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Role of Distractors in Delayed Matching-to-Sample Arrangements in Tests for Emergent Relations

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Abstract

Some studies have presented math tasks as distractors in Delayed Matching-to-Sample (DMTS) procedures between the offset of the sample stimulus and the onset of the comparison stimuli in tests for equivalence class formation. The main findings have been a decrease in experimenter-defined correct matching performance when participants have been exposed to such distractors. Therefore, the purpose of two experiments in the present study was to extend the knowledge of how different types of distractors may or may not influence equivalence class formation in DMTS procedures. Experiments 1 and 2 were arranged as ABA designs. The A-phases were arranged without distractors and the B-phases with distractors during testing. In the test phases, dictation tasks were used as distractors in Experiment 1, while echoic tasks were used as distractors in Experiment 2. The results showed that matching accuracy and equivalence class formation were reduced in the B-phases but not in the A-phases in Experiment 1, while the echoic tasks did not influence performance in Experiment 2. The results are also discussed on the basis of the criterion of correct responding.

Key words: stimulus equivalence, matching accuracy, delayed matching-to-sample, distractors.

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Novelty and Significance

What is already known about the topic?

- Delayed Matching-to-Sample procedures often lead to high yields of responding in accordance with stimulus equivalence.
- One interpretation of the high yield of equivalence responding in Delayed Matching-to-Sample is that rehearsal may be needed to "carry information" about the sample throughout the delay until comparison selection and that such rehearsal facilitate equivalence responding.
- Using math tasks as distractors in the delay during equivalence testing affect equivalence responding negatively.

What this paper adds?

- In previous studies, math tasks have been used as distractors in the current study different types of distractors used to test if they could affect stimulus equivalence responding.
- Results in the current study show that the distractors do not affect matching performance to the same degree as the math tasks used in previous studies.

Stimulus equivalence is defined by properties of reflexivity, symmetry, and transitivity (e.g., Sidman & Tailby, 1982). For example, participants are presented six conditional discriminations, A1B1, A2B2, A3B3, B1C1, B2C2, and B3C3 arranged as a linear series training structure (A→B→C). When the participants perform according to an experimenter-defined criterion, a test for emergent relations is employed. The feature of reflexivity is shown if the participant matches stimulus A to stimulus A, stimulus B to stimulus B, and stimulus C to stimulus C. Secondly, responding according to symmetry is shown if they match stimulus C to stimulus B and stimulus B to stimulus A. The feature of transitivity refers to when participants match stimulus A to stimulus

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C. It is important to note that equivalence class formation is considered to be a binary outcome, which means that participants either form equivalence classes or not. The most commonly used criteria for responding in accordance with stimulus equivalence is 90% correct responding or above on test trials (for an overview see Arntzen, 2012).

The most common arrangements to establish necessary baseline relations for testing of equivalence class formation are Simultaneous Matching-to-Sample (SMTS) procedures (e.g., de Rose, Hidalgo, & Vasconcellos, 2013) and DMTS procedures (e.g., Arntzen, 2006; Arntzen, Galaen, & Halvorsen, 2007; Lian & Arntzen, 2013; Vaidya & Smith, 2006). In an SMTS arrangement, the sample stimulus is present at the same time as the comparison stimuli, while in a DMTS arrangement, the presentation of the sample stimulus is discontinued, followed by a delay interval before the comparison stimuli are presented. Several authors have suggested that participants need to show mediating behavior to respond correctly in DMTS arrangements (e.g., Blough, 1959; Lowenkron, 1998).

The role of mediating behavior on stimulus equivalence class formation has been widely discussed (e.g., Horne & Lowe, 1997; Sidman, 1997). However, even if the role of mediating behavior is an unresolved issue, it has been found that mediating behavior may have a facilitating effect on responding in accordance with stimulus equivalence (e.g., Eikeseth & Smith, 1992). Also, the findings that participants are more likely to respond in accordance with stimulus equivalence in DMTS procedures compared to SMTS procedures (e.g., Arntzen, 2006; Saunders, Chaney, & Marquis, 2005) may be used to argue that DMTS procedures might more readily lead participants to rehearse names given to the stimuli and thus lead to the higher equivalence yields in DMTS procedures (e.g., Arntzen & Vie, 2013).

Rehearsal is often not directly observable, hence one must make interpretations. One possible approach to strengthening or weakening interpretations regarding rehearsal in stimulus equivalence responding in DMTS procedures is to introduce tasks which may or may not function as distractors in the delay between the offset of the sample and onset of the comparison stimuli.

A variety of types of tasks have been used as distractors. For example, meaningful and irrelevant or nonsense language-like tasks (Greene, 2014), silence, music, letters of the alphabet, and additional digits (Taylor & Hirt, 1975), and counting backward (Putnam, 1971). However, it is of interest to expand the knowledge of what type of distractors might disrupt stimulus equivalence class formation when using a DMTS arrangement. Since such research has, until now, focused on math tasks, the main findings have been that the number of participants responding in accordance with stimulus equivalence has decreased in the distractor conditions compared to the conditions without distractors (Arntzen, 2006; Arntzen & Vie, 2013).

Experiment 4 in Arntzen (2006), arranged a DMTS procedure to test for the emergence of derived relations. Math tasks were introduced as potential distractors during the delays. In testing, the participants went through a sequence of phases with simultaneous matching, 0-s delay, and 3-s delay conditions. The potential distractors were multiplication tasks consisting of numbers from 2 to 25, and these tasks were presented on an adjacent computer. The main findings were that participants responded in accordance with stimulus equivalence in the first two phases but not in the final phase with the math tasks as potential distractors. The implication was that math tasks functioned as distractors and could hinder responding in accordance with stimulus equivalence.

Arntzen and Vie (2013) replicated and expanded the findings of Experiment 4 in Arntzen (2006). The authors employed ABA and BAB experimental designs (A without potential distractors and B with potential distractors) with a 6-s delay DMTS procedure. The matching-to-sample tasks were presented on one screen, and the potential distractors were presented on an adjacent screen. The potential distractors were addition and subtraction tasks. Furthermore, the participants were required to say both the task and the answer out loud, and type the answers on a numeric keypad. In the first A-phase without potential distractors, in the ABA design, six out of six participants responded in accordance with stimulus equivalence. In the B phase, with the potential distractors, only two of six participants responded in accordance with stimulus equivalence. In the last A-phase, without potential distractors, five of six participants formed equivalence classes. For the other six participants assigned to the BAB design, none responded in accordance with stimulus equivalence in the first B-phase. In the A-phase, five of six responded in accordance with stimulus equivalence, but in the last B-phase, only two of six did so. Arntzen and Vie (2013) suggested, as in Arntzen (2006), that one interpretation of these findings could be that the distractors restricted some mediating behavior during the delay.

Since both Arntzen (2006) and Antzen and Vie (2013) used math tasks as potential distractors, it seems important to assess what other types of tasks might function as distractors. The present experiments were an assessment of different types of tasks that may or may not function as distractors and also as systematic replications and extensions of Arntzen (2006), and Arntzen and Vie (2013). Hence, two experiments were employed to study the effects of different types of tasks as potential distractors on matching accuracy and responding in accordance with stimulus equivalence.

Experiment 1

Several studies have found that if the distractor task is of a different material than the ongoing task, then little interference is expected (e.g., Craik, 2014; Mozolic, Long, Morgan, Rawley-Payne, & Laurienti, 2011). Hence, one assumption is that if verbal rehearsal during the delay is responsible for equivalence formation in DMTS procedures, one might expect that a distractor consisting of a verbal task will disrupt or hinder rehearsal.

The purpose of Experiment 1 was to assess if dictation tasks might function as distractors like previous types of distractors (see Arntzen, 2006; Arntzen & Vie, 2013) and to test whether a distractor with a verbal component affects stimulus equivalence performance. In the present experiment, the participants had to type four-letter meaningful words on the keyboard as they were dictated.

An additional rationale for selecting such a task was that the dictation tasks would take less time to complete than math tasks, which was a limitation of the Arntzen and Vie (2013) study. Hence, when the math tasks were introduced as distractors in Arntzen and Vie, the median time used on the task varied notably across participants, from 5.2 s to 13.7 s. Furthermore, in the BAB design, there was a reduction in the median time for the distractor tasks from the first B-phase (range from 5.9 s to 10.3 s) to the second B-phase (5.2 s to 7.4 s). Another problem was that the distractors were presented on an adjacent screen, giving the participants an opportunity to see the comparison array before the distractor tasks were finished. For example, in animal studies, it has been shown that distractors that are presented at the same time as the comparison array have little or no effect on matching performance (Wright, Urcuioli, Sands, & Santiago, 1981). Therefore, the distractor tasks in the current study were presented on the same screen as the matching-to-sample task.

METHOD

Participants

Ten students, nine females, with a mean age of 29 years (ranging from 20 to 54 years old), participated in the study. They were recruited primarily at OsloMet, Oslo and Akershus University College and via personal contacts. The participants had no previous experience with either stimulus equivalence experiments or with the stimuli employed in the experiment. The participants were given an informed consent form with general information about the experiment, such as information about their anonymity, and that they could withdraw from the experiment at any time without any punishing consequences. All participants were fully debriefed after completing the experimental session. The debriefing involved a short overview of the properties involved in responding in accordance with stimulus equivalence, a description of their results, and examples of the use of equivalence-based instruction. Finally, they were thanked for their participation. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Design

An ABA design was used in the experiment. In each phase, training and testing were conducted once. Establishing baseline conditional discriminations were identical for all three phases. However, during the testing for equivalence class formation, the participants began with a phase without distractors (A), then a phase with distractors (B), and finally another phase without distractors (A). For all phases, including training and testing, a 3-s DMTS procedure was used. If the participant did not respond in accordance with stimulus equivalence in the first phase, the experimental session was discontinued.

Setting and Apparatus

The experiment was conducted in a laboratory setting, and the experimental session took place in an office cubicle measuring 52 sq ft that contained a table and a chair. The matching-to-sample tasks were presented on a personal computer with Windows 7 as the main operation system. The laptop had a 17-inch screen. A computer mouse was connected to the computer, and the participants used the mouse to click on the stimuli. A custom-made matching-to-sample software was used. The software presented the stimuli and the programmed consequences on the screen. Furthermore, the program collected the results automatically, which included the number of training trials, which sample stimulus was presented, the selected comparison stimulus, and whether the selection was correct or incorrect according to the experimenter-defined classes. The matching-to-sample program controlled the distractor program. The participant also wore a set of Koss PortaPro headphones through which the dictation was played. The distractor program automatically collected the participants' text inputs, the time to type the word, and whether the word that was written down was correct.

Stimuli

Three different sets of visual stimuli were used in the present experiment (see Figure 1). The stimulus sets consisted of Arabic, Cyrillic, Chinese, Hebrew, and

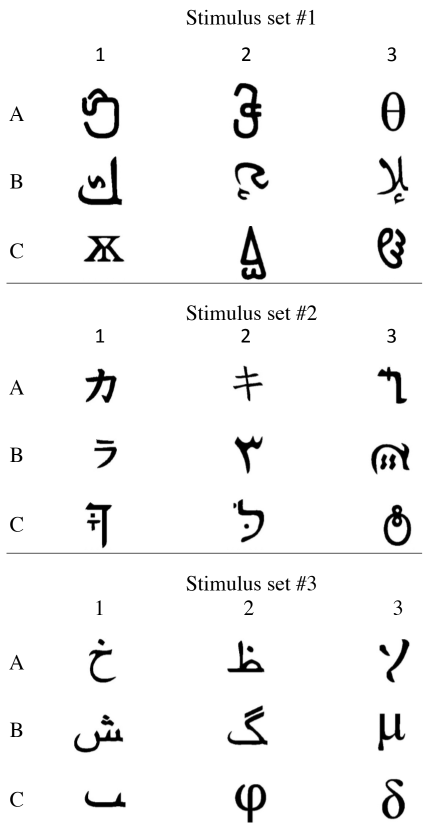

Figure 1. The stimulus sets used. The numbers indicate the experimenter-defined classes and the letters indicate the different class members.

Japanese characters and were identical to the sets used in Arntzen and Vie (2013). In the first phase, Stimulus Set #1 was presented. In the second phase, Stimulus Set #2 was presented. Finally, Stimulus Set #3 was presented in the last phase.

Different stimulus sets for each condition were used to reduce the effects of being exposed to training and test multiple times. The sample was always presented in the middle of the screen, and the comparisons were presented in random order in the corners of the display (17 cm diagonally from the sample stimulus). The average stimulus size was 3.5 × 2.5 cm. Also, the stimuli were presented in mouse-click-sensitive rectangular areas of 10.5 × 3.8 cm.

Instruments

The following instructions were presented in Norwegian on the computer screen:

> A stimulus will appear in the middle of the screen. You should click on it with the left mouse button. Three other stimuli will appear. Choose one of these with the use of the left mouse button. If you choose the stimulus we have defined as correct, words such as “correct”, “great”, etc. will be presented on the screen. If you press an incorrect

stimulus, "wrong" will be presented on the screen. At the bottom of the screen, the number of correct responses will be counted. During some stages of the experiment, the computer will not give feedback about whether the choices are correct or incorrect. However, based on what you have learned, you can get all of the tasks correct. Words will be presented during the experiment. A rectangle will appear at the bottom of the screen. Use the keyboard to type the presented word in the rectangle, and press the Enter key to continue.

Do your best to get everything right. Good luck!

Procedure

Training baseline conditional discrimination. The mouse cursor was automatically set to a fixed position, 3 cm above the left side of the click-sensitive area of the sample stimulus. The fixed position was set before the presentation of the sample stimulus. When the participants clicked on the sample stimulus, it remained on the screen for 1 s before it was offset. After a 3-s delay, the comparisons were presented. Clicking on one of the comparison stimuli was followed by a programmed consequence on the screen for 0.5 s and an inter-trial interval of 0.5 s. Correct responses resulted in a variety of textual stimuli such as super, very good, and awesome presented in the middle of the screen. Incorrect responses resulted in the presentation of the text incorrect. In the test for stimulus equivalence, no programmed consequences were presented for any response. A many-to-one (MTO) training structure and simultaneous protocol, which means that all baseline relations were established before the test, was initiated. The MTO structure was chosen to be able to compare the results of the current study with the study by Arntzen and Vie (2013). The baseline trials were presented on a serialized basis (see Table 1). First, AC relations were trained first (A1/C1C2C3, A2/C1C2C3, and A3/C1C2C3) until the participants responded 100% correctly on the AC-trials in blocks consisting of nine trials (9 of 9). Then, BC relations (B1/C1C2C3, B2/C1C2C3, and B3/C1C2C3) were trained separately, until the participants responded 100% correctly on the BC-trials in blocks consisting of nine trials (9 of 9). Finally, AC and BC relations (A1/C1C2C3, A2/C1C2C3, A3/C1C2C3, B1/C1C2C3, B2/C1C2C3, and B3/C1C2C3) were trained in mixed order in 18-trial blocks. The criterion was set to 100% correct responses within each block (18 of 18). When the 100% criterion was met in a mixed block, the programmed consequences were gradually thinned out for each block with 100% correct responding. The programmed consequences began with a probability of 75% in a block, then 50%, 25%, and 0%. When the participants showed 100% correct responses in the block with no programmed consequences, the test for equivalence class formation was initiated.

Testing of equivalence class formation. This test consisted of baseline trials, symmetry trials, and equivalence trials in one block with 54 trials. The baseline probes were the same as the trials presented during training (A1/C1C2C3, A2/C1C2C3, A3/C1C2C3, B1/C1C2C3, B2/C1C2C3, and B3/C1C2C3). The symmetry trials were C1/A1A2A3, C2/A1A2A3, C3/A1A2A3, C1/B1B2B3, C2/B1B2B3, and C3/B1B2B3. The equivalence trials were A1/B1B2B3, A2/B1B2B3, A3/B1B2B3, B1/A1A2A3, B2/A1A2A3, and B3/A1A2A3. Each trial was presented three times, which leads to 18 baseline probes, 18 symmetry, and 18 equivalence trials being presented in the test block. The criterion for responding in accordance with stimulus equivalence was defined as above 90% correct on all the baseline, symmetry, and equivalence trials.

Distractors during testing. Distractors were introduced in the delay between the offset of the sample stimulus and the onset of the comparison stimuli when testing for emergent relations in the B-phases. The distractors consisted of 54 Norwegian four-letter words read aloud by a prerecorded voice. The median time for the recordings was 0.8 s. The sound level was set to approximately 60 dB. The words were presented in a fixed order. However, since the order of the test trials was randomized, the distractors were presented in different trials across participants. A text input field followed 2 s after the prerecorded voice began. When the participants had written two letters or more, they could press enter to remove the text input field, and the comparison stimuli were presented.

Table 1. Overview of the Procedure.

Condition		Trial types	% Probability of programmed consequences per trial
Serialized training		A1/C1C2C3, A2/C1C2C3, A3/C1C2C3	100
Serialized training		B1/C1C2C3, B2/C1C2C3, B3/C1C2C3	100
Mixed training		A1/C1C2C3, A2/C1C2C3, A3/C1C2C3, B1/C1C2C3, B2/C1C2C3, B3/C1C2C3	100
Mixed training		A1/C1C2C3, A2/C1C2C3, A3/C1C2C3, B1/C1C2C3, B2/C1C2C3, B3/C1C2C3	75
Mixed training		A1/C1C2C3, A2/C1C2C3, A3/C1C2C3, B1/C1C2C3, B2/C1C2C3, B3/C1C2C3	50
Mixed training		A1/C1C2C3, A2/C1C2C3, A3/C1C2C3, B1/C1C2C3, B2/C1C2C3, B3/C1C2C3	25
Mixed training		A1/C1C2C3, A2/C1C2C3, A3/C1C2C3, B1/C1C2C3, B2/C1C2C3, B3/C1C2C3	0
Mixed testing	Baseline relations	A1/C1C2C3, A2/C1C2C3, A3/C1C2C3 B1/C1C2C3, B2/C1C2C3, B3/C1C2C3	0
	Symmetry	C1/A1A2A3, C2/A1A2A3, C3/A1A2A3 C1/B1B2B3, C2/B1B2B3, C3/B1B2B3,	
	Equivalence	A1/B1B2B3, A2/B1B2B3, A3/B1B2B3 B1/A1A2A3, B2/A1A2A3, B3/A1A2A3	

Note: For all training conditions it was 100% mastery criterion, and 90 % criterion in the test condition.

Results and Discussion

The main findings were that seven out of 10 participants responded in accordance with stimulus equivalence in the phases without distractors and that nine of 10 did not respond in accordance with stimulus equivalence in the phase with distractors (see Table 2). The Fisher's exact test (FET) shows a significant difference between the first A phase and the B phase, p= .0001, and between the B phase and the second A phase the p= .0198. Thus, the results replicated the findings of Arntzen (2006) and Arntzen and Vie (2013). However, the matching accuracy for some participants in the current experiment is close to the 90% criterion.

It seems important to underline that when comparing participants exposed to different conditions, reporting only the number of participants who respond in accordance with stimulus equivalence or not as the dependent variable might lead to a difference between parameters that makes them appear bigger than they are. One solution might be, as is done in the current experiment, also to show the percentages for each participant

Table 2. An Overview of Results of Experiment 1.

P#	No distractors (A)					Distractors (B)							No distractors (A)				
	TT	%BSL	%SYM	%EQ	ECF	TT	%BSL	%SYM	%EQ	ECF	%ADT	MDT	TT	%BSL	%SYM	%EQ	ECF
3110	279	**100**	**100**	**94.4**	**Y**	234	22.2	22.2	44.4	N	90	2.4	207	**94.4**	**94.4**	**100**	**Y**
3221	594	**94.4**	**94.4**	**100**	**Y**	378	72.2	**100**	**100**	N	95	2.6	450	**100**	**94.4**	**100**	**Y**
3116	243	**94.4**	**100**	**94.4**	**Y**	288	77.7	**94.4**	88.8	N	100	2.3	153	**94.4**	**100**	**100**	**Y**
3118	216	**94.4**	**100**	**94.4**	**Y**	162	83.3	**100**	**94.4**	N	NA	NA	144	**100**	**100**	**100**	**Y**
3111	225	**94.4**	**94.4**	**100**	**Y**	180	**94.4**	88.8	**100**	N	100	2.6	315	**100**	**100**	**94.4**	**Y**
3240	396	**100**	**94.4**	**100**	**Y**	144	**94.4**	**94.4**	88.8	N	98	2.3	135	**100**	**100**	**100**	**Y**
3115	162	**94.4**	**94.4**	**94.4**	**Y**	594	88.8	**94.4**	72.2	N	100	2.2	315	**100**	88.8	**100**	N
3114	162	**100**	**94.4**	**100**	**Y**	261	**94.4**	**100**	88.8	N	100	1.9	189	83.3	**94.4**	**94.4**	N
3223	162	**100**	**94.4**	**100**	**Y**	117	**94.4**	**100**	88.8	N	100	3.6	279	**100**	88.8	**100**	N
3238	216	**100**	**94.4**	**100**	**Y**	180	**100**	**94.4**	**100**	**Y**	98	1.2	180	**100**	**94.4**	**100**	**Y**

Notes: The Percentages in bold indicate that the participant responded within the criteria of 90% set by the experimenters on the experimenter-defined definitions; The number of trials presented for each trial type was 18; P#= Participant number; TT= Number of training trials; BLS= Baseline probes; SYM= Symmetry probes; EQ= Equivalence probes; ECF= Equivalence class formation; Y= Yes; N= No; %ADT= Percent accuracy for distractor tasks; MDT= Median seconds taken for dictation tasks.

matching performance and make the reader aware that participants are close to the criterion used.

Figure 2 shows the mean gain or loss in accuracy (mean of baseline, symmetry, and equivalence) for each participant. Nine of the 10 participants show a decrease in mean accuracy ranging from 1.8 to 68.5% when comparing the mean accuracy in the first A-phase with the B-phase, while the remaining participant showed neither an increase nor a decrease in accuracy comparing the first A-phase and B-phase. When comparing the B-phase with the second A-phase, eight of the 10 participants showed an increase in mean accuracy of 3.7 to 66.6%, while one of the two final participants showed no gain, and the last participant showed a decrease in mean accuracy of 3.7%.

Six participants (P3110, P3221, P3116, P3118, P3111, and P3240) responded in accordance with equivalence in the first A-phase but did not form equivalence classes when the distractors were presented (B-phase). They formed classes again in the second A-phase.

If verbal rehearsal during the delay is responsible for correct matching performance for these participants, the decrease in matching performance in phase B is hindered by the verbal distractor. Other studies have found that distractors of the same material as the ongoing task leads to much interference while distractors of a different material than the ongoing task leads to little interference (e.g., Craik, 2014; Mozolic *et alii*, 2011).

It is difficult to conclude about the effect of the distractor for P3111 and P3240 since they responded just below the criteria of 90%. P3238 responded differently than the other participants in the distractor phase, with no decrease in accuracy in the distractor phase compared to the phases without distractors. For these participants, it might be the case that rehearsal during the delay was not needed to show high matching accuracy in the distractor phase which is in accordance with Lowenkron (1998) who argues that continuous rehearsal might occur if it is differentially reinforced by leading to higher matching accuracy.

Three participants (P3115, P3114, and P3223) responded in accordance with stimulus equivalence in the first A-phase and did not form equivalence classes in the B-phase or the second A-phase. There could be an effect of the distracting task because of the

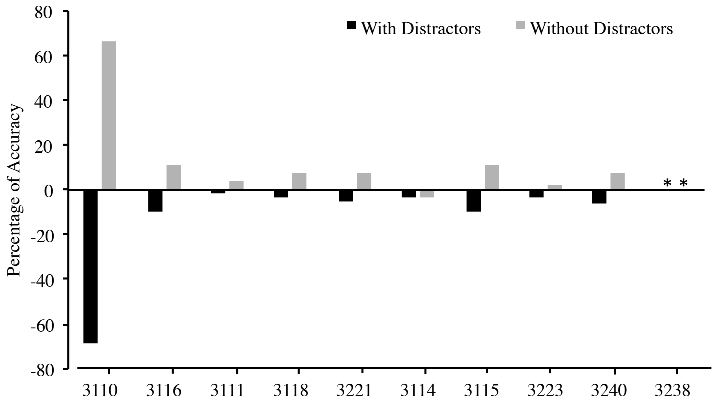

Figure 2. Each participant is represented with two bars, black and gray. The black bars indicated the difference in percentage in accuracy from the first A-phase (without distractors) to the B-phase (with distractors), and gray bars indicate the difference in percentage from the B-phase (with distractors) to the second A-phase (without distractors). * indicates a 0% difference.

change from the first A-phase to the B-phase but how strong an effect is questionable because the participants do no form classes in the second A-phase.

Comparing the time used by the participants to select the correct comparison under the test for equivalence class formation shows that the time used in the A-phases was shorter than the time used in the distractor phase for all participants (see Table 3). A repeated-measures ANOVA showed a statistically significant effect of distractors on reaction time $F(1.56, 14.04)= 63.98$, $p= .0001$. In the B-phase when the participants also had to solve the dictation tasks, seven participants (P3115, P3114, P3223, P3111, P3116, P3240, and P3110) used more than a second longer when choosing the correct comparison in the test. The two last participants (P3221and P3238) showed the same pattern but used less than a second more time to choose the correct comparison in the distractor phase. Thus, the reaction time results replicate the finding that reaction time often increases when distractors are introduced (e.g., Artchakov *et alii*, 2009; Mozolic *et alii*, 2011).

Table 3. Median Time in ms Used on Selecting the Correct Comparison in the Stimulus Equivalence Test.

P#	A	B	A	Difference A-B	Difference B-A
3115	2467	3712	1956	1246	1756
3114	2091	3310	2757	1218	552
3223	2052	3689	1520	1637	2169
3111	1887	3722	1802	1834	1920
3116	1881	3439	2089	1559	1351
3240	1839	3025	1504	1186	1521
3110	1825	3549	1952	1724	1597
3221	1934	2759	1855	825	904
3238	1349	1955	1325	606	630
Average	1925	3240	1862	1315	1377

Note: The reaction time data for P3118 was lost and is therefore not included in the table.

All participants answered the dictation distractor tasks with an average of 96% correct, with the lowest score of 90% correct and the highest score of 100%. The mean correct score for participants during the distractor task was on the average higher in the current study than it was in Arntzen and Vie (2013). The higher score on the distractor task in the present experiment may be related to differences in difficulty levels while performing the required tasks, solving math tasks versus typing dictated words.

In the current study, the median time the participants were engaged by the distractor tasks ranged from 1.2 s to 3.6 s which is less than in Arntzen and Vie (2013). Therefore, the difference in range could be accounted for by the fact that the distractor in Arntzen and Vie (2013) required the participants to show more types of behavior; they were instructed to say the math tasks aloud, say the answer, and then write down the answer. In the present study, the four-letter words were read aloud to the participants, and they had to type them in.

Experiment 2

Some findings from cognitive research have shown that distractors within the same sensory modality as the task are substantially more disruptive than distractors from different sensory modalities. For example, Artchakov et al. (2009) trained visual DMTS tasks and auditory DMTS tasks in rhesus monkeys. In both DMTS tasks, the monkeys were required to hold down a lever throughout the sample presentation and until the comparison stimulus was presented. If the sample and comparison were presented at the same position, a reward was presented if the monkeys released the lever within 1,000 ms. If the sample and comparison were presented in different positions, the monkey had to hold the lever for 1,000 ms or more after the presentation of the comparison stimulus to receive the reward. In the visual DMTS task, a green LED was presented as a sample on either the left side or the right side of a LED panel. Then, after a delay of 3,100 ms, the comparison was either presented to the left or right side of the LED panel. In the auditory DMTS task, the sample and comparison consisted of a 500 Hz tone which was presented by loudspeakers positioned on the left and right side of the monkey. The distractors were presented in the middle of the delay, with the visual distractor consisting of the simultaneous lighting of eight LEDs on the LED panel, and the auditory distractor consisting of a 50 Hz tone presented intermittently from the left and right loudspeakers. The results showed that the distractors resulted in a decrease in correct responses and an increase in reaction time. Furthermore, the visual DMTS task was impaired to a larger degree by the visual distractor than the auditory distractor, and the auditory distractors affected the performance of the auditory task more than the visual distractors.

Since the DMTS task in the current study is a visual-visual matching task, it might be that the reduction in matching accuracy in Experiment 1 was affected by the visual component in the dictation task rather than the distractor being a verbal task. Thus, an auditory-vocal task was selected as a distractor in Experiment 2 to test if a verbal task without a visual component would affect matching performance.

METHOD

Participants

Eight female and two male students with a mean age of 23 years, ranging from 16 to 28 years old, participated in Experiment 2. They were recruited primarily at OsloMet, Oslo and Akershus University College and via personal contacts. The participants had no previous experience with stimulus equivalence or psychology experiments. They were paid approximately 26 US dollars for their participation. The participants were given the same informed consent form as the participants in Experiment 1. Following the experiment, participants were thoroughly debriefed and thanked for their participation. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Design

An ABA design was used in which the A-phases had no distractors, and the-B phase had distractors.

Setting, Apparatus, Stimulus Material, Instructions, and Procedure

The setting, apparatus, stimulus material, instructions, and procedure were the same as in Experiment 1, except that instead of typing the four-letter words, the participants had to say the words aloud. The integrated laptop microphone recorded the content of the participants' verbal responses. A sound file was generated for each trial. Also, the on-screen instructions were changed from describing the dictation task to: "In the course of the experiment, words will be presented to you that you are going to say out loud." Before the test was initiated, a reminder was presented to the participants with the following text: "You are going to repeat the words that you hear right after you hear them."

Results and Discussion

Nine out of 10 participants responded in accordance with stimulus equivalence in both phases without distractors, while four out of 10 did not form equivalence classes in the distractor phase (see Table 4). The Fisher's exact test (FET) showed no significant difference between the phases. By visual inspection, the results do not replicate to the same degree as Experiment 1 in the current experiment, and Arntzen (2006) and Arntzen and Vie (2013). Hence, the present experiment did not show a substantial decrease in the number of participants who responded in accordance with stimulus equivalence as the dependent variable in the distractor condition. Also, there are more participants who are closer to the 90% criterion than in Experiment 1.

Figure 3 shows the mean gain or loss in accuracy from the first A-phase to the B-phase with distractors, and from the B-phase to the second A-phase. Five of the 10 participants showed a decrease in mean accuracy of 1.8 to 9.3% from the first A-phase to the B-phase. Four of the participants did not show an increase or a decrease, and the final participant showed a gain of 1.8% from the A-phase to the B-phase. In the last A-phase, seven of the 10 participants showed an increase of mean accuracy of 1.9 to 9.3% compared to the B-phase. Two participants showed a decrease of 1.8% of mean accuracy, while the final participant did not show a decrease or increase in mean accuracy.

An analysis at the individual level shows P3211 responded in accordance with stimulus equivalence in the first A-phase, followed by not showing such performance

Table 4. Results in Experiment 2.

P#	No distractors (A)					Distractors (B)						No distractors (A)				
	TT	%BSL	%SYM	%EQ	ECF	TT	%BSL	%SYM	%EQ	ECF	%ADT	TT	%BSL	%SYM	%EQ	ECF
3211	297	**100**	**100**	**100**	**Y**	207	**100**	**100**	83.3	N	NA	144	**100**	**100**	**94.4**	**Y**
3215	333	**94.4**	**100**	**94.4**	**Y**	261	**100**	**94.4**	N		100	207	**94.4**	**100**	**100**	**Y**
3241	288	**100**	**100**	**100**	**Y**	351	88.8	**94.4**	88.8	N	100	180	**100**	**100**	**100**	**Y**
3228	225	**94.4**	**100**	**100**	**Y**	198	88.8	88.8	**94.4**	N	100	279	**94.4**	**100**	83.3	N
3242	153	**100**	**94.4**	**100**	**Y**	144	**100**	**94.4**	**100**	**Y**	100	126	**100**	**100**	**100**	**Y**
3224	243	**100**	**94.4**	**100**	**Y**	162	**100**	**100**	**94.4**	**Y**	100	117	**100**	**100**	**100**	**Y**
3226	144	**100**	**100**	**100**	**Y**	153	**94.4**	**100**	**100**	**Y**	100	135	**100**	**100**	**100**	**Y**
3229	180	**100**	**100**	**100**	**Y**	225	**100**	**100**	**100**	**Y**	100	333	**94.4**	**100**	**100**	**Y**
3230	144	**100**	**100**	**94.4**	**Y**	153	**100**	**100**	**100**	**Y**	100	177	**100**	**100**	**100**	**Y**
3206	153	**100**	**100**	**100**	**Y**	108	**100**	**100**	**100**	**Y**	100	144	**94.4**	**100**	**100**	**Y**

Notes: The Percentages in bold indicate that the participant responded within the criteria of 90% set by the experimenters on the experimenter-defined definitions; The number of trials presented for each trial type was 18; P#= Participant number; TT= Training trials; BLS= Baseline probes; SYM= Symmetry probes; EQ= Equivalence probes; ECF= Equivalence class formation; Y= Yes; N= No; %ADT= Percent accuracy on the distractor tasks.

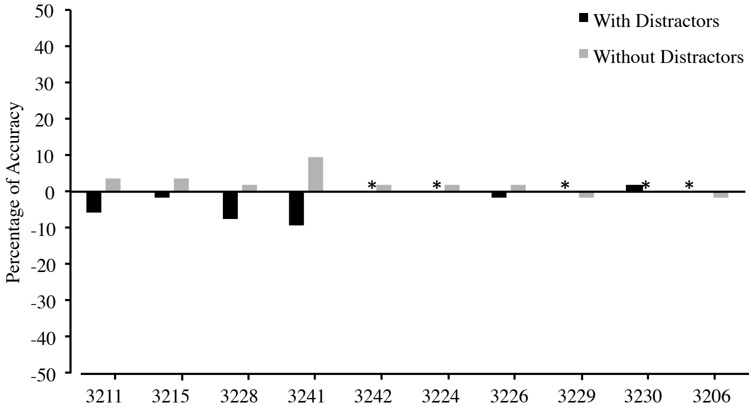

Figure 3. Each participant is represented with two bars, black and gray. The black bars indicated the difference in percentage in accuracy from the first A-phase (without distractors) to the B-phase (with distractors), and gray bars indicate the difference in percentage from the B-phase (with distractors) to the second A-phase (without distractors). * indicates a 0% difference.

in the phase with distractors, and finally showed equivalence class formation in the last A-phase. This pattern of responding was replicated by two participants (P3215 and P3241). P3228 replicated the pattern for the first A-phase and the B-phase but not for the last A phase.

Thus, the results seem to indicate that the auditory-vocal task as distractor affected the performance or maybe interrupted rehearsal. However, P3215 showed a decrease from 94.4% in the first phase without distractor to 88.8% in the distractor condition. The result of P3215 seems like some of the participants in Experiment 1, and it is difficult to conclude if the distractors had an effect.

The other six participants (P3242, P3224, P3226, P3229, P3230, and P3206) responded above the 90% criterion in all three phases, so the echoic task did not influence the MTS performance. These results could support the notion that the distractors of a different sensory modality than the DMTS task (auditory-vocal task vs. visual-visual task) affect the matching performance to a lesser extent as has been shown by Artchakov *et alii* (2009).

The reaction time data in the present experiment are mixed compared to the data from Experiment 1. The repeated-measures ANOVA showed no statistical differences. Firstly, three of the participants (P3211, P3228, and P3241) used less time in selecting the correct comparison in the A-phases than in the B-phase (see Table 5). These data are

Table 5. Median Time in ms used on selecting the correct comparison in the Stimulus Equivalence Test in Experiment 2.

P#	A1	B	A2	Difference A1-B	Difference B-A2
3211	2449	2896	2323	446	573
3228	2448	3620	2710	1172	910
3241	1631	2985	1583	1354	1402
3226	1754	1901	1821	146	79
3224	1919	1920	1451	1	469
3206	2535	2356	2071	-179	285
3215	2161	1812	1689	-350	123
3230	1733	1721	1600	-12	121
3242	1381	1149	1365	-232	-216
3229	2613	2444	2709	-169	-265
Average	2062	2280	1932	217	348

in correspondence with the findings in Experiment 1 and could indicate that the echoic task influenced the solving of the MTS task. However, two more participants (P3224 and 3226) showed a similar pattern, but the difference in time used among the phases was marginal, so it is not possible to argue anything about the effect of the echoic task.

Secondly, P3206, P3215, and P3230 used more time selecting the correct comparison during the first A-phase than during the B-phase and even less time in the second A-phase. P3242 and P3229 used more time selecting the correct comparison during the A-phases compared to the B-phases. These results support the notion that the echoic as a distractor did not affect reaction time as much as the distractors in Experiment 1.

General Discussion

The purpose of the present experiments was to assess the effects of dictation and echoic tasks as potential distractors on matching accuracy in a DMTS procedure. Both distractor tasks consisted of verbal components and, thus, might interrupt potentially ongoing rehearsal. Furthermore, the purpose was also to extend the knowledge of the effects of distractors by using other types of distractors than the math tasks used in previous studies (Arntzen, 2006; Arntzen & Vie, 2013). The results of Experiment 1 showed that nine of 10 participants during the test phase with distractors showed matching accuracy below 90% on the baseline, symmetry, and equivalence trials. These results replicated the findings of Arntzen (2006) and Arntzen and Vie (2013), which showed a matching accuracy higher than the experimenter-defined criterion in the phases without distractors and a matching accuracy lower than the experimenter-defined criterion of 90% in the phases with distractors. However, the matching accuracy in Experiment 1 was closer to the 90% criterion than in the study by Arntzen and Vie (2013).

In Experiment 2, the matching accuracy was higher in the distractor phase (echoic tasks) compared to the distractor phase (dictation tasks) in Experiment 1 and Arntzen and Vie (2013). Four of the 10 participants did not respond in accordance with stimulus equivalence in the distractor phase in Experiment 2. Therefore, it is possible to conclude that the dictation tasks seemed to affect the MTS performance, while the auditory-vocal task did not. Since both distractor tasks, the dictation task and the echoic task consisted of meaningful words, the differences in the results are probably related to more involvement by the participants with the dictation task -listening, spelling correctly, and looking when typing the words. In contrast with the echoic task (Experiment 2), participants only had to listen and say the word aloud.

Another difference between the distractors used in Experiments 1 and 2 is that the dictation tasks consisted of both visual and auditory components, whereas the echoic tasks had no visual components. The challenge of spelling correctly could be reflected in the median reaction times for the dictation tasks.

The procedural differences between the distraction tasks in Experiments 1 and 2 could also have an effect. Hence, the dictation tasks in Experiment 1 required the participant's hands to be placed on the keyboard during the delay to complete the task, which then must be returned to the mouse to click the stimuli, whereas the vocal task in Experiment 2 did not require the participant's hand to leave the mouse during the delay.

The results on an individual level show that some participants revealed a substantial decrease in performance in the distractor phase, while others did not. If mediating behavior is needed to respond correctly in DMTS arrangements, the results might indicate that there are different problem-solving strategies across the participants. Lowenkron (1998) suggested that continuous rehearsal occurs only if it is differentially reinforced, and thus, it might be that P3110, who showed the largest decrease in matching performance in phase with distractors, used continuous rehearsal as a strategy to perform correctly on the DMTS task. While other participants who did not show a decrease may have used a different strategy which the distractor did not affect.

In Experiment 1, reaction time to correct comparison during testing showed a clear pattern. Hence, the participants used more time to select the correct comparison in the B-phase, with distractors than in the A phases without distractors. In Experiment 2, however, only two participants showed the same pattern with a similar difference as in the A and the B phases in Experiment 1. Findings have shown an increase in reaction time from the end of training to the beginning of the testing for emergent relations, and also with a smaller difference in reaction time from training to test for participants responding in accordance with stimulus equivalence, compared to participants who did not form equivalence classes (e.g., Arntzen *et alii*, 2007; Arntzen, Grondahl, & Eilifsen, 2010; Bentall, Dickins, & Fox, 1993; Eilifsen & Arntzen, 2009).

In the current study, participants in Experiment 1 used longer time selecting the correct comparison and had lower matching performance in the distractor condition than the participants in Experiment 2. These findings are comparable with previous findings showing that longer reaction time correlates with lower matching performance. Also, it has been found that reaction time increase as a function of longer delays in DMTS procedures (Baron & Menich, 1985). If longer delays are an indication of the DMTS task being more extensive, then there is the possibility to interpret that the distractor task in Experiment 1 makes the DMTS task more extensive than the distractors in Experiment 2.

The differences in the matching performance between Experiment 1 and Experiment 2 may be related to the fact that the distractor task in Experiment 1 was more extensive than the auditory-vocal tasks that were used in Experiment 2. (1) It is possible to infer that the distractor in Experiment 2 is a part of the distractor task in Experiment 1. In Experiment 1, the participants may have echoed the word and then emitted four responses by typing the letters. Contrarily, the participants in Experiment 2 showed only an echoic response by repeating the word aloud. (2) In Experiment 1, participants had to hear the word and spell it correctly while typing it. Hence, they were likely looking at the screen while typing to avoid spelling errors, while in Experiment 2 participants only had to hear the word and say it aloud. (4) The percentage of correct performance on the distractor task was 100% for the participants in Experiment 2, while it spanned a range of 90-100% correct in Experiment 1. (5) The reaction time data may also support the notion of the echoic task being less extensive since the pattern is not as clear as in Experiment 1.

Also, if the visual component caused the difference in matching accuracy between Experiments 1 and 2, the results are in line with findings that distractors of the same modality as the MTS task lead to lower accuracy than distractors of different modalities (e.g., Artchakov *et alii*, 2009).

Several researchers have suggested that mediating behavior may be responsible for participants responding in accordance with stimulus equivalence (e.g., Horne & Lowe, 1996; Lowenkron, 1988). If this is the case, then mediating behavior may be responsible for participants responding correctly in DMTS procedures. One such account where DMTS procedures have been used is joint control. Joint control can be described as occurring when two discriminative stimuli jointly set the occasion for a response (see Lowenkron, 1998). Lowenkron showed that when the participants maintained hand signs previously trained to each sample and comparison, there was a substantial increase in accuracy of matching performance. In other joint control studies, self-echoic has been used instead of hand signs and then blocking. Also, distractor trials have been introduced to prevent the self-echoic behavior. According to several authors, blocking of self-echoic behavior has been shown to deteriorate correct selection in several joint control studies (e.g., Degraaf & Schlinger, 2012; Gutiérrez, 2006; Lowenkron, 2006). There is the possibility in all the current experiments that participants used self-echoic behavior in the same way as in the joint control studies. If this is the case, then the above chance responding of the participants may be accounted for by the possibility that they could solve the distractor task and then continue to repeat the self-echoic behavior after the distractor task had been solved.

Another account that suggests that mediating behavior may be responsible for equivalence responding is naming (see Horne & Lowe, 1996). Horne and Lowe suggest that naming involves bidirectional speaker and listener behavior which makes stimulus equivalence responding possible. Naming can occur as giving the same name to the stimuli within a class or by giving different names to the stimuli within a class. If stimuli within the same class are given different names by the participant, intraverbal naming, according to Horne and Lowe, may occur. Using Horne and Lowe's account in interpreting the DMTS procedure employed in the current experiment, it may be possible for participants first to tact the sample, then hear the sample and self-echoic either the sample or the potentially correct comparisons throughout the delay before seeing the correct comparison and selecting the correct comparison.

Whether mediating behavior is necessary in DMTS arrangements is hard to prove or disprove, if not impossible. However, that mediating behavior may facilitate equivalence has been shown in several experiments (e.g., Devany, Hayes, & Nelson, 1986; Eikeseth & Smith, 1992). Eikeseth and Smith (1992) showed that participants with learning disabilities first responded in accordance with stimulus equivalence when they labeled the stimulus members within each class with a common name. There is the possibility that participants start to name the stimuli within each class without the experimenters arranging the contingencies explicitly, which is accordance with the findings of Horne and Lowe (1996) who reported that participants who were trained on visual-visual matching started to give names to the stimuli. For example, Sidman, Willson-Morris, and Kirk (1986) found, with children with learning disabilities as participants, that auditory-visual classes lead to a higher number of participants responding in accordance with stimulus equivalence than if visual-visual classes were used. The auditory-visual modality of Sidman *et alii* (1986) may have led to participants giving names to the stimuli. In light of the findings of Horne and Lowe (1996), Eikeseth and Smith (1992), and Sidman *et alii* (1986), it may be possible that there is mediating behavior in the DMTS task that was affected by the distractors. It is important to note that, if the participants are naming the stimuli, one could argue that it might be easier to name the stimuli used in the A-phases than in the B-phase with distractors and that this is the reason for the difference in matching performance across the phases in the current experiment. However, the findings in the ABA and BAB designs used in Arntzen and Vie (2013), with the same stimulus sets used in the current experiments, showed that the distractors affected stimulus equivalence responding in all the B phases.

The findings in the present study call for many further experiments. Since it is only inferred that something is happening during the delay by appealing to the reducing effect of the distractor tasks on matching accuracy, one experiment is to observe behavior during the delay by asking the participants to talk aloud using silent dog procedures (e.g., Alvero & Austin, 2006; Arntzen, Halstadtro, & Halstadtro, 2009; Hayes, White, & Bissett, 1998). The silent dog procedure has three control conditions to demonstrate that performance on an experimental task are controlled by verbal behavior and that the overt verbal behavior shown by the participants are functionally equivalent to covert verbal behavior. One of the controls is to test if task performance is affected by disrupting ongoing verbal behavior. Thus, using silent dog procedures may be a fruitful approach in distractor experiments (see Cabello & O'Hora, 2016 for a more detailed description of silent dog procedures). Making participants talk aloud may also shed some light on how or whether the participants are giving names to the stimuli as shown in a recent publication by Vie and Arntzen (2017).

In the present study, meaningful words were used as distractors. For some of the participants, it is difficult to argue that the distractor task had some effect or at least we do not know. It could be that echoing meaningful words is not robust enough to hinder MTS performance, while meaningless words as distractors could affect stimulus equivalence class formation differently. An experiment exploring the differential effects of a dimension of meaningful words to meaningless words could clarify this issue.

It might be argued that participants could rehearse and solve the distractor tasks concurrently with the distractors used in the current study – since some of the participants' performances were close to the 90 % mastery criterion. To test if other distractor tasks can completely impede matching performance in a DMTS setup one might use distractors which have shown to affect performance in SMTS procedures. For example, Rehfeldt and Dixon (2000) asked participants to recite the alphabet while solving SMTS tasks in a silent dog procedure, and Cabello (2005, as cited in Cabello & O'Hora, 2016) asked participants to count numbers and recite the alphabet also in a silent dog procedure with SMTS tasks. Both distractors impeded participants performance.

Different stimulus sets were used for each condition in the present experiment. It is possible that the change of stimulus sets could have influenced the results. However, even if employing the same stimulus set for each condition can increase the chance of a sequence effect, an experiment should explore the possibility of replicating the findings with only one stimulus set for all conditions.

Participants in the current study was exposed to the distractors after extensive training. It has been found that mediating behavior can change over time (e.g., Cabello, Luciano, Gómez, & Barnes-Holmes, 2004). Hence, it might be important to introduce distractors in different parts of an experiment – for example introducing distractors during thinning of the programmed consequences and not only during testing for responding in accordance with stimulus equivalence.

Finally, it seems important to test the effect of different procedural variables on emergent relations under conditions with distractors. For example, instead of using MTO, a linear training structure (LS) with more than three members in each class will give the possibility to observe whether emergent relations with greater nodal numbers are affected more by the distractor tasks than emergent relations with fewer nodes. Since training with linear training structure is less likely to produce equivalence class formation (Arntzen, 2012; Saunders & Green, 1999), one could include at least one meaningful stimulus to each class, which has been shown to increase the probability of responding in accordance with stimulus equivalence (Arntzen, Nartey, & Fields, 2015).

In sum, the present study shows that dictation tasks function as distractors similarly to the math task used in Arntzen (2006) and Arntzen and Vie (2013) when the number of participants who respond in accordance with stimulus equivalence is used as the dependent measure. However, it is important to emphasize that some participants had a high matching accuracy even with distractors during tests. Therefore, the effects of the distractors do not seem to be particularly robust with the use of visual inspection. It seems that distractors within the same material as the MTS task hinder the performance more than if the distractors are not of the same material. Hence, the results of Experiment 2 with the auditory-vocal task as a distractor, do not affect the matching performance to a lesser degree than the math tasks used in Arntzen (2006) and Arntzen and Vie (2013) and the dictation tasks used in Experiment 1.

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