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AMERICAN PSYCHOLOGICAL ASSOCIATION

Journal of Experimental Psychology: General

ISSN: 0096-3445

2024, Vol. 153, No. 10, 2573–2587
https://doi.org/10.1037/xge0001620

Social Contagion of Challenge-Seeking Behavior

Cansu Ogulmus[1], Ying Lee[1], Bhismadev Chakrabarti[1, 2], and Kou Murayama[1, 3, 4]
[1] School of Psychology and Clinical Language Sciences, University of Reading
[2] Department of Psychology, Ashoka University
[3] Department of Social Sciences, Hector Research Institute of Education Sciences and Psychology, University of Tübingen
[4] Research Institute, Kochi University of Technology

Despite having little economic utility, people are sometimes motivated to seek challenges (i.e., proactively choosing to work on a more difficult task than an easier one). The present study investigated whether just observing others' challenge-seeking behaviors could motivate people to seek more challenging tasks—the social contagion effect of challenge-seeking. The participants were presented with pairs of options, each associated with a math word problem of a certain difficulty level. We examined whether the participants' preference for a more challenging (i.e., more difficult) option changes after observing the decisions of others who hold a challenge-seeking or a challenge-avoiding attitude. Five experiments consistently showed that, while the participants generally avoided challenging word problems, observing challenge-seeking in others increased the probability of participants choosing more challenging options. These results indicate that our motivation to seek challenges may be instilled, in part, through social processes.

Public Significance Statement

Our research has revealed that challenge-seeking behavior can be promoted through social influence. This provides the groundwork for future research to unravel the influence of various social factors on challenge-seeking behavior and to design interventions that evoke positive feelings about challenges in schools and workplaces.

Keywords: social contagion, challenge-seeking, mastery behavior, achievement motivation

Supplemental materials: https://doi.org/10.1037/xge0001620.supp

Chess, Rubik's Cube, crossword puzzles, and Sudoku are among popular simple intellectual entertainments. People engage in these mental challenges to experience the thrill of discovery (Latorre & Soto-Sanfiel, 2011). Every year, participants from 30 different countries attend puzzle contests (World Puzzle Federation, n.d.), and over 600,000 Sudoku magazines are sold per month in Japan (Do you sudoku?, 2005). These individuals invest a great deal of effort, time, and money to experience brief moments of satisfaction, suggesting a desire to seek challenges. Critically, previous studies have found that attitudes and norms held toward challenge-seeking can influence achievement and engagement. For example, lower achieving students with positive challenge-seeking norms improved their academic

This article was published Online First September 9, 2024.
Megan M. Saylor served as action editor.
Cansu Ogulmus https://orcid.org/0000-0002-2522-9560
Ying Lee https://orcid.org/0000-0001-9491-4919
Bhismadev Chakrabarti https://orcid.org/0000-0002-6649-7895
Kou Murayama https://orcid.org/0000-0003-2902-9600
This project is supported by the Leverhulme Trust (Project Code: H5404100 awarded to Kou Murayama) and the Alexander von Humboldt Foundation (the Alexander von Humboldt Professorship endowed by the German Federal Ministry of Education and Research awarded to Kou Murayama).

The authors have no conflicts of interest to disclose. The authors have complied with the American Psychological Association's ethical standards and code of conduct when handling data collection.

Prior to this publication, Cansu Ogulmus presented this work at the LEAD Anniversary Conference at Eberhard Karls University of Tübingen (Germany), held from October 19 to 21, 2022. Anonymized data, analysis codes, supplementary analyses and materials (https://osf.io/tdwzs), and preregistration of the last experiment (https://osf.io/6cgwh) are available on the Open Science Framework.

Cansu Ogulmus played a lead role in conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, software, visualization, writing–original draft, and writing–review and editing. Ying Lee played a supporting role in conceptualization and writing–review and editing. Bhismadev Chakrabarti played a supporting role in conceptualization, supervision, and writing–review and editing. Kou Murayama played a lead role in conceptualization, funding acquisition, methodology, and supervision and a supporting role in project administration, resources, and writing–review and editing.

Correspondence concerning this article should be addressed to Cansu Ogulmus, School of Psychology and Clinical Language Sciences, University of Reading, Earley Gate, Whiteknights Road, Reading, RG6 6ES, United Kingdom, or Kou Murayama, Hector Research Institute of Education Sciences and Psychology, University of Tübingen, Europastraße 6, 72072 Tübingen, Germany. Email: cansu.ogulmus@gmail.com or k.murayama@uni-tuebingen.de

performance after getting informed about the malleable nature of intelligence (Yeager et al., 2019). Another study showed that sales representatives with high challenge-seeking tendencies employed desired work strategies in the selling process and achieved a greater number of sales (Miao et al., 2007). Overall challenge-seeking is positively correlated with academic intrinsic motivation and is predictive of academic success (Porter et al., 2020). Therefore, investigating factors that influence challenge-seeking behavior has great practical implications.

Challenge-seeking is a behavioral manifestation of an achievement-related driving force that energizes the individual to take action (Harter, 1981; Ryan & Deci, 2000). It is often operationalized as the number of choices made to engage in difficult or demanding tasks rather than taking the easier option (Porter et al., 2020). It is indicative of the inclination to invest the mental and/or physical effort needed to achieve a challenging goal. Although closely linked, challenge is distinct from effort. The level of difficulty or challenge corresponds to a property of a stimulus that determines how much mental or physical work is required, whereas effort is the intensity of mental or physical work exerted to perform an activity (Inzlicht et al., 2018). Effort has been quantified as the degree of engagement in a tedious but skill-developing task (e.g., the amount of time spent solving math problems) despite more enjoyable distractors (e.g., watching entertaining videos; Galla et al., 2014). While effort is a mental or a physical investment, challenge-seeking is the willingness to make an investment. The relationship between effort and challenge-seeking has previously been shown. For instance, when children were led to believe that their efforts were effective and valued, they showed greater challenge-seeking tendencies (Master, 2011; Mueller & Dweck, 1998).

Various theories have been proposed to understand why we seek out challenges. According to the self-determination theory (Ryan & Deci, 2020), people seek optimally difficult challenges to satisfy their need for competence; this is the motivation to feel a sense of mastery, where one can succeed and grow. Challenges that are too difficult and frequent are perceived as aversive, while challenges that are too easy are found to be boring. Only when challenges are balanced with one's perception of their skills is a pleasant sensation from being fully engaged with an activity, a flow state, experienced (Csikszentmihalyi, 2014). McClelland et al. (1953) have suggested that the need for achievement, which represents the strength of an individual's concern with achievement, provides the impulse toward facing challenges in the interest of attaining excellence (Lee, 1996; McClelland & Clelland, 1961; McClelland et al., 1989). This impulse could be satiated by the feeling of success, intensified by the anticipation of failure (McClelland et al., 1949), and guided by self-attributed explicit achievement goals (McClelland et al., 1989). Maintaining positive self-esteem, self-definition (Gendolla & Richter, 2010), and the self-improvement motive (Sedikides & Strube, 1997) are also suggested to precede challenge-seeking behavior.

Building upon these theoretical backgrounds, empirical studies have identified a number of factors promoting challenge-seeking behavior, such as mastery goal orientation (A. J. Elliot & Harackiewicz, 1996; Jagacinski et al., 2008; W. Lee & Kim, 2014) and growth mindset (Kray & Haselhuhn, 2007; Rege et al., 2021; Yeager et al., 2019). Furthermore, Sakaki et al. (2023) showed that challenge-seeking behavior is associated with activity in reward-related areas in the brain (e.g., the ventral striatum), suggesting its positive rewarding value. In addition to the studies indicating the trait-like nature of challenge-seeking behavior, previous research suggests its malleability to contextual factors. For instance, performance-based rewards and salient negative feedback (Malkiewich et al., 2016) reduced challenge-seeking tendencies, while autonomy (Pathania et al., 2019) and ego-involving instructions (Jagacinski et al., 2008) facilitated it.

However, there is a lack of empirical work examining the perception and interpretation of *social cues* altering challenge-seeking behavior, except for a few studies showing the effects of social support (Baten et al., 2020; Reinboth et al., 2004) and social comparison (Jagacinski et al., 2008). This lack of empirical evidence is rather surprising, as both the self-determination theory and the theory of the need for achievement indicate the importance of social context (Bandura, 1977; Deci & Ryan, 1985; McClelland et al., 1953).

We propose that challenge-seeking behavior can be transmitted through *social contagion*. When people observe others seeking challenges, they become inclined to seek challenges themselves. Levy and Nail (1993) defined social contagion as the unintentional transmission of one's behaviors, attitudes, and motives to people in their social environment. This social contagion has been observed in various forms (Burgess et al., 2020). For example, there have been many studies showing that people have a tendency to imitate others' motor behavior (imitation or mimicry). This phenomenon has been experimentally studied in stimulus–response compatibility research, in which the participants were faster at executing the motor actions (hand, arm, foot, or mouth) cued by differently colored stimuli (e.g., open your hand for the blue cue, close it for the red cue) when the videos of the same motor actions were superimposed over the cues (Stürmer et al., 2000). Mimicking others' behaviors extends to various motor actions including face rubbing, foot shaking (Chartrand & Bargh, 1999), face touching (Cheng & Chartrand, 2003), posture (Lafrance & Broadbent, 1976), facial expressions (Seibt et al., 2015), and even speech patterns (Adank et al., 2013). Research has also shown that people have a tendency to conform to social norms (Cialdini et al., 1990; Lindenberg et al., 2021) or the actions of the majority (Zaki et al., 2011). Individuals often shift their initial choices toward the preferences of others (Asch, 1951, 1956; Zaki et al., 2011), especially if the observed others are believed to be experts (Campbell-Meiklejohn et al., 2010; Izuma & Adolphs, 2013). There are also studies showing the contagion effects of mental states such as emotions (Hatfield et al., 1993; Parkinson, 2011; Wild et al., 1992, 1997), attitudes (Newman, 2004), and decision-making behavior such as risk-seeking (Reiter et al., 2019; Suzuki et al., 2016).

Despite the vast literature on the imitation of motor actions, conformity to social norms, and the contagion of emotions, attitudes, and decision making, the number of studies showing the social contagion of *motivated* behavior is still limited. To engage in challenge-seeking behavior, people are required to have a substantial motivation because challenge-seeking involves a considerable mental and/or physical cost. The biggest cost is the requirement of effort mobilization (e.g., Kool et al., 2010) that challenge-seeking involves. In fact, when a task is made challenging, for example, frequent task switching (Kool et al., 2010), there is an increased demand on the working memory (Westbrook et al., 2013) and an increased number of shifts in spatial attention (Apps et al., 2015). This normally requires the substantial mobilization of effort. Exerting effort is considered aversive, and the rewards associated with highly effortful cognitive tasks are often devalued (*effort discounting*; Apps et al., 2015). Moreover, engaging in challenging cognitive activities requires the utilization of one's limited time (Tse et al., 2020), money (Hanson, 2023), and cognitive resources (Chen et al., 2018; Palmwood & McBride, 2019). Investing time or money to pursue certain challenges means sacrificing skill enhancement in other domains (Tse et al., 2020). When cognitive resources are used, it can lead to declines in performance related to subsequent cognitive tasks (Sweller, 1988). Furthermore, challenge-seeking always entails the risk of failure. The expectation of failure and the uncertainty of outcomes that accompany challenge-seeking behaviors are likely to induce anxiety (Hobfoll et al., 2018; Maddi, 2004; Ortega & Pipal, 1984), especially for those suffering from certain health problems (Low et al., 2009). If challenge-seeking behavior is practiced too frequently, the performers' anxiety levels will proportionally increase as well (Csikszentmihalyi, 2014). Therefore, the social contagion of challenge-seeking behavior requires a change in people's motivation, which cannot be easily reduced to mere imitation (Chartrand & Bargh, 1999; Cheng & Chartrand, 2003; Lafrance & Broadbent, 1976) or norm conformity (Cialdini et al., 1990).

There are several studies showing the effects of social contagion on motivated behavior (Radel et al., 2015; Wild et al., 1997). For example, some studies have examined the social contagion of motivation using survey and social network data collected in real classrooms (Li & Stone, 2018; McNabb et al., 2020; Rienties et al., 2009; Shin & Ryan, 2014). However, these studies are correlational in nature. Research on goal priming has sometimes shown the causal effects of social cues on people's goals (for a review, see Bargh, 2006). For instance, individuals exhibited heightened perseverance and performance in an anagram task when they were primed with the images/names of their significant others who held achievement-oriented goals (Chartrand et al., 2007; Fitzsimons & Bargh, 2003; Morrison et al., 2007; Shah, 2003). However, research on goal priming has suffered from replication issues (Doyen et al., 2012; Harris et al., 2013; Kahneman, 2012; Pashler et al., 2013), and there is a definite need for establishing a robust social contagion effect for motivated behavior.

In this study, we investigated whether challenge-seeking is socially contagious in a rigorous manner using a task that enabled us to measure the participants' behaviors before and after observing others' challenge-seeking behaviors. In a *challenge-seeking task* adapted from Suzuki et al. (2016), the participants were asked to observe two confederates deciding to solve easy or difficult math word problems. The participants were either presented with a confederate that showed a challenge-seeking attitude followed by a confederate with a challenge-avoiding attitude, or vice versa. This way, we manipulated the challenge-seeking behavior of confederates within participants. Importantly, the task included trials in which the participants selected the math word problems they preferred to solve, and challenge-seeking behavior was operationalized as the frequency of selecting more difficult math word problems. We hypothesize that after observing a challenge-seeking confederate, the participants would show an increase in challenge-seeking behavior, compared to their baseline challenge-seeking tendencies. Similarly, after the participants observe a challenge-avoiding confederate, they would show a decrease in challenge-seeking behavior.

Although the main research question was to examine the presence of the social contagion effect, we also conducted exploratory analyses to investigate the correlates of said contagion effects using the variables previously revealed to indicate differences in challenge-seeking behavior. These include age (Giambra, 1974; Veroff et al., 1980), gender (Beyer, 1990; Slade & Rush, 1991), math anxiety and math self-concept (Broda et al., 2023), as well as achievement goal orientation (A. J. Elliot & Dweck, 2013; Jagacinski et al., 2008; W. Lee & Kim, 2014) and trait intrinsic motivation (Moneta, 2004).

Method

Participants and Design

A total of 309 participants were recruited for four experiments (Experiments 1–4). Sample sizes for experiments were all predetermined (i.e., there was no interim analysis) by considering the study budget at the time of each experiment. In addition to these experiments, we conducted a preregistered replication study (Experiment 5), consisting of 149 participants. The preregistration of Experiment 5 is available on the Open Science Framework at https://osf.io/6cgwh. To determine the sample size, we first conducted a power analysis using $\alpha = .05/3$, power = .80, and $dz = 0.45$, which is the effect size from Experiment 3. This indicated the desired sample size of 55. Because the effect size included some uncertainty and we had a budget to collect more data, we aimed to collect data from 100 usable participants. Therefore, we decided to recruit about 150 participants to account for a 30% possible exclusion rate (which was estimated by previous experiments; see below).

After the first experiment, we noticed that there were quite a few participants who (a) suggested that they had some doubts about the confederates in the postexperiment survey that asked whether they believed if the confederates were real people and (b) failed to correctly predict the challenge-seeking tendencies of the two confederates. While we understand that these behaviors do not necessarily indicate that our manipulation was unsuccessful for these participants (e.g., the use of the manipulation check question might have hinted that the confederates might not be real), we decided to adopt a conservative approach and exclude these participants. We maintained these exclusion criteria in the following experiments. In total, the first 32 and then 114 participants were excluded for respective reasons, and the details of these criteria are described in the additional online materials at https://osf.io/tdwzs. Two more participants were discarded from the statistical analysis for technical reasons.

These criteria resulted in a final sample of 310 participants across all experiments. See Table 1 for final sample sizes and participant demographics. Age, gender, and math anxiety characteristics were not significantly different across the participants who were excluded versus those who were included in the statistical analysis, except for Experiment 3, in which significantly greater mean math anxiety scores were observed for the included participants (additional online Table S1 at https://osf.io/tdwzs; Ogulmus et al., 2023). All participants received a fixed amount of payment for compensation.

Experimental Procedure

All experiments were conducted online using Prolific. Because the payment was not contingent on the amount of challenge-seeking behavior, one could argue that the Prolific participants may be especially challenge-avoiding in order to obtain payment with minimum effort. To examine this possibility, we compared the Prolific workers' math-related challenge-seeking behaviors and math anxiety levels with those of university students (see the additional

Table 1
Initial and Final Sample Sizes and Participant Characteristics Across All Experiments

Experiment name	Initial sample size	Final sample size	M_{age} (years) (*SD*)	Age range (years)	Mean math anxiety score (*SD*)
Experiment 1	68 (24F, 43M, 1NS)	35 (15F, 19M, 1NS)	22.1 (3.9)	18–34	2.4 (1.4)
Experiment 2	80 (37F, 43M)	52 (24F, 28M)	22.7 (3.5)	18–36	2.5 (1.2)
Experiment 3	84 (49F, 32M, 3NS)	62 (36F, 24M, 2NS)	22 (3.7)	18–36	3.1 (1.0)
Experiment 4	77 (50F, 27M)	50 (37F, 13M)	24.6 (5.9)	18–49	2.8 (1.4)
Experiment 5 (preregistered)	150 (81F, 64M, 4NS)	111 (63F, 45M, 3NS)	23.7 (4.8)	18–50	2.5 (1.2)

Note. Math anxiety scores ranged from 1 (*not at all*) to 6 (*very anxious*). F, M, and NS symbols in gender rows stand for "female participants," "male participants," and "not-specified participants," respectively.

online materials for details at https://osf.io/tdwzs) in a study using a similar experimental design (Ogulmus, 2023). There were no clear differences between them.

The participants first read the information sheet and then filled out the consent form and the demographic information survey. Detailed information on how demographic information was recorded can be found in the additional online materials at https://osf.io/tdwzs. During the instructions phase, the participants practiced the challenge-seeking task for the duration of three trials, and their permission to anonymously replay their task choices to future participants was requested. Those who accepted chose a cartoon animal avatar image and created a nickname for themselves. Unbeknownst to the participants, their choices were not shared with the future participants of the study. This procedure was used to maintain the plausibility that the two confederates demonstrated throughout the experiment were recordings from previous participants of the study. After choosing a nickname and an avatar image, and seeing the ones chosen by the two confederates, the participants proceeded to the challenge-seeking task. When they finished, they filled out the postexperiment tasks and surveys. Before being redirected to Prolific, the participants were thanked, presented with a debrief form, and compensated £10 (per hour of their time). This study was given a favorable opinion by the University Research Ethics Committee at the University of Reading (UREC; Ethics Approval Number: UREC 21/08).

Challenge-Seeking Task

In each trial, a pair of red–gray pie charts representing the difficulty level of different word problems was presented on a white background (Figure 1A). Specifically, participants were told that its percentage indicates the correct answer rate (accuracy) of the word problem in a large sample pilot study. For instance, a pie chart showing 40% accuracy meant that 40% of the participants in the pilot study answered that word problem correctly. Note that we did not present participants with the word problems directly to avoid potential effects from their content. Instead, participants were led to believe that each pie chart represented a different word problem, which they might solve after the task (see the explanation about "make-your-choice trials" below). In this task, choosing the low accuracy word problem was considered a challenge-seeking behavior (i.e., preference for a more challenging/difficult task).

There were three types of trials. First, we measured participants' own challenge-seeking behavior using *make-your-choice* trials. Second, we induced challenge contagion manipulation by displaying confederates' challenge-seeking behavior in *observe* trials. Last, we checked whether participants correctly learned confederates' challenge-seeking tendencies in *predict trials.* The details of each type of trial are described below.

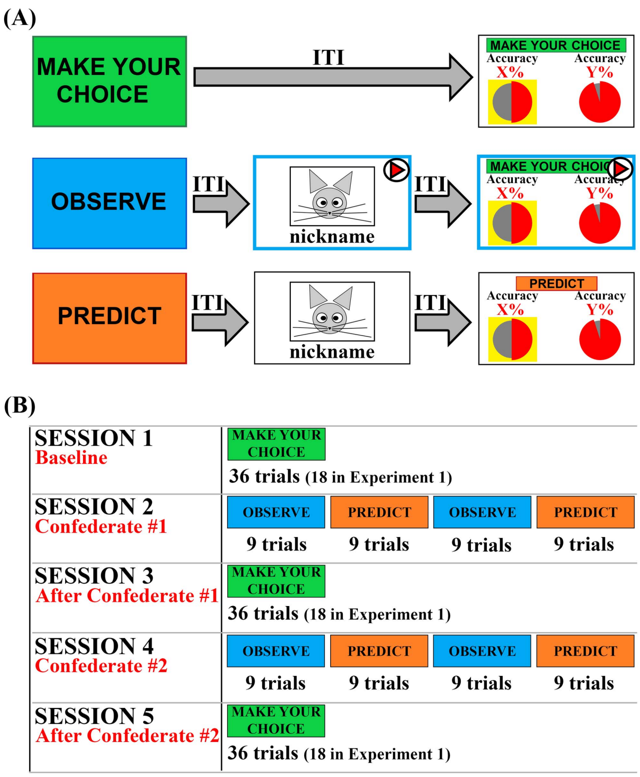
Make-Your-Choice Trials. In the make-your-choice trials, participants were asked to choose the word problems that they would like to solve based on their accuracy percentage value (difficulty). Participants were told that they would solve five word problems from their pool of selected questions at the end of the experiment. There were 36 make-your-choice trials per session for all experiments (except Experiment 1: 18 trials). A green colored "make your choice" cue was presented for 2 s at the beginning of these trials. The trials had a time limit of 6 s, after which they were presented with a warning sign in red that said "miss" (Figure 1A).

Observe Trials. In observe trials, the participants passively watched pie charts being selected by two different confederates. Unbeknownst to the participants, these confederates were computer-generated. For all participants, one confederate always chose 16 difficult word problems out of 18, referred to as the *challenge-seeking confederate*; the other always chose 16 easy word problems out of 18, referred to as the *challenge-avoiding confederate*. To simulate humanlike random behaviors, confederates were programed to display preference-incongruent behavior (e.g., challenge-seeking confederate choosing the easier option) in two out of 18 trials and to miss one out of 18 trials. Such trials were selected at random. A blue-colored image that says "observe" was presented for 2 s to signal the beginning of observe trials. The avatar image and nickname of the confederate were presented for 2 s right after the cue image. The screen had a blue frame throughout the trial to remind participants not to give a response (Figure 1A).

Predict Trials. Observe trials were followed by the predict trials. In these trials, participants were presented with a pair of pie charts, and they were asked to guess the word problem choices of the confederate whom they had just seen in the precedent observe trials. These trials helped us eliminate the participants who did not pay attention to the choices of the confederates during the observe trials or those who could not learn the challenge-seeking tendencies of the confederates. There were 18 predict trials per session. An orange box that says "predict" was displayed for 2 s to signal the start of predict trials. The avatar image and nickname of the confederate followed the cue image and presented for 2 s (Figure 1A). As in make-your-choice trials, participants were asked to respond within 6 s.

Figure 1

Trial Types and Numbers as Used in Challenge-Seeking Task



Note. Colored boxes represent different trial types (make-your-choice, observe, and predict). Make-your-choice trials in Sessions 1, 3, and 5 were used to measure participants' challenge-seeking, while social manipulations were applied in Sessions 2 and 4 using observe trials, in which the participants watched either a challenge-seeking or a challenge-avoiding confederate making word problem choices for themselves, and checked using predict trials, in which the participants guessed the word problem choices of the confederates. (A) Trial structure. Observe trials were highlighted with a light blue frame on the screen. Each trial type was signaled with a cue image for 2 s. In observe and predict trials, participants saw the nickname and the avatar image of the confederate for 2 s after the cue image. ITI stands for intertrial interval (M = 3 s, minimum = 2 s, maximum = 6 s). (B) Session structure. The number of make-your-choice trials was 18 per session in Experiment 1 and 36 per session for the rest of the experiments. Please note that the avatar image shown in this figure is for demonstration purposes only. The actual avatar images used in the experiment have been concealed to comply with copyright restrictions. See the online article for the color version of this figure.

Three types of trials were systematically placed in the five separate sessions in the experiment (Figure 1B). The first session consisted of 36 "make-your-choice" trials, which were used to assess participants' challenge-seeking behavior before the experimental manipulation (*baseline challenge-seeking*). In Sessions 2 and 4, observe and predict trials were intermixed with four blocks of nine trials, with the aim to manipulate the perceived behavior of the confederates as well as assess whether the participants correctly learned the confederates' behavioral tendency. Challenge-seeking and challenge-avoiding confederates were assigned to different sessions, and the order of the confederates was counterbalanced across participants. Half of the participants first observed the challenge-seeking confederate in Session 2, followed by the challenge-avoiding confederate in Session 4, while the other half observed this sequence in reverse order.

Sessions 3 and 5 also consisted of 36 make-your-choice trials each. Here the aim was to assess the effects of observing the challenge-seeking and challenge-avoiding confederates on participants' word problem choices.

Each experiment had a total of 180 trials (except for Experiment 1, which only had 126 trials) and lasted for 25–30 min. Each experiment used slightly different versions of the challenge-seeking task (see a full list of changed parameters in the additional online materials at https://osf.io/tdwzs). For example, we adjusted the number of confederate-incongruent trials to increase the plausibility of confederates in Experiments 2 and 3. We also changed the range of pie-chart percentage values to remove extremely difficult or easy word problems. Despite these minor differences, all experiments were aimed to examine the same social contagion effect of challenge-seeking behavior. The only exception was Experiment 4, in which we also investigated the effect of observing confederates on participants' confidence in correctly answering the word problems or their perceptions of word problem difficulty. These two factors could influence individuals' willingness to seek challenges. Therefore, in Experiment 4, apart from making word problem selections, participants were asked to rate their confidence and word problem difficulty from 1 (*not confident at all*/*very easy*) to 10 (*very confident*/*very hard*). Due to these additional elements, participants' challenge-seeking behavior in this experiment may not be straightforwardly interpreted. Nevertheless, we included this experiment for the sake of completeness.

Questionnaires and Additional Tasks

We measured participants' math anxiety (in all experiments), math self-concept (in Experiments 1–3), achievement goals, and trait intrinsic motivation (in Experiment 3 only) for exploratory purposes.

Math anxiety was measured using the following single item: "On a scale from 1 to 5, how math anxious are you" (Núñez-Peña et al., 2014).

Math self-concept was measured using six items (e.g., "It is easy to understand things in math") in which participants provided ratings on a 5-point scale ranging from 1 = *not true* to 5 = *absolutely true* (Marsh et al., 2019). Item reliability was good (Cronbach's α was .94).

Achievement goals were measured using a 2 × 2 Achievement Goal Questionnaire with four subscales: mastery-approach ("I want to learn as much as possible"), mastery-avoidance ("I worry that I may not learn all that I possibly could"), performance-approach ("It is important for me to do better than others"), and performance-avoidance ("I just want to avoid doing poorly"; A. J. Elliot & McGregor, 2001) adapted for our experiments (e.g., replaced "content of class" with "solutions to word problems"). Subscale items had acceptable reliabilities (Cronbach's α for mastery-approach, mastery-avoidance, performance-approach, and performance-avoidance were .80, .74, .70, and .55, respectively). Participants reported their ratings on a 7-point scale, ranging from *strongly disagree* (1) to *strongly agree* (7). Ratings within each subscale were averaged to create four achievement indices: mastery approach index, mastery avoidance index, performance approach index, and performance avoidance index.

Trait intrinsic motivation was measured using 12 items gathered from the three intrinsic motivation subscales of Global Motivation Scale: *to know* (e.g., "In general, I do things because I like making interesting discoveries"), *toward accomplishment* (e.g., "In general, I do things for the pleasure I feel mastering what I am doing"), and *to experience stimulation* (e.g., "In general, I do things in order to feel pleasant emotions"; Guay et al., 2003). Subscale items had good reliabilities (Cronbach's α for "to know," "toward accomplishment," and "to experience stimulation" were .85, .74, and .86, respectively). Participants reported their ratings on a 7-point scale ranging from *does not correspond accordingly* (1) to *corresponds completely* (7), and three intrinsic motivation indices were created by averaging the ratings for each subscale: knowledge index, accomplishment index, and stimulation index.

When the challenge-seeking task ended, participants were asked to complete an additional task (solving word problems) and a manipulation check survey, but these data were not subject to statistical analysis. Importantly, however, the survey included a binary question (yes/no) asking about the plausibility of confederates in the online experiment ("Did you believe that the participants you watched were real people? If not, why?"). This item was used to exclude participants (see our description of participants).

Data Analysis

We measured participants' choices at three time points: baseline, after observing the challenge-seeking confederate, and after observing the challenge-avoiding confederate. We refer to them as (a) baseline, (b) challenge-seeking, and (c) challenge-avoiding conditions.

Our main dependent variable is *challenge-seeking rates*, which is operationalized as the proportion of make-your-choice trials where the participant chose to solve the more difficult word problem. Each participant had three challenge-seeking rates, each corresponding to each of the make-your-choice sessions (Sessions 1, 3, and 5).

Data analysis was conducted using RStudio 2022.7.1.554 (RStudio Team, 2022) and IDE for R Version 4.1.3 (R Core Team, 2022). Mixed analysis of variance (ANOVA) was conducted using the "anova_test" function from the "rstatix" library (Kassambara, 2022). The sample size for Experiment 5 (preregistered) was determined using the "pwr.t.test" from the pwr package (Champely, 2020). Post hoc *t* tests were conducted using the "pairwise_t_test" function in the "stats" library (R Core Team, 2022) and corrected for multiple comparisons using the Bonferroni–Holm method. Exploratory logistic generalized linear model analysis was conducted using the "glmer" function from the "lme4" library (Bates et al., 2015). Meta-analysis was conducted using the "metafor" library (Viechtbauer, 2010). Figures were created using the "ggplot2" (R Core Team, 2022) and "metafor" libraries, as well as the "Open-visualizations in R and Python tutorial" (van Langen, 2020).

Transparency and Openness

Journal article reporting standards (Kazak, 2018) were followed when reporting sample sizes, data exclusions, experimental manipulations, and measures. Anonymized behavioral data and the analysis code are available in Open Science Framework (https://osf.io/tdwzs). Designs and analyses of Experiments 1–4 were not preregistered.

Results

Participants' Challenge-Seeking at Baseline

In all five experiments, participants generally avoided challenging word problems. Challenge-seeking rates across participants were between 12% and 30% at baseline, Experiment 1: .30 (SD = .31), Experiment 2: .18 (SD = .25), Experiment 3: .22 (SD = .26), Experiment 4: .12 (SD = .20), and Experiment 5 (preregistered): .19 (SD = .25).

This tendency to avoid challenging tasks was especially prevalent when the difference between the accuracy levels of two options was greater. A mixed-effects logistic regression model predicting word problem selection by the accuracy difference between the two word problems showed a decrease in the choice of harder word problem with the increase between the options' accuracy values, Experiment 1: $\beta = .03$, $SE = 0.009$, 95% CI [0.01, 0.05], $p = .003$; Experiment 2: $\beta = .02$, $SE = 0.002$, 95% CI [0.01, 0.02], $p < .001$; Experiment 3: $\beta = .03$, $SE = 0.003$, 95% CI [0.02, 0.03], $p < .001$; Experiment 4: $\beta = .03$, $SE = 0.003$, 95% CI [0.03, 0.04], $p < .001$; and Experiment 5 (preregistered): $\beta = .03$, $SE = 0.002$, 95% CI [0.02, 0.03], $p < .001$. This finding indicates that participants' choices were not random; they were highly guided by the difficulty level of the word problems.

To ensure that the effect of accuracy difference was not explained by the accuracy of the easier word problem, an additional mixed-effects logistic regression model was conducted. Specifically, this model included a predictor variable containing the accuracy value of the easy option in addition to that of the absolute difference between the accuracy values. The dependent variable was defined as the proportion of selecting easy word problems. Note that the model needed a different operationalization of the dependent variable in order to accommodate the new predictor variable. The accuracy value difference significantly predicted easy word problem selections even after controlling for the accuracy of the easy problem (additional online Table S2 at https://osf.io/tdwzs).

As the literature suggests that uncertainty is a driving factor of information-seeking behavior (van Lieshout et al., 2021), we also examined the role of uncertainty in choice behavior. Specifically, we calculated the entropy value of each pie chart using Boltzmann's entropy equation (Chamberlain & Hunten, 1990) and then took the difference between the entropy values of the pie charts. Note that entropy value is largest if the accuracy is 50%. This difference in entropy values was added to the previous mixed-effects logistic regression. We found that participants were more likely to select the higher entropy option as the difference between the options' entropy values increased. The effects of accuracy difference remained significant (Table 2). These results indicate that participants' choices were also guided by the uncertainty of their success; and word problems with accuracy values of around 50% were preferred more frequently.

Social Effects of Confederates' Choices on the Participants' Challenge-Seeking

Results From Individual Experiments

Results from the initial four experiments are jointly presented in Figure 2A (reported in additional online Table S3 at https://osf.io/

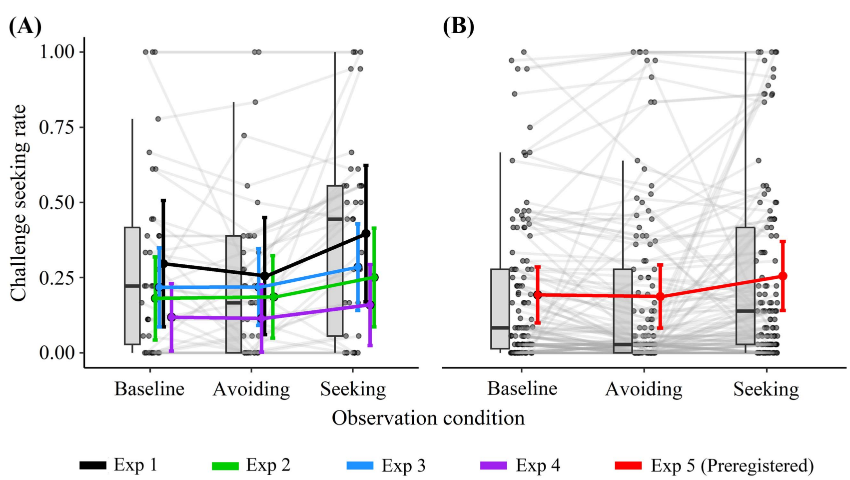
Table 2
Random-Effect Binomial Regression Analysis: Accuracy Difference and Uncertainty Difference Between Options

Experiment name		Estimate	*SE*	*p*	95% CI *LL*	95% CI *UL*
Experiment 1	Accuracy difference	0.03	0.011	.003	0.01	0.05
	Uncertainty difference	2.56	0.702	<.001	1.19	3.94
Experiment 2	Accuracy difference	0.02	0.001	<.001	0.01	0.02
	Uncertainty difference	0.77	0.220	<.001	0.33	1.20
Experiment 3	Accuracy difference	0.03	0.003	<.001	0.02	0.03
	Uncertainty difference	1.26	0.477	.008	0.33	2.19
Experiment 4	Accuracy difference	0.03	0.003	<.001	0.03	0.04
	Uncertainty difference	0.96	0.341	.005	0.29	1.62
Experiment 5 (preregistered)	Accuracy difference	0.03	0.002	<.001	0.02	0.03
	Uncertainty difference	0.81	0.301	.007	0.22	1.40

Note. *LL* = lower limit; *UL* = upper limit; CI = confidence interval; *SE* = standard error.

tdwzs). When the challenge-seeking condition was compared to the baseline condition, while generally greater challenge-seeking rates were observed in the challenge-seeking condition (all studies $p < .10$, additional online Table S4 at https://osf.io/tdwzs), the difference was statistically significant only in Experiment 3 when applied to a Holm-corrected α level (.05); Experiment 1, $t(34) = 2.37$, $p = .047$, $dz = 0.40$; Experiment 2, $t(51) = 2.24$, $p = .059$, $dz = 0.31$; Experiment 3, $t(61) = 2.63$, $p = .021$, $dz = 0.33$; and Experiment 4, $t(49) = 1.73$, $p = .182$, $dz = 0.24$. Greater challenge-seeking rates were observed in the challenge-seeking condition compared to the challenge-avoiding condition; Experiment 1, $t(34) = 3.67$, $p = .002$, $dz = 0.62$; Experiment 2, $t(51) = 2.52$, $p = .045$, $dz = 0.35$; Experiment 3, $t(61) = 3.52$, $p = .002$, $dz = 0.45$; and Experiment 4, $t(49) = 2.06$, $p = .133$, $dz = 0.29$ (Holm-corrected α level = .05). Pairwise comparisons of the challenge-seeking rates between the baseline and the challenge-avoiding conditions did not show significant effects in any of the experiments (Holm-corrected α level = .05; *p* values in Experiments 1–4 = .235, .763, .977, and .843, respectively). These results are generally in keeping with our first hypothesis that observing a challenge-seeking confederate increased challenge-seeking behavior, albeit results were more compelling when challenge-seeking rates in the challenge-seeking condition were

Figure 2
Challenge-Seeking Rates in Each Observation Condition



Note. Each participant's challenge-seeking rate for each observation condition is represented by gray points with connecting light gray lines for Experiments 1–4 (Panel A) and for Experiment 5 (preregistered; Panel B). Gray box plots show median challenge-seeking rates and lower/upper quartile values for each observation condition. Group-averaged challenge-seeking rates for each observation condition are demonstrated with black (Experiment 1), green (Experiment 2), blue (Experiment 3), purple (Experiment 4), and red (Experiment 5 [preregistered]) colored plots. It is possible to argue that the shift in challenge-seeking behavior can be explained by the regression to the mean. However, if the regression effect played a role in this context, we would expect to observe the opposite pattern in the challenge-seeking and challenge-avoiding conditions, which is not evident in our data. Exp = experiment. See the online article for the color version of this figure.

compared to that of the challenge-avoiding condition than to that of baseline. Nevertheless, all experiments showed the same direction of effects, and the effect sizes seem to be comparable. On the other hand, contrary to our second hypothesis, we did not obtain evidence that observing a challenge-avoiding confederate decreased challenge-seeking behavior relative to baseline.

In order to assess the reliability of the observed effects in Experiments 1–4, we conducted a preregistered experiment (Experiment 5) with a larger sample size ($N = 111$). This replication experiment employed the same procedure as Experiment 4 but did not include the confidence and perceived difficulty ratings (see additional online materials at https://osf.io/tdwzs). A 3 (observation condition) by 2 (confederate order) mixed ANOVA[1] showed a significant main effect of observation condition, $F(1.67, 181.63) = 6.78$, $p = .003$, $\eta^2_G = .01$; but not a main effect of confederate order, $F(1, 109) = 0.79$, $p = .375$, $\eta^2_G = .01$, nor an interaction effect between observation condition and confederate order, $F(1.67, 181.63) = 1.43$, $p = .242$, $\eta^2_G = .01$ (Figure 2B). Importantly, individual paired-samples t tests with Holm-adjusted α level showed significantly greater challenge-seeking rates in the challenge-seeking condition ($M = .26$, $SD = .30$) compared to both the challenge-avoiding condition ($M = .19$, $SD = .28$), $t(110) = 2.90$, $p = .013$, $dz = .28$, and the baseline condition ($M = .19$, $SD = .25$), $t(110) = 2.88$, $p = .013$, $dz = .27$. Challenge-seeking rates in the challenge-avoiding and baseline conditions were not significantly different, $t(110) = 0.33$, $p = .746$, $dz = .03$. These findings are consistent with the first four experiments, supporting our first hypothesis, but not our second hypothesis.

We believe that the absence of a significant effect between the baseline and challenge-avoiding condition was due to the floor effect, as participants generally avoided challenges (see the Discussion section). However, it is possible that participants felt a sense of similarity towards the challenge-avoiding confederate, and that this sense of similarity made participants adopt challenge-avoiding behavior. Furthermore, the contrasting challenge-seeking tendencies of the challenge-seeking confederate and participants may have contributed to the increased behavioral shift. To explore these possibilities, we first quantified the degree of similarity between each participant and confederate by calculating the absolute difference between the participants' challenge-seeking behaviors at the baseline condition and the confederates' challenge-seeking behaviors. We also computed the extent of behavioral change in both the challenge-avoiding and challenge-seeking conditions by taking the difference between the participants' challenge-seeking behaviors at the baseline and the participants' challenge-seeking behaviors after observing each confederate. The correlation of these two quantities for each experiment is reported in the additional online Table S6 at https://osf.io/tdwzs. No statistically significant correlations were observed in any of the experiments, suggesting that (a) the similarity between the participants and the challenge-avoiding confederate does not provide a plausible explanation for the absence of a statistically significant effect in the challenge-avoiding condition and (b) the incongruency between the participants' and challenge-seeking confederate's behavioral tendencies is unlikely to contribute to our results.

We also tested the possibility that an accurate prediction is a necessary condition for the contagion effect. The degree of social contagion was not correlated with the participants' accuracy in correctly predicting the challenge-seeking tendencies of the challenge-seeking (additional online Figure S1 at https://osf.io/tdwzs) and challenge-avoiding (additional online Figure S2 at https://osf.io/tdwzs) confederates (see additional online Table S7 at https://osf.io/tdwzs for mean and SD values of participants' predictions regarding each confederates' challenge-seeking tendencies).

Integrated Results

We further conducted a meta-analysis (including Experiment 5, the preregistered experiment) to get a more accurate estimate of the effect size. The forest plot is presented in Figure 3. The integrated effect size for the comparison between the challenge-seeking and challenge-avoiding conditions was $dz = 0.39$, 95% CI [0.27, 0.51]. The integrated effect size for the comparison between the challenge-seeking and baseline conditions was $dz = 0.30$, 95% CI [0.26, 0.34]. The integrated effect size for the comparison between the challenge-avoiding condition and baseline conditions was $dz = -0.04$, 95% CI [−0.10, 0.03].[2]

Changes in Self-Confidence and Perceived Difficulty of Word Problems

There is a possibility that the observed shifts in challenge-seeking behaviors may result from a change in the participants' perception of the difficulty of questions or from an increase in their self-confidence in correctly answering the math word problems. After observing the challenge-seeking confederate, the participants might have thought that (a) word problems were not as difficult as they initially believed or (b) they were as capable as the confederate in solving hard math word problems. To test these explanations for the observed change in challenge-seeking behavior, we compared the participants' ratings of self-confidence and perceived difficulty across observation conditions in Experiment 4.

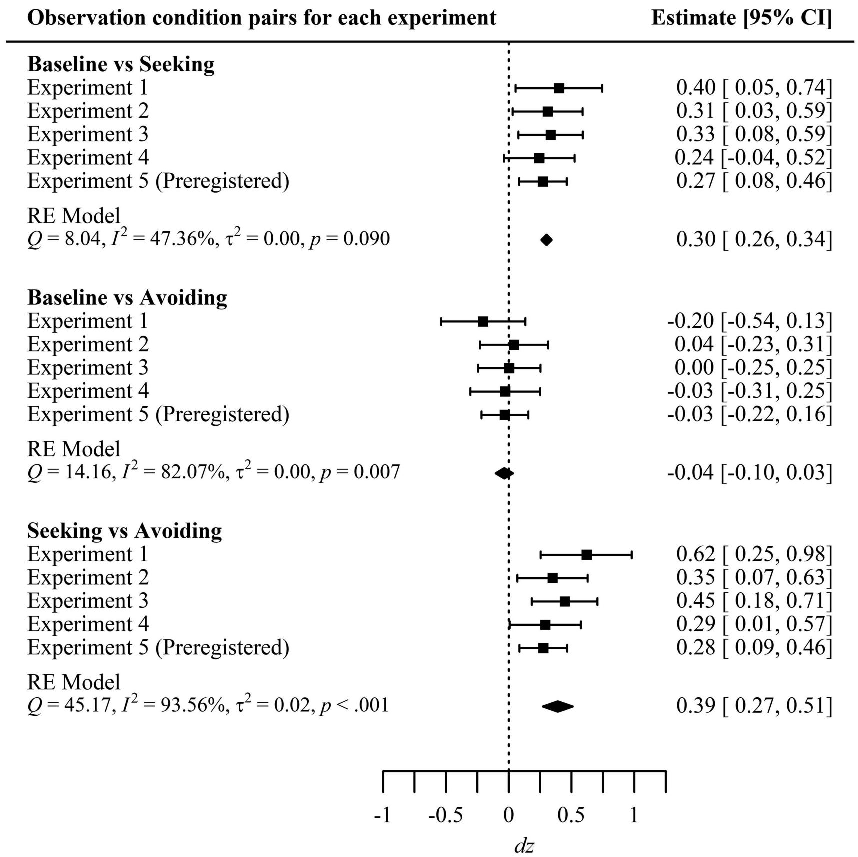
Using a repeated measure ANOVA, we examined the effect of observation condition and word problem difficulty (low accuracy, high accuracy) on perceived difficulty and self-confidence ratings. As expected, participants' perceived difficulty was greater for the harder word problems, $F(1, 49) = 57.07$, $p < .001$, $\eta^2_G = .26$, $t(149) = 11.50$, $p < .001$, $dz = .94$, and their self-confidence ratings were significantly greater for the easier word problems, $F(1, 49) = 114.04$, $p < .001$, $\eta^2_G = .33$, $t(149) = 16.26$, $p < .001$, $dz = 1.33$. Importantly, neither the perceived difficulty, $F(2, 98) = 0.83$, $p = .441$, $\eta^2_G = .002$, nor the self-confidence ratings changed across observation conditions, $F(1.63, 79.87) = 2.43$, $p = .105$, $\eta^2_G = .01$. Also, there were no significant interaction effects between the perceived difficulty of word problems and observation conditions, $F(1.76, 86.24) = 0.75$, $p = .460$, $\eta^2_G = .001$, and the self-confidence ratings and observation conditions, $F(2, 98) = 0.49$, $p = .616$, $\eta^2_G = .001$ (see Table 3 for mean and SD

[1] Note that the Mauchly's test indicated a violation of the assumption of sphericity in Experiment 2 ($p < .001$), Experiment 3 ($p = .017$), and Experiment 5 (preregistered; $p < .001$). To address this issue, degrees of freedom adjusted using the Greenhouse–Geisser method were reported (additional online Table S3 at https://osf.io/tdwzs). We also replicated the results using mixed general linear models, which we report in the additional online Table S5 at https://osf.io/tdwzs.

[2] We also conducted an exploratory analysis to examine the contagion effect in participants who did not believe that the confederates were real (at the end of the experiment session, we asked the participants whether they believed the confederates were real people). The integrated results indicate comparable and significant social contagion effects (additional online Tables S8 and S9 and Figure S3 at https://osf.io/tdwzs).

Figure 3

Forest Plot of Meta-Analysis Showing the Difference Between Challenge-Seeking, Challenge-Avoiding, and Baseline Conditions for All Experiments



Note. Effect size and 95% confidence interval of paired comparisons between the challenge-seeking, challenge-avoiding, and baseline conditions for all experiments. Squares show effect estimates for each experiment, and diamond shape shows the pooled effect estimate. Values in the bottom left corner show the test of heterogeneity. CI = confidence interval; RE Model = random-effects model.

values of each group). These results show that the observed increases in the challenge-seeking rates may not be due to changes in participants' confidence in their abilities or to the perceived difficulty of word problems.

Additional Exploratory Analyses

Building on participants' preference for high entropy word problems, we examined the differences in uncertainty-seeking behavior across observation conditions. Uncertainty-seeking behavior was defined as choosing the word problem with an accuracy value closer to 50%. Mean uncertainty-seeking scores were calculated for each observation condition. A 3 (observation condition: baseline, challenge-seeking, and challenge-avoiding) × 2 (confederate order: challenge-seeking first, challenge-avoiding first) mixed ANOVA did not indicate a significant effect of observation condition, confederate order, or an interaction (additional online Table S10 at https://osf.io/tdwzs). Therefore, it is unlikely that the observed behavioral shift across observation conditions is related to uncertainty-seeking.

We also conducted an additional exploratory analysis to examine whether the change in participants' challenge-seeking tendencies was related to their age, gender, math anxiety scores, math self-concept, achievement goals, or trait intrinsic motivation. Behavioral shift across challenge-seeking and challenge-avoiding conditions was positively correlated with participants' self-reported mastery-approach achievement goals ($r = .26$, $p = .042$, $N = 62$) and trait intrinsic motivation (particularly the "motivation to know" subscale; $r = .27$, $p = .031$, $N = 62$). Participants' mastery-approach achievement goals were also positively correlated with the behavioral shift between challenge-seeking and baseline conditions ($r = .28$, $p = .028$, $N = 62$). Other types of achievement goals, age, gender, math anxiety, and math self-concept were not significantly correlated with the change in challenge-seeking behavior in any of the experiments (additional online Table S11 at https://osf.io/tdwzs). Meta-analyses of four experiments regarding the correlation between three participant demographics (age, gender, and math anxiety) and the shift in challenge-seeking behavior across observation conditions indicated negligible pooled effect sizes (additional online Figures S4–S6 at https://osf.io/tdwzs).

Table 3
Mean and Standard Deviation Values of Participants' Self-Confidence and Their Perceived Difficulty Ratings of Easier and Harder Pie Charts Aggregated for Each Observation Condition

Observation condition	Problem difficulty	Self-confidence		Perceived difficulty	
		M	*SD*	*M*	*SD*
Baseline	Easier	7.0	1.1	4.4	1.3
	Harder	5.1	1.7	6.1	1.6
Challenge-avoiding	Easier	6.8	1.1	4.3	1.5
	Harder	4.8	1.8	6.2	1.8
Challenge-seeking	Easier	6.9	1.2	4.1	1.4
	Harder	4.8	1.6	6.1	1.6

Note. "Easier" and "harder" word problems were defined in relative terms. Specifically, for each pair of options, the option with lower accuracy was categorized as "harder," whereas the option with higher accuracy was categorized as "easier."

Finally, we explored participants' sensitivity to the temporal sequence pattern of the confederates' choices to determine whether participants mimicked the observed temporal sequence. We performed a correlation analysis between each confederate's temporal choice sequence and the participants' predicted choice sequence. This involved calculating individual correlations for each participant and computing the average across participants. The resulting averaged correlations were small and often negative ($r = -0.07$ to -0.19 in the challenge-seeking condition; $r = 0.05$–0.19 in the challenge-avoiding condition; additional online Table S12 at https://osf.io/tdwzs). These results indicate that participants did not replicate the temporal sequence observed in the confederate's choices.

Discussion

Our results provide support for the hypothesis that challenge-seeking behaviors are socially contagious. Specifically, consistent with the hypothesis, our experiments largely demonstrated that challenge-seeking rates were greater after observing a challenge-seeking confederate than after observing a challenge-avoiding confederate and, to some extent, compared to the participants' baseline challenge-seeking rates. These results are in keeping partially with our hypotheses and are in line with the empirical studies showing that motivation is socially contagious (Burgess et al., 2020). Our findings highlight the important role of social context in influencing challenge-seeking behavior. The findings are also consistent with the literature, underscoring the importance of the social environment in the development of challenge-seeking motivation, such as the achievement motive (Rosen & D'andrade, 1959; for a review, see A. J. Elliot et al., 2010).

It is important to note that "contagion" is a phenomenon, not a specific mechanism. Therefore, the important next step is to understand the underlying mechanisms of the observed contagion effects of challenge-seeking behavior. With this aim, qualitative data designed to probe deeper into the self-reported reasons for the social contagion of challenge-seeking behaviors would offer valuable insights. As noted earlier, given the motivated nature of challenge-seeking behavior, the current findings cannot be readily explained by simple mechanisms such as imitation/mimicry or social conformity. Imitation or mimicry (these terms are generally used interchangeably; for a review, see Heyes, 2011) is identified as the unintentional reproduction of others' behaviors after a mere observation (Arnold & Winkielman, 2020; Iacoboni, 2005). It is typically observed in low-level behaviors such as posture (Lafrance & Broadbent, 1976), facial expression (Seibt et al., 2015), and speech patterns (Adank et al., 2013). However, our experiments did not involve the observation of our confederates' motor actions, body language, or facial expressions. Instead, the participants solely observed the choices made by the confederates. Although the effects of social and emotional context were shown to influence the degree of mimicry (for a review, see Arnold & Winkielman, 2020; Seibt et al., 2015), the mimicry of higher order behaviors has not been reliably established in the literature. Therefore, we believe our observed increase in challenge-seeking behavior is unlikely to reflect mimicry per se.

Regarding social conformity, researchers have identified two different types of conformity effects: informational and normative conformity (Deutsch & Gerard, 1955). Informational conformity refers to the act of conforming to others' behaviors because of the belief that they possess more accurate information (Cialdini & Goldstein, 2004; Deutsch & Gerard, 1955; Kallgren et al., 2000). Similar effects have been observed in the literature of anchoring, where arbitrarily set standards/demands changed the numeric estimates or decisions (e.g., judicial sentencing decisions; Englich et al., 2006; listing price predictions; Beggs & Graddy, 2009; probability estimates; Plous, 1989; for a review, see Bahník et al., 2022). However, the current experiment measured only the participants' preferences, and the participants were aware that there were no right or wrong answers about their choice. Therefore, it is unlikely that the change in behavior is related to informational conformity. Normative conformity refers to changing one's behavior to match that of others in order to be liked and accepted or because of social pressure (Deutsch & Gerard, 1955). One of the most well-known examples is Asch's (1951, 1956) line judgment experiments in which the participants conformed to the evidently incorrect responses of a unanimous majority. While normative conformity can take place over preferences, the value attributed to the confederate plays an important role in its occurrence. The conformity literature has consistently demonstrated that individuals tend to favor things approved by their peers while showing disapproval for those endorsed by disliked others (Campbell-Meiklejohn et al., 2010; Izuma & Adolphs, 2013; Zaki et al., 2011). Importantly, in the current experiment, the participants did not have enough information about the confederates (e.g., physical appearance). Consequently, the shift in challenge-seeking behavior is probably not a result of normative conformity.

Another potential explanation is the change of perception: Specifically, when the participants observed others preferring challenging word problems, their perception about the task difficulty inferred from accuracy rates or their own confidence changed, which led to a challenge-seeking behavior. However, our results from Experiment 4 did not support such a change of perception. Specifically, observing others did not have a significant effect on the change in the perceived difficulty of the task or the participants' subjective confidence to solve the problem.

An additional plausible interpretation involves goal or motivation contagion. Goal contagion is a specific manifestation of social contagion, wherein individuals infer and adopt the objectives pursued by others (Aarts et al., 2004; Dik & Aarts, 2007; Laurin, 2016; Loersch et al., 2008). As noted earlier, research on goal contagion using social priming has been criticized due to replicability issues (Doyen et al., 2012; Harris et al., 2013; Kahneman, 2012; Pashler et al., 2013), but the present study, which used a preregistered replication, showed there to be a robust and consistent effect. It should be noted that goal or motivation contagion is still a descriptive phenomenon, and future research should pursue the computational mechanisms underlying such effects (see Murayama & Jach, 2023).

We speculate that social reward-learning plays an important role here. Murayama (2022) has argued that reward-learning is a critical mechanism through which one learns the value of intrinsically motivated behavior. Motivation is socially constructed through the observation of others' actions. Specifically, when observing others' motivated behavior, one could infer the (hidden) rewarding value of the behavior, even if the behavior is not directly rewarded. This idea was originally proposed by Bandura (1977) and has received much support in recent years. Using neuroscientific approaches, for example, several studies have shown that such a social process indeed involves reward-learning (Garvert et al., 2015; Klucharev et al., 2009; but see also McNabb et al., 2020). This account is also consistent with the findings that challenging options are associated with reward-network activation in the brain (Sakaki et al., 2023). Although the present study did not directly examine the role of reward processing in the social contagion effect of challenge-seeking behavior, future studies should examine this possibility.

Our results showed that the participants generally avoided challenges when possible. At baseline, challenge-seeking behaviors were present at most 30% of the time. This supports the law of less work principle (Hull, 1943) and points to the role of effort in our task. Demanding activities, such as those requiring repeated task switching, frequent attention shifting (Kool et al., 2010), or involving challenging math problems (Rege et al., 2021), were usually disliked and avoided (Inzlicht et al., 2018); rated as having considerably less subjective value; and higher monetary rewards were given up to avoid them (Apps et al., 2015; Westbrook et al., 2013). Our observations of challenge avoidance could reflect a reduced subjective value of challenging options. Previous research showed that mental effort exertion can be socially contagious (Desender et al., 2016). It would be interesting to expand our research further by considering the social contagion of effort with measures that quantify the subjective value of challenging options.

Contrary to our second prediction, we did not see a decrease in the participants' challenge-seeking behavior after observing the challenge-avoiding confederate. One possible reason is the floor effect. As noted above, people had a general tendency to avoid challenge-seeking behavior, and there was only limited room for the participants to decrease the challenge-seeking behavior even further. However, it is also possible that the challenge-seeking and challenge-avoiding confederates had an asymmetric effect on the participants' challenge-seeking. Future studies should examine this potential asymmetric effect by using a design that does not suffer from the floor effect.

The positive correlation between mastery-approach achievement goals and susceptibility to the social contagion of challenge-seeking aligns with previous research that linked mastery-approach achievement goals and challenge-seeking behavior (Abercrombie et al., 2022; Jagacinski et al., 2008). Importantly, we did not see a significant inverse relationship with a challenge-avoiding confederate. This means that mastery-approach goals predict challenge-seeking behavior only when participants are confronted with a challenge-seeking person. These results might indicate that mastery-approach goals require social cues to manifest into observable behaviors (see also Friedel et al., 2007; Régner et al., 2007; Tian et al., 2017).

Finally, we found that, on top of the avoidance of challenging options, the participants generally preferred the options that have higher entropy (i.e., options that had accuracy values closer to 50%). This is normally the point where environmental challenge and skills match, and previous studies indicated that people have the highest motivation in such a situation (Atkinson & Litwin, 1960; Keller & Bless, 2008; Ulrich et al., 2016). This preference for "optimal challenge" is also consistent with recent literature in curiosity, indicating that people become interested in a task that has a large potential for learning progress (Gottlieb et al., 2013). Therefore, it is not surprising that we found the same tendency in our experiments. However, observing the challenge-seeking confederate did not significantly influence the preference for optimal challenge, indicating that our findings are specific to challenge-seeking behavior. It would be interesting to examine whether people also exhibit contagion effects when they observe others seeking optimal challenges.

Constraints on Generalizability

One limitation of the present study is that we conducted experiments online, where the participants were unable to see or interact with actual confederates. Therefore, there may be some constraints on the generalizability of our findings (Simons et al., 2017). While it is encouraging that we could still demonstrate challenge-seeking contagion via remote social interaction, which may be perceived as less real by participants, face-to-face social interactions have many qualitatively different elements from remote social interactions such as body language and tone of voice. For instance, greater average sympathetic nervous system activation, linked to emotional and attentional processing, and increased theta power, associated with reward prediction error, in face-to-face compared to remote job interviews (Balconi & Cassioli, 2022). Investigation of challenge-seeking contagion in face-to-face interactions is necessary to complement our study.

An additional potential limitation may be the absence of an investigation aimed at answering whether the observed social contagion extends to social interactions with nonhuman agents. To gain insights from the current data, we analyzed the data from the participants who expressed doubts about the plausibility of the confederates. The results yielded effect sizes comparable to those observed in the participants included in the statistical analysis (Footnote 3; see additional online Tables S8 and S9 and Figure S3 at https://osf.io/tdwzs). We are unsure whether these participants really doubted the existence of the confederates because this was based on a post hoc reaction to the question explicitly suggesting the possibility that the confederates are not real. Nevertheless, these preliminary findings align with the prior research, which has suggested that there can be a shift in the temporal discount rate (Garvert et al., 2015) or risk preferences (Suzuki et al., 2016) toward the interaction partners, whether human or computer. This is not surprising considering how humans often employ strategies that they use in their face-to-face social interactions, such as giving polite responses or showing reciprocity (Nass & Moon, 2000), when they engage with a computer agent. Humans can even infer goals from nonhuman agents (Johnson et al., 2001). Further investigation employing a control condition in which the participants are explicitly informed that they will be observing computer-selected word problems is needed.

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Received May 19, 2023
Revision received May 13, 2024
Accepted May 17, 2024 ■