**Supplementary Materials: Changing emotional visual and auditory memories: Are modality-matched dual tasks more effective?**

**Supplement 1: Detailed description of the preliminary study**

The motivation for conducting a preliminary study was to try and equate the difficulty of the visual and auditory task used in the main experiments. The used tasks were adopted from an earlier study investigating modality-specific interference with emotional future thoughts in public speaking anxiety (Homer, Deeprose, & Andrade, 2016). In this study, it was reported that participants rated the visual and auditory task as equally difficult (*t*(11) = 1.39, *p* = .191). However, a project by a visiting PhD student (Adam Stewart; Plymouth University) in our lab indicated that these two tasks were in fact not equated when using an objective (rather than a self-report) measure of cognitive load, the Random Interval Repetition (RIR) task (van den Hout et al., 2011; Vandierendonck, De Vooght, & Van der Goten, 1998). In the RIR task, participants are asked to react as quickly as possible to a stimulus (e.g., a pure tone) while conducting another task. Reaction times (RTs) towards the stimulus can be used as an index to what extent the task is cognitively demanding. Using the RIR task, it was found that visual task was more cognitively demanding than the auditory task, using the same task parameters as Homer et al. (2016).

As such, the aim of the preliminary study was to compare different variants of the visual task (i.e., with different stimulus timing parameters; see below) to the auditory task using the RIR task as an objective index of cognitive load. Particularly, the speed of stimulus presentation in the visual task was varied because earlier studies have indicated that the speed of eye-movement tasks can modulate its difficulty (Maxfield, Melnyk, & Hayman, 2008; van Veen et al., 2015). We chose to vary the speed of the visual task, rather than the auditory task, because we feared that changing the speed of the sound files in the auditory task would distort the perceptibility of the spoken letters. Hence, we decreased the speed of the visual task by Homer et al. (2016) in three conditions by 10%, 25%, and 50% (i.e., by increasing the letter presentation time and inter-trial interval; see Methods).

**Methods**

**Participants**

Twenty-four healthy students from Utrecht University participated in this preliminary study. No information on gender or age was collected, because this was deemed irrelevant for the task at hand. The sample size was based on the contrabalancing scheme for this preliminary experiment, accounting for all possible orders of the four different tasks (see below). Furthermore, a sample size of 24 provided good statistical power (> .80) to detect medium and large effect sizes (Cohen’s f > .25) for a fully within-subjects design and the alpha-level set at .05.

**Materials**

The experiment was built using Presentation software ([www.neurobs.com](http://www.neurobs.com)). Two lab computers (Dell Optiplex 7040) controlled stimulus timing, one for the RIR task and one for administering the control, visual, and auditory tasks.

For the RIR task, we made use of a mild electric stimulation to the fingers as the neutral stimulus to which participants had to react. The intensity of the electrical stimulation was determined together with the participants in order to make sure its intensity was clearly perceptible, but not uncomfortable. Electrical stimulation was administered using a Coulbourn Aversive Finger Stimulator. Participants had to react to the administration of the electrical stimulation by clearly saying the Dutch word “ja” (English: “yes”) in the microphone of a Sennheiser headset.

**Procedure**

**RIR task.** As described above, the RIR task made use of a mild electrical stimulus. This stimulus was administered during the control, visual, and auditory task (see below). It was presented for 50 ms with an inter-trial interval (ITI) of either 950 or 1550 ms (randomly determined). Participants were instructed to clearly say “ja” whenever they felt the electrical stimulus on their fingers. RT was logged using the voice key plug-in of Presentation.

**Visual task.** The visual task in described in detail in the main manuscript. In brief, participants were required to identify a target stimulus (e.g., ‘q’) in between distractors (e.g., ‘p’). Letters were presented alternatingly on the left and right side of the computer screen. Participants were asked to identify the target letter by keeping their head still and only moving their eyes. In the three different version of the visual task, we varied the speed of stimulus presentation of the visual task. In the fast version, letters were presented for 220 ms and with a 330 ms ITI between the letters. In the medium version, letters were presented for 250 ms and with a 375 ms ITI. Finally, in the slow version, letters were presented for 300 ms and with a 450 ms ITI.

**Auditory task.** The auditory task is described in detail in the main manuscript. In brief, participants heard letters through headphones and had to identify a target (e.g., ‘d’) presented in between distractors (e.g., ‘p’). Letters were presented for 588 ms.

**Control task.** As a baseline, we also included a control condition. In the control condition, participants merely had to watch a black screen for the same duration as the visual and auditory tasks (4 times 24 s).

**Results**

**Data preprocessing**

Trials without a response or with responses below 200 ms or above 1500 ms for the RIR task were removed from the data, as is common for this type of RT tasks (Whelan, 2008). Data of 6 participants were excluded because they had more than 80% missing responses. This high proportion of missing responses is due to the use of the voice key methodology, which tends to result in a high proportion of missing responses (i.e., the voice key is required to have a fairly high threshold for detecting responses, otherwise the data will be influenced by a large proportion of false positive responses).

**Statistical tests**

RTs were analyzed using a repeated measures ANOVA with task (control, auditory, visual\_fast, visual\_medium, and visual\_slow) as a within-subject factor. This analysis indicated a significant effect of the factor task, *F*(4, 68) = 29.72, *p* < .001, partial eta2 = .64. Follow-up paired t-tests indicated that both the auditory task and all versions of the visual task differed significantly from the control task, t-values > 5.8, p-values < .001. Surprisingly, however, RTs during the auditory task also differed significantly with RTs during the different versions of the visual task, t-values > 2.8, p-values < .013. Finally, RTs for the different versions of the visual task did not significantly differ from each other, t-values < 0.5, p-values > .629 (see Figure S1; and see the main text of the manuscript for the exact means and SDs for each condition).

Figure S1. Random interval repetition task reaction times for each of the different tasks included in the preliminary study.

**Discussion**

As expected, RTs in the RIR task were slower for the auditory and visual tasks, compared to the control task. However, unexpectedly, each version of the visual tasks resulted in slower RTs compared to the auditory task, which indicates that each version of the visual task was more difficult than the auditory task. Furthermore, there were no significant differences between the different versions of the visual task. This is somewhat surprising, because previous studies have shown that increasing the speed of eye-movement tasks makes these tasks more difficult and more cognitively demanding (Maxfield et al., 2008; van Veen et al., 2015). One possible explanation is that the differences between the different versions of the visual task were not extreme enough to obtain clear differences in cognitive load. Other studies may want to vary the parameters of the visual task more extremely.

The large difference observed between the auditory and visual tasks may be explained by differences in how attention is cued. Whereas the visual task requires endogenous cueing (i.e., making eye movement to focus on the letters), the auditory task only requires exogenous cueing (i.e., attending the spoken letters). Given these different types of attentional cueing, it may be difficult to equate the cognitive load of these two tasks (Posner, 1980), unless extreme stimulus parameters are used (i.e., extremely fast presentation of letters in the auditory task or extremely slow presentation of letters in the visual task). Because such extreme adaptations may fundamentally change the tasks and limit their (clinical) applicability, we decided to go ahead with the main experiment using the current version of the auditory task and the slowest version of the visual task (with the reasoning that the slowest version of visual task is, at least theoretically, most comparable in cognitive load to the auditory task). Note that, despite not finding the parameters that equate the difficulty of the two tasks, the results of this preliminary study provided useful information in that they showed that the visual task is more cognitively demanding than the auditory task, which is useful for the interpretation of the results of the main experiments.

**References**

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**Supplement 2: Means and standard deviations of the emotionality ratings, vividness ratings, and memory retrieval easiness ratings for the combined results of Experiment 1 and 2.**

| Table S1  *Memory emotionality ratings for the combined results of Experiment 1 and 2.* | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PrePost | | Memory | | Task | | Mean | | SD | | N |
| Pre |  | Auditory |  | Auditory |  | 70.70 |  | 22.27 |  | 96 |  |
|  |  |  |  | Visuo-spatial |  | 74.58 |  | 18.20 |  | 96 |  |
|  |  |  |  | Control |  | 72.54 |  | 21.11 |  | 96 |  |
|  |  | Visual |  | Auditory |  | 65.89 |  | 22.83 |  | 96 |  |
|  |  |  |  | Visuo-spatial |  | 64.51 |  | 23.17 |  | 96 |  |
|  |  |  |  | Control |  | 65.18 |  | 21.64 |  | 96 |  |
| Post |  | Auditory |  | Auditory |  | 54.52 |  | 24.47 |  | 96 |  |
|  |  |  |  | Visuo-spatial |  | 63.54 |  | 20.86 |  | 96 |  |
|  |  |  |  | Control |  | 58.71 |  | 24.03 |  | 96 |  |
|  |  | Visual |  | Auditory |  | 56.60 |  | 25.68 |  | 96 |  |
|  |  |  |  | Visuo-spatial |  | 55.88 |  | 25.30 |  | 96 |  |
|  |  |  |  | Control |  | 55.52 |  | 23.44 |  | 96 |  |
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| Table S2  *Memory vividness ratings for the combined results of Experiment 1 and 2.* | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PrePost | | Memory | | Task | | Mean | | SD | | N |
| Pre |  | Auditory |  | Auditory |  | 78.26 |  | 16.21 |  | 96 |  |
|  |  |  |  | Visuo-spatial |  | 80.89 |  | 16.04 |  | 96 |  |
|  |  |  |  | Control |  | 79.75 |  | 18.68 |  | 96 |  |
|  |  | Visual |  | Auditory |  | 78.65 |  | 16.71 |  | 96 |  |
|  |  |  |  | Visuo-spatial |  | 79.11 |  | 17.35 |  | 96 |  |
|  |  |  |  | Control |  | 77.99 |  | 18.13 |  | 96 |  |
| Post |  | Auditory |  | Auditory |  | 53.57 |  | 23.91 |  | 96 |  |
|  |  |  |  | Visuo-spatial |  | 66.13 |  | 21.02 |  | 96 |  |
|  |  |  |  | Control |  | 60.10 |  | 23.13 |  | 96 |  |
|  |  | Visual |  | Auditory |  | 65.45 |  | 22.24 |  | 96 |  |
|  |  |  |  | Visuo-spatial |  | 64.44 |  | 21.59 |  | 96 |  |
|  |  |  |  | Control |  | 64.54 |  | 22.15 |  | 96 |  |
|  | | | | | | | | | | |

| Table S3  *Memory retrieval easiness ratings for the combined results of Experiment 1 and 2.* | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Task | | Memory | | Mean | | SD | | N | |
| Visuo-spatial |  | Visual |  | 49.65 |  | 21.83 |  | 96 |  |
|  |  | Auditory |  | 61.58 |  | 23.05 |  | 96 |  |
| Auditory |  | Visual |  | 58.97 |  | 23.17 |  | 96 |  |
|  |  | Auditory |  | 45.10 |  | 23.37 |  | 96 |  |
| Control |  | Visual |  | 73.86 |  | 19.81 |  | 96 |  |
|  |  | Auditory |  | 75.38 |  | 19.92 |  | 96 |  |
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