of the media multitasking questions with "Most of the time" or "All of the time" (see Appendix F).

CHAPTER III: RESULTS

All null hypothesis significance testing adopted an alpha level of .05. For all primary analyses, I report the Cohen's *d* effect size (along with Cohen's U_3 [the proportion of data in the smaller-mean distribution that are exceeded by the median score in the larger-mean distribution], percent overlap between distributions, and probability of superiority; Cohen, 1988; Magnusson, 2023) and the 95% CI around the mean differences between experimental conditions. Although not specified in the preregistration, all ANCOVAs used Type III sums of squares (significance did not change when using Type I sums of squares). Data are available on the Open Science Framework (https://osf.io/uczqw/).

All analysis and data visualizations were conducted in R 4.2.1 (R Core Team, 2023).[4] I used the following packages: *tidyverse* to group and sub-divide data by condition (v1.2.3; Wickham et al. 2019), *psych* to calculate reliability statistics and summary statistics (v2.2.9; Revelle et al., 2023), *car* to calculate the ANCOVAs for this study (v3..1.0; Fox et al., 2019), *splithalf* to calculate spearman brown correlations (v2.2.2; Parsons et al., 2021), *jmv* to calculate correlations and additional condition-specific descriptive statistics (v2.3.4; The Jamovi Project, 2023), *lsr* to conduct all null-hypothesis significance testing (v0.5.2; Navarro, 2015), and *effectsize* to calculate Cohens *d* for all *t*-tests (v0.8.0; Ben-Schar et al., 2020). Figures were created using *cowplot* to format figures (v1.1.1; Wilke et al., 2021), *paletteer* to input custom plot colors (v1.5.0; Hvitfeldr, 2021), *ggsignif* to add *p*-values to relevant plots (v0.6.4;

[4] Cohen's U_3, percent overlap between distributions, and probability of superiority were calculated via an online R dashboard (Magnusson, 2023).

Constantin, 2021), *lattice* to create scatterplots (v0.22.5; Sarkar, 2008), and *ggrain* to create raincloud plots of the data (v0.0.3; Allen et al., 2021).

Data Analysis Exclusions and Replacements

Subjects' data were excluded and replaced with an eligible participant for the following preregistered reasons. First, if participants failed to answer eight or more (≥ 67%) thought probes during the video lecture, they were asked to return their submission, they were not paid, and we did not use their data (n = 6); task instructions to subjects warned that missing thought probes would count as failed attention checks and would lead to rejected submissions. For the remaining exclusion criteria, we replaced participants' data but they were fully paid for their participation: (a) reporting < 4 hrs sleep the previous night (n = 9); (b) correctly indicating via the suspicion measure that they knew the purpose of the research and became aware of it during the video lecture (n = 29); (c) indicating either that their environment was extremely noisy, that they were extremely distracted by their external environment during the study, that they used media "Most of the time" or "All of the time" during the study, or that they used outside resources during the test (n = 9).

I also preregistered a pretest exclusion criterion, which stipulated that we would replace data from participants scoring ≥ 50% on the final 8 questions of the lecture pretest. These questions were created to measure participants' preexisting knowledge on the lecture topic. However, after examining the unexpectedly large number of participants that met this exclusion criterion (n = 141), I gathered that the multiple-choice question foils may have been insufficiently plausible and allowed participants to guess the correct answers; the lecture topic was obscure enough that it is unlikely that so many participants had expertise in it. Due to the high number of participants that scored ≥ 50% on this section of the pretest, this preregistered

exclusion criterion was abandoned. All analyses of learning and test performance should thus be interpreted as exploratory and with caution until further research with better test questions is conducted.

As preregistered, I obtained a final sample of 352 participants (Male = 180, Female = 157, Gender-Nonconforming/Nonbinary = 15) with 176 participants per condition. The retained sample had a *M* age of 29.2 (SD = 4.43) years, with participants in the following age ranges (18–25 = 83, 26–30 = 112, 31–35 = 152, and N/A = 5).[5] Participants lived in the United States (*n* = 114), the United Kingdom (*n* = 213), and Canada (*n* = 25). The race/ethnicity composition of our sample was as follows: East Asian descent (*n* = 16), South Asian descent (*n* = 15), Black or African descent (*n* = 44), Hispanic or Latin descent (*n* = 6), North American or Alaskan Native (*n* = 2), Middle Eastern: Arab or North African (*n* = 6), White: European descent (*n* = 263); due to a programming error, participants were limited to selecting only one race/ethnicity.

Manipulation Check

Confederate attentiveness was effectively manipulated. Participants rated the attentive confederates (*M* = 7.76, SD = 1.80) as significantly—and considerably—more attentive than the inattentive confederates (*M* = 5.54, *SD* = 2.09), $t(350) = 10.70$ $p < .001$, 95% CI [1.81, 2.63], $d = 1.14$ ($U_3 = 87.3\%$; 56.9% overlap between distributions; 79.0% probability of superiority).

Preregistered Primary Analyses

TUT Rates by Confederate Attentiveness

As hypothesized, participants in the attentive-confederates condition had significantly lower overall mean TUT rates (*M* = 0.39, *SD* = 0.25) than did participants in the inattentive-

[5] Five participants provided non-sensible age responses (e.g., 0, 0, 0, 0, and 9); these entries were recoded as N/A's.

confederates condition (M = 0.47, SD = 0.27); $t(350) = -2.92$, 95% CI [-0.14, -0.03], p = .004, d = 0.31 (U_3 = 62.2%; 87.7% overlap between distributions; 58.7% probability of superiority), but with a moderate effect size. Raincloud plots for all the TUT rate variables are presented in Figure 1; all descriptive statistics are presented in Table 1.

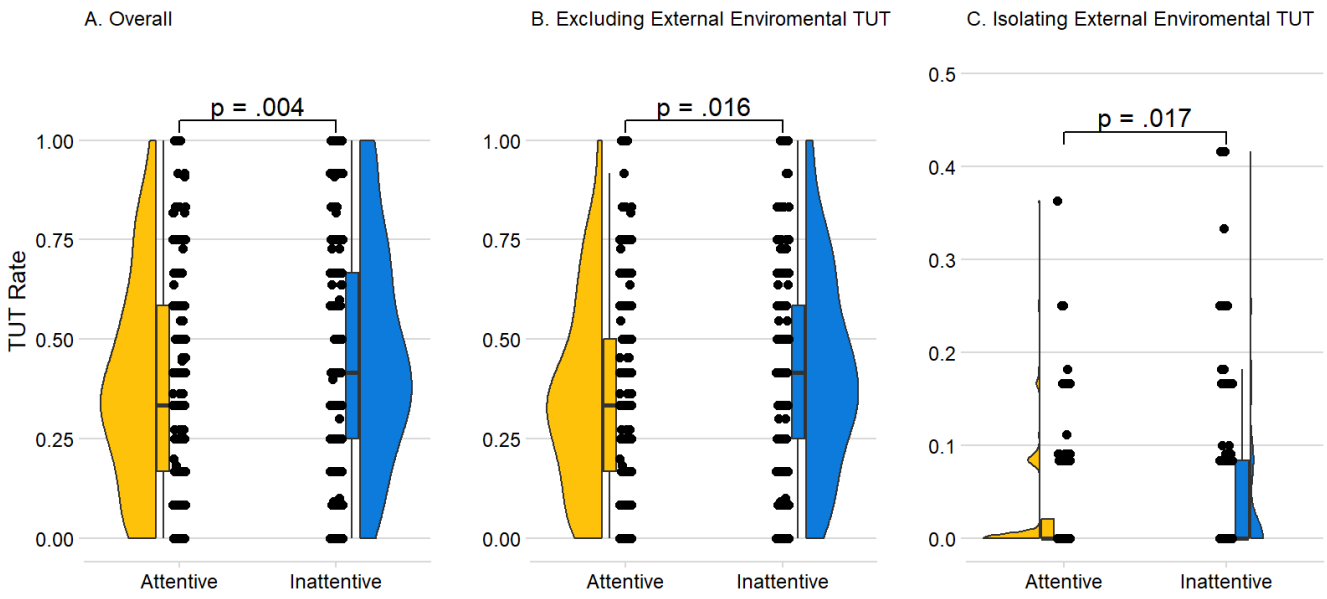
To account for environmental distraction that may have been caused by the confederates, I re-analyzed TUT rates after excluding probe response option 7 ("external environment," or environmental distraction). This preregistered analysis found, again, that participants in the attentive condition had lower TUT rates, with a similar effect size (M = 0.36, SD = 0.24) than did those in the inattentive condition (M = 0.42, SD = 0.25); $t(350) = -2.43$, 95% CI [−.11, −.01], p = .016, d = 0.26 (U_3 = 60.3%; 89.7% overlap between distributions; 57.3% probability of superiority). Contrary to my preregistered prediction, even when probe responses of being distracted by the "immediate environment" were removed from the TUT rate, the between-groups difference persisted, indicating that inattentive confederates didn't only create momentary visual distractions.

Lastly, I calculated each participant's rate of TUTs focused on the external environment. In line with the previous analyses, participants in the attentive condition experienced significantly lower environment-focused TUT rates, with a similar effect size (M = 0.03, SD = 0.06) than did those in the inattentive condition (M = 0.05, SD = 0.08); $t(350) = -2.39$, 95% CI [−.03, −.00], p = .017, d = 0.25 (U_3 = 59.9%; 90.1% overlap between distributions; 57.0% probability of superiority), suggesting that participants may have been drawn to think about inattentive confederates more frequently than about attentive confederates.

Posttest Performance

As noted above, the preregistered plan for this analysis involved excluding participants that scored ≥ .50 on the final 8 pretest questions, but we abandoned this plan based on the large number of participants who scored highly. Again, given the somewhat obscure lecture topic, I think it is unlikely that many of our participants would have been experts in it; it is much more likely that the pretest multiple-choice foils were not effectively written to prevent guessing and to create a valid test of prior knowledge. Moreover, if these pretest questions did not effectively measure prior knowledge, the posttest questions may not have effectively measured postlecture knowledge or learning. These analyses must therefore be considered exploratory and provisional until additional research can support them.

Figure 1. TUT Rate by Confederate Attentiveness Condition



Note. Panel C, Isolating External Environmental TUT, intentionally uses a 0 to 0.5 y-axis to ensure that the data-points are presented large enough for the reader to view.

Table 1. Descriptive Statistics for the Primary Variables of Interest

	Attentive						Inattentive					
	M	*SD*	Median	95% CI	Skew	Kurtosis	*M*	*SD*	Median	95% CI	Skew	Kurtosis
TUT Rate:												
Overall	0.39	0.25	0.33	[0.35, 0.42]	0.37	−0.61	0.47	0.27	0.42	[0.43, 0.51]	0.26	−0.74
Excluding	0.36	0.24	0.33	[0.32, 0.40]	0.48	−0.38	0.42	0.25	0.42	[0.40, 0.46]	0.31	−0.53
Isolating	0.03	0.06	0.00	[0.02, 0.04]	2.49	7.69	0.05	0.08	0.00	[0.03, 0.06]	2.06	4.41
Learning:												
Pretest Total Score	0.45	0.11	0.45	[0.43, 0.46]	0.16	0.02	0.46	0.11	0.45	[0.44, 0.47]	−0.07	0.46
Pretest General Items	0.48	0.15	0.50	[0.46, 0.51]	−0.08	0.09	0.48	0.15	0.50	[0.46, 0.51]	−0.39	0.53
Pretest Domain Items	0.39	0.15	0.38	[0.37, 0.41]	0.19	0.33	0.42	0.15	0.38	[0.39, 0.44]	0.13	−0.40
Posttest Score	0.55	0.14	0.55	[0.53, 0.57]	−0.26	0.04	0.54	0.14	0.55	[0.52, 0.56]	−0.23	−0.36
Motivation to Learn	7.15	2.24	8.00	[6.82, 7.49]	−0.98	0.83	6.73	2.38	7.00	[6.37, 7.08]	−0.79	0.23
Goal Contagion	7.21	1.76	7.50	[6.95, 7.47]	−0.86	1.78	5.42	2.11	5.50	[5.11, 5.73]	−0.44	−0.28
Social Influence	2.83	0.75	3.00	[2.71, 2.94]	−0.40	−0.30	2.86	0.74	3.00	[2.75, 2.97]	−0.27	−0.37
Self-rated Attentiveness	6.61	2.02	7.00	[6.31, 6.91]	−0.57	−0.02	6.36	2.03	7.00	[6.10, 6.67]	−0.50	−0.08

Note. The Excluding Environmental TUT rate variable and Isolating Environmental Probe TUT rate variables represent the recalculation of participant TUT rate via a proportion of off-task probe responses by excluding or isolating participants environmental ("external environment") probe responses. Variables under the "Learning" label represent a proportion of participants correct answers on each respective test, including the combined score, questions about the general topic (pretest general items), and questions about the specific lecture material (pretest domain items) The motivation to learn variable is represented by a 0-10 scale. The goal contagion score is a composite average of participants responses to the two-goal contagion sub-scales. The social influence score is a composite of participant responses to the three social influence sub-scales.

Prior to conducting the preregistered ANCOVA, with total pretest score as a covariate, I ensured the data met the model assumptions of variable independence and homogeneity of variance. The ANCOVA didn't indicate significant differences in posttest accuracy between participants in the attentive-confederates condition (M = 0.55, SD = .14) and the inattentive-confederates condition (M = 0.54, SD = .14), $F(1, 349) = 0.66$, $p = .417$ but it did indicate that pretest scores were significantly associated with posttest performance, $F(1, 349) = 36.84$, $p < .001$. This null result of confederate condition on learning might be surprising, given previous findings that participants in the company of inattentive confederates performed worse on postlecture assessments than did participants with attentive confederates (Forrin et al., 2022; Kalsi et al., 2022). At the same time, the high pretest performance here did not leave much room for improvement on the posttest; moreover, as already noted, the pretest, the posttest, or both, may not have been sufficiently valid assessments of knowledge or learning.

Preregistered Secondary Analyses

TUT Rate by Motivation

To further explore confederate-condition differences in TUT rate, following from Kalsi et al. (2023), I analyzed all three TUT measures while controlling for participants' prelecture motivation to learn score. As hypothesized in the current study and as reported in Kalsi et al. (2023), when controlling for prelecture motivation to learn scores, participants in the inattentive-confederates conditions still showed significantly higher TUT rates than did those in the attentive-confederates condition, $F(1, 349) = 7.00$ $p = .009$. The same was true when recalculating TUT rates to exclude external environment TUT responses, $F(1, 349) = 4.72$, $p = .030$, and also when analyzing only the external environment TUT rates, themselves, $F(1, 349) =$

5.00, $p = .027$. These findings indicate that attention contagion influenced participant TUT rate above and beyond their preexisting motivation to learn.

Self-reported Attentiveness Ratings

Contrary to my hypothesis (and prior findings), the self-reported attentiveness ratings that participants provided after the lecture video did not differ significantly between the attentive-confederates condition ($M = 6.61$, $SD = 2.02$) and the inattentive-confederates condition ($M = 6.36$, $SD = 2.03$), $t(350) = 1.13$, 95% CI [−.18, .69], $p = .260$, $d = 0.12$ ($U_3 = 54.8\%$; 95.2% overlap between distributions; 53.4% probability of superiority). At the same time, participants' self-reported attentiveness ratings significantly and strongly correlated with their overall TUT rate, $r(350) = −.56$, 95% CI [−.63, -.49], $p < .001$ (for the full correlation matrix see Table 2).

Goal Contagion Ratings

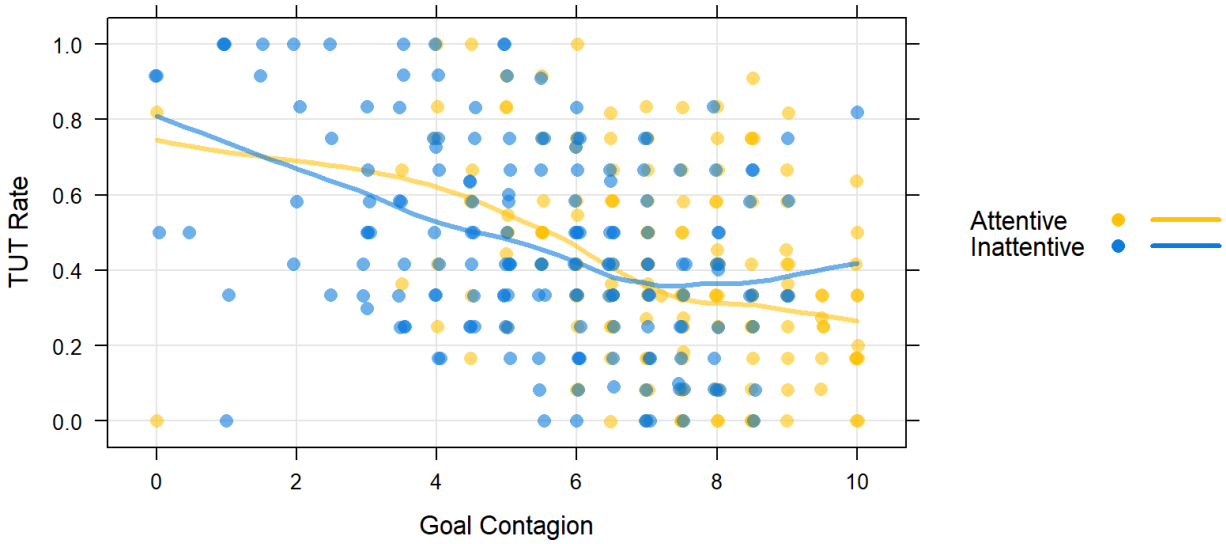
The two goal contagion scales yielded a Spearman-Brown coefficient of $r = 0.70$. I therefore created a composite score of these ratings by averaging them (indicating how important the lecture material was and how motivated to learn the other participants appeared to be).

As predicted, participants in the attentive-confederates condition ($M = 7.21$, $SD = 1.76$) scored significantly higher than did those in the inattentive-confederates condition ($M = 5.42$, $SD = 2.11$), $t(350) = 8.64$, 95% CI [1.38, 2.20], $p < .001$, $d = 0.92$ ($U_3 = 82.1\%$; percent overlap between distributions = 64.6%; 74.2% probability of superiority), with a large effect size. In addition, goal contagion scores were significantly negatively associated with overall TUT rate, $r(350) = −.38$, 95% CI [-.47, -.29], $p < .001$, and this correlation was significant in each confederate condition separately: inattentive condition, $r(350) = −.33$, 95% CI [−.46, −.19], $p < .001$, and attentive condition, $r(350) = −.37$, 95% CI [−.49, −.24], $p < .001$, see Figure 2

Table 2. Correlations and 95% CI for Primary Study Variables

Variable	1	2	3	4	5	6	7	8
1. Overall TUT Rate	—							
2. Excluding Environmental	0.96 [0.95, 0.97]	—						
3. Isolating Environmental	0.39 [0.30, 0.47]	0.13 [0.02, 0.23]	—					
4. Pretest Score	−0.27 [−0.36, -0.17]	−0.28 [−0.37, −0.18]	−0.03 [−0.13, 0.08]	—				
5. Posttest Score	−0.28 [−0.37,−0.19]	−0.28 [−0.38, −0.18]	−0.08 [−0.18, 0.02]	0.31 [0.21, 0.40]	—			
6. Motivation to Learn	−0.18 [−0.28, −0.08]	−0.17 [−0.27, −0.06]	−0.10 [−0.20, 0.00]	−0.02 [−0.13, 0.08]	0.04 [−0.07, 0.14]	—		
7. Goal Contagion	−0.38 [−0.47, −0.29]	−0.34 [−0.43,−0.25]	−0.22 [−0.32, −0.12]	−.04 [−0.14, 0.07]	0.13 [0.03, 0.24]	0.32 [0.22, 0.41]	—	
8. Social Influence	0.04 [−0.07, 0.14]	0.01 [−0.10, 0.11]	0.11 [0.01, 0.21]	−0.06 [−0.16, 0.04]	−0.03 [−0.13, 0.08]	0.08 [−0.02, 0.18]	0.04 [−0.06, 0.15]	
9. Self-Reported Attentiveness	−0.56 [−0.63, −0.49]	−0.52 [−0.60, −0.44]	−0.30 [−0.40, −0.21]	0.09 [−0.01, 0.20]	0.20 [0.10, 0.30]	0.37 [0.28, 0.46]	0.60 [0.53, 0.66]	0.03 [−0.07, 0.14]

Figure 2. Scatterplot for Goal Contagion Composite Score and TUT Rate



For completeness and transparency, I also examined each of the two goal contagion subscales separately. The first question, about the importance of the lecture materials, yielded significantly higher ratings in the attentive condition (M = 7.15, SD = 2.53) than in the inattentive condition (M = 6.30, SD = 2.17), $t(350) = 3.40$, 95% CI [.35, 1.34], $p < .001$, $d = 0.36$ (U_3 = 64.8%; 84.9% overlap between distributions; 60.6% probability of superiority), with a moderate effect size. Similarly, for the second question, about the other participants' motivation to learn, participants in the attentive condition produced significantly higher ratings (M = 7.27, SD = 1.95) than did participants in the inattentive condition (M = 4.54, SD = 2.19), $t(350)$= 12.35, 95% CI [2.30, 3.16], $p < .001$, $d = 1.32$ (U_3 = 90.7%; overlap between distributions = 50.9%; 82.5% probability of superiority), with a very large effect size.

To further analyze whether the experimental manipulation of confederate attentiveness influenced participants' composite goal contagion scores, above and beyond preexisting differences in motivation, I conducted an exploratory (not preregistered) analysis (ANCOVA) comparing confederate-condition goal contagion composite scores while controlling for

participants' initial motivation to learn scores. Again, participants in the attentive condition had significantly higher goal contagion scores than participants in the inattentive condition, above and beyond the effects of their initial motivational (goal) state, $F(1, 349) = 71.78$, $p < .001$ (additionally, motivation to learn scores were significantly associated with goal contagion scores, $F[1, 349] = 37.45$, $p < .001$).

Social Influence Ratings

The three social influence scales had internal consistencies of ($\alpha = 0.62$) and ($\omega t = 0.66$). Although these were on the low side of acceptable, I created a composite score by taking the average of the three social influence scales.

Contrary to my hypothesis, there was no significant difference between confederate conditions, $t(350) = -0.47$, 95% CI [−.19, .12], $p = 0.636$, $d = 0.05$ ($U_3 = 52.0\%$; 98.0% overlap between distributions; 51.4% probability of superiority), with the attentive-condition participants' ratings ($M = 2.83$, $SD = 0.75$) only slightly lower than those in the inattentive condition ($M = 2.86$, $SD = 0.74$). When examining each individual question in this measure, this null trend persisted, indicating no significant differences in social influence scores between confederate conditions.[6] Additionally, there was no significant association between participants' TUT rates and social influence scores, $r(350) = 0.04$, 95% CI [-.07, .14], $p = 0.470$ (see Figure 3).

[6] Measure 1, attentive ($M = 3.17$, $SD = 0.93$) and inattentive ($M = 3.17$ $SD = 0.95$): $t(350) = 0.00$, 95% CI [−.20, .20, $p = 1.00$, $d = 0.00$ ($U_3 = 50.0\%$; 100.0% overlap between distributions; 50.0% probability of superiority); Measure 2, attentive ($M = 2.61$, $SD = 0.98$) and inattentive ($M = 2.58$ $SD = 1.07$): $t(349) = -0.28$, 95% CI [−.25, .18], $p = .778$, $d = 0.03$ ($U_3 = 51.2\%$; 98.8% overlap between distributions; 50.8% probability of superiority); Measure 3, attentive ($M = 2.70$, $SD = 0.99$) and inattentive ($M = 2.84$ $SD = 0.99$): $t(350) = 1.29$, 95% CI [−.07, .34], $p = .20$, $d = 0.14$ ($U_3 = 55.6\%$; 94.4% overlap between distributions; 53.9% probability of superiority).

Figure 3. Scatterplot: Social Influence and TUT Rate

CHAPTER IV: DISCUSSION

The current online study examined attention contagion, TUT rate, and learning in virtual lectures. Previous studies explored attention contagion and learning in laboratory (Forrin et al., 2021) and virtual (Kalsi et al., 2023) settings, finding that inattention can spread from one individual to another. Kalsi et al. (2023) is the study most relevant to the current research because, similar to the current study, it examined attention contagion and learning in a virtual lecture. However, that study was limited by only measuring attention with a single retrospective rating scale. Participants' response to this measure may not have accurately reflected their attention states for the entire 30-min lecture. Their data, then, might not illuminate participants' actual in-lecture experience, leaving questions unanswered about TUT rate and in-lecture attention in virtual settings.

Forrin et al. (2021), in contrast, measured TUT rate with thought probes embedded into the learning material, but their in-person study surprisingly found non-significant differences between attentive- and inattentive-confederate conditions in the laboratory: Participants in the inattentive condition showed non-significantly higher TUT rates (p = .136) and environmental distraction rates (p = .24) than did those in the attentive condition. At the same time, probed on-task reports (the only other response option) yielded significantly higher on-task report rates for the attentive-confederates condition than the inattentive-confederates condition. The significant effect on on-task reports found by Forrin et al. (2021), along with Kalsi et al. (2023) not measuring TUT rates in their study, suggested the need to further examine the spread of TUT via attention contagion in virtual learning environments.

Participants in the present study, recruited from Prolific from the U.S., U.K., and Canada, watched a 30 min lecture with either attentive or inattentive confederate "participants" (who

were prerecorded). During the lecture, participants responded to 12 thought probes to indicate the content of their immediately preceding thoughts. Additionally, participants completed a pretest and posttest to measure their baseline level of knowledge and the amount of learning that occurred during the lecture. Following from Kalsi (2023), the current study included scales measuring goal contagion and social influence to further explore possible mechanisms of attention contagion.

The Influence of Attention Contagion on TUT Rates

As predicted, participants' TUT rates significantly differed between the attentive-confederate and inattentive-confederate conditions, with participants in the inattentive condition experiencing an increased mean TUT rate. This difference in TUT rates had a moderate effect size and persisted when calculating TUT rates in multiple ways, such as excluding probe responses about external-environment distractions and considering only environmental-distraction probe responses. The presence of inattentive confederates appears to increase both internally and externally focused TUTs.

This finding is interesting, considering that Kalsi et al. (2023) reported a nonsignificant condition difference in participants' ratings of distraction caused by confederate behavior. In the current study, distraction caused by confederate behavior (and other environmental stimuli and events) was categorized as external environmental distraction, whereas Kalsi et al. (2023) measured distraction via a self-report postlecture measure. It should be noted that, although it is plausible that a sizeable amount of external environmental distraction probe responses in the current study reflected distraction caused by confederates, it is also possible that the inattentive behavior of confederates simply made participants more distractable, generally, to stimuli in their

environment. Unfortunately, we cannot make this distinction with the data available, as participants' qualitative experiences were not measured.

Nonetheless, both studies approached the measurement of attention differently. The Kalsi et al. (2023) postlecture self-report used a single timepoint to measure a participant's attentiveness across their previous experiences. It therefore relied on participants remembering their experiences and aggregating them into a single retrospective report, but such reports may be influenced by performance on the task, hindsight bias, or fatigue. In contrast, probed measurement uses distributed experience sampling to create a record of attentiveness across the entire task. This probe-caught methodology does not rely on participants retrospectively consolidating their perception of many experiences into one response, but it allows them to indicate their momentary experience at numerous timepoints during the given task. I therefore argue that the current data provide a more faithful measure of participants' in-lecture experience than does Kalsi et al. (2023).

The (Non-)Influence of Attention Contagion on Retrospective Attentiveness Reports

Counter to Secondary Hypothesis 6 (and contrary to the findings from Kalsi et al. 2023), the present participants in the inattentive condition did not retrospectively rate themselves as having been significantly less attentive during the lecture than did participants in the attentive condition, even though inattentive-confederate participants reported more TUTs in the moment and even though they rated their peers' behavior as more inattentive. This juxtaposition between participants' retrospective self-rating of attentiveness and their experience-sampled TUT rate suggests a disconnect between actual and perceived (or remembered) experiences. The nonsignificant result in the current study may have occurred for several reasons.

First, this result could indicate that participants struggled to accurately reflect on their momentary experiences, signaling a metacognitive difficulty that culminated in imperfect retrospective reporting of their in-lecture attention state. This speculation is informed by data from Kane et al. (2021), which indicated that retrospective reports have poorer validity than do TUT probe responses. That study compared various types of thought probes, presented in two tasks (a Sustained Attention to Response Task [SART] and an arrow flanker task), to assess mind-wandering measurement validity: thought-content probes (used in the current study; what each participant was mind-wandering about), intentionality probes (why participants were mind-wandering), and depth probes (the extent of on-task thinking versus mind-wandering via a Likert scale). In addition to their assigned probe-type condition, all participants also completed a post-task retrospective questionnaire about their TUTs in the prior task (retrospective reporting of mind-wandering). Overall, results indicated that, across all tasks, content, intentionality, and depth probe TUT rates correlated more strongly with one another between tasks (SART and Flanker; *r*s = .61–.65) than they did with retrospective reports within the same task (*r*s = .32–.43). The current findings of a condition effect on probed TUT reports but not on post-task attentiveness ratings, informed by data from Kane et al. (2021), bolster the argument that retrospective self-report attention measures may not faithfully capture participants' actual experiences.

Second, the non-significant between-condition differences in participants' retrospective attentiveness ratings may have occurred due to Prolific participants' penchant for overcautious identification and answering of possible attention checks. An informal review of recurring conversations among Prolific participants on public user forums (e.g., https://www.reddit.com/r/ProlificAc/), indicates skeptical and cautious approaches by Prolific

participants. Users frequently mention measures that may remotely be construed as an attention check and electing to answer them conservatively to avoid possible repercussions (even when they do not qualify as attention checks under Prolific guidelines). For example, one participant posted that they responded to the following Likert scale, “On a scale from 1 to 7, how would you rate your willingness to take risks on financial matters” by choosing response option “1” because the measure instructions said, “choose only one”. This experimental instruction is presumably instructing participants to only choose one scale response, but this user interpreted it as an attention check and responded with “1” because they “weren’t going to risk it [receiving a rejection due to failing an attention check]” (username “Invaderzap,” retrieved from [https://www.reddit.com/r/ProlificAc/comments/155r591] on [8/13/2023]).

Though the current study’s retrospective attention rating scale does not meet the Prolific criteria for an attention check (see www.prolific.co), the placement (following the lecture) and content of the attention measure may have skewed participants’ ratings via agreement bias—participants answering in a way that they believe is pleasing to researchers. Unlike the embedded thought probes, this attention-rating measure lacked instructions indicating that it is normal to sometimes be off task and to answer the measure honestly. Thus, participants in both conditions may have given a response in the middle of the 0–11 response scale to avoid potential repercussions for failing what they assumed to be an attention check, yielding in a nonsignificant difference between confederate conditions.

In closing, however, it should be noted that the retrospective measure of attentiveness correlated significantly and substantially with probed TUT rates ($r = -0.56$). So, although there is reason to think that the retrospective reports were more error prone than were probed TUT reports, their data should not be completely discounted, and further work should examine where

in-the-moment probed reports and retrospective reports of mind wandering and inattention are associated versus dissociated.

Methodological Improvements: Comparing Past and Present Research

In contrast to the present findings of a significant effect of confederate attentiveness on TUT in a virtual lecture, Forrin et al. (2021) reported a non-significant effect of confederate attentiveness on TUT rate and external distraction reports in a laboratory setting, although the means for each were in the predicted direction (*p*s < .14). This difference in results between studies may have occurred for the following reason.

The present study used an expanded thought probe battery (see Appendix G) that provided participants with concrete and well-defined categories to accurately categorize the content of their thoughts via thought probe responses, with six probe response options that indicated TUT. According to Kane et al. (2021), the usage of these expanded probe categories may reduce reporting bias by increasing the specificity required for participants to deliberately categorize their TUT experiences. The probe battery used by Forrin et al. (2021) provided participants with three options, “on lecture”, “unrelated to the lecture or current environment”, or “information in the environment unrelated to lecture”, with only option two counting as a TUT. These probe options essentially provided participants with an “on-task” or “off-task” response paradigm that doesn’t force participants to commit to a particular content of off-task thoughts. As noted by Kane et al., (2021), these more generic on vs. off task paradigms are potentially more vulnerable to reactivity and bias. The additional processing required by the current study’s content probes encouraged participants to be careful when qualifying the state of their thoughts, reducing the probability that they erroneously or impulsively chose “on-task” or “off-task” mental states.

The current findings concur with Kalsi et al. (2023) that inattentiveness can spread from one individual to another in virtual settings. However, Kalsi (2023) did not measure TUT, relied on retrospective measures to assess inattentiveness, and used non-recorded (live) confederates to create the lecture environment. To carefully expand upon the findings of Kalsi et al. (2023), the current study made a notable methodological change to tightly control between-trial variation by using pre-recorded confederates in lieu of live confederates. Due to this change, all participants within each condition experienced an identical lecture environment (e.g., all confederate behaviors were identical for all participants within each condition). Using live confederates, like Forrin et al. (2021) and Kalsi et al. (2023), contributes unique (error) variance into each trial and highlights the importance of each confederate's acting abilities, because, as opposed to prerecording their performances, the manipulated behaviors (either attentive or inattentive) must be effectively recreated during each trial. On the countermand, prerecorded confederate performances only need to produce one effective performance during filming. In addition to the performance demands, using live confederates necessitates an increased staffing demand to cover each session, yielding in various sets of confederates during data collection. Kalsi et al. (2023) used the same set of 6 confederates, but during each trial randomly selected 4 of the 6 to be visible to each participant, meaning each trial was composed of a different combination of confederates and had reduced control when compared to a prerecorded manipulation. Though prerecording confederates is beneficial for reducing trial variance, it is limited by a lack of confederate reactivity to participants in-lecture actions and the believability of each confederate's recorded acting performance. These limitations will be discussed further in the limitation section below.

Attention Contagion and Learning

All the present results about learning should be treated as provisional and exploratory because the number of participants that scored ≥ 50% on the lecture-specific pretest questions (n = 141) raised concerns about the question foils not being effective lures. With that considered, the current study found no significant difference in posttest performance between the attentive and inattentive conditions, failing to support primary Hypothesis 2. This result is opposite to the previous studies on attention contagion, which found that participants assigned to conditions with inattentive confederates performed worse on posttests (Forrin et al., 2021; Kalsi et al., 2023).

However, though there were not significant condition differences in posttest performance, the findings did align with a large number of studies that show a negative correlation between TUT rate and test performance (e.g., Hollis & Was, 2016; Kane et al., 2021; Lindquist & McLean, 2011; Risko et al., 2012). Here, participants showed a negative and significant, $r(350) = -0.28$, 95% CI [−.37, −.19], $p < 0.001$, association between overall TUT rate and posttest scores. Additionally, participants also showed a negative correlation between TUT rate and prettest scores, $r(350) = -0.27$, 95% CI [−.37, −.17], $p < 0.001$. Since TUT rate correlated negatively with both the pretest (completed before TUTs were measured) and the posttest scores, these data may indicate that individuals who experience high levels of TUT may generally perform worse on assessments at both baseline and post content, rather than indicating that TUTs during the lecture impaired lecture comprehension. In any future work to replicate the present study, the pretest and posttest should be revised and further piloted to ensure they effectively measure participant learning.

Goal Contagion Versus Social Influence as Possible Mechanisms of Attention Contagion

As predicted, participants in the inattentive condition scored significantly lower on the goal contagion measures, measuring how important the lecture material was to them and how motivated to learn the other participants appeared to be, than did participants in the attentive condition; participants in both conditions showed a significant negative association between goal contagion and TUT rate. These results both support secondary Hypothesis 6 and match the findings from Kalsi et al. (2023).

It should be noted, however, that the current study measured goal contagion differently than did Kalsi et al. (2023). I examined goal contagion with scales indicating the perceived motivation of confederates and the participants' level of interest in the lecture content. This measured participants' inferences about the confederates' goal directed behavior (i.e., how motivated they are to learn the lecture material) and the activation of a related behavior towards a similar goal (i.e., how interesting participants found the material; Brohmer et al., 2021). This measure of goal contagion followed from the tradition of Aarts et al. (2004) that enabled inference of others' goal directed behavior and related activation in participants. Kalsi et al. (2023), in contrast, measured goal contagion by measuring participants' motivation to learn *prior to the lecture* and a retrospective rating of motivation to learn during the lecture, with participants in the attentive condition rating themselves as more motivated to learn during the lecture. I believed that it was important to measure participants' perceptions of confederates' goal directed behavior in addition to participants' perceptions of the lecture material. Doing so allowed measurement of participants' perceptions of the confederates' motivation.

The observation and use of confederate behavior to infer further meaning is vital to the goal-contagion process, as it allows participants to construct a perceived goal based on the

confederates' behavior—eventually leading to the participant embodying the confederates' goal and attention states—thereby causing attention contagion. Presumably, this embodiment of confederate goals happens because the confederate behavior signals the importance, or lack thereof, of the information being conveyed and is thus used by participants as a metric to inform their own goal directed behavior for that specific context. Given the extensive literature on goal contagion (Bargh et al., 1996; Chartrand et al., 1999; Loersch et al., 2008), it will be informative to further explore the association between attention contagion, goal directed behavior, participants' perception of the experience, and thought content.

Regarding social influence measures, in contrast, there were no significant differences between the attentive and inattentive conditions. Social influence was evaluated via a three-item that closely matched the normative social influence measures used in Kalsi et al. (2023). These results provide evidence against the premise that social influence drives attention contagion, and they align with null findings from Kalsi et al. (2023). This nonsignificant result may have been caused by the fleeting nature of the social group that was "formed" for each participant in both studies. Since each group was likely perceived as temporary by participants, and participants did not have any long-term threat of social exclusion for violating group norms, social influence had limited power to incentivize behavior change. I discuss this further in the limitations section below. Future studies should explore social influence and attention contagion in more solidified and stable groups, such as in authentic classroom settings, in which participants might care about the long-term implications of how their group members perceive their behavior.

Limitations

Though the current research effectively explored the influence of attention contagion on TUT in a virtual-lecture setting, some aspects of the design may limit generalizability, specifically: lack of confederate reactivity, limitations of participants' computers, inability to monitor participant webcam activity, issues with evaluating learning, and a lack of a social dynamic that is typically present in educational environments.

Lack of Confederate Reactivity

A primary issue limiting the generalizability of the current study is a feature that is also a strength, using prerecorded research confederates. Though this design choice tightly controlled the experimental manipulation, this created the potential issue that confederates could not react to participants' behaviors. For example, if during the lecture a participant were to wave at any of the confederates to interact with their "fellow participants", suspicions might be raised by the lack of reaction from the confederates. I addressed this scenario by including a suspicion measure in the procedure and replacing participants who indicated that they became suspicious of the confederates, or the purpose of the study, during the lecture (attentive condition $n = 13$; inattentive condition $n = 16$). Thus, none of the participants in the retained sample expressed suspicion of the confederates and, presumably, none tried to interact with them. In future work on attention contagion, researchers will need to choose between tightly controlling confederate behaviors and allowing for confederate reactivity.

Limitations of Participants' Computers

Using a video lecture with prerecorded confederates and a livestream of each participant's camera-stream during an online experiment created very large experiment files, which resulted in long experiment download times for participants (depending on their computer

and Wi-Fi performance). Based on informal piloting conducted prior to launching the study and on correspondence with participants during data collection, most participants experienced download wait times of 5–7 min, while some experienced times of 10–15 min, and in some extreme cases (participants using older computers lacking RAM or processing power, or with slow Wi-Fi connections) participants faced download times of 30+ min. Unfortunately, there is no way of knowing how long it took each participant to load the program, but given the size of the experiment, variation in download speeds were inevitable. Those participants with older computers and weaker Wi-Fi connections that faced longer download times may have begun the experiment more frustrated than the other participants or may have voluntarily withdrawn their participation altogether. However, since the current design used pseudorandom assignment, if this did occur, it should have occurred equally often in each experimental condition.

Monitoring Webcam Activity

Due to limited server space and constraints on time, I could not videorecord participants' trials to ensure that they had their webcam uncovered for the duration of the study. Recording each session would have also provided opportunities to code participants' behavior for attentiveness and to correlate it with other attentiveness measures. However, 30 min of recorded video for 352 participants would produce an insurmountable amount of data, all of which would take a little over 7 continuous days to review.

Though I cannot be certain that each participant had their webcam uncovered, I can have a fair degree of confidence. Four intentional design features increased the likelihood that participants had their webcam uncovered. First, the research sample was prescreened on Prolific to ensure that each participant had a webcam and consented to use the webcam during studies. Second, the code that created a livestream of participants webcams during the study was

intentionally designed to malfunction if it failed to register an accessible webcam during the experiment; if a participant did not have a webcam and somehow made it past the Prolific prescreening, they would receive an error when trying to complete the lecture. Third, participants were explicitly instructed that they were required to uncover their webcam during the lecture, and though it was not explicitly stated, participants could have interpreted these instructions to indicate that a researcher would review footage to ensure compliance. Lastly, just prior to joining the lecture, participants were presented with a screen that initiated their webcam, showing a livestream of their webcam on the screen, and asking participants one final time to uncover their webcam. Participants were instructed to, "hit spacebar to continue when you see yourself on the screen;" if participants did not uncover their camera, they would only see a black square. If keeping their camera covered was unintentional, this should have incentivized a participant to uncover their camera.

Pretest Performance and Evaluation of Learning

As mentioned earlier, a prior plan to exclude participants who scored ≥ 50% on the final 8 questions of the lecture pretest was abandoned. This was done because many participants met and exceeded this performance criterion and it would have been cost- and time-prohibitive to replace that many participants (n = 141); as well, with so many participants earning high pretest scores, it could raise concerns about the representativeness of the retained subjects who did not. This, unfortunately, signals that despite my best efforts to create a valid assessment, the pretest may have failed to effectively gauge participants' preexisting knowledge on the topic and, thus, the application and generalizability of these analyses of learning should be viewed skeptically. Since participants performed very well on this portion of the pretest, which was composed of

some questions from the postlecture test, the possibility of their demonstrating new learning from the video was limited.

Social Dynamics

Lastly, within most learning environments, social hierarchies form to govern the behaviors of group members. This change of behavior occurs because individuals do not want to disrupt the group dynamic by engaging in behaviors that violate group norms. In a real educational setting, violating a group norm can cause an individual to experience repercussions for their actions, including ostracism. Due to the design of the current study and the inherently temporary nature of the created "social group", these social dynamics were likely not formed and so participants may have not felt any real social pressure to actively conform to their group members' behaviors. Therefore, though the current data seem to refute social influence as a mechanism of attention contagion in non-hierarchical groups, the potential role of social influence as a mechanism of attention contagion should be further examined within preestablished social hierarchies, where social repercussions are possible.

REFERENCES

Aarts, H., Gollwitzer, P. M., & Hassin, R. R. (2004). Goal contagion: perceiving is for pursuing. *Journal of Personality and Social Psychology*, *87*(1), 23. https://doi.org/10.1037/0022-3514.87.1.23

Allen M, Poggiali D, Whitaker K, Marshall TR, van Langen J, Kievit RA (2021). "Raincloud plots: a multi-platform tool for robust data visualization." *Welcome Open Research*, **4**(63). doi:10.12688/wellcomeopenres.15191.2.

Ben-Shachar MS, Lüdecke D, Makowski D (2020). "effectsize: Estimation of Effect Size Indices and Standardized Parameters." *Journal of Open Source Software*, **5**(56), 2815. doi:10.21105/joss.02815, https://doi.org/10.21105/joss.02815.

Brohmer, H., Eckerstorfer, L., van Aert, R. C. M., & Corcoran, K. (2021). Do behavioral observations make people catch the goal? A meta-analysis on goal contagion. *International Review of Social Psychology*, *34*(1), Article 3. https://doi.org/10.5334/irsp.428

Brysbaert, M. (2019). How many participants do we have to include in properly powered experiments? A tutorial of power analysis with reference tables. *Journal of Cognition*, *2*(1), 16. http://doi.org/10.5334/joc.72

Campbell, E., & Salathé, M. (2013). Complex social contagion makes networks more vulnerable to disease outbreaks. *Scientific Reports*, *3*(1), 1905. https://doi.org/10.1038/srep01905

Carciofo R, Du F, Song N, Zhang K (2014) Mind Wandering, Sleep Quality, Affect and Chronotype: An Exploratory Study. *PLoS ONE* 9(3): e91285. https://doi.org/10.1371/journal.pone.0091285

Carriere, J. S. A., Seli, P., & Smilek, D. (2013). Wandering in both mind and body: Individual differences in mind wandering and inattention predict fidgeting. *Canadian Journal of Experimental Psychology/Revue Canadienne de Psychologie Expérimentale*, *67*(1), 19–31. https://doi.org/10.1037/a0031438

Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: The perception–behavior link and social interaction. *Journal of Personality and Social Psychology*, *76*(6), 893. https://doi.org/10.1037/0022-3514.76.6.893

Chisholm, J. D., Risko, E. F., & Kingstone, A. (2013). The embodiment of focus: investigating the impact of learning behavior on our cognitive state and other's perception of our cognitive state. *Journal of Experimental Psychology: Human Perception and Performance*, *39*(1), 100–110. https://doi.org/10.1037/a0028444

Cialdini, R. B., & Goldstein, N. J. (2004). Social influence: Compliance and conformity. *Annual Review of Psychology*, *55*(1), 591–621. https://doi.org/10.1146/annurev.psych.55.090902.142015

Cialdini, R. B., Reno, R. R., & Kallgren, C. A. (1990). A focus theory of normative conduct: Recycling the concept of norms to reduce littering in public places. *Journal of Personality and Social Psychology, 58(6), 1015.*

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. L. Erlbaum Associates.

Constantin A, Patil I (2021). "ggsignif: R Package for Displaying Significance Brackets for 'ggplot2'." PsyArxiv. doi:10.31234/osf.io/7awm6, https://psyarxiv.com/7awm6.

Fallone, G., Acebo, C., Arnedt, J. T., Seifer, R., & Carskadon, M. A. (2001). Effects of acute sleep restriction on behavior, sustained attention, and response inhibition in

children. *Perceptual and Motor Skills*, *93*(1), 213-229.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39(2),* 175–191. https://doi.org/10.3758/BF03193146

Forrin, N. D., Huynh, A. C., Smith, A. C., Cyr, E. N., McLean, D. B., Siklos-Whillans, J., Risko, E. F., Smilek, D., & MacLeod, C. M. (2021). Attention spreads between students in a learning environment. *Journal of Experimental Psychology: Applied*, *27*

Fox, J., Weisberg S (2019). Car: An R Companion to Applied Regression, Third edition. Sage, Thousand Oaks CA. https://socialsciences.mcmaster.ca/jfox/Books/Companion/.

Gligoric, N., Uzelac, A., & Krco, S. (2012). Smart classroom: Real-time feedback on lecture quality. *International Conference on Pervasive Computing and Communications Workshops*. https://doi.org/10.1109/PerComW.2012.6197517

Hodas, N. O., & Lerman, K. (2014). The Simple Rules of Social Contagion. *Scientific Reports*, *4*(1), 4343. https://doi.org/10.1038/srep04343

Hollis, R. B., & Was, C. A. (2016). Mind wandering, control failures, and social media distractions in online learning. *Learning and Instruction*, *42*, 104–112. https://doi.org/10.1016/j.learninstruc.2016.01.007

Hvitfeldt E (2021). paletteer: Comprehensive Collection of Color Palettes. R package version 1.3.0, https://github.com/EmilHvitfeldt/paletteer.

Iacopini, I., Petri, G., Barrat, A., & Latora, V. (2019). Simplicial models of social contagion. *Nature Communications*, *10*(1), 2485. https://doi.org/10.1038/s41467-019-10431-6

InvaderZap. (2023, July 21st). *Possible attention check? I wasn't going to risk it* [Online forum post]. https://www.reddit.com/r/ProlificAc/comments/155r59l/possible_attention_check_i_wasnt_going_to_risk_it/

Jones, M. H., Alexander, J. M., & Estell, D. B. (2010). Homophily Among Peer Groups Members' Perceived Self-Regulated Learning. *The Journal of Experimental Education*, *78*(3), 378–394. https://doi.org/10.1080/00220970903548020

Kalsi, S. S., Forrin, N. D., Sana, F., MacLeod, C. M., & Kim, J. A. (2023). Attention contagion online: Attention spreads between students in a virtual classroom. *Journal of Applied Research in Memory and Cognition*, 12(1), 59–69. https://doi.org/10.1037/mac0000025

Kane, M. J., Carruth, N. P., Lurquin, J. H., Silvia, P. J., Smeekens, B. A., von Bastion, Miyake, A. (2021). Individual differences in task-unrelated thought in university classrooms. *Memory & Cognition*, 49, 1247-1266. https://doi.org/10.3758/s13421-021-01156-3

Kane, M. J., Gross, G. M., Chun, C. A., Smeekens, B. A., Meier, M. E., Silvia, P. J., & Kwapil, T. R. (2017). For Whom the Mind Wanders, and When, Varies Across Laboratory and Daily-Life Settings. *Psychological Science, 28(9)*, 22–49. https://doi.org/10.1177/0956797617706086

Kane, M. J., Meier, M. E., Smeekens, B. A., Gross, G. M., Chun, C. A., Silvia, P. J., & Kwapil, T. R. (2016). Individual differences in the executive control of attention, memory, and thought, and their associations with schizotypy. *Journal of Experimental Psychology: General, 145*(8), 1017–1048. https://doi.org/10.1037/xge0000184

Kane, M. J., Smeekens, B. A., Meier, M. E., Welhaf, M. S., & Phillips, N. E. (2021). Testing the construct validity of competing measurement approaches to probed mind-wandering

reports. *Behavior Research Methods*, 1-40. https://doi.org/10.3758/s13428-021-01557-x

Kane, M. J., Smeekens, B. A., von Bastian, C. C., Lurquin, J. H., Carruth, N. P., & Miyake, A. (2017). A combined experimental and individual-differences investigation into mind wandering during a video lecture. *Journal of Experimental Psychology: General*, *146*(11), 1649–1674. https://doi.org/10.1037/xge0000362

Killingsworth, M. A., & Gilbert, D. T. (2010). A wandering mind is an unhappy mind. *Science*, *330*(6006), 932–932. https://doi.org/10.1126/science.1192439

Lee, T., Kim, D., Park, S., Kim, D., & Lee, S-J. (2022). Predicting mind-wandering with facial videos in online lectures. In Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR) Workshops (pp. 2104-2113).

Levy, D. A., & Nail, P. R. (1993). Contagion: A theoretical and empirical review and reconceptualization. *Genetic, Social & General Psychology Monographs*, *119*(2), 233-284.

Lindquist, S. I., & McLean, J. P. (2011). Daydreaming and its correlates in an educational environment. *Learning and Individual Differences*, *21*(2), 158–167. https://doi.org/10.1016/j.lindif.2010.12.006

Loersch, C., Aarts, H., Payne, K., B., & Jefferis, V. E. (2008). The influence of social groups on goal contagion. *Journal of Experimental Social Psychology*, *44*(6), 1555–1558. https://doi.org/10.1016/j.jesp.2008.07.009

Magnusson, K. (2023). *Interpreting Cohen's d effect size: An interactive visualization* (Version 2.6.0) [Web App]. R Psychologist. https://rpsychologist.com/cohend/

McVay, J. C., & Kane, M. J. (2010). Does mind wandering reflect executive function or executive failure? Comment on Smallwood and Schooler (2006) and Watkins (2008). *Psychological Bulletin, 136*(2), 188–197. https://doi.org/10.1037/a0018298

McVay, J. C., Kane, M. J., & Kwapil, T. R. (2009). Tracking the train of thought from the laboratory into everyday life: An experience-sampling study of mind wandering across controlled and ecological contexts. *Psychonomic Bulletin & Review*, *16*(5), 857–863. https://doi.org/10.3758/PBR.16.5.857

McVay, J. C., Meier, M. E., Touron, D. R., & Kane, M. J. (2013). Aging ebbs the flow of thought: Adult age differences in mind wandering, executive control, and self-evaluation. *Acta Psychologica*, *142*(1), 136–147. https://doi.org/10.1016/j.actpsy.2012.11.006

Mehrabian, A. (1969). Significance of posture and position in the communication of attitude and status relationships. *Psychological Bulletin*, *71*(5), 359–372. https://doi.org/10.1037/h0027349

Mottet, T. P., & Beebe, S. A. (2000, November). Emotional contagion in the classroom: An examination of how teacher and student emotions are related [Paper Presentation]. Annual Meeting of the National Communication Association, Seattle, WA, https://eric.ed.gov/?id=ED447522

Navarro, D. (2015). Learning statistics with R: A tutorial for psychology students and other beginners. (Version 0.6). University of New South Wales, Sydney, Australia. R package version 0.5.1, https://learningstatisticswithr.com.

Nolan, J. M., Schultz, P. W., Cialdini, R. B., Goldstein, N. J., & Griskevicius, V. (2008). Normative social influence is underdetected. *Personality and Social Psychology Bulletin*, 34(7), 913-923. https://doi.org/10.1177/0146167208316691

Parsons, S., (2021). splithalf: robust estimates of split half reliability. Journal of Open Source Software, 6(60), 3041, https://doi.org/10.21105/joss.03041

Peirce, J., Gray, J. R., Simpson, S., MacAskill, M., Höchenberger, R., Sogo, H., Kastman, E., & Lindeløv, J. K. (2019). PsychoPy2: Experiments in behavior made easy. *Behavior Research Methods, 51*(1), 195–203. https://doi.org/10.3758/s13428-018-01193-y

Pratt, J., Radulescu, P. V., Guo, R. M., & Abrams, R. A. (2010). It's alive! Animate motion captures visual attention. *Psychological Science, 21*(11), 1724-1730. https://doi.org/10.1177/0956797610387440

Radel, R., Sarrazin, P., Legrain, P., & Wild, C. (2010). Social contagion of motivation between teacher and student: Analyzing underlying processes. *Journal of Educational Psychology.* https://doi.org/10.1037/a0019051

R Core Team (2023). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.y, 102, 577–587.

Rambaran, J. A., Hopmeyer, A., Schwartz, D., Steglich, C., Badaly, D., & Veenstra, R. (2017). Academic functioning and peer influences: A short-term longitudinal study of network–behavior dynamics in middle adolescence. *Child Development, 88*(2), 523–543. https://doi.org/10.1111/cdev.12611

Real SAT II (1st). (1998). The College Board.

Revelle, W. (2023). psych: Procedures for Psychological, Psychometric, and Personality Research (Version 2.3.9) [R package]. Northwestern University, Evanston, Illinois. https://CRAN.R-project.org/package=psych

Risko, E.F., Anderson, N., Sarwal, A., Engelhardt, M. and Kingstone, A. (2012), Everyday attention: Variation in mind wandering and memory in a lecture. *Applied Cognitive Psycholo*gy, 26: 234-242. https://doi.org/10.1002/acp.1814

Risko, E. F., Anderson, N., Sarwal, A., Engelhardt, M., & Kingstone, A. (2011). Everyday attention: Variation in mind wandering and memory in a lecture. *Applied Cognitive Psychology, 26,* 234 –242. https://doi.org/10.1002/acp.1814

Risko, E.F., Anderson, N., Sarwal, A., Engelhardt, M. and Kingstone, A. (2012), Everyday attention: variation in mind wandering and memory in a lecture. *Applied. Cognitive Psychology*., 26: 234-242. https://doi.org/10.1002/acp.1814

Sarkar D (2008). *Lattice: Multivariate Data Visualization with R*. Springer, New York. ISBN 978-0-387-75968-5, http://lmdvr.r-forge.r-project.org.

Sayette, M. A., Reichle, E. D., & Schooler, J. W. (2009). Lost in the sauce: The effects of alcohol on mind wandering. *Psychological Science*, *20*(6), 747-752. https://doi.org/10.1111/j.1467-9280.2009.02351.x

Smallwood, J., & Schooler, J. W. (2006). The restless mind. *Psychological Bulletin*, *132*(6), 946–958. https://doi.org/10.1037/0033-2909.132.6.946

Smallwood, J., & Andrews-Hanna, J. (2013). Not all minds that wander are lost: the importance of a balanced perspective on the mind-wandering state. *Frontiers in Psychology*, *4*, 441. https://doi.org/10.3389/fpsyg.2013.00441

Szpunar, K. K., Khan, N. Y., & Schacter, D. L. (2013). Interpolated memory tests reduce mind wandering and improve learning of online lectures. *Proceedings of the National Academy of Sciences*, *110*(16), 6313-6317. https://doi.org/10.1073/pnas.1221764110

The jamovi project (2023). jamovi (Version 2.3) [Computer Software]. Retrieved from https://www.jamovi.org

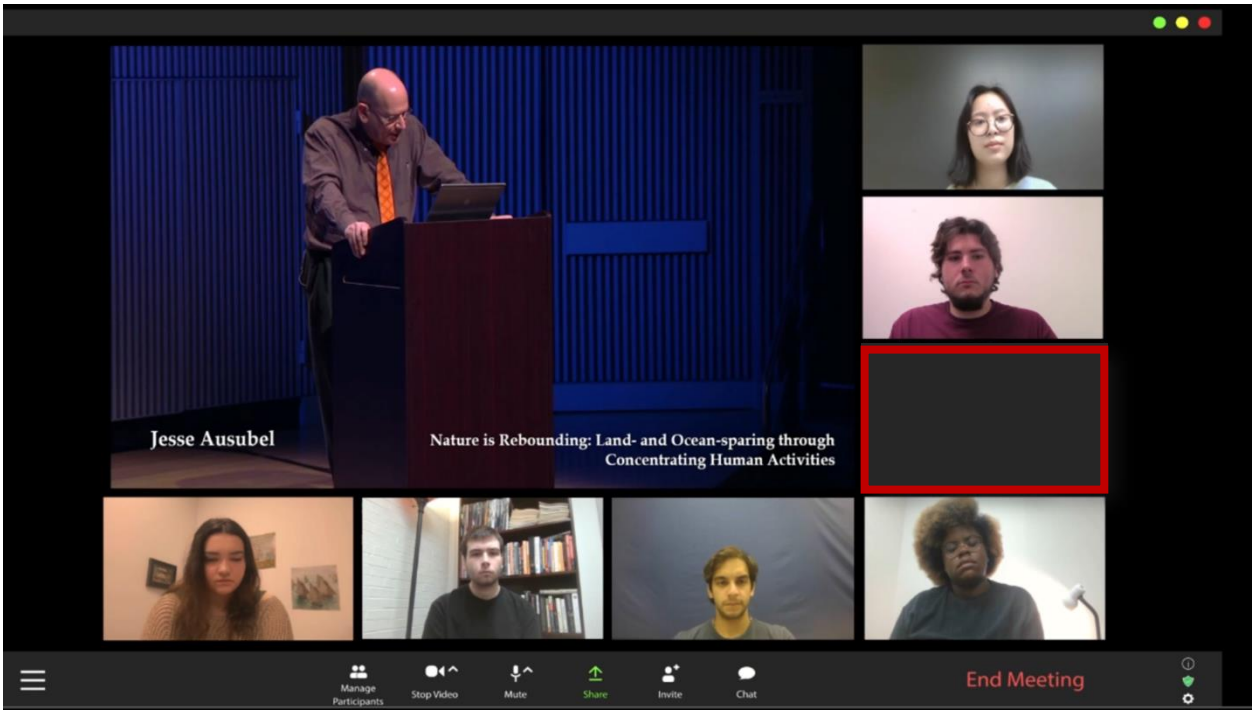
Wammes, J. D., Seli, P., Cheyne, J. A., Boucher, P. O., & Smilek, D. (2016). Mind wandering during lectures II: Relation to academic performance. *Scholarship of Teaching and Learning in Psychology*, *2*(1), 33–48. https://doi.org/10.1037/stl0000055

Ware, J. E., & Williams, R. G. (1975). The Dr. Fox effect: A study of lecturer effectiveness and ratings of instruction. *Journal of Medical Education*, *50*(2), 149–156.

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L. D., François, R.,Yutani, H. (2019). Welcome to the tidyverse. *Journal of Open Source Software*, 4(43), 1686. https://doi.org/10.21105/joss.01686

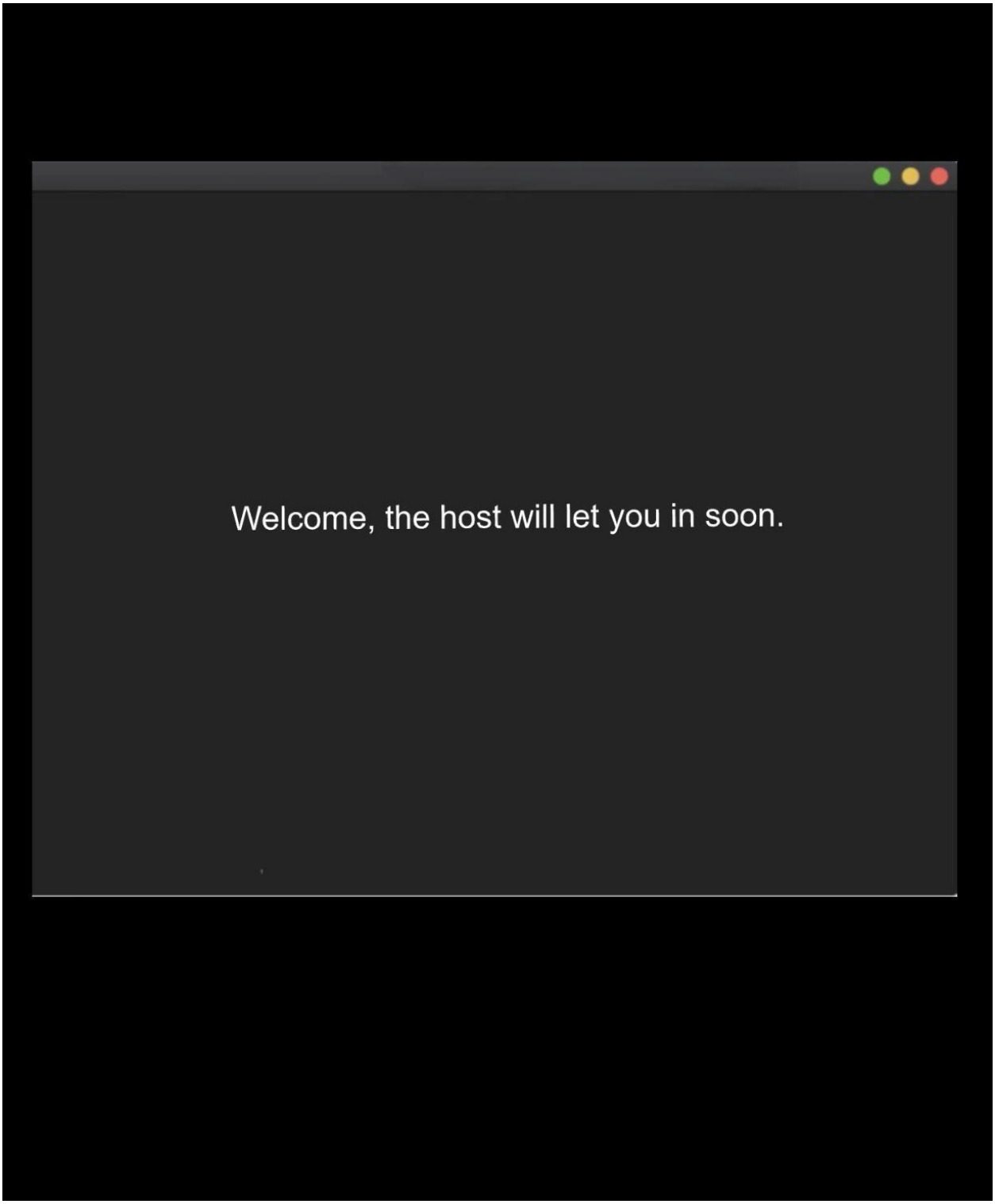
Wilke, C., Fox, S. J., Bates, T., Manalo, K., Lang, B., Barrett, M., Stoiber, P., Denney, B., Hesselberth, J., wsteenhu, Manalo, K., Lang, B., Selker, R., Uhlitz, F., & zaczap. (2021). wilkelab/cowplot: 1.1.1 (1.1.1). Zenodo. https://doi.org/10.5281/zenodo.4411966

APPENDIX A: VIDEO LECTURE ENVIRONMENT



Note. The red rectangle indicates the location of participant video-feeds during the experiment, the rectangle was not present during the experiment.

APPENDIX B: PRELECTURE WAITING ROOM



APPENDIX C: PRELECTURE TEST

Domain pretest:

1. **All of the organisms of one species living in one area are known as a(n):**
    a. Community
    b. Population*
    c. Organelle
    d. Ecotype

2. All the organisms living in one area are known as a(n):
    a. Community*
    b. Population
    c. Species
    d. Ecotype

3. **Epiphytes are:**
    a. A climax community of plants in the desert
    b. photosynthetic plants that grow on trees rather than supporting themselves*
    c. vegetation found in grasslands
    d. decomposers in taiga

4. **The result of the action of decomposers is:**
    a. Decrease in Ammonia
    b. Increase in Transpiration
    c. Nitrogen Fixation*
    d. Increase in Oxygen Ecotype

5. **Eutrophication refers to:**
    a. The process that caused the depletion of the ozone layer
    b. Global Warming
    c. The process that happens to a lake when it over-absorbs nutrients*
    d. All of the above

6. **Today's worldwide human population can best be described as:**
    a. Oscillating
    b. Declining
    c. Fluctuating Near Equilibrium
    d. Growing Exponentially*

7. **Characteristics of the arctic tundra biome include which of the following (select 1):**
    a. Long & Cold Winters*
    b. Coniferous Trees as the Dominant Species
    c. High Levels of Precipitation
    d. Short & Temperate Winters

8. **All of the following processes occur as part of the carbon cycle EXCEPT:**
    a. Transpiration*
    b. Organic Decay
    c. Forest Fires
    d. All of the above

9. **Which of the following plays the greatest role in producing acid rain:**
    a. Methane
    b. Sulfur Oxide*
    c. Carbon Dioxide
    d. Carbon Monoxide

10. **Fs that influence population density include which of the following:**
    a. Competition with the Same Species
    b. Competition among Different Species
    c. Predation
    d. All of the above*

11. **Which of the following individuals is most fit in evolutionary terms:**
    a. a child who does not become infected with any of the usual childhood diseases (e.g., measles or chickenpox)
    b. a 40 year old woman with 7 children*
    c. An 80 year old woman with 1 child
    d. a childless man who can run a mile in less than 5 minutes

12. **Which of the following biomes contains the greatest diversity of species:**
    a. Temperate forest
    b. Temperate grassland
    c. Boreal taiga
    d. Tropical Rainforest*

13. **When did the great reversal begin in the U.S. use of resources?^**

a. 1959
b. 1970*
c. 2014
d. 2021

14. What does most corn become? ^

a. Food for cows and pigs *
b. Tortillas
c. A gasoline additive
d. Alcohol

15. Which of the following is good for water conservation? ^

a. Corn
b. Potatoes *
c. Tomatoes
d. Animal

16. How much food (in lbs) is thrown away globally in a one-year time span? ^

a. 500,000
b. 985,000
c. 1.3 billion*

17. What is a forest transition?^

a. The use of forests for agriculture
b. Losing more forest than gaining
c. Gaining more forest than losing *
d. The use of forest for house development

18. How has water consumption changed since 1970? ^

a. Bottling companies have expanded production
b. Less water is used for agriculture
c. It has increased*
d. It has decreased

19. What is the most produced crop in the U.S.? ^

a. Wheat
b. Soybeans
c. Potatoes
d. Maize *

20. What is dematerialization? ^

a. Fewer people owning items
b. Using less to produce more *
c. Producing less to use more
d. The breaking of an item

*Indicates correct answer

^ Indicates questions included in pre and postlecture tests

APPENDIX D: LECTURE POSTTEST

1. What did the group of students in New Jersey first do when they came across the bear in the woods?
    a. Run
    b. Call The Police
    c. Take Pictures *
    d. Ignore the bear
2. How many black bears were killed in New Jersey after the hunt?
    a. 100
    b. 267*
    c. 516
    d. 472
3. According to the lecturer, does our economy work in tandem with nature?
    a. Yes
    b. No *
    c. Sometimes
    d. We don't know yet
4. When did the great reversal begin in the U.S. use of resources?^
    a. 1959
    b. 1970*
    c. 2014
    d. 2021
5. Why did the series of decouplings occur?
    a. To prevent our economy from advancing from exploitation*
    b. To keep bears away
    c. Because they wanted to
    d. To encourage our economy to advance and exploit
6. What does most corn become? ^
    a. Food for cows and pigs *
    b. Tortillas
    c. A gasoline additive
    d. Alcohol
7. Which of the following is good for water conservation? ^
    a. Corn
    b. Potatoes *
    c. Tomatoes
    d. Animal
8. How much food (in lbs) is thrown away globally in a one-year time span? ^
    a. 500,000
    b. 985,000
    c. 1.3 billion*
    d. 2.8 billion

9. What is a forest transition?^
    a. The use of forests for agriculture
    b. Losing more forest than gaining
    c. Gaining more forest than losing *
    d. The use of forest for house development
10. When did forest transitions begin in the US?
    a. 1900 *
    b. 1958
    c. 1977
    d. 2002
11. What is the most important ecological trend on Earth Today?
    a. Waste management
    b. Global greening*
    c. Renewable resources
    d. Global warming
12. What is the MAIN cause for more plant growth in Finland?
    a. More CO2
    b. More rain
    c. Longer growing season*
    d. More nitrogen
13. What did trains used to be made of?
    a. Wood *
    b. Steel
    c. Bronze
    d. Other metals
14. What animal is still being consumed at a higher rate?
    a. Beef
    b. Chicken *
    c. Fish
    d. Pork
15. How has water consumption changed since 1970? ^
    a. Bottling companies have expanded production
    b. Less water is used for agriculture
    c. It has increased*
    d. It has decreased

16. When did acre and yield decouple?
    a. 1940 *
    b. 1950
    c. 1960
    d. 1970
17. What is the most produced crop in the U.S.? ^
    a. Wheat
    b. Soybeans
    c. Potatoes
    d. Maize *
18. All of the following are agricultural inputs EXCEPT which one?
    a. Nitrogen
    b. Phosphorous *
    c. Water
    d. Potash
19. What crop is keeping water from being scarce in Idaho and California?
    a. Soy
    b. Corn
    c. Wheat
    d. Potatoes *
20. What is dematerialization? ^
    a. Fewer people owning items
    b. Using less to produce more *
    c. Producing less to use more
    d. The breaking of an item

* Indicates correct answer
^ Indicates questions included in pre and postlecture test

APPENDIX E: GOAL CONTAGION AND SOCIAL INFLUENCE MEASURES

Goal Contagion:

1. “How important was the lecture content.”
   0 (“Not at all”) to 10 (“Extremely”)

2. “On average, how motivated to learn did the other participants appear.”
   0 (“Not at all”) to 10 (“Extremely”)

Social Influence:

"To what extent do you agree/disagree with the following statements"

1."Sometimes I thought about the fact that other participants could see me"

2. "I paid more attention because other participants could see me"

3."I paid more attention because I know the researcher will be able to see me."

("strongly disagree"), ("disagree"), ("agree"), or ("strongly agree").

APPENDIX F: INCLUSION QUESTIONNAIRE

Demographics:

1. "*What is your biological age in years"?*
Response: free response text box

2. "*Please type in your birth year"?*
Response: free response text box

3. "*What is your gender identity"?*
(a.) Female (b.) Male (c.) Non-binary/Gender Non-conforming (d.) I do not identify with any of these

4. *"Please indicate the race and ethnicity that best describes you, if you identify with multiple options, select all options that apply"*
   (a.) Black or African America (b.) Asian (c.) Caucasian (d.) Native Hawaiian or Other Pacific Islander (e.) American Indian or Native Alaskan

5. "*Which of these is the highest level of education you have completed"?*
   (a.) Highschool Diploma/A-Levels (b.) Technical/Community College (c.)Undergraduate degree: BA/BSc/other (d.) Graduate Degree: MA/MSc/MPhil (e.) Doctoral Degree

Inclusion:

1. "*While completing the experiment how noisy (people, TV, movies) was your immediate environment.*"
   "not at all noisy", "somewhat noisy," "moderately noisy", or "extremely noisy"

2. "*During the experiment, how distracted were you by your immediate environment."*
   "not at all distracted", "slightly distracted", "moderately distracted", or "extremely distracted"

3. "*During the experiment how often did you interact with: phone (calls or texts), email, or social media; video games."*
   "never", "some of the time", "most of the time", or "all of the time"

4. "*Did you use any outside resources during the post-lecture test (e.g., a search engine)"*
   "Yes" or "No"

APPENDIX G: EMBEDDED THOUGHT PROBES

Instructions:

At certain times during the lecture the video square will turn grey and you will be prompted to indicate the content of your thoughts directly preceding the grey screen, indicate the content of your thoughts by typing the corresponding keyboard key (1-8) that most closely aligns with your thought content. During this experiment, you may begin thinking about things other than the task at hand. When asked, via a thought probe, what you were just thinking about, please try your best to honestly assess the content of your thoughts directly preceding the probe. After clicking the "click to continue" button below, you will be presented with a sample thought probe to familiarize you with the process.

Probes:

Please indicate the content of your thoughts just before this message—this will occur via a multiple-choice window on the video screen:

(1) *On-task on the lecture* - participants are on task and thinking about the current content being discussed in the video

(2) *Lecture-related ideas* - participants are thinking about an aspect of the lecture topic that is not currently being presented in the video

(3) *How well I'm understanding the lecture* - participants are actively evaluating their comprehension of the lecture material

(4) *Everyday personal concerns* - thoughts about everyday tasks, goals, concerns, or personal worries (e.g., "Did I turn the oven off before leaving the house"?)

(5) *Daydreams* - thoughts about fantasies or unrealistic events

(6) *Current state of being* - thoughts about one's current physical, emotional, or psychological state

(7) *External environment* - thoughts about something lecture-unrelated in the immediate environment

(8) *Other* – any thoughts that fit outside of the other categories.