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Methodological refinements in the behavior-analytic study of distraction: A preliminary investigation

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ABSTRACT
Traditional approaches to the study of distraction have involved evaluations of the effect of a stimulus on specific task performance, but without a conceptual analysis of how the stimulus might actually interfere with the specific task. In the present study, we evaluated the potentially distracting effects of various classes of stimuli that were related to the task in different ways. We found that moderate-intensity stimuli that were topographically similar or were members of an equivalence class that included similar stimuli to the task (i.e., the discriminative stimulus and the target behavior) had the greatest distracting effects, high-intensity stimuli that were dissimilar had minor distracting effects and low-intensity stimuli that were dissimilar had negligible distracting effects.

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Distraction is a colloquial term that has been adopted in the scholarly literature as a descriptor for environmental stimuli (i.e., distractors) that cause disruptions (e.g., response-rate decrements and errors) in performance. The characteristics of distractors and their various effects on performance have long been studied in psychology and, to a lesser extent, behavior analysis. However, given that behavior analysts are interested in the effects of environmental conditions on established operant performance (e.g., Barton, 1986; Hopkins, 1968; O'Reilly et al., 2012), distraction is an ideal candidate for further investigation.

In the behavior-analytic literature, few studies have directly and systematically evaluated the effects of introducing a potentially distracting stimulus on task performance. Kim, Carr, and Templeton (2001) evaluated nearby peer participation in a similar task (saying the English names of Hindi characters) on the fluent performance by college students and found mixed results (i.e., four out of nine participants had response reductions in the presence of peers). More recently, using a translational research preparation, Demeter, Sarter, and Lustig (2008) evaluated a screen flash as a distractor during a signal detection task with college students (i.e., key pressing in a signal detection shape discrimination task) compared to rats in a similar preparation.

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The authors found that, although humans showed better performance overall, the two species showed similar response reductions in the presence of the distracting stimulus. Howell, Byrd, and Marr (1986) evaluated the relation between a drug (i.e., cocaine) and a distractor (i.e., white noise) during a lever-press task with squirrel monkeys. The authors found that similar response-rate disruptions occurred in the presence of each of the two stimuli.

The study of distraction has also been described within the psychology literature. For example, Kalfus and Stokes (1987) evaluated the presence of peer tutors as distractors for preschool children during their completion of an auditory–visual conditional discrimination task and found that it took up to eight times as long to complete the task when peers were present. Singer, Cauraugh, Murphy, Chen, and Lidor (1991) evaluated the effects of auditory (white noise) and visual (strobe light) distractors on adults' completion of a simple manual task and found that performance was suppressed the most during combined distractor conditions compared to individual stimulus presentation. Using a laboratory preparation with rats as participants, Hirsh and Burk (2013) evaluated the role of flashing lights as distractors on the acquisition, a two-lever discrimination preparation involving two simultaneously available levers (e.g., left lever and right lever), each of which had a corresponding stimulus (e.g., red light, green light). The authors found that initial stimulus presentation decreased overall accuracy, but rats exposed to the stimuli in later phases had higher accuracy compared to rats that had not previously been exposed to stimuli. Recently, Minamoto, Shipstead, Osaka, and Engle (2015) evaluated the effects of distractors (i.e., similar vs. different visual characteristics to task) on humans completing a memorization task when cognitive load varied (i.e., difficulty level; number of faces asked to remember between 0 and 3). The authors found that when the task included few stimuli for memorization, visually similar distractors produced lower response rates and when the task included multiple stimuli for memorization, visually similar distractors no longer resulted in lower rates of responding.

There are two notable commonalities between treatments of distraction within the behavior analysis and psychology literatures. The first of these includes the structural treatment of distractors. For example, potential distractors are often described in terms of their topographical (e.g., letters, numbers, shapes and colors) or sensory properties (e.g., auditory, visual and tactile). Not surprisingly, this structural approach makes it difficult to integrate results between studies and evaluate distractors that have other relevant features (e.g., intensity and function) that would also be likely to affect particular task performances, either by reducing response rate or by introducing errors. A second similarity between the literatures includes the ways in which performance and distraction are measured. These studies typically introduce potentially distracting stimuli and assess changes in overall task performance with measures such as mean response latency and percentage of correct responses (e.g., Barton, 1986; Demeter et al., 2008; Hirsh & Burk, 2013; Hopkins, 1968). This approach is potentially problematic because distraction is only evaluated based on an aggregate of a participant's responding during an entire session (the molar level), which is one degree removed from the effects of a single stimulus on a single response (the molecular level).

Distraction may be an important concept for behavior analysts to further investigate for a few reasons. The first reason is the role that distraction plays in certain areas of behavior analysis. For example, in precision teaching, performance stability and endurance is often evaluated by measurement in the face of distraction (Johnson & Layng, 1994). Based on our current knowledge of this phenomenon, there is little guidance for the selection of stimuli hypothesized to serve as distractors. Second, as mentioned earlier, there are features of stimuli (e.g., function) not typically identified by researchers that may be important for comparison across investigations. The function of a distractor may affect performance differentially based on how it is related to the source of stimulus control over the target behavior. For example, a distractor that is topographically similar or a member of an equivalence class (e.g., hearing letters read aloud) that is similar to the discriminative stimulus (S^D) might interfere with the task by evoking extraneous verbal behavior or an observing response that competes with the target behavior. Additional classifications of stimuli that specify a relation to the experimental task provide greater opportunities for research findings to be translated into application. A final reason for behavior analysts to study distraction is the availability of measurement tools sensitive enough to capture momentary occurrences of distraction. The measures typically used to evaluate distraction (e.g., percentage of correct trials and mean response latency) represent multiple instances of distraction during the completion of a task. For example, an evaluation of distraction on a driving task might report that loud music and a talking passenger each produced a 25% reduction in driving accuracy. However, a cumulative record, which is sensitive enough to capture moment-to-moment responding, might show that loud music results in periodic minor distraction but that a talking passenger results in a single instance of a critical error.

The purpose of the present study was to evaluate the potentially distracting (i.e., task disruptive) effects of stimuli that were differentially related to the experimental task. Stimuli differed based on their sensory modality (auditory and visual), their topographical similarity (or equivalence class membership) to the task and their intensity (low, moderate and high). Potential secondary contributions to the literature on distraction involve the use of a cumulative record for improved detection of distraction at the molecular level and the use of the suppression ratio (Estes & Skinner, 1941) to provide an additional way to quantify response suppression (or distraction).

Method

Participants and setting

Four undergraduate students attending a public university consented and participated in the study. Participants were introductory psychology students (two males and two females) between the ages of 19 and 23 and they were recruited through the psychology department's participant pool. The students participated for up to 2 h in one laboratory visit in exchange for course credit only. All sessions were conducted in a 4 × 3 m austere experimental room that contained a computer, desk and two chairs.

Experimental preparation

Participants sat in front of a laptop computer (see Figure 1). The computer displayed a blank white screen. Prior to beginning the task, participants were verbally given the following general description of the task:

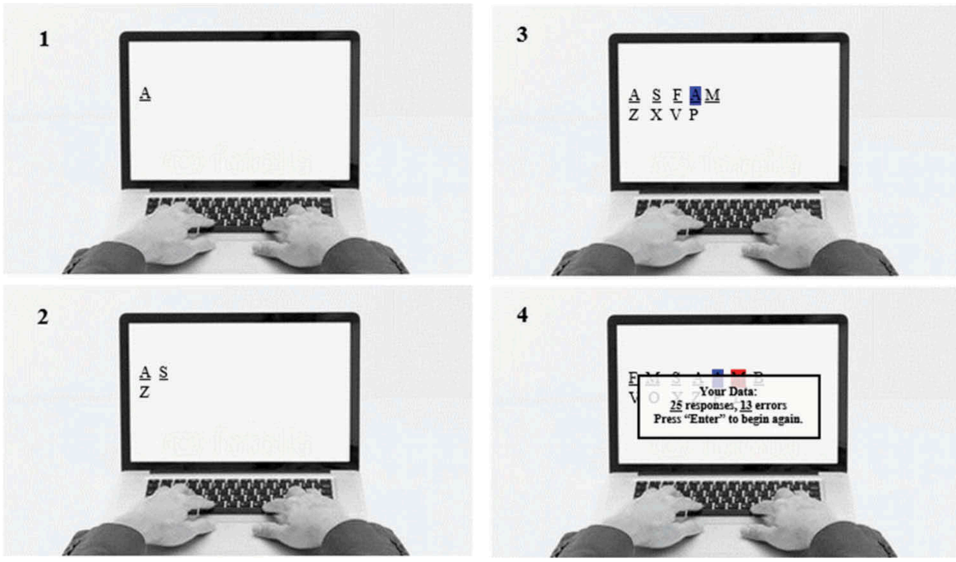

Figure 1. Visual depiction of the experimental task. The complete experimental task includes a series of 10 paired associates on the screen at a time; upon completion of the 10 pairs in the sequence, all pairs disappear and the next stimulus is presented in the position where the letter "A" is located in panel 1 of the image. The series of 10 associates are repeatedly presented as many times as possible during a 1 min period of time; when the timing is complete, a feedback screen appears and provides information on the number of responses completed and the number of errors during the trial. [To view this figure in color, please see the online version of this journal.]

> In multiple 1-min timings you will be learning sequences of random letter pairs, a few of which have colors associated with them. You will learn the correct pairs by initially pressing any key on the laptop and seeing the correct letter appear below it and the next letter will appear next to it immediately. Your first goal is to try press the correct corresponding letter on the keyboard when you see each letter during the task. There are 10 unique pairs in the sequence and they will be presented in a different order throughout each 1-min trial. At the end of each 1-min trial, you will see a screen that tells you how many errors you made and how many total responses you completed. In the beginning you will make multiple errors as you learn the pairs and will probably only complete between 10 and 20 responses. As you practice each 1-min trial, you will make fewer errors and complete a higher number of responses in each 1-min. timing. You will repeat 1-min timings until you have no errors and a high number of responses, the computer will then display screen indicating that you have mastered the sequence. Instructions will be provided on the computer screen for each stage of experiment. When you are ready to begin, press the "Enter" key on the keyboard.[1]

After pressing the "Enter" key, a 1-min timing began. A single letter then immediately appeared on the left side of the screen (Figure 1, panel 1, letter "A"). After the participant pressed any key, the correct associate (Figure 1, panel 2, letter "Z") appeared below the original letter and a new letter simultaneously appeared to the right of the original letter (Figure 1, panel 2, letter "S"). This constituted the first trial in the 1-min timing. The original letter and its correct associate beneath it and each subsequent pair remained on the screen until the participant responded to the 10th letter. Seven of the 10 pairs appeared in black font against a white background. Three of the 10 pairs appeared in black font against a colored background (i.e., blue, red and green).[2] The screen was then cleared and the process repeated with the same 10 paired associates presented in a different randomly generated order (Figure 1, panel 3). This process repeated until 1 min had elapsed, at which point the participant was presented with their data from the timing, which included total responses correct and incorrect (Figure 1, panel 4).

The stimuli and apparatus described above were selected because of their familiarity to the participant population (i.e., English letters and laptop computer) and ease of data collection (i.e., response data were easily generated from the software). The various features of the paired-associates task were selected to ensure that the task was neither too easy nor too difficult. If the task was too easy, a participant could achieve the performance goal before enough data were generated for the experimental comparison. If the task was too difficult, participants might have difficulty progressing through experimental conditions. After numerous rounds of testing with pilot participants, we selected 10 paired associates with a subset appearing on colored backgrounds and random presentation order to achieve this goal (i.e., neither too easy nor too difficult).

Measurement

The experimental task was programmed in Microsoft Visual Basic© 2010. Calibration of the experimental task software was completed to ensure that settings were accurate and produced all necessary data prior to each session. The computer program recorded each key press, the exact time of its press and whether the key press was correct. The dependent measures were responses per min, a suppression ratio and errors per min. *Responses per min* was calculated by dividing the number of key presses (including incorrect responses) by 1 min per timing. This response rate (all responses) was selected to capture absolute decrements in the rate of responding (rather than underestimating if incorrect responses were removed), regardless of the accuracy of those responses. The *suppression ratio* was calculated by dividing the response rate during distraction by the last timing of the training phase. We selected the suppression ratio because it provided quantification of the decrement in responding produced by a given distractor as a single value. In addition, the suppression ratio is a single value used to express a proportion of the baseline rate, which has been used previously in related behavioral research (Mace et al., 1990). The suppression ratio was calculated by dividing the average response rate during the 1-min timing prior to distraction to the response rate during the 1-min timing where the distractor was introduced. Finally, the dependent measure of *errors per min* was calculated by dividing the number of incorrect key presses by 1 min.

Procedure

Phase 1: pretraining

Participants were seated alone in front of a laptop computer with a 43 cm screen. Pretraining involved the participant completing two 1-min timings exactly as they would complete during the remainder of the experiment but with a designated practice sequence that was different from test sequences. There were no performance criteria that needed to be met during pretraining.

Phase 2: training

Experimental task training involved participants learning each of four different task sequences of stimulus pairs, one sequence at a time, over multiple 1-min timings. Each participant was exposed to 4 different groups of 10 predetermined paired associates for which they completed 1-min trials until mastery and subsequent distractor phases. Sequence order varied across participants (see Table 1) and phases 2 (i.e., training) and 3 (i.e., distractor presentation) were completed for each sequence before beginning the next one (e.g., sequence 1: training and distractors; sequence 2: training and distractors). All participants completed 1-min timings of each sequence repeatedly until they reached the predetermined performance goal for each of sequences 1, 2, 3 and 4 (i.e., 58, 60, 55 and 50 rate per minute, respectively), without any errors. Training ended when each participant met a mastery criterion of three timings at or above the performance goal for the sequence (could be nonconsecutive). The performance goals were slightly different for each sequence due to differences in the paired-associates within each task having different optimal performance rates (i.e., location of keys on keyboard). We based the goal for each sequence on the performance of test participants' response rates. Response rates from the last timing of each of the sequences in the training phase were used in suppression ratio calculations.

Phase 3: distractor presentation

Following mastery of a sequence of paired associates, the distractor presentation phase began. Each participant was presented with six additional timings, each of which included the presentation of one of six distracting stimuli (hereafter referred to as a distractor). See Table 2 for detailed descriptions of the six potential distractors used in this study. Distractors were classified as either auditory or visual, topographically related or unrelated to the task, and presented at low, medium or high intensity. The auditory distractors were all presented through the computer speakers. The visual distractors were all presented as superimposed visual effect conditions on the task screen. The intensity (i.e., low, medium and high) of the stimuli were classified based their hypothesized interference with each sensory modality (e.g., high-intensity visual stimuli disrupted the visual field such that task stimuli could still be seen but were not as clear, medium-intensity visual stimuli were present in the visual field but did not block access to the visual stimuli of the experimental task). Participants were always able to respond to task stimuli, even when distractors were being presented. For practical reasons, we did not include every possible combination of the stimulus properties (modality, intensity and task relatedness), which would have resulted in 36

Table 1. Presentation order of sequences and distractor modalities across participants.

Participant	Sequence 1	Sequence 2	Sequence 3	Sequence 4
1	1 Auditory, visual	2 Auditory, visual	3 Visual, auditory	4 Visual, auditory
2	3 Visual, auditory	4 Auditory, visual	1 Auditory, visual	2 Visual, auditory
3	4 Auditory, visual	3 Auditory, visual	2 Visual, auditory	1 Visual, auditory
4	2 Auditory, visual	1 Visual, auditory	4 Visual, auditory	3 Auditory, visual

Table 2. Descriptions of distractors.

Sensory modality	Topographically similar to task + medium intensity	Topographically dissimilar to task + high intensity	Topographically dissimilar to task + low intensity
Visual	VS All sequence letters appear in various places on the computer screen without disrupting the view of experimental stimuli	VD Entire computer screen with transparent black and white pixel overlay (but experimental stimuli can still be detected)	VLI Lines in unidentifiable shapes appear in various places on the computer screen without disrupting view of experimental stimuli
Auditory	AS Sequence letters randomly read aloud by a person and presented through computer speakers (63 dB)	AD Alert siren of an emergency vehicle presented through computer speakers (90 dB)	ALI Muffled talking of a crowd of people, words undetectable, presented through computer speakers (35 dB)

AS: auditory similar; VS: visual similar; AD: auditory dissimilar; VD: visual dissimilar; ALI: auditory low-intensity; VLI: visual low-intensity.

conditions. Instead, we limited variation in modality presentation order (i.e., two sequences with all visual presented first and two sequences with all auditory presented first) and prioritized variation of presentation order for task relatedness and intensity features within participants.

Each distractor was presented for a period of 3 s on a fixed-time 10-s schedule for each sequence. More specifically, in a timing with distractors, the first presentation occurred 10 s after beginning a timing, for a period of 3 s, each additional distractor was presented at 20, 30, 40 and 50 s; there were five total distractor presentations in a 1-min timing. Immediately after completing training for a sequence, each participant received distracting stimuli by modality (see Table 1) as the primary presentation variable (e.g., each of the three visual stimuli presented first, followed by auditory stimuli), within each modality, intensity was varied. After all six distractors were presented across six 1-min timings of a particular sequence, the participant would repeat this process for the next randomly assigned sequence until they had completed all four sequences.

Experimental design

A formal experimental design was not used.

Results

Table 3 (see also Figure 2, representative cumulative records of one sequence of two distractors across all participants) shows suppression ratios for each distractor type, per sequence, for each participant. The auditory stimulus of hearing letters read aloud (AS) produced the greatest median suppression ratios across participants 1, 2, 3 and 4 (.786, .775, 763 and .788, respectively) for all sequences. The visual stimulus of letters appearing on the screen (VS) produced the second greatest median[3] suppression ratios across participants 1, 2, 3 and 4 (.800, .824, .797 and .861, respectively). The distracting effects of the AS and VS stimuli were likely not a function of stimulus intensity because the intensity was purposefully kept at a moderate level. The high-intensity auditory stimulus of an alert siren (AD)

Table 3. Suppression ratios and medians across sequences and participants.

Modality	Participant Sequence	1	2	3	4
VS	1	.859	.812	.784	.892
	2	.906	.781	.812	.836
	3	.741	.836	.775	.719
	4	.724	.872	.810	.885
	Median	.8	.824	.797	.861
VD	1	.906	.857	.815	.923
	2	.906	.890	.843	.918
	3	.897	.945	.965	.807
	4	.741	.945	.823	.951
	Median	.902	.918	.833	.921
VLI	1	.984	.984	.937	.938
	2	.984	.953	.953	1.0
	3	.982	1.0	.982	.964
	4	.948	1.02	.983	.967
	Median	.983	.992	.968	.966
AS	1	.813	.797	.703	.846
	2	.812	.75	.766	.787
	3	.724	.8	.793	.789
	4	.759	.818	.759	.705
	Median	.786	.775	.763	.788
AD	1	.906	.843	.846	.862
	2	.906	.812	.921	.902
	3	.896	.8	.931	.982
	4	.823	1.0	.896	.787
	Median	.902	.823	.909	.882
ALI	1	.938	.968	.906	.892
	2	.937	.843	.984	1.0
	3	.983	1.01	.948	1.0
	4	.983	1.1	.965	.951
	Median	.961	.989	.957	.975

AS: auditory similar; VS: visual similar; AD: auditory dissimilar; VD: visual dissimilar; ALI: auditory low-intensity; VLI: visual low-intensity.

produced the third greatest median suppression ratios across participants 1, 2, 3 and 4 (.902, .823, .909 and .882, respectively). The high-intensity black-and-white pixilation (VD) had the following suppressive effects across participants 1, 2, 3 and 4 (.902, .918, .883 and .921, respectively). Interestingly, the AD and VD stimuli produced relatively weak distraction even though the stimuli were presented at the highest intensities. The low-intensity auditory stimulus of muffled talking (ALI) had the following suppressive effects across participants 1, 2, 3 and 4 (.961, .989, .957 and .975, respectively) for all sequences. The low-intensity visual stimulus of unfamiliar shape screen animations (VLI) had the following suppressive effects across participants 1, 2, 3 and 4 (.983, .992, .968 and .966, respectively) for all sequences.

Representative cumulative records of the distractor that suppressed responding the most and the least for each participant (i.e., auditory similar, AS; visual low intensity, VLI respectively) from sequence 3 are depicted in Figure 2. The black data path on each cumulative record represents the last training timing (No Distractor) on sequence 3 for each participant. The grey data path on each cumulative record represents the distraction timing for AS (left panels) and VLI (right panels) on sequence 3 for each participant. Gray bars on each cumulative record represent the presentation time of distractors during a timing. As seen in the cumulative records, reductions in responding

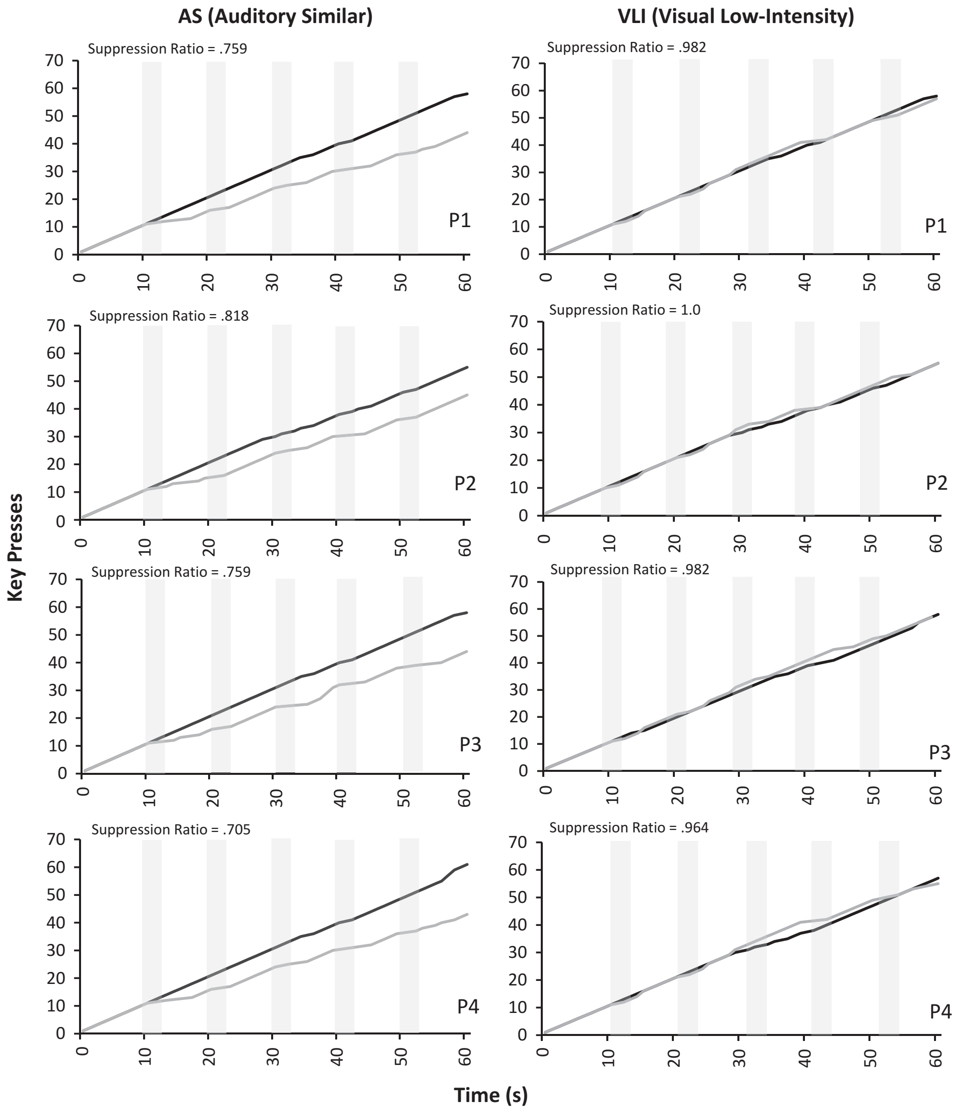

Figure 2. Cumulative records of performance during auditory similar (AS) distractor presentation and the visual low intensity (VLI) during sequence 3 for each participant. [To view this figure in color, please see the online version of this journal.]

occurred immediately following the introduction of VS distractors. The suppression ratios for the AS data for participants 1, 2, 3 and 4, respectively, were .759, .818, .759 and .705, indicating that the AS stimulus did serve as a distractor for each of these participants. The suppression ratios for the VLI data for participants 1, 2, 3 and 4, respectively, were .982, 1.0, .982 and .964, indicating that the VLI stimulus did not serve as a distractor for each of these participants.

Figure 3 shows error frequencies for each distractor type, per sequence, for each participant. The auditory stimulus of hearing letters read aloud (AS) produced the greatest total error frequencies across participants 1, 2, 3 and 4 (8, 9, 9 and 12,

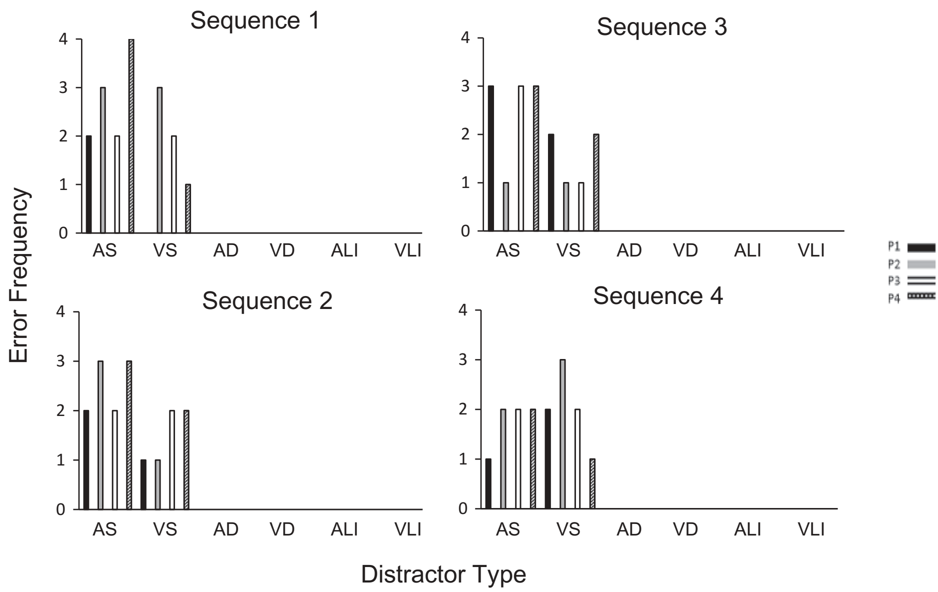

Figure 3. Error frequencies per sequence across distractor type for each participant. AS: auditory similar; VS: visual similar; AD: auditory dissimilar; VD: visual dissimilar; ALI: auditory low-intensity; VLI: visual low intensity. [To view this figure in color, please see the online version of this journal.]

respectively) for all sequences. The visual stimulus of letters appearing on the screen (VS) produced the only other error frequencies across participants 1, 2, 3 and 4 (5, 8, 7 and 6, respectively). The remaining stimuli (i.e., AD, VD, ALI and VLI) did not produce errors in responding for any of the participants during any of the sequences.

Discussion

Traditional approaches to the study of distraction have involved the evaluation of an effect of a stimulus on specific task performance but without a conceptual analysis of how the stimulus might actually interfere with the specific task (e.g., Hirsh & Burk, 2013). By contrast, the primary focus of the present study was to evaluate distractors based on the probable source of stimulus control and their relation to the task. We found that potentially distracting stimuli that included letters had the greatest distracting effects on responding, regardless of auditory or visual sensory modality (the AS and VS conditions). In addition, these stimuli also generated the only errors that occurred in the study. We propose one explanation for these findings. It is possible that participants engaged in covert verbal behavior to solve the paired-associates task (e.g., "z goes with a"; Gutierrez, 2006; Palmer, 2009). If this was indeed the case, the presentation of letters (auditory or visual) might have interfered with this covert responding. This speculative account is supported by the fact that stimuli that were unrelated to the task but were nonetheless salient (i.e., AD and VD) produced less suppression. In addition, we also found that low-intensity stimuli unrelated to the task (i.e., VLI and ALI) had very little impact on response rates and in most cases were barely identifiable via visual inspection of cumulative records.

Secondary purposes of the present study were to explore the use of cumulative records for the identification of distraction on a molecular basis and use a suppression ratio to quantify distraction at a more molar level. As seen in Figure 2, the cumulative records showed corresponding response decrements immediately after distractor presentation. Without the momentary evaluation of responding made possible with the cumulative record, a more molar (i.e., session based) summary could mask a temporary and minor decrement in performance that under some circumstances could be important (e.g., a single instance of slightly drifting into the other lane while driving). Because distraction is necessarily a decrement between current and past performance, its quantification can be efficiently expressed as a single value. The suppression ratio appears to be well-suited to this purpose and allowed us to efficiently compare the effects of potentially distracting stimuli across a large set of data. For example, Figure 4 depicts 96 instances of potential distraction (i.e., 24 cumulative records of distractor presentations per participant, multiplied by 4 participants), due to the economy of the suppression ratio. A potential barrier to the generality of our findings was the presentation of the distractors for only brief periods of time (i.e., every 10 s) instead of continuously (e.g., Binder, 1996). Although these brief presentations were sufficient for detecting differences between classes of potentially distracting stimuli, they may not represent how these stimuli are presented in naturalistic settings. For example, in an evaluation of cell phone alerts as distractors on driving performance, brief presentations would be sufficiently representative. However, in an evaluation of loud music on academic performance, it would be useful to evaluate the distracting effects of continuous presentation.

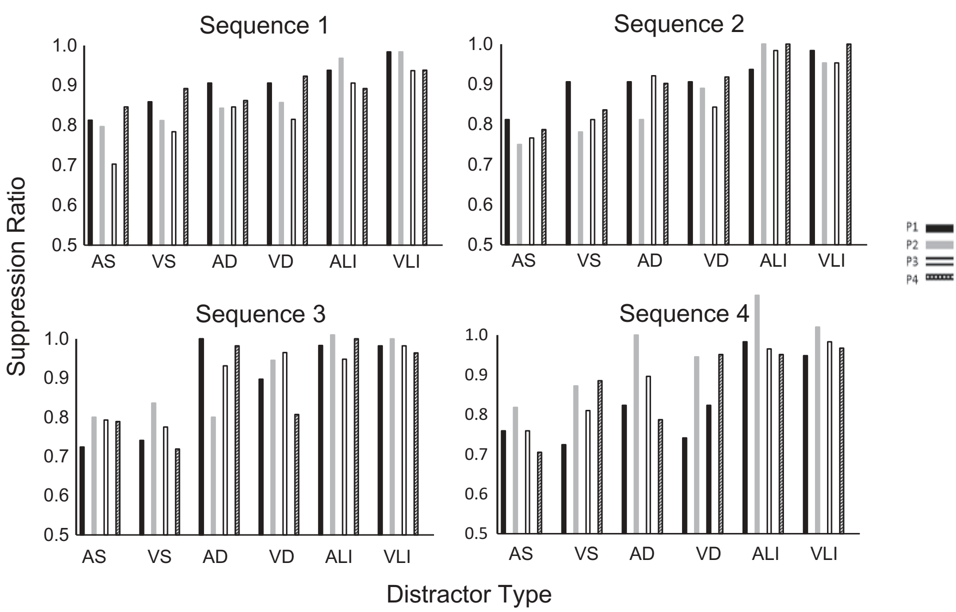

Figure 4. Suppression ratios per sequence across distractor type for each participant. AS: auditory similar; VS: visual similar; AD: auditory dissimilar; VD: visual dissimilar; ALI: auditory low-intensity; VLI: visual low intensity. [To view this figure in color, please see the online version of this journal.]

The key limitation of the present study was the single presentation of each distractor across sequences with no replication of the effects within the sequence to permit an appropriate single-case experimental design (e.g., alternating treatments design). However, we replicated distractor presentation within participants and across different sequences of the same experimental task (i.e., each participant had 4 replications and in total there were 16) as a control for this and the general effects were replicated. We encourage future researchers to use multiple stimulus presentations within a traditional single-case experimental design.

In conclusion, the present study contributes to the literature on distraction in three ways. First, we illustrated that the differentially distracting effects of stimuli might have correlated with the way certain stimuli interacted with the task irrespective of stimulus intensity or general sensory modality. Second, we found the cumulative record, which appears to be new to the study of distraction, to be useful in identifying the momentary effects of distraction. Finally, the suppression ratio proved to be particularly relevant for efficiently quantifying the behavioral effects of distraction. Given the importance of the topic of "distraction" and the relevance of behavior analysis to its investigation, we hope the three modest contributions of the present study will help facilitate further behavior-analytic research on the topic.

Notes

1. Complete documentation of the textual instructions provided within the program can be obtained from the first author.
2. The top letters of these three pairs also appeared as the top letters in three of the seven pairs with a white background. The colored background served as a conditional stimulus in that its appearance indicated that a different letter should be selected compared to when it was presented against a white background.
3. Medians were chosen as our measure of central tendency to provide a more sensitive measure of response suppression by eliminating outliers that might be attributed to order effects.

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Disclosure statement

No potential conflict of interest was reported by the authors.

References

Barton, L. E. (1986). Maintenance of therapeutic change by momentary DRO. *Journal of Applied Behavior Analysis*, *19*, 277–282. doi:10.1901/jaba.1986.19-277

Binder, C. (1996). Behavioral fluency: Evolution of a new paradigm. *The Behavior Analyst*, *19*, 163–197. Retrieved from http://link.springer.com/journal/40614

Demeter, E., Sarter, M., & Lustig, C. (2008). Rats and humans paying attention: Cross-species task development for translational research. *Neuropsychology*, *22*, 787–799. doi:10.1037/a0013712
Estes, W. K., & Skinner, B. F. (1941). Some quantitative properties of anxiety. *Journal of Experimental Psychology*, *29*, 390–400. doi:10.1037/h0062283
Gutierrez, R. D. (2006). The role of rehearsal in joint control. *The Analysis of Verbal Behavior*, *22*, 183–190. Retrieved from http://link.springer.com/journal/40616
Hirsh, A. H., & Burk, J. A. (2013). Repeated visual distracter exposure enhances new discrimination learning and sustained attention task performance in rats. *Behavioural Processes*, *92*, 147–151. Retrieved from http://www.journals.elsevier.com/behavioural-processes/
Hopkins, B. L. (1968). Effects of candy and social reinforcement, instruction, and reinforcement schedule leading on the modification and maintenance of smiling. *Journal of Applied Behavior Analysis*, *1*(2), 121–129. doi:10.1901/jaba.1968
Howell, L. L., Byrd, L. D., & Marr, M. J. (1986). Similarities in the rate-altering effects of white noise and cocaine. *Journal of the Experimental Analysis of Behavior*, *46*, 381–394. doi:10.1901/jeab/1986.46-381
Johnson, K. R., & Layng, T. V. J. (1994). The Morningside Model of generative instruction. In R. Gardner, III, D. M. Sainato, J. O. Cooper, T. E. Heron, W. L. Heward, J. E. Eshleman, & T. A. Grossi (Eds.), *Behavior analysis in education* (pp. 173–197). Belmont, CA: Wadsworth.
Kalfus, G., & Stokes, T. (1987). Generalization as a function of a preschool peer-tutor's presence: Facilitation or distraction. *Educational Research Quarterly*, *11*, 26–36. Retrieved from http://erquarterly.org/
Kim, C., Carr, J. E., & Templeton, A. (2001). The effects of fluency building on performance over "long" durations and in the presence of a distracting social stimulus. *Journal of Precision Teaching & Celeration*, *17*, 7–26. Retrieved from http://celeration.org/the-journal/
Mace, F. C., Lalli, J. S., Shea, M. C., Lalli, E. P., West, B. J., Roberts, M., & Nevin, J. A. (1990). The momentum of human behavior in a natural setting. *Journal of the Experimental Analysis of Behavior*, *54*, 163–172. doi:10.1901/jeab.1990.54-163
Minamoto, T., Shipstead, Z., Osaka, N., & Engle, R. W. (2015). Low cognitive load strengthens distractor interference while high load attenuates when cognitive load and distractor possess similar visual characteristics. *Attention, Perception, & Psychophysics*, *77*, 1659–1673. doi:10.3758/s13414-015-0866-9
O'Reilly, M., Aguilar, J., Fragale, C., Lang, R., Edrisinha, C., Sigafoos, J., … Didden, R. (2012). Effects of a motivating operation manipulation on the maintenance of mands. *Journal of Applied Behavior Analysis*, *45*, 443–447. doi:10.1901/jaba.2012.45-443
Palmer, D. C. (2009). The role of private events in the interpretations of complex behavior. *Behavior and Philosophy*, *37*, 3–19. Retrieved from http://www.behavior.org/resource.php?id=319
Singer, R. N., Cauraugh, J. H., Murphy, M., Chen, D., & Lidor, R. (1991). Attentional control, distractors, and motor performance. *Human Performance*, *4*, 55–69. doi:10.1207/s15327043hup0401_3