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Context matters: The structure of task goals affects accuracy in multiple-target visual search

Kait Clark [a,*], Matthew S. Cain [b], R. Alison Adcock [c], Stephen R. Mitroff [a]

[a] Duke University, Center for Cognitive Neuroscience, Department of Psychology & Neuroscience, USA
[b] Brown University, Department of Cognitive, Linguistic, & Psychological Sciences, USA
[c] Duke University Medical Center, Department of Psychiatry, USA

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ABSTRACT

Career visual searchers such as radiologists and airport security screeners strive to conduct accurate visual searches, but despite extensive training, errors still occur. A key difference between searches in radiology and airport security is the structure of the search task: Radiologists typically scan a certain number of medical images (fixed objective), and airport security screeners typically search X-rays for a specified time period (fixed duration). Might these structural differences affect accuracy? We compared performance on a search task administered either under constraints that approximated radiology or airport security. Some displays contained more than one target because the presence of multiple targets is an established source of errors for career searchers, and accuracy for additional targets tends to be especially sensitive to contextual conditions. Results indicate that participants searching within the fixed objective framework produced more multiple-target search errors; thus, adopting a fixed duration framework could improve accuracy for career searchers.

1. Introduction

Numerous careers require individuals to conduct difficult visual searches; for example, radiologists search medical images for abnormalities, and airport security screeners search luggage for contraband. Accuracy for these tasks is critically important, as any errors could result in fatalities, and career searchers are trained to detect target items with as few errors as possible. Nevertheless, radiologists, airport security screeners, and other highly trained professional searchers still regularly miss targets. As such, a primary goal in applied visual search research is to identify the causes of search errors with the ultimate goal of improving accuracy and performance (Clark et al., 2013).

Visual searches conducted by professionals often present a number of significant complexities. One particular difficulty arises because search arrays can contain more than one target—a medical image could contain multiple abnormalities (e.g., a tumor and a fracture), and a suitcase X-ray could contain multiple banned items (e.g., a water bottle and a gun). Research in academic radiology has investigated the challenges associated with searching for multiple targets and identified a phenomenon known as “satisfaction of search” (SOS; Smith, 1967), the idea that observers tend to be less accurate in detecting a second target after having identified one target in a display (see Berbaum, 2012; for a review). The SOS phenomenon was originally believed to result from an early termination of search, assuming that an observer was “satisfied” with the meaning of the display after the identification of one target and discontinued searching (Tuddenham, 1962). However, further research suggests that this is not the primary cause of SOS because observers do continue to search after detecting one target (e.g., Berbaum et al., 1991). Instead, the decline in second-target accuracy may arise because of attentional disruptions related to the identification of the first target and the depletion of available cognitive resources (Cain and Mitroff, 2012), resulting in faulty decision-making (Berbaum et al., 1998) or faulty pattern recognition (Samuel et al., 1995).

Most investigations of SOS have used radiologists as participants and medical images as stimuli (Berbaum, 2012), but recent experimental work in cognitive psychology has used non-professional participants and precise manipulations of simplified stimuli (e.g., Fleck et al., 2010) to understand the nature of multiple-target visual search more generally (e.g., Cain et al., 2011; Cain and Mitroff, 2012; Fleck et al., 2010). Non-professional participants who search simplified displays demonstrate decrements in second-target accuracy paralleling those seen in radiology, revealing that SOS is a generalizable search phenomenon and not specific to the radiological community. Furthermore, multiple-target search paradigms can be a useful means for investigating the impacts of nuanced cognitive processes; contextual factors such as anticipatory anxiety (Cain et al., 2011) and time pressure (Fleck et al., 2010) can have substantial effects on

* Corresponding author. Center for Cognitive Neuroscience, Duke University, LSRC Building, Box 90999, 450 Research Drive, Durham, NC 27708, USA. Tel./fax: +1 919 668 6144.
E-mail address: kait.clark@duke.edu (K. Clark).

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second-target accuracy without altering accuracy for single-target searches.

Exploring how multiple-target search accuracy can be improved is critical because most professional searches occur in settings where multiple targets are possible, and errors can have a tangible and direct impact on health and national security. The goal of the current study is to investigate whether the structure under which searchers complete their tasks can affect accuracy. Both radiologists and airport security screeners conduct series of searches as part of their jobs, but they do so under different constraints: Radiologists typically operate with a *fixed objective* (e.g., assigned to assess 45 mammography images), while airport security screeners are scheduled to search for a *fixed duration* (e.g., scheduled to serve as an X-ray screener at the passenger checkpoint for a 30-min period).

Both radiologists and airport security screeners are trained to maximize accuracy and, in effect, should be attempting the same process—carefully examining each display for potentially harmful targets, regardless of the number of cases yet to be scanned or the amount of time left before the end of a shift. However, it is well known that the conceptual framework of a situation can dramatically alter behavior. For example, a substantially larger proportion of respondents are likely to support a medical program if presented in terms of the proportion of lives saved rather than proportion of lives lost, despite identical results between the conditions (e.g., Tversky and Kahneman, 1981). Given that contextual factors (e.g., anticipatory anxiety and time pressure) can have negative effects on second-target accuracy in a multiple-target visual search (Cain et al., 2011; Fleck et al., 2010), we hypothesized that the framework under which an individual searches could also potentially alter performance. Specifically, we tested whether there are differences in accuracy when a search is completed within a task structure similar to radiology (searching with a fixed objective) versus airport security screening (searching for a fixed duration).

To address this question, we tested non-professional participants using a version of an established multiple-target search task with simplified stimuli that has reliably induced the SOS effect (e.g., Fleck, et al., 2010) and demonstrated sensitivity to environmental contexts (e.g., Cain and Mitroff, 2012; Clark et al., 2011). Professional and non-professional searchers tend to produce comparable patterns of multiple-target errors (Biggs et al., 2013); however, it is important to account for potential differences in motivation between these groups in order to compare their search behavior. Undergraduate research participants may not be as concerned with their accuracy as radiologists and airport security screeners, for whom an error could have fatal consequences. Since assessing goal-relevant performance is only meaningful if individuals are truly attempting to attain the goal (Locke and Latham, 1990; Erez and Zidon, 1984), and monetary incentives offer a simple means to strengthen goal commitment (Locke et al., 1988), we provided a performance-based monetary incentive to increase the likelihood that the participants would genuinely attempt to achieve the instructed task goals. Related work using this motivational structure and the same multiple-target search task found enhanced accuracy in financially motivated versus non-motivated conditions (Clark et al., 2011).

In the current experiment, we compared multiple-target search accuracy among participants searching with a fixed objective versus a fixed duration.[1] Two groups of participants completed an experimental search paradigm in which they accumulated points for accurate searching and were informed that the individual who achieved the "best" performance out of a set of 10 participants would receive an additional $50 in compensation. The paradigm was identical in each of the two conditions except for the framework of the participants' task goal: In the *Fixed Objective* condition, participants were to achieve a specified number of points as quickly as possible; in the *Fixed Duration* condition, participants were to accumulate as many points as possible during a specified number of minutes. For the *Fixed Objective* condition, "best" was defined as the individual who achieved the specified points goal in the shortest number of minutes; for the *Fixed Duration* condition, "best" was defined as the individual who achieved the highest number of points in the specified time period. Importantly, the two conditions were structured such that the optimal strategy in both was identical—to maximize one's rate of point accumulation.

2. Methods

2.1. Participants

Forty undergraduate students were recruited from the Duke University community; 20 were randomly assigned to each condition (*Fixed Objective*: Mean age = 20.15 years (SD = 1.46), 17 female; *Fixed Duration*: Mean age = 19.70 years (SD = 1.34), 13 female). Participants provided informed consent and received $15 for their participation. Each participant had a 10% chance of earning an additional $50—the best performer from each of two consecutively recruited cohorts of 10 participants in each condition received the $50 bonus (i.e., 4 total bonuses were awarded, 2 for each condition). Participants were not informed of their relative performance at the time of testing. After collecting and analyzing data from each set of ten participants, bonus recipients were contacted via email and invited back to the laboratory to collect payment. All other participants were notified via email that they had not received the bonus but thanked for their participation.

2.2. Apparatus

Stimuli were presented on a Dell Inspiron computer with a 20-inch CRT monitor and programmed in MATLAB (The MathWorks, Natick, MA) using the Psychophysics Toolbox (Version 3.0.8, Brainard, 1997; Pelli, 1997; Kleiner et al., 2007). Participants were seated without head restraint at a viewing distance of approximately 57 cm from the screen and completed the experiment individually in a dimly lit room.

2.3. Design

Participants completed a modified version of a multiple-target visual search task that reliably reveals an SOS effect (e.g., Cain and Mitroff, 2012; Cain et al., 2011; Fleck et al., 2010; See Fig. 1). Each trial contained 25 items, consisting of a short bar (0.9° long) and a long bar (1.3° long), each 0.3° wide, which approached one another perpendicularly to form 'T' shapes and pseudo-'L' shapes. Target 'T' shapes were defined as items in which a short bar approached a longer bar at its exact midpoint; the remaining items were considered distractor pseudo-'L's and were defined as items in which the short bar approached the longer bar at any point other than its exact midpoint. The shapes subtended a total area of 1.3° × 1.3° and were presented on a rendered grayscale "cloudy" background with a brightness range of 10–50% black. Distractor pseudo-'L' shapes were always between 28 and 66% black, and target 'T' shapes were presented in two visibility levels: high-salience targets (relatively dark; 66–70% black) and low-salience targets (relatively light; 28–40% black). The high-salience targets were easier to detect and distinguish from the background and

[1] The paradigm employed here is meant to approximate the nature of searches conducted by radiologists and airport security screeners, but key manipulations are necessarily altered. For example, the *Fixed Objective* structure is similar to radiological searches, but true radiological searches use a "Fixed Trials" structure, as immediate accuracy information is not feasible. A "Fixed Trials" condition would have substantially altered the strategy such that speed would be irrelevant.

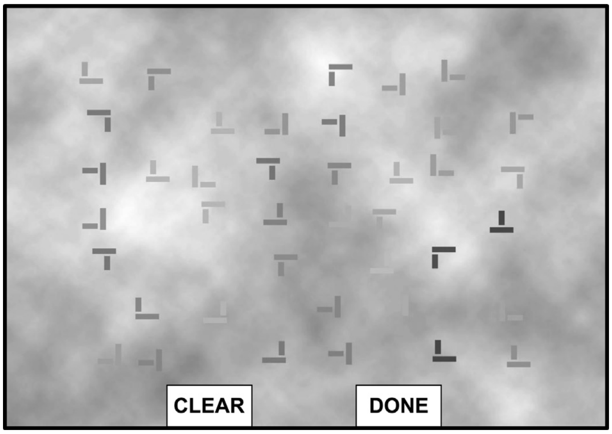

Fig. 1. Sample trial. Example display for a dual-target trial. This display contains one high-salience target 'T' (far right, middle) and one low-salience target 'T' (middle, far bottom).

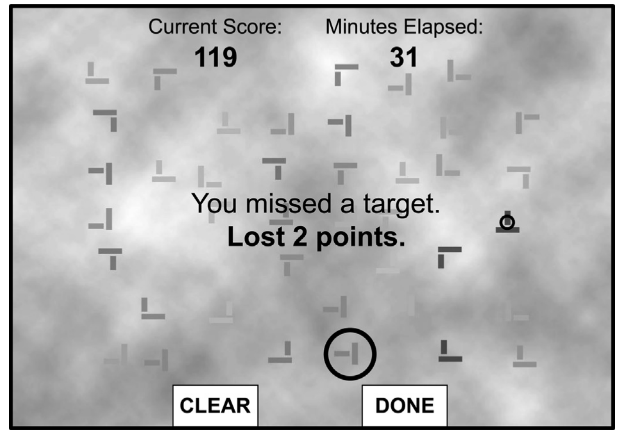

Fig. 2. Sample feedback screen. Example feedback screen displayed following trial completion. On this example dual-target trial, the participant identified the high-salience target (denoted by the small circle) but missed the low-salience target (denoted by the large circle; red in experiment).

distractor items compared to the low-salience targets. There were 0, 1, or 2 targets on each trial; single-target trials contained a target of either relatively low or high salience, and dual-target trials contained one high-salience target and one low-salience target. Each stimulus was placed within a randomly selected cell of an invisible 8×7 grid with a total stimulus space of $25.4° \times 19.1°$.

Each trial began with a fixation cross appearing for 0.5 s at the center of the screen, after which the cross was replaced with the search array of 25 items. Participants used the mouse to click on each item they determined was a target and had the option to correct a misclick by clicking a 'CLEAR' button at the bottom of the screen. There was no time limit for individual trials; the experiments were self-paced, and participants clicked a 'DONE' button at the bottom of the screen to terminate each trial. Four types of trials were employed throughout the experiment: no-target trials, single-target trials with a high-salience target, single-target trials with a low-salience target, and dual-target trials with one high-salience target and one low-salience target. Trial distribution was based upon Fleck et al. (2010; Experiment 3) and pre-determined with rates of 20% no-target trials, 40% high-salience single-target trials, 16% low-salience single-target trials, and 16% dual-target trials. Exact trial-type rates varied slightly across individuals, as participants completed a different number of trials, depending on their accuracy and speed within the task constraints (see Sections 2.5 and 3.1).

2.4. Scoring and feedback

Participants received 1 point for every trial completed correctly (no misses, no false alarms) and lost 2 points for every trial in which an error was made (either a miss or a false alarm).[2] Feedback was provided after each trial regarding the number of points gained or lost on the trial (See Fig. 2). When an error was committed and points were lost, the type of error was printed on screen (e.g., "You missed a target" or "You clicked on a non-target"), and mistakes were highlighted in red. Two facts about cumulative performance were displayed after each trial: a running tally of the total number of points accumulated thus far and the number of minutes that had elapsed. Participants viewed the feedback screen between trials for as long as they liked and then pressed the spacebar to proceed to the next trial. Time spent viewing the feedback screen did not contribute to the participants' total elapsed time on experiment.

2.5. Framing of task by condition

Participants in the *Fixed Objective* condition were provided a goal of 230 total points and informed that the participant who reached 230 points in the fewest number of minutes, within a set of 10 participants, would receive an additional $50. Participants in the *Fixed Duration* condition were given 70 min to complete the task and informed that the participant who accumulated the highest number of points in the 70-min period, within a set of 10 participants, would receive an additional $50. The two frameworks were designed to be roughly equivalent, as pilot data suggested that the acquisition of 230 points required an average of 70 min. The total number of experimental trials varied by participant, as participants completed as many trials as were necessary to reach 230 points or as many trials as were necessary to reach 70 min. Some participants in the *Fixed Objective* condition did not reach the full 230-point goal. Participants were scheduled for a 90-min session, and auxiliary activities (informed consent, practice trials, etc.) typically required 20 min, allowing 70 min for the experimental trials. If participants in the *Fixed Objective* condition reached 90 min of total participation, the experimenter entered the testing room and terminated the experiment, even if the participant had not yet accumulated 230 points. As pilot data suggested that 70 min was the average time required to accumulate 230 points, it was expected that some participants would not achieve the goal in the time allowed; their data were still included in the analyses.

Prior to the experimental session, each participant completed a brief practice session with an experimenter present. The practice sessions for each condition were shortened versions of the task framework they would complete in the experimental session. Participants in the *Fixed Objective* condition were to accumulate 23 points in the shortest amount of time; participants in the *Fixed Duration* condition were to accumulate as many points as they could in a 7-min period. Feedback provided during the practice session was identical to that provided during the experimental session. After completion of the practice session, participants confirmed they understood the task, the experimenter left the room, and participants began the experimental session.

[2] This scoring procedure was implemented based upon the trial-type distribution and pilot data. A 2-point penalty for incorrect trials was required to prevent participants from strategically terminating the trial immediately after finding only one target. Because there were more trials with 1 target than 2, without a penalty, the optimal strategy would be to quickly accumulate points on single-target trials only without searching for second targets.

3. Results

For all results, effect size and confidence intervals are reported (see Fritz et al., 2011 for calculation recommendations). Effect size was assessed using a modified calculation of Cohen's *d* (Cohen, 1962) recommended when the groups are similar in size but may have different standard deviations (Cohen, 1988; Keppel and Wickens, 2004), yielding one version of Hedge's *g* (Hedges, 1982). Like Cohen's *d*, Hedge's *g* values of 0.8, 0.5, and 0.2 are generally representative of large, medium, and small effect sizes, respectively (Cohen, 1988). The 95% confidence intervals for effect sizes were calculated as recommended for normally distributed data and reasonable sample sizes (Grissom and Kim, 2005; Hedges and Olkin, 1985).

3.1. Comparability of experimental parameters between conditions

The two conditions were designed to broadly comparable based on pilot data. There was no significant difference in the total number of experimental trials completed between the conditions (*Fixed Objective*: Mean = 342.95, SD = 54.15; *Fixed Duration*: Mean = 375.60, SD = 113.52; $t(38) = 1.16$, $p = 0.25$; $g = 0.37 \pm 0.63$). As specified by experimental parameters, all participants in the *Fixed Duration* condition spent exactly 70 min on the task, and participants in the *Fixed Objective* condition spent an average of 61.69 min (SD = 9.32). Twelve of the 20 participants in the *Fixed Objective* condition reached the goal of 230 points before 70 min of time on task; for the remaining 8 participants, the experiment was terminated at 70 min, despite not having reached the goal.

3.2. Equivalent performance on basic measures

Participants in the *Fixed Objective* and *Fixed Duration* conditions demonstrated similar performance in terms of both single-target accuracy and response time. There were no significant differences between the conditions for accuracy on single-target trials for either high-salience targets (*Fixed Objective*: Mean = 96.88%, SD = 2.20%; *Fixed Duration*: Mean = 97.65%, SD = 1.58%; $t(38) = 1.27$, $p = 0.21$; $g = 0.40 \pm 0.63$) or low-salience targets (*Fixed Objective*: Mean = 68.88%, SD = 13.71%; *Fixed Duration*: Mean = 73.31%, SD = 8.06%; $t(38) = 1.25$, $p = 0.22$; $g = 0.39 \pm 0.63$). False alarm rates (percentage of trials on which any non-target was clicked) were very low and did not differ between conditions (*Fixed Objective*: Mean = 0.82%, SD = 0.63%; *Fixed Duration*: Mean = 0.89%, SD = 0.68%; $t(38) = 0.31$, $p = 0.76$; $g = 0.10 \pm 0.62$). There were also no differences between the conditions in terms of response time across any trial type (See Table 1). Finally, the rate of point accumulation was equivalent between the conditions (reported as *points per minute*; *Fixed Objective*: Mean = 3.44, SD = 0.94; *Fixed Duration*: Mean = 3.65, SD = 1.07; $t(38) = 0.67$, $p = 0.51$; $g = 0.21 \pm 0.62$).

3.3. Dual-target accuracy and satisfaction of search

There were significant differences between the conditions for second-target accuracy (See Fig. 3A). For dual-target trials on which the high-salience target was found first, participants in the *Fixed Duration* condition were significantly more accurate in finding the low-salience target as well (*Fixed Objective*: Mean = 58.06%, SD = 13.93%; *Fixed Duration*: Mean = 69.88%, SD = 8.96%; $t(38) = 3.19$, $p = 0.002$; $g = 1.01 \pm 0.66$).

Satisfaction of search (SOS) is calculated as the difference in accuracy for low-salience targets between single-target trials and dual-target trials in which the high-salience target was found first (e.g., Cain and Mitroff, 2012). Participants in the *Fixed Objective* condition revealed a highly significant SOS effect (10.82%; $t(19) = 5.19$, $p < 0.001$; $g = 0.78 \pm 0.64$), but participants in the *Fixed Duration* condition did not (3.44%; $t(19) = 0.17$, $p = 0.17$; $g = 0.40 \pm 0.64$) (See Fig. 3A). To assess the degree to which the SOS effect was modulated by the *Fixed Objective* versus *Fixed Duration* conditions, a 2 × 2 ANOVA was run on the low-salience target accuracy data with Condition (*Fixed Objective* versus *Fixed Duration*) as a between-subjects factor and Trial Type (single-target trials versus dual-target trials) as a within-subjects factor. There were main effects of both Condition ($F(1,38) = 6.21$, $p = 0.02$; $g = 0.71 \pm 0.64$) and Trial Type ($F(1,38) = 19.87$, $p < 0.001$; $g = 0.64 \pm 0.64$) as well as a significant Condition × Trial Type interaction ($F(1,38) = 5.33$, $p = 0.026$; $g = 0.73 \pm 0.64$), indicating that the SOS effect was larger in the *Fixed Objective* condition compared to the *Fixed Duration* condition (See Fig. 3B).

Additional analyses reveal that both groups remained relatively consistent in their performance over the course of the experiment. To assess performance over time, the data were divided into quarters for each participant (i.e., separated into the first, second, third, and fourth 25% of trials; see Fig. 4). A *Quarter* factor (First, Second,

Table 1
Response times by trial type. Means (and standard deviations) in seconds for each trial type in the *Fixed Objective* and *Fixed Duration* conditions.

Trial type	High-salience single target	Low-salience single target	Dual target	No target
Fixed objective	11.36 (3.59)	11.81 (3.35)	9.01 (1.81)	13.10 (8.82)
Fixed duration	12.71 (5.02)	13.44 (5.69)	9.98 (3.34)	14.43 (6.42)
Statistical test	$t(38) = 0.98$, $p = 0.34$	$t(38) = 1.11$, $p = 0.28$	$t(38) = 1.14$, $p = 0.26$	$t(38) = 0.55$, $p = 0.59$

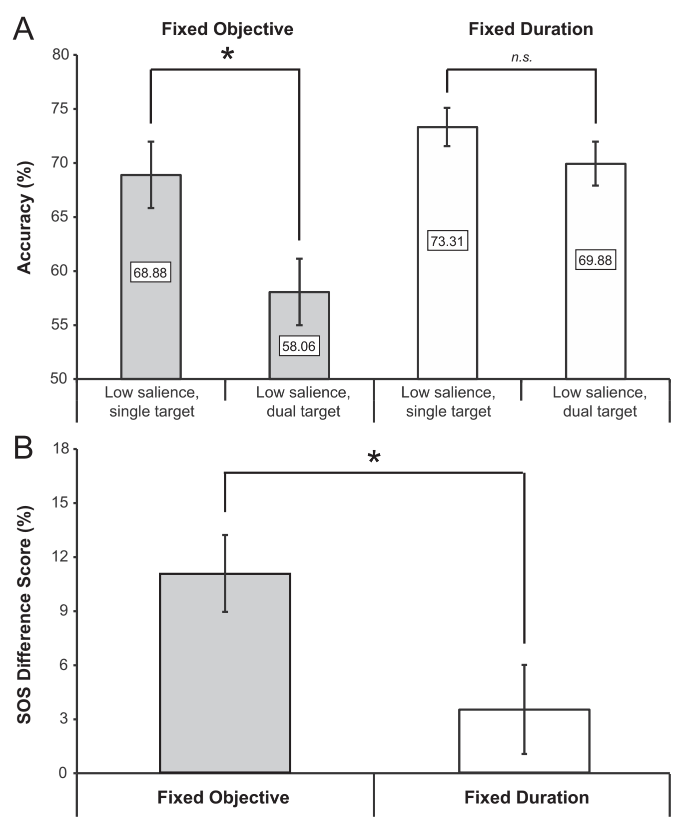

Fig. 3. 3A) Accuracy rates by trial type. 3B) SOS difference scores. 3A) Accuracy rates for low-salience targets in the *Fixed Objective* and *Fixed Duration* conditions: Single-target trials versus dual-target trials (provided the high-salience target was detected first). Error bars represent standard error of the mean. 3B) SOS difference scores (difference between accuracy rates in Fig. 3A) in the *Fixed Objective* and *Fixed Duration* conditions. Error bars represent standard error of the mean.

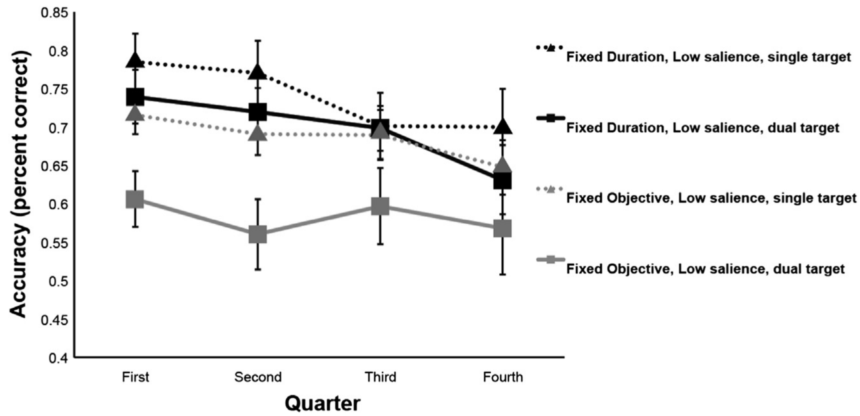

Fig. 4. Accuracy rates over time. Accuracy rates for low-salience targets in single- and dual-target trials in the *Fixed Objective* and *Fixed Duration* conditions during each quarter of trials over the course of the experiment.

Third, Fourth) was added to the above analysis, and there was marginal, but non-significant, main effect of Quarter on accuracy ($F(3,38) = 2.415$, $p = 0.067$); post-hoc tests demonstrated a general decline in accuracy toward the end of the experiment, with accuracy significantly lower in the Fourth quarter of trials compared to the first ($t(38) = 2.61$, $p < 0.01$). Most important for the current questions, there was no significant interaction between Condition and Quarter ($F(3,15) = 0.619$, $p = 0.60$), indicating that the differences in accuracy between the Fixed Duration and Fixed Objective conditions remained constant over the course of the experiment.

4. Discussion and conclusions

Detecting a second target after having detected a first target in a display is a cognitively challenging task, and accuracy for additional targets tends to be uniquely sensitive to contextual influences that do not disrupt single-target searches. For example, accuracy impairments specific to second targets are observed under conditions such as anticipatory anxiety (Cain et al., 2011) and time pressure (Fleck et al., 2010). Here, we find that the even the mere structure of an observer's search goals can affect accuracy in the same manner as stressful contexts, resulting only in differences specific to accuracy for second targets. There was a significant decrease in second-target accuracy for participants who were searching with a specified objective compared to those who were searching for a specified duration, suggesting that the structure of an observer's search goals affects his or her accuracy in detecting multiple targets.

Our participants were non-professionals who were motivated to search accurately with a performance-based monetary incentive. Participants were randomly assigned to one of two conditions and completed identical experimental paradigms; the only difference between the conditions was the framework in which they completed the task. Critically, the two frameworks called for employment of the same optimal strategy; whether attempting to achieve an objective in the shortest amount of time or to accomplish as much as possible in a specified period of time, searchers are attempting to maximize search efficiency in both conditions. However, humans are prone to irrationally conceptualize constructs such that objectively identical frameworks can dramatically alter decisions and behavior (Tversky and Kahneman, 1981).

Our analyses reveal that search performance, for the most part, was quite similar between the conditions, and there is no evidence that participants in the opposing frameworks were consciously employing different strategies or approaches to the task. Participants in the two conditions spent an equivalent amount of time assessing the search arrays and performed equally well on trials containing only one target. The only difference between the conditions was the likelihood with which participants found the additional targets on dual-target trials, with superior accuracy for multiple targets for the *Fixed Duration* condition. That is, the group of participants who were instructed to accomplish as much as possible in a specified time period found second targets more deftly than those who were instructed to achieve a specified goal in the shortest number of minutes. Unlike those in the *Fixed Duration* condition, participants in the *Fixed Objective* condition produced a satisfaction-of-search effect, showing a substantial decline in accuracy for second targets.

All participants completed a modified version of a search task that typically elicits SOS (Fleck et al., 2010, Experiment 3), and both groups completed this task under motivated conditions, a manipulation which can alleviate the SOS effect (Clark et al., 2011). Interestingly, only those in the *Fixed Duration* condition showed the benefits associated with monetary incentives for this task; participants in the *Fixed Objective* condition performed similarly to non-motivated individuals in prior studies (e.g., Fleck, et al., 2010). Both groups were incentivized with a monetary reward, but performance on cognitive tasks can be modulated by the *nature* of the motivation (e.g., Callan and Schweighofer, 2008; Murayama and Kuhbandner, 2011). Motivation to avoid a punishment, for example, can be particularly stressful and promote anxiety (Davis and Whalen, 2001; Lang and Bradley, 2009), resulting in a decline in cognitive performance (Murty et al., 2011). All of our participants were motivated to earn a reward, and there were no punishments to avoid (unless the scoring penalty for errors is considered a punishment in itself); however, it is possible that the *Fixed Objective* condition elicited more anxiety and stress than the *Fixed Duration* condition.

As mentioned, previous work has demonstrated that certain contexts tend to exacerbate errors specific to second targets in dual-target displays. Fleck et al. (2010) found decreased accuracy under time pressure: observers committed significantly more errors when trials had a 15-s time limit than a 30-s time limit, despite the fact that participants rarely exceeded either time limit, and there were no differences between response times in the 15- versus 30-s conditions. Cain et al. (2011) found that second-target errors were exacerbated when observers were searching under anticipatory anxiety. In some experimental blocks, participants were aware that they may receive a brief, uncomfortable shock to the wrist; in others, participants were aware that they may hear a neutral tone. In both cases, the shocks and tones occurred completely independent of performance, but second-target accuracy was significantly worse when anticipating the possibility of receiving an aversive shock than hearing a tone.

Both time pressure and anticipatory anxiety are potentially stressful contexts, and given that stressful motivation may inhibit cognitive performance (Davis and Whalen, 2001; Lang and Bradley, 2009), it is entirely possible the *Fixed Objective* framework examined here induced perceptions of time pressure and/or anxiety in the participants. Factually, both conditions imposed the same amount of time pressure, as speed is equally critical when attempting to achieve the most points over a specified duration or when attempting to achieve a set number of points in the shortest amount of time. However, the framework of achieving a workload goal as quickly as possible might feel significantly more stressful than accomplishing as much as possible in a pre-determined amount of time. With the present data, we can only speculate about the role of the psychological and physiological states of the observer in these frameworks, but the strong similarities between our results and prior investigations of multiple-target search accuracy suggest that stress may be a common denominator.

Future work can speak to the underlying mechanism by which the task constraints in the current study influenced performance, however, regardless of the specific mechanism our data support the notion that second-target accuracy is improved when observers are searching for a certain period of time compared to when observers are searching to achieve an objective. This finding has direct implications for the structure of constraints for career searchers: Airport security screeners currently conduct searches for a pre-determined duration regardless of how many bags they search in that time; radiologists, on the other hand, are typically aware of a number of cases to be scanned until the job is complete. As second-target accuracy is a substantial problem in the radiological community, our data suggest that radiologists could benefit from a change in protocol. Rather than assigning a number of cases to each doctor, radiologists could be assigned to assess cases for a certain amount of time. This procedural modification could effectively increase second-target accuracy without decreasing efficiency as we find identical speeds for searching in the two frameworks.

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