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Intrinsic motivation and attentional capture from gamelike features in a visual search task

Andrew T. Miranda · Evan M. Palmer

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Abstract In psychology research studies, the goals of the experimenter and the goals of the participants often do not align. Researchers are interested in having participants who take the experimental task seriously, whereas participants are interested in earning their incentive (e.g., money or course credit) as quickly as possible. Creating experimental methods that are pleasant for participants and that reward them for effortful and accurate data generation, while not compromising the scientific integrity of the experiment, would benefit both experimenters and participants alike. Here, we explored a gamelike system of points and sound effects that rewarded participants for fast and accurate responses. We measured participant engagement at both cognitive and perceptual levels and found that the point system (which invoked subtle, anonymous social competition between participants) led to positive intrinsic motivation, while the sound effects (which were pleasant and arousing) led to attentional capture for rewarded colors. In a visual search task, points were awarded after each trial for fast and accurate responses, accompanied by short, pleasant sound effects. We adapted a paradigm from Anderson, Laurent, and Yantis (*Proceedings of the National Academy of Sciences* 108(25):10367-10371, 2011b), in which participants completed a training phase during which red and green targets were probabilistically associated with reward (a point bonus multiplier). During a test phase, no points or sounds were delivered, color was irrelevant to the task, and previously rewarded targets were sometimes presented as distractors. Significantly longer response times on trials in which previously rewarded colors were present demonstrated attentional capture, and positive responses to a five-question intrinsic-motivation scale demonstrated participant engagement.

A. T. Miranda · E. M. Palmer (✉)
Department of Psychology, Wichita State University, 1845 North Fairmount Wichita,
Kansas 67260-0034, USA
e-mail: evan.palmer@wichita.edu

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A problem that a number of university research labs face, whether they are aware of it or not, is the motivation of people who participate in their studies. A number of studies have focused on this concern, such as by assessing individual differences in participants' motivation and how these motivations change during the course of a semester (Roman, Moskowitz, Stein, & Eisenberg, 1995; Van Lange, Schippers, & Balliet, 2011); making a typically boring experimental task more enjoyable by incorporating gamelike features (Porter, 1995; Washburn, 2003); and understanding the use of rewards as incentives for participation, motivation, and performance (Brase, 2009; Heyman & Ariely, 2004; Sharp, Pelletier, & Lévesque, 2006). However, many, if not most, of the data generated in empirical studies have come from undergraduate student volunteers who were usually participating in the experiment in exchange for course credit (Perlman & McCann, 2005). In this situation, the goals of the participant and the goals of the experimenter do not align—the participant wants to earn the course credit as quickly as possible, whereas the experimenter wants motivated and engaged participants. However, many experiments are boring, so participants, who may not be particularly motivated to perform well in the first place, may "tune out" and perform with minimal attention to the task.

Currently, the two most common incentive methods that psychology labs use to motivate and recruit participants are participation in exchange for course credit or a monetary payment (Brase, 2009). Monetary incentives can increase motivation in participants, depending on how the monetary rewards are structured and delivered. In particular, monetary rewards based on participant performance tend to be the most effective (Blinder, 1990; Eisenberger & Cameron, 1996; Jenkins, Mitra, Gupta, & Shaw, 1998). Unfortunately in most cases, the monetary incentives used in psychology experiments are not structured in this way, but instead are provided via a flat fee (Brase, 2009). This arrangement may, ironically, also cause the participant to exert minimal effort, by lowering intrinsic motivation, and thus causing the participant to perform worse than if he or she were not paid at all (Ariely, Gneezy, Loewenstein, & Mazar, 2009; Heyman & Ariely, 2004). The participant's goal may become to earn the money itself rather than to perform well on the task (Brase, 2009; Eisenberger & Cameron, 1996; Weiner, 1980). For instance, if participants are paid a flat fee for participating in an experiment, they may rush through the experiment in order to maximize their earnings per hour, rather than taking their time to perform the task well, as the experimenter is actually hoping for.

We feel it is important to create studies in which the experimenters' and participants' motivations coincide, in which participants *want* to provide good data for the experimenters because that is the most entertaining and interesting way to complete the experiment. Such an arrangement would benefit all parties involved.

We believe that two hallmarks indicate that participants have been successfully motivated during an experiment. One is at the cognitive level, provided by the participants' self-reported intrinsic motivation (e.g., Ryan & Deci, 2000) at the end of an experiment. The other is at the perceptual level, in which the participant's biological reward system (e.g., Hickey, Chelazzi, & Theeuwes, 2010a) has been engaged, resulting in a change in visual prioritization for rewarded stimuli. Below, we review evidence regarding changes in cognitive and perceptual processing in response to various types of rewards.

Cognitive and perceptual engagement

Intrinsic-motivation research has suggested that a powerful way to motivate is not by the use of incentives for participation, but rather by creating an inherently enjoyable experience (i.e., an experiment) in which participants are motivated because they want to do well at the task (Deci, Koestner, & Ryan, 1999; Ryan & Deci, 2000). This is opposed to extrinsic motivation, in which participants are participating in the experiment only to earn their incentive. Creating an experience with positive feedback, moderate challenges, and obtainable goals provides a setting in which participants are no longer participating because it is something they have to do, but rather something they *want* to do (Csikszentmihalyi, 1997, 2000; Elliot et al., 2000; Haradkiewicz & Elliot, 1998; Ryan & Deci, 2000). As is demonstrated below, the present study created an experience that produced this powerful type of motivation.

At the perceptual level, attentional capture is one particular phenomenon that has been observed for visual features associated with monetary rewards (Anderson, Laurent, & Yantis, 2011a, 2011b, 2012; Della Libera & Chelazzi, 2006, 2009; Hickey, Chelazzi, & Theeuwes, 2010a, 2010b). When certain features are associated with monetary reward, the neurological reward network becomes engaged, and the features develop a higher attentional priority than do nonrewarded stimuli (Hickey et al., 2010b). Evidence suggests that when these features develop a higher attentional priority, they increase in salience, and therefore produce attentional capture (Anderson et al., 2011a, 2011b; Hickey et al., 2010b). This perceptual phenomenon, along with the known influences on motivation levels, provides insight into the power of this reward system. Identifying ways in which this reward system can be activated during experimental tasks can be useful for researchers who are interested in providing an engaging experiment for their participants. Outside of the laboratory, numerous activities engage the neurological reward system, as well as promote intrinsic motivation. One of the best examples is video games.

In 2011, consumers spent over $24 billion dollars on the gaming industry (Entertainment Software Association, 2012). Additionally, 21 % of gamers spent an average of 15 h per week gaming in 2011 (NPD Group, Inc., 2012). Due to these facts, video-game players are an excellent example of individuals who take part in a task simply because they want to rather than because they are earning an external reward. Additionally, a number of studies have provided evidence that video games lead to certain perceptual benefits (see Spence & Feng, 2010, for a review). Therefore, we used principles from video games as a method of increasing intrinsic motivation and engaging the neurological reward system.

Explorations of the practice of incorporating gamelike features into experimental tasks has been done before (e.g., Hawkins, Rae, Nesbitt, & Brown, 2013; McPherson & Burns, 2007, 2008; Porter, 1995; Washburn, 2003). Findings from these studies suggested that by integrating interactive animations and graphics so that the experience becomes more like playing a game, participants' performance does not suffer, and they in fact become more interested. However, there has yet to be a systematic exploration of how these methods can both (1) lead to high levels of intrinsic motivation and (2) engage the neurological reward system. We hypothesized that by incorporating specialized gamelike features into an experimental task, we could engage both of these systems.

The video-gamelike reward system that we incorporated was made up of two components: a point system and sound effects. We encouraged participants to value and accumulate points by imbuing the points with subtle social significance. In our experiments, both a participant's current score and the highest score achieved by any previous participant were always visible on the screen. This "high score" was genuine, and if any participant surpassed it during the experiment, he or she was greeted with the blare of synthesized trumpets, a congratulatory feedback screen, and his or her current score becoming the new high score. Thus, one source of reward from our point system was the subtle competition between a participant and all of the participants who had gone before (Tauer & Harackiewicz, 1999).

We chose pleasant, arousing sound effects (as determined by a pilot study) to accompany the delivery of bonus points because we hypothesized that participants would find this association to be rewarding. Pleasant and arousing visual stimuli (i.e., pictures of naked people) automatically capture visual attention (Most, Smith, Cooter, Levy, & Zald, 2007), and pleasant and arousing auditory stimuli increase participant motivation (Miranda & Palmer, 2011). Thus, by employing arousing and pleasing sound effects that were associated with points, we intended for the accumulation of points to become a rewarding experience, in and of itself.

In the present study, the points and sound effects served two purposes. The baseline allocation of points reinforced good participant behavior, and the bonus points further emphasized the visual stimuli associated with high and low rewards. Pleasant sound effects indicated not only whether the trial was correct or incorrect, but also, more dramatically, whether a participant earned a bonus point multiplier, streak bonus, or new high score. As we detail in the experiments below, this combination of points and sound effects not only increased participant motivation, but also led to attentional capture.

Experiment 1: Points and sounds

We attempted to determine whether nonmonetary rewards could lead to positive intrinsic motivation in participants and, when the rewards were associated with certain stimuli, also produce an increase in salience that led to attentional capture. The implementation of points and sounds was to be reminiscent of a video game. The point system consisted of four components: the player score, the overall high score, a correct-trial streak counter, and the bonus multipliers (Fig. 1). Points were only earned on correct trials with RTs faster than 1,000 ms. Faster responses resulted in more points.[1] Having the overall high score visible encouraged between-subjects competition for a more enjoyable experience (Tauer & Harackiewicz, 1999; Vorderer, Hartmann, & Klimmt, 2003). The streak bonus provided extra points for every five correct trials in a row and increased in value the longer that the streak continued. Finally, bonus multipliers were administered according to a predetermined payoff scheme, as in previous research on attentional capture using monetary rewards (Anderson et al., 2011b; Della Libera & Chelazzi, 2009).

Sound effects were also intended to be similar to those used in video and mobile gaming platforms. We chose two sound effects to accompany the delivery of bonus point multipliers and evaluated them in a short pilot study. Ten participants rated the sounds on scales from –1 (*unpleasant*) to +1 (*pleasant*) and from –1 (*inhibiting*) to +1 (*arousing*). The electric whip sound, which was rated as being moderately more pleasant, $t(9) = 1.93$, $p = .083$, two-tailed, and significantly more arousing than the sonic hammer sound, $t(9) = 4.32$, $p < .01$, two-tailed, was chosen for the high-reward condition (Fig. 2). The sonic hammer sound effect was used for the low-reward condition. We chose short bursts of positive and arousing sound effects in order to facilitate participant engagement and enjoyment. Previous research in our lab indicated that positive, arousing sounds increased participant motivation more than did negative, inhibiting sounds (Miranda & Palmer, 2011).

Method

Participants A group of 24 undergraduates ($M = 21.55$ years old, $SD = 4.37$) from Wichita State University participated in the experiment in exchange for course credit. All were screened to ensure that they had normal color vision. Before beginning the session, all participants provided informed consent in accord with the Wichita State University Institutional Review Board

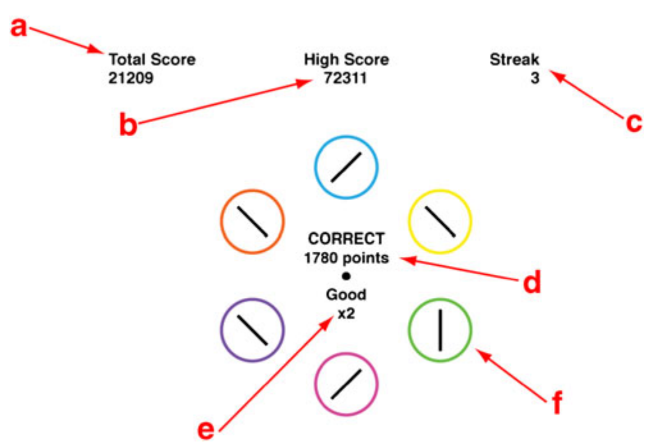

Fig. 1 Sample screen from Experiment 1 of a low-reward trial. (a) The participant's current score, updated in real time as points are awarded. (b) The highest total score achieved by a previous participant. (c)The number of correct trials in a row. (d) Performance feedback and points earned on the current trial, updated in real time as bonuses are applied. (e) Point multiplier and encouraging text, displayed on 50 % of correct trials (either "Good x2" or "EXCELLENT! x10"). (f) Target circle (always red or green) with an oriented line to be reported (either horizontal or vertical). Note that the experimental stimuli had a black background with white text and white target and distractor lines

[1] The formula for the trial points was MAX[0, (1,000 – RT) * 2]. For example, a 700-ms response resulted in 600 points earned, and any RT 1,000 ms or over resulted in 0 points.

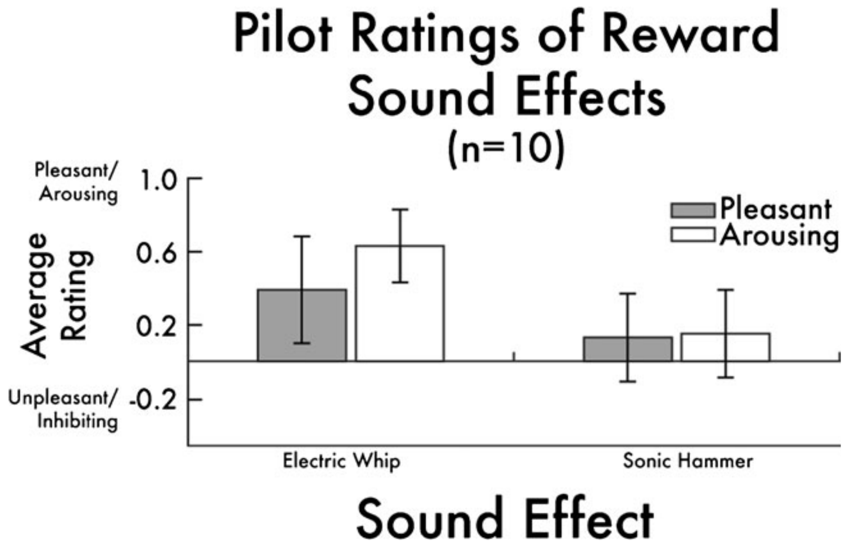

Fig. 2 Results of the pilot study evaluating how pleasant and arousing the bonus point multiplier sound effects were. Participants rated the sounds on scales from –1 (*unpleasant*) to +1 (*pleasant*) and from –1 (*inhibiting*) to +1 (*arousing*). The electric whip sound, which was rated as being moderately more pleasant and significantly more arousing than the sonic hammer sound, was chosen for the high-reward condition. Error bars indicate 95 % confidence intervals

guidelines. Upon completion, all participants were debriefed about the purposes of the study. Two participants were removed from the analysis for having an overall proportion correct more than three standard deviations below the mean.

Materials The experiment was programmed in MATLAB 2010A using the Psychophysics Toolbox (Brainard, 1997; Pelli, 1997). Stimuli were presented and responses gathered on one of five 2.4-GHz Mac Mini computers driving identical 17-in. diagonal Dell 1704FPV flat-panel screens at 1,280 × 1,024 pixel resolution and 60-Hz screen refresh rate. Participants sat approximately 45 cm from the screen, and each wore Sony MDR-V150 Dynamic Stereo Headphones with the volume set at a comfortable level to hear the trial feedback sounds. Detailed information about the sound effects that were used during the training phase can be found in the Appendix.

Procedure The experiment consisted of a training phase, a test phase, and a short intrinsic-motivation questionnaire. We first describe the training and test phases here, and then the questionnaire phase below. During the training phase, participants searched for one of two possible colored target circles among five colored distractor circles. The search display consisted of a target circle (1.5º × 1.5º of visual angle, either red or green) and five distractor circles (chosen from the colors blue, cyan, magenta, orange, violet, or yellow) arranged in a circular pattern (6.7º radius) around a fixation dot. During the test phase, the search display target was a shape singleton (either a diamond among circles or a circle among diamonds), and all stimuli were one of the eight colors listed above, although color was irrelevant to the task. In both the training and test phases, participants' task was to report via keypress the orientation of the line inside the target circle by pressing the "A" key, for a horizontal line, or the "Quote" key, for a vertical line. Distractor circles (or diamonds) contained lines tilted ±45º.

During the training phase, a trial sequence consisted of a warning display, a search display, and a feedback display (Fig. 3). The warning display consisted of a white fixation dot (0.3º × 0.3º of visual angle) presented on a black background. After 266 ms, it increased in size (0.7º × 0.7º of visual angle) prior to search display onset. Next, the search display appeared for 660 ms and then disappeared if the participant had not responded within that time window.

Next, either a high or low tone was played, to indicate correct or incorrect performance, respectively. The high and low tones were sounds from a Fisher Price toy xylophone and lasted for 300 ms each (see the Appendix for information on all of the sound effects presented). Following the trial performance feedback, on 50 % of the trials (randomly determined before the experiment began), either a high- or low-reward bonus was administered if the participant answered the trial correctly. Low rewards consisted of the message "Good," multiplication of the points earned on that trial x2, and the sound of a "sonic hammer." High rewards consisted of the message "EXCELLENT!," multiplication of the points earned on that trial x10, and the sound of an "electric whip." Following bonus reward feedback (if any occurred on the trial), bonus points for streaks of correct trials (+1,000 points for every five trials in a row correct) were delivered. Finally, if participants had surpassed the high score during that trial, the screen was blanked, "NEW HIGH SCORE!!" was displayed in the middle of the screen, a trumpet fanfare sound effect was played, and the high score began reflecting the player's current score for the rest of the experiment. To discourage anticipatory responses, trials with RTs of <100 ms resulted in a text display of "TOO FAST!" in red letters for 5 s in both the training and test phases.

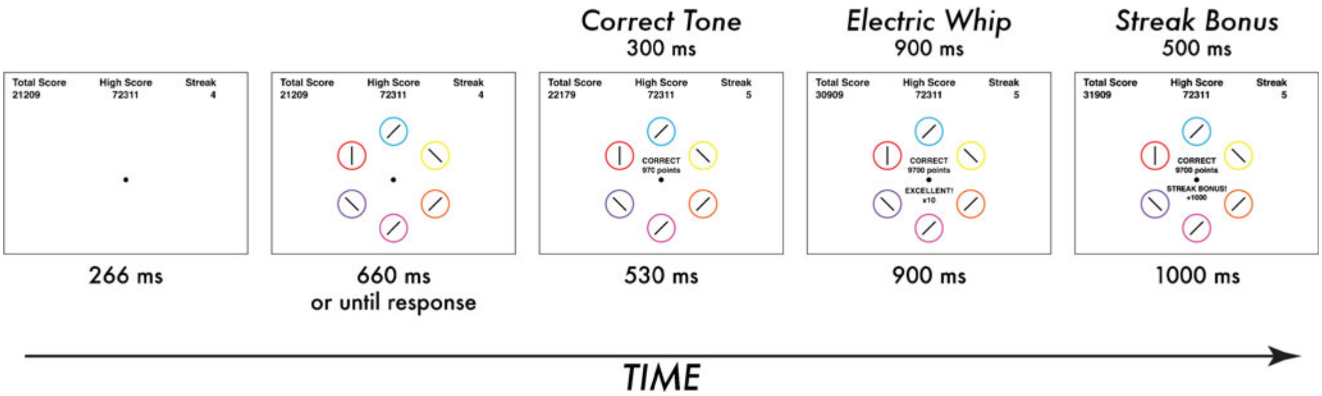

Fig. 3 Timing and display sequence for a correct trial with a high-reward bonus and streak bonus of five trials correct in a row. Text along the top reports sound feedback and duration while text along the bottom reports durations for each visual display. Note that the experimental stimuli had a black background with white text and white target and distractor lines

During the test phase, the search display layout was similar to the training phase, except that color became irrelevant to the task (participants were informed of this), and the new target was identified by a shape singleton. The keyboard responses and distracting tilted lines remained the same as during the training phase. The same auditory feedback for correct and incorrect trials was provided as during the training phase. On incorrect trials, the word "INCORRECT" was displayed for 3 s. Otherwise, all points-related sound effects, points, and references to points were removed (see Fig. 4). Thus, any differences in response times (RTs) during the test phase were due to salience associations established during the training phase.

Following the test phase, a self-report questionnaire was administered in order to assess intrinsic motivation. Self-report questionnaires have been shown to be a reliable method of assessing intrinsic motivation in laboratory tasks (Amabile, DeJong, & Lepper, 1976; Elliot et al., 2000; Haradkiewicz & Elliot, 1998; Zuckerman, Porac, Lathin, & Deci, 1978). A five-question survey was used in our study. The questions asked participants to rate (1) how boring or interesting they found the experiment, (2) whether they enjoyed the experiment, (3) the scientific value of the experiment, (4) whether they would be willing to participate in the experiment again, and (5) whether they would be willing to recommend the experiment to a friend. Ratings could be entered using a continuous slider on a scale from –1 (negative attribute) to + 1 (positive attribute) and reflected the entire experience. Questions 1–4 were adapted from the literature (Amabile et al., 1976; Festinger & Carlsmith, 1959). Favorable ratings on these four questions gave an indication that the task itself was interesting and enjoyable and that the participant's motivation did not rely on external incentives. Question 5 was included to see how participant recruitment might be affected by an intrinsically motivating task.

Design During the training phase, half of the participants were assigned to have red as the high-reward color and green as the low-reward color, whereas the other half of the participants experienced the opposite arrangement. Red and green appeared the same numbers of times during the experiment, and only one of the two colors was present on every trial. Each stimulus location had the same number of red and green stimulus appearances, and the same numbers of high-, low-, and no-reward stimulus appearances. Whether the line was horizontal or vertical was determined randomly on every trial.

Points were earned on every trial if the participant responded correctly in less than 1,000 ms, but bonus points were only awarded on 50 % of the trials, divided equally between the low- and high-reward conditions. In the high-reward condition, 80 % of the trials received a 10x bonus to point value, and 20 % of the trials received a 2x bonus. In the low-reward condition, 80 % of the trials received a 2x bonus to point value and 20 % of the trials received a 10x bonus. For the 50 % of trials on which rewards occurred, this probabilistic reward structure was analogous to that used by Anderson et al. (2011a, 2011b, 2012).

Results

Training phase We were interested in whether participants would show differences in their RTs or accuracy for the high-

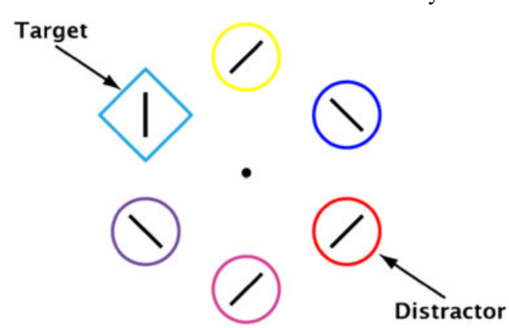

Fig. 4 Sample screen for the test phases of all three experiments and control experiments. Participants searched for a shape singleton (depicted in the upper left) and reported the orientation of the line inside. Previously rewarded targets were sometimes presented as distractors (depicted at the bottom right). Note that the experimental stimuli had a black background with white text and white target and distractor lines

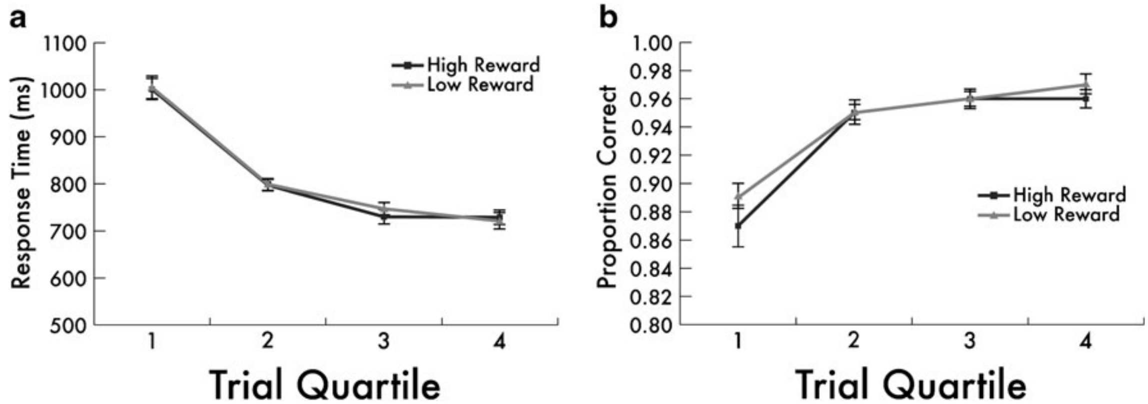

Fig. 5 Training-phase performance data for Experiment 1. (a) Participants decreased their average RTs over time equally in both the high- and low-reward conditions. (b) Participants increased their accuracy over time, but did not differ in their performance for high- or low-reward targets. Error bars are within-subjects confidence intervals (Cousineau, 2005; Morey, 2008)

and low-reward stimuli during training. To evaluate this question, we divided the 480 training trials into 120-trial quartiles and examined RTs and accuracy for the high- and low-reward stimuli over time (Fig. 5). A 2 × 4 (Reward Condition × Quartile) repeated measures analysis of variance (ANOVA) was conducted for both the RT and (arcsine-transformed) accuracy data. The analyses detected main effects of quartile for both the RT, $F(3, 63) = 58.86$, $p < .0001$, $\eta_p^2 = .74$, and accuracy, $F(3, 63) = 32.89$, $p < .0001$, $\eta_p^2 = .61$, data, but no differences in performance between the high- and low-reward conditions, nor an interaction between quartile and reward condition (all ps$> .10$). Thus, participants became better at the task over time but performed equally well on low- and high-reward stimuli.

Test phase The data from the test phase are of particular interest and are depicted in Fig. 6. To evaluate RTs in the test phase for the three distractor conditions (previous high-reward, previous low-reward, and previous no-reward), we conducted a one-way repeated measures ANOVA. Response times shorter than 200 ms and longer than 3,000 ms were excluded from the analysis (approximately 0.5 % of trials, overall). The ANOVA detected a significant effect of reward, $F(2, 42) = 3.47$, $p < .05$, $\eta_p^2 = .14$, and planned comparisons revealed that distractors in the high-reward condition slowed RTs significantly more than did distractors in the no-reward condition, $t(21) = 2.86$, $p < .01$. Neither of the other two comparisons reached significance (both ps $> .05$).[2]

Intrinsic-motivation questionnaire The data from the post-experiment questionnaire are depicted in Fig. 7. To evaluate whether or not participants displayed signs of intrinsic motivation, the average responses to each question were computed, along with the 95 % confidence intervals. Questions with confidence intervals not overlapping zero were considered to be significantly positive (or negative). Participants had significantly positive endorsements of the notions that the experiment was scientifically important, that they would be willing to participate in the experiment again, and that they would be willing to recommend the experiment to a friend.

[2] To verify that red and green were not more physically salient than the other six distractor colors, eight new participants took part in a control experiment that consisted of only the test phase. The results indicated no significant differences in RTs from having a red distractor present, a green distractor present, or neither present, $F(2, 14) = 1.31$, $p = .30$, $\eta_p^2 = .16$.

Discussion

Participants in this study reported significantly positive ratings of the experiment in three of five categories, indicating reliable intrinsic motivation in our sample. One benefit of this positive intrinsic motivation is that participants were interested of their own accord in doing well at the task, aligning their motivations with the experimenters'. Informally, many participants reported being specifically interested in achieving the high score during their session. Another benefit of positive intrinsic motivation from this experiment is that people reported being likely to recommend the study to a friend and being willing to participate in another study. This sort of positive regard may have long-term, subtle benefits for a laboratory, such as people being more willing to sign up for experiments from the laboratory because they find those experiments to be entertaining.

The results also indicated attentional capture for visual features associated with gamelike points and sound effects. Typically, experiments exploring attention and reward associations have used money as the reward (e.g., Anderson et al., 2011a, 2011b, 2012; Della Libera & Chelazzi, 2006, 2009; Hickey et al., 2010a, 2010b). To our knowledge, this is the first demonstration of reward association coming from

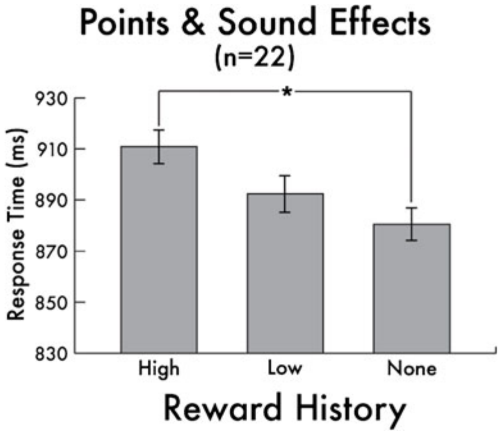

Fig. 6 Attentional capture results from Experiment 1. Significant attentional capture is indicated by longer RTs during the test phase on trials containing stimuli with a history of high reward, as opposed to trials containing stimuli with no history of reward. Error bars are within-subjects confidence intervals (Cousineau, 2005; Morey, 2008)

gamelike features. This particular combination of points and sound effects might be useful for laboratories interested in studying reward association without the cost or possible unintended negative consequences of monetary payments (Ariely et al., 2009; Heyman & Ariely, 2004), and with the added benefit of increased intrinsic motivation among participants.

This initial study indicates that our specialized gamelike features can lead to both positive participant intrinsic motivation and reward system engagement, but it is unclear which aspect of the gamelike features—points or sound effects—led to the positive motivation or attentional capture. The following two experiments attempted to tease apart the contributions of these two components.

Experiment 2: Points only, no sound effects

The results from the first experiment revealed that our specialized gamelike features in the form of points and sound effects could produce both attentional capture and positive intrinsic motivation. However, it was not clear from the previous experiment which aspects of our manipulations led to which behavioral outcomes. The point system that we used had its closest theoretical similarity to monetary rewards that have previously been shown to lead to attentional capture (e.g., Anderson et al., 2011b). In this experiment, points were still presented as the gamelike features to participants, but the sound effects were completely removed.

Method

Participants A group of 33 undergraduates (M = 22.55 years old, SD = 5.76) from Wichita State University participated in this experiment in exchange for course credit. All were screened to ensure that they had normal color vision, and all provided informed consent. None of the participants had taken part in the first experiment (or control study). Two participants were removed from analysis for having an overall proportion correct more than three standard deviations below the mean, leaving data from 31 participants.

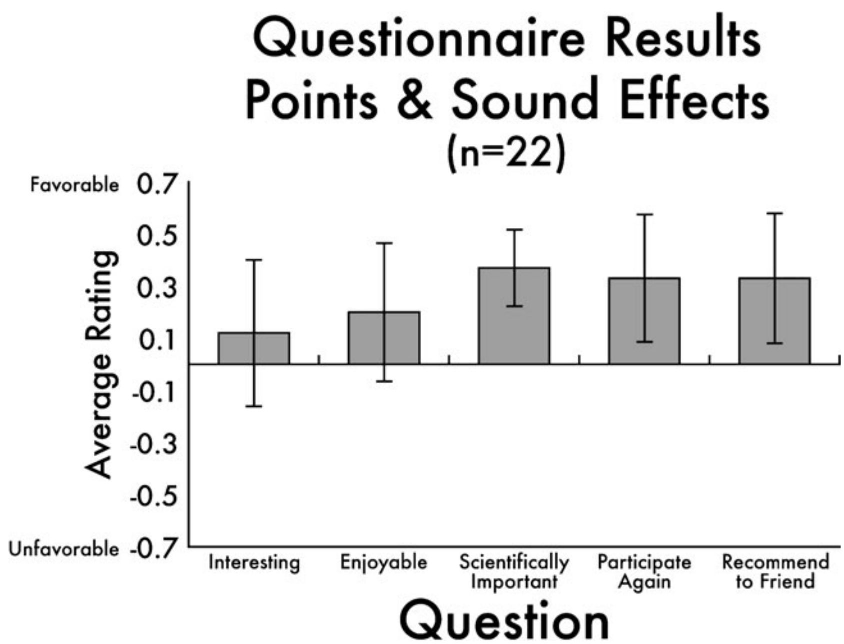

Fig. 7 Intrinsic-motivation results from Experiment 1. Participants had significantly positive responses to three of the five intrinsic-motivation questions. Error bars represent 95 % confidence intervals

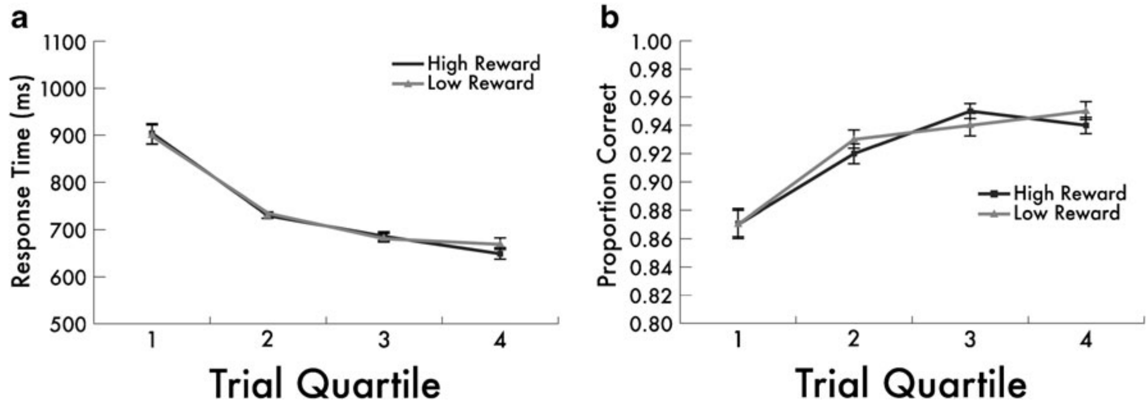

Fig. 8 Training-phase performance data for Experiment 2. (a) Participants decreased their average RTs over time, but did not differ in their performance for low- and high-reward targets. (b) Participants increased their accuracy over time equally in both the high- and low-reward conditions. Error bars are within-subjects confidence intervals (Cousineau, 2005; Morey, 2008)

Design The materials, procedure, stimuli, and timing, including the point system, were all exactly the same as in Experiment 1, except that no sound effects were played. Essentially, the computer volume was turned off in this experiment. Participants were still required to wear headphones during the study, as they had in Experiment 1.

Results

Training phase To detect any differences in performance during the training phase, we again broke the 480 training trials into quartiles and examined the mean RT and accuracy over time for the high- and low-reward conditions. Two 2 × 4 (Reward Condition × Quartile) within-subjects ANOVAs revealed main effects of quartile for the RT, $F(3, 90) = 62.01$, $p < .001$, $\eta_p^2 = .67$, and (arcsine-transformed) accuracy, $F(3, 90) = 24.76$, $p < .001$, $\eta_p^2 = .45$, data. However, the analyses did not detect any significant main effects of reward condition or Reward Condition × Quartile interaction (all *p*s > .10). See Fig. 8 for a depiction of these data.

Test phase The data from the test phase of Experiment 2 are depicted in Fig. 9. To evaluate RTs in the test phase for the three distractor conditions (previous high reward, previous low reward, and no previous reward), we conducted a one-way repeated measures ANOVA. RTs shorter than 200 ms and longer than 3,000 ms were excluded from the analysis (approximately 0.6 % of trials, overall). The ANOVA failed to detect any significant effect of reward, $F(2, 60) = 0.63$, $p = .54$, $\eta_p^2 = .02$.[3]

Intrinsic-motivation questionnaire The data from the post-experiment questionnaire are depicted in Fig. 10. As in Experiment 1, we calculated the mean ratings for each question, along with their 95 % confidence intervals. Although all questions received positive ratings, on average, two questions had confidence intervals that did not overlap zero. Participants reported that they found the experiment significantly enjoyable and also that they would be willing to recommend the experiment to a friend.

Discussion

The results of the second experiment indicated that points alone, when associated with certain visual features, lead to positive intrinsic motivation but do not lead to attentional capture. We were able to provide an enjoyable experience for participants through our point system, which rewarded consistent, accurate, and quick performance, and created an anonymous social competition between participants to achieve the highest point total in the study. Self-determination theory, a well-known theory of motivation in social psychology, states that when a task is enjoyable yet challenging, it can lead to a more positive experience and can enhance intrinsic motivation (Ryan & Deci, 2000). With our point system, participants were able to challenge themselves by attempting to surpass the high score and seeing how many correct trials in a row they could achieve. Because we encouraged fast and accurate performance with the point system, participants had a more favorable than unfavorable experience, and their motives aligned with ours as the researchers.

However, it is interesting to note that arbitrary points are not reinforcing enough on their own to engage the attentional reward system, despite the fact that the point payoff structure that we used was almost directly analogous to the monetary payment structure employed by Anderson et al. (2011b).

[3] To verify that red and green were not more physically salient than the other six distractor colors, seven new participants took part in a control experiment that consisted of only the test phase. The results indicated no difference in RTs from having a red distractor present, a green distractor present, or neither present, $F(2, 12) = 0.138$, $p = .87$, $\eta_p^2 = .02$.

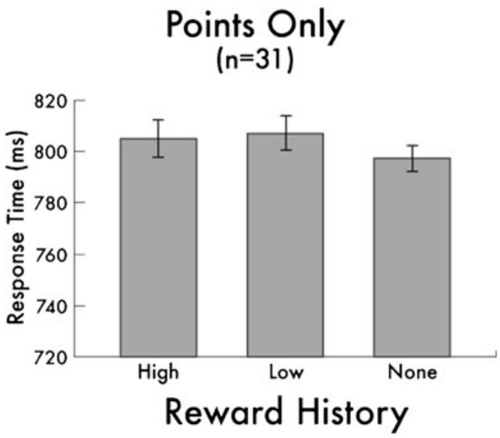

Fig. 9 Attentional capture results from Experiment 2. No significant attentional capture was observed. Error bars are within-subjects confidence intervals (Cousineau, 2005; Morey, 2008)

Thus, assigning points is not directly analogous to giving payment for performance. Our point system led to positive intrinsic motivation, but it did not lead to attentional capture in the same way that monetary payments do. In the next experiment, we explored whether sound effects alone could produce attentional capture and positive intrinsic motivation.

Experiment 3: Sound only, no points

The results from the second experiment revealed that our point system alone led to positive intrinsic motivation but was not sufficient to produce attentional capture via reward association. Experiment 3 focused on the other important component of the first experiment, sound effects, to see whether they could produce attentional capture and/or positive participant motivation by themselves.

Method

Participants A group of 23 undergraduates ($M = 20.95$ years old, $SD = 2.95$) from Wichita State University participated in this experiment in exchange for course credit. All provided informed consent and were screened to ensure that they had normal color vision. None of them had participated in the first two experiments (or control studies). One participant was removed from the analysis for having an overall proportion correct more than three standard deviations below the mean, leaving data from 22 participants.

Design The materials, procedure, stimuli, and timing were all exactly the same as in Experiments 1 and 2, except that the point system was removed. The sound effects were identical to those of Experiment 1, except without the text indications of point allocation, bonus points, streak bonuses, or high-score achievement. All participants wore headphones, as in Experiments 1 and 2.

Results

Training phase To detect any differences in performance during the training phase, we again examined mean RTs

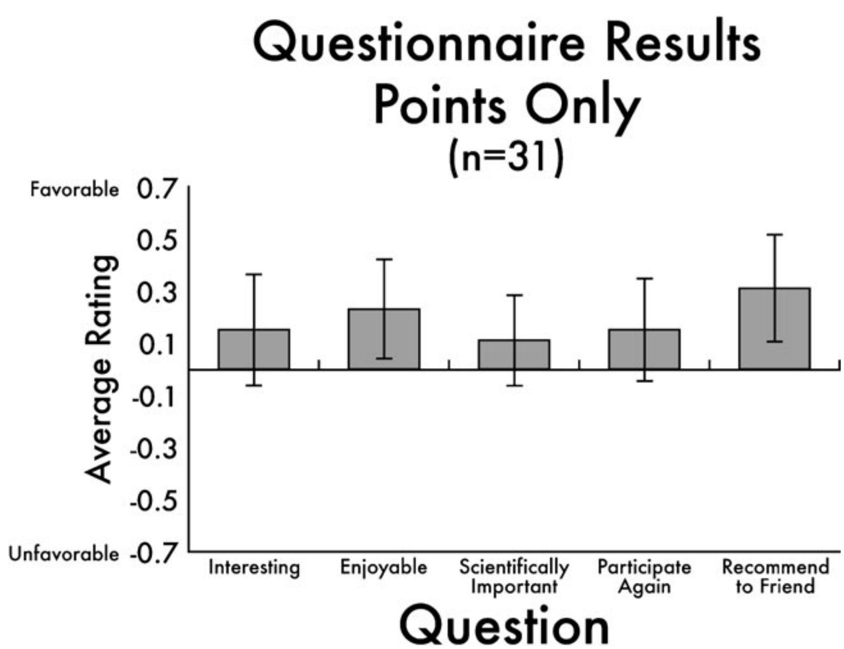

Fig. 10 Intrinsic-motivation results from Experiment 2. Participants rated the experiment as being enjoyable and reported that they would be willing to recommend the experiment to a friend. Error bars indicate 95 % confidence intervals

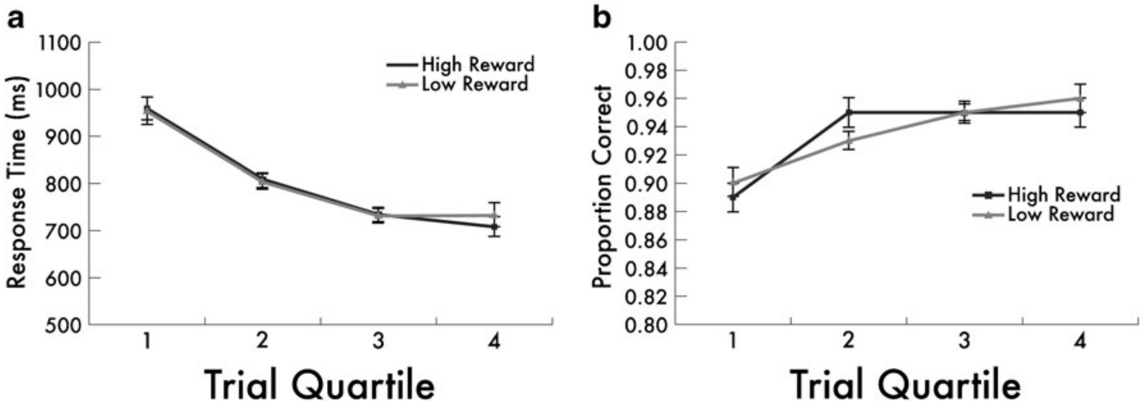

Fig. 11 Training-phase performance data for Experiment 3. (a) Participants decreased their average RTs over time, but did not differ in their performance for low- and high-reward targets. (b) Participants increased their accuracy over time equally in both the high- and low-reward conditions. Error bars are within-subjects confidence intervals (Cousineau, 2005; Morey, 2008)

and accuracy as a function of quartile for the low- and high-reward stimuli. Two 2 × 4 (Reward Condition × Quartile) within-subjects ANOVAs revealed main effects of quartile for the RT, $F(3, 63) = 23.41$, $p < .001$, $\eta_p^2 = .53$, and (arcsine-transformed) accuracy data, $F(3, 63) = 11.91$, $p < .001$, $\eta_p^2 = .36$. The analyses did not detect significant main effects of reward condition or Reward Condition × Quartile interaction (all $p > .10$). See Fig. 11 for a depiction of these data.

Test phase The data from the test phase of Experiment 3 are depicted in Fig. 12. To evaluate RTs in the test phase for the three distractor conditions (previous high reward, previous low reward, and no previous reward), we conducted a one-way repeated measures ANOVA. RTs shorter than 200 ms and longer than 3,000 ms were excluded from the analysis (approximately 0.3 % of trials, overall). The ANOVA detected a significant effect of reward, $F(2, 42) = 5.97$, $p < .01$, $\eta_p^2 = .22$, and planned comparisons revealed that distractors previously associated with high reward slowed RTs significantly more than did low-reward distractors, $t(21) = 2.17$, $p < .05$, and significantly more than distractors not previously associated with reward $t(21) = 4.18$, $p = .001$. We observed no significant difference between previous low rewards and no previous reward ($p > .05$).[4]

Intrinsic motivation questionnaire The data from the postexperiment questionnaire are depicted in Fig. 13. As before, we calculated mean responses and 95 % confidence intervals for the five intrinsic-motivation questions. Participants gave significantly negative ratings to the notion that the experiment was interesting, and they did not differ from zero on the other four questions.

Discussion

In this experiment, participants never saw any indication of points whatsoever, but nonetheless heard all of the sound effects associated with the allocation of points in the previous experiments. Thus, they heard the xylophone note, electric whip, and sonic hammer sound effects (among others), but had no idea why those particular sounds were being played at those particular times. Nonetheless, even without a visible point system to contextualize the sounds, these arousing, pleasant auditory stimuli alone were sufficient to produce attentional capture via reward association. Previous research has shown that neutral visual stimuli, after being paired with aversive auditory noise, can later on capture visual attention (Smith, Most, Newsome, & Zald, 2006; Zeelenberg & Bocanegra, 2010). Here, we showed that neutral visual stimuli associated with positive auditory sounds can produce attentional capture.

Participants did not particularly enjoy this experiment as compared with the previous two experiments, rating it as being significantly uninteresting. Overall, participants were not significantly positive in their evaluations of whether they found the experiment enjoyable or scientifically important, and they provided no indication that they would be willing to participate in the experiment again or recommend it to a friend. Thus, it appears that the point system is responsible for the mostly

[4] To verify that red and green were not more physically salient than the other six distractor colors, eight new participants took part in a control experiment that consisted of only the test phase. The results indicated no difference in RTs from having a red distractor present, a green distractor present, or neither present, $F(2, 14) = 0.074$, $p = .93$, $\eta_p^2 = .01$.

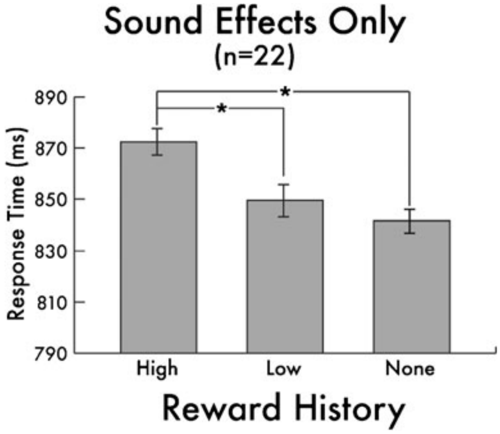

Fig. 12 Attentional capture results from Experiment 3. Significant attentional capture is indicated by longer RTs during the test phase on trials containing stimuli with a history of high reward, as opposed to trials containing stimuli with a history of low reward or with no reward history. Error bars are within-subjects confidence intervals (Cousineau, 2005; Morey, 2008)

positive experiences that participants reported having in the first two experiments.

General discussion

The first experiment reported here established that the point system and sound effects together led to both positive intrinsic motivation and reward system engagement, as evidenced by favorable responses to the postexperiment questionnaire and by attentional capture by the rewarded stimuli, respectively. The second experiment demonstrated that the point system alone yielded positive intrinsic motivation but was not rewarding enough to produce attentional capture. The third experiment established that the sound effects engaged the attentional reward system, in that they led to attentional capture, but they were not motivating on their own, since participants generally did not enjoy that experiment.

To evaluate the differential influence of sound effects and points more formally, we compared the magnitudes of attentional capture and the intrinsic-motivation ratings from Experiments 2 and 3. The amount of attentional capture in the high-reward as compared with the no-reward condition was significantly greater in Experiment 3, with sounds only, than in Experiment 2, with points only, $t(51) = 2.06$, $p < .05$, two-tailed. A 2 × 5 (Experiment × Question) mixed ANOVA on the intrinsic-motivation questionnaire ratings detected main effects of experiment, $F(1, 50) = 4.74$, $p < .05$, $\eta_p^2 = .09$, and question, $F(4, 200) = 8.51$, $p < .001$, $\eta_p^2 = .15$, as well as a significant interaction of experiment by question, $F(4, 200) = 6.71$, $p < .001$, $\eta_p^2 = .12$. Participants in the points-only experiment had significantly higher ratings on the intrinsic motivation questionnaire than did participants in the sound-effects-only experiment. Thus, across three experiments, we established that the gamelike features used here engaged two dissociable reward systems—one explicit and cognitive, and the other implicit and perceptual.

Further evidence that two different systems were engaged came from the fact that we found no signifi-

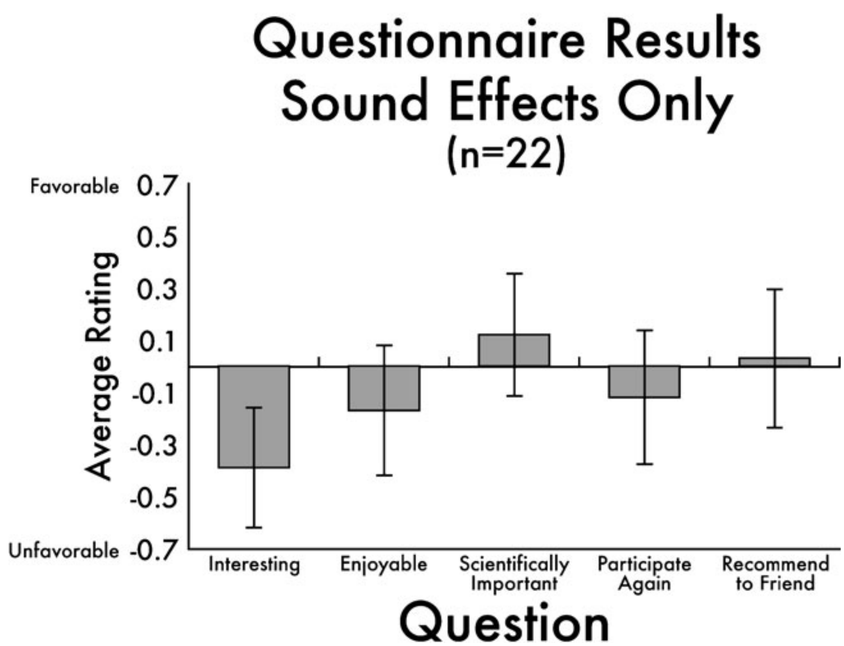

Fig. 13 Intrinsic-motivation questionnaire results from Experiment 3. Participants gave negative answers to whether the experiment was interesting, but otherwise ratings did not differ from neutral. Error bars indicate 95% confidence intervals

cant correlation between the magnitude of attentional capture and the degree of satisfaction with the study in any of the three experiments or the training phases (all *p*s > .05). Additionally, we found evidence to support the assertion of Hawkins et al. (2013) that the level of engagement does not improve performance, since no significant differences in either response time or proportion correct emerged across the three experiments (all *p*s > .10). Thus, whereas our manipulations led to positive intrinsic motivation and attentional capture, those two effects appear to be independent of each other, and also independent of overall levels of performance.

We believe that it is important to align the goals of the participant with the goals of the experimenter, such that participants are intrinsically motivated to complete the experiment. In this regard, we found that the assignment of points on a trial-by-trial basis, along with mild, implicit social competition via the display of a high score, led to more positive evaluations of the research experience for participants. In particular, they were consistently more likely to endorse the idea that they would recommend the study to a friend when the point system was used. This may be particularly beneficial for recruitment in laboratories where participants receive course credit and not money for participation. When the point system was removed, participant evaluations of the study turned unfavorable, with no significant positive ratings and reports that participants found the experiment significantly uninteresting. Thus, a simple point system, of the sort described here, leads to a more favorable experience for participants and allows the experimenter to encourage positive participant behavior without monetary payment. Future research should be conducted to investigate whether the intrinsic motivation provided by these gamelike features can yield increased participant recruitment, and possibly higher quality data.

A more generic benefit of using such a point system (rather than, say, paying a flat fee to participants, regardless of their performance) is that points provide instantaneous feedback to the participant and may allow the experimenter to shape participant behavior on a trial-by-trial basis. The experimenter can formulate the performance-to-point mapping in ways that encourage good participant behavior and better overall data collection. In our study, the faster and more accurate was the participants' performance in the task, and the more trials in a row that they got correct, the more points they earned. However other schemes could be just as easily implemented, such as one that emphasized speed over accuracy, or vice versa. In any case, since the experimenter controls the performance-to-point mapping, participants' response tendencies may be able to be shaped in any way that the experimenter chooses. As a general experimental method, this may allow for better participant engagement than would be obtained by merely rewarding participants at the end of an experiment with a flat monetary payment or course credit.

To summarize, it is possible to achieve significant attentional capture and positive participant motivation by using gamelike features in a visual search task. Our study indicates that the use of both points and sound effects is particularly effective in this regard, with points leading to positive participant motivation and sound effects leading to attentional capture. Besides being interesting theoretically, this finding also has significant practical value. We propose that these gamelike features could be applied to many studies to enhance attentional allocation to a task and increase participant motivation.

Appendix

Table 1 Sound effects were truncated to last for the amount of time indicated in the duration column

Sound Effect Name	Event	Duration	Source
Fisher Price5.wav	Correct trial	300 ms	www.freesound.org/people/tombola/sounds/49219/
Fisher Price25.wav	Incorrect trial	300 ms	www.freesound.org/people/tombola/sounds/49209/
Energy Whip 1.wav	High reward	900 ms	www.freesound.org/people/ejfortin/sounds/49694/
STAB 002 mastered 16-bit.wav	Low reward	900 ms	www.freesound.org/people/Jovica/sounds/2327/
tada1.wav	New high score	1,500 ms	www.freesound.org/people/jobro/sounds/60443/
btn107.wav	Correct trial streak	500 ms	www.freesound.org/people/junggle/sounds/28917/

All sounds were obtained from freesound.org and used under a Creative Commons License.

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