



Linguistic dual tasking reduces emotionality, vividness and credibility of voice memories in voice-hearing individuals: Results from a controlled trial

Alyssa Jongeneel^{a,b,*}, Suzanne C. van Veen^c, Dorien Scheffers^d, Heleen Riper^a, Marcel A. van den Hout^c, Mark van der Gaag^{a,b}, David van den Berg^{a,b}

^a Department of Clinical Psychology, VU University and Amsterdam Public Health Research Institute, Van der Boechorstraat 7, 1081, BT, Amsterdam, the Netherlands

^b Parnassia Psychiatric Institute, Zoutkeetsingel 40, 2512, HN, Den Haag, the Netherlands

^c Department of Clinical Psychology, Utrecht University, Heidelberglaan 1, 3584, CS, Utrecht, the Netherlands

^d PsyQ, Lijnbaan 4, 2512, VA, Den Haag, the Netherlands

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ABSTRACT

Dual taxation of the working memory during recall is an effective strategy to reduce the emotionality and vividness of *visual* intrusive memories and potentially changes dysfunctional beliefs associated with the memories. This study tested the hypothesis that dual tasking decreases emotionality, vividness and credibility of *auditory* intrusive images (i.e., memories of auditory hallucinations) with a two-level (time: pre and post; condition: dual tasking and recall only) within-subjects design. Thirty-seven voice-hearing participants selected two negative voice-hearing experiences. They recalled one of these experiences while performing a lingual dual task (i.e., language game on smartphone app) and recalled one memory without a dual task (in counterbalanced order). During the pre-test and post-test, emotionality and vividness of the voice-hearing memories were rated, as well as the credibility of the voice statements. There was a significantly greater decrease in emotionality, vividness and credibility during dual tasking than during recall only. This study provides proof of principle that the salience and credibility of the content of auditory hallucinations can be reduced by dual tasking; the clinical implications are also discussed.

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1. Introduction

Traumatic events can result in involuntary re-experiencing of memories, i.e. intrusive memories (Krans et al., 2009). Intrusive memories are multi-modal mental images, including visual, auditory, olfactory, gustatory, and bodily sensations (Ehlers et al., 2002; Kosslyn, 1994; Krans et al., 2009), and form the hallmark symptom of post-traumatic stress disorder (PTSD) (Ehlers et al., 2004; Hackmann et al., 2004).

It has been theorized that a proportion of auditory verbal hallucinations (AVH, 'hearing voices') may be conceptualized as intrusive auditory images (Morrison et al., 2002; Morrison, 2001; Steel et al., 2005; Waters et al., 2006). More specifically, several models state that some AVH may be considered to be decontextualized memories that are experienced as sensory perceptions (Hardy, 2017; Steel et al., 2005; Waters et al., 2012, 2006). This is supported by strong associations

between experiencing childhood trauma and AVH (Bentall et al., 2012; McCarthy-Jones, 2011), objective observation of similarities in content and theme between traumatic experiences and AVH (Hardy et al., 2005), and the subjective experience of people reporting hallucinations that appear to be replays of actual past events (McCarthy-Jones et al., 2014).

It is established that predominantly emotionality of voices and negative voice-related beliefs (e.g. believing the negative comments that the voices make) are an important cause of voice-related distress (Daalman et al., 2011; Hacker et al., 2008), and decreasing or modifying these beliefs in psychological therapies, such as cognitive therapy (e.g. Birchwood et al., 2014) and imaginary rescripting (Paulik et al., 2018), is proven to be effective in decreasing voice-hearing distress. Dual tasking, i.e. performing a (visual or auditory) task while retrieving a memory, is used routinely in clinical practise to decrease emotionality, vividness, and negative beliefs of visual intrusions. The exact underlying mechanism of dual tasking remains debatable, although there is some evidence that it is based on the working memory (WM) theory of Baddeley (1992). According to the working memory account, dual tasking limits the information processing capacity of the WM

* Corresponding author at: Department of Clinical Psychology, VU University and Amsterdam Public Health research institute, Van der Boechorstraat 7, 1081 BT, Amsterdam, the Netherlands.

E-mail address: a.jongeneel@parnassiagroep.nl (A. Jongeneel).

(Baddeley and Andrade, 2000). Since memories appear to be susceptible to change during retrieval (James et al., 2015), taxing WM during retrieval reduces the vividness and emotionality of memories more than retrieval only.

However, the focus of the present research is not on investigating potential underlying working mechanisms. Since it has been repeatedly shown that dual tasking decreased the vividness and emotionality of visual images (e.g. Lee and Cuijpers, 2013; Van Schie et al., 2016; Van Veen et al., 2015), we aimed to investigate whether the dual tasking procedure could also decrease emotionality of auditory images; there is some evidence that suggests that way. Several student-based studies, using (autobiographical) memories that were classified as primarily visual or primarily auditory, found that vividness and emotionality of mainly auditory images were reduced after a dual task compared to recall only (Baddeley and Andrade, 2000; Kemps and Tiggemann, 2007; Kristjánsdóttir and Lee, 2011). A study that tested this hypothesis in a clinical sample with PTSD patients, used one primarily visual and one primarily auditory traumatic memory, and these memories were both subjected to three counterbalanced conditions, i.e. visual taxation, auditory taxation, and recall while staring at a dot. Emotionality was rated before and after the experiment. Emotionality of both the visual and auditory autobiographical images decreased, irrespective of the condition (Matthijssen et al., 2017). Although more research is needed, this tentatively suggests that salience of auditory memories can be affected by dual tasking. Besides, it has been observed in clinical practice that dual tasking may also change the credibility of beliefs associated with the memory (De Jongh et al., 2010). Therefore, dual tasking is potentially an interesting treatment for reducing distress of voices by targeting voice-hearing memories.

Recently, mHealth applications based on dual tasking have been deployed as an intervention for (mainly) visual intrusive images. This has produced mixed results, e.g. Tetris was found to be effective, whereas other dual tasks did not decrease vividness and emotionality of intrusions (Asselbergs et al., 2018; Iyadurai et al., 2017; James et al., 2015). In the present study, we used one of the functions in 'Temstem' (an application developed for voice-hearers) as the experimental dual task (for details, see Jongeneel et al., 2018). In this function, WM is taxed by a linguistic game, while the user recalls a recent episodic memory of hearing voices.

Two decades ago, research concerning the effectiveness of dual tasking in processing visual intrusive images started by laboratory-setting investigations using a cross-over design (e.g. Andrade et al., 1997; Van Den Hout et al., 2001) and when effectiveness was established, research engaged in studying whether dual tasking decreased future intrusions. Pursuing this two-step approach, the present study is a first proof-of-principle study to test the hypothesis that the mobile dual tasking procedure decreases the emotionality, vividness, and credibility of disturbing episodic memories of AVH compared to recall only in voice-hearing individuals. If results are found to be positive, future studies can investigate whether the decrease of salience and credibility of voice-memories by dual tasking results in a decrease of future intrusions, or voice-hearing.

2. Methods

2.1. Participants

This study was part of a larger randomized controlled trial that tested the efficacy of a smartphone application (Temstem) in participants with frequent and disturbing AVH. Participants were recruited from 12 participating specialized mental healthcare institutions in the Netherlands. Further details of this trial are published elsewhere (Jongeneel et al., 2018). Participants of this trial ($N = 89$) received treatment as usual (TAU) and were after the baseline assessment randomized into one of two groups: 'Temstem and AVH monitoring' or 'AVH monitoring only'. All 44 participants in the experimental condition

(Temstem and AVH monitoring) received face-to-face instructions by the researcher on how to use Temstem and subsequently performed the current experiment. 37 Participants completed this experiment. They all provided signed informed consent. Table 1 presents an overview of baseline characteristics of the participants.

All procedures in this study comply with the ethical standards of the relevant national and institutional committees on human experimentation, and with the Helsinki Declaration of 1975 (as revised in 2008). This study was approved by the medical Ethics Committee of the VU University Medical Centre (METC number: 2015.435/NL53684.029.15).

2.1.1. Inclusion criteria

- Presence of AVH with subjective distress for longer than 1 month;
- Presence of AVH during a minimum of 4 days a week, in at least three of the last 4 weeks;
- Able to recall two distinct negative and clear episodic memories of hearing voices, both with an emotionality rating of ≥ 60 on a scale of 0–100.

2.1.2. Exclusion criteria

- Inadequate competence with the Dutch language;
- Current involuntary hospitalization in a closed ward;
- Limited cognitive abilities (estimated IQ < 70);
- Medication changes in the last month; antipsychotics and antidepressants
- Currently receiving CBT for AVH;
- Not willing or capable to learn to use a smartphone;
- Intensive previous or current use of Temstem.

2.2. Design

This sub study had a repeated measures within-subjects design with two levels: time (*pre-* and *post-assessment*) and condition (*dual tasking* and *recall only*). We counterbalanced the order of the two conditions and the order of the memories that were assigned to these conditions (e.g. the most emotional memory to the first or second condition, and vice versa). This means that all participants performed both conditions and that both the order in which participants performed the conditions and the memories that were used were randomized (Table 2). This protocol was adapted from van Veen et al. (2015) and the procedures were adjusted (as required) for the purpose of the present study. The main adjustments were that all mentions of memories concerning an 'event' were changed into memories concerning a 'voice-hearing experience'; the memory was not necessarily a at least a week old since persons often heard the same voice with the same message frequently and they focussed on the most recent situation; and the hotspot was focussed on the most disturbing statement, not the most disturbing image.

Table 1

Baseline characteristics of the study population ($n = 37$).

Female, no. (%)	23 (62.2)
Age in years: mean (SD)	44.1 (11.6)
Primary DSM-IV-TR chart diagnosis, no. (%)	
Schizophrenia	11 (29.7)
Schizoaffective disorder	9 (24.3)
Psychotic disorder NOS	6 (16.2)
Post-traumatic stress disorder	3 (8.1)
Borderline personality disorder	3 (8.1)
Other ^a	5 (13.5)
Voice-hearing duration, in years: mean (SD)	15.5 (10.3)

NOS = not otherwise specified.

^a Other consists of: major depressive disorder, bipolar disorder, personality disorder NOS, obsessive compulsive disorder, and dissociative identity disorder.

Table 2
Counterbalanced randomization order (condition by memory).

Order #	First experiment	Second experiment
1	Recall only Memory with highest emotionality score	Dual tasking Memory with lowest emotionality score
2	Recall only Memory with lowest emotionality score	Dual tasking Memory with highest emotionality score
3	Dual tasking Memory with highest emotionality score	Recall only Memory with lowest emotionality score
4	Dual tasking Memory with lowest emotionality score	Recall only Memory with highest emotionality score

Note: both memories with highest and lowest scores had a emotionality rating of ≥ 60 .

2.3. Experimental procedure

Participants were asked by the researcher to recall two clear, negative episodic memories of hearing a disturbing voice (see Fig. 1 for procedure). Almost all memories were evoking negative affect: insulting ($n = 33$), commanding ($n = 18$), threatening ($n = 10$), or commenting ($n = 10$). They rated the emotionality of both disturbing memories for inclusion and counterbalancing purposes. Then, identical to the EMDR protocol, participants retrieved the whole memory including the context. Subsequently, for each memory, the experimenter asked the participant to select and focus on the most disturbing statement, or the ‘hotspot’, of the memory; e.g. the moment the voice said: “Nobody

loves you” or “Harm yourself”. Memory hotspots often correspond to daily life intrusions and are, therefore, identified and processed during treatment of traumatic experiences (Grey and Holmes, 2008; Holmes et al., 2005). After selecting these hotspots, the experiment started.

All instructions were pre-programmed and were presented i) visually on a computer screen prior to each step in the experiment, and ii) verbally via headphones during the experiment. The experimenter sat next to the participant during the instruction phase to check whether instructions were understood well and sat behind the participant during the experiment. At pre-test, participants rated the vividness, emotionality, and credibility (i.e. to what degree the participant thought the voice statement was credible, e.g. “Nobody loves you” was scored with 80, because someone believed this was true) of the first target memory on a 100-mm visual analogue scale (VAS) that ranged from 0 (=not at all vivid/unpleasant/credible) to 100 (=very vivid/unpleasant/credible). After this rating, the first experimental condition was conducted followed by the post-test rating of vividness, emotionality, and credibility of the first target memory. For the second target memory, this procedure was then repeated with the other experimental condition. Since both conditions involved different memories, there was no wash-out period between experimental conditions; after the first condition, participants continued directly with the second condition.

In the ‘recall only’ condition, participants were asked to recall the memory hotspot while a black screen was presented, which they were instructed to ignore (8×24 s, with 10-s breaks). In the ‘dual-task’ condition, participants recalled the target memory and concurrently performed a linguistic dual task. In this task, words consecutively appeared in the middle of a smartphone screen and the participant had to tap the number of syllables the word contained (e.g. superman consists of three syllables, so a participant tapped three times on the screen).

2.4. Statistical analysis

Since limited research has been conducted on this specific subject, our sample size calculation was based on the outcomes of a study that most resembled the present study design (Matthijssen et al., 2017), and a meta-analyses that reported effect sizes of EMDR on visual images (medium for clinical trials and large for laboratory studies) (Lee and Cuijpers, 2013). To detect medium effects (Cohen’s $d = 0.5$) with a power of 0.80 and an α -level of 0.05 (two-tailed), 34 participants with complete data were needed.

All analyses were performed using SPSS Statistics version 23. Correlations were analysed using the mean baseline scores of emotionality, vividness, and credibility of both conditions. Three two-way repeated measures analyses of variance (ANOVAs) were conducted with time (pre- and post-assessment) and condition (dual tasking vs recall only) as the within-subject factors, and with emotionality, vividness, and credibility as outcomes.

3. Results

Mean scores of emotionality, vividness, and credibility ratings in the recall only condition and dual tasking condition are presented in Table 3. Baseline emotionality and vividness ($r = 0.43, p < .01$) were significantly positively correlated. Correlations between emotionality and credibility ($r = 0.27, p = .109$) and vividness and credibility ($r = 0.23, p = .151$) were not significant.

Mean pre-test to post-test difference scores of the outcomes for both conditions are shown in Fig. 2. The 2 (Time: pre-test vs. post-test) \times 2 (Condition: recall only vs. dual tasking) repeated ANOVAs showed a significant main effect for Time for all outcome measures (see Table 4). There was no significant main effect for Condition for any of the outcome measures. Crucially, the main Time \times Condition interaction analysis was in line with our expectations, i.e. statistically significant for all

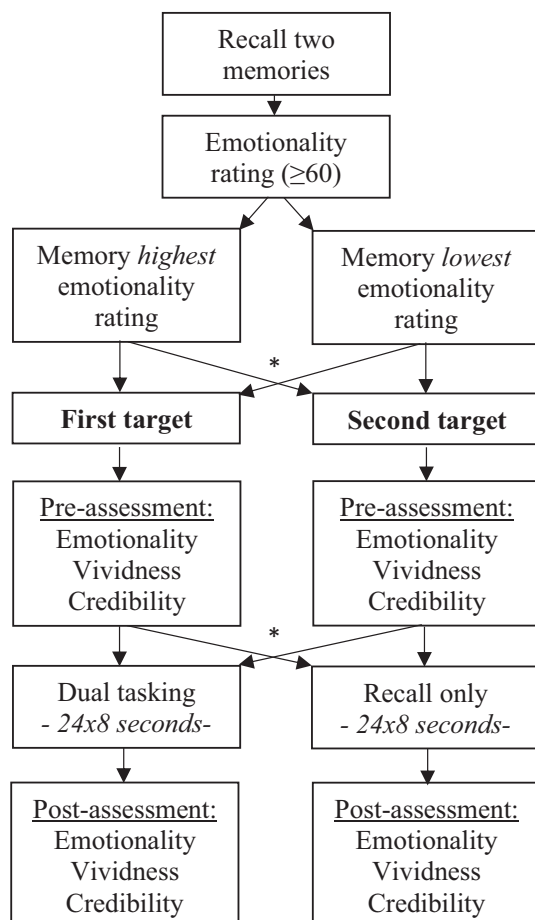


Fig. 1. Procedure. Note: * = randomized in counterbalanced order.

Table 3
Mean and difference scores of outcomes in both conditions.

Measure	Condition	Moment	Mean	SD	N
Emotionality	Recall only	Pre	81.7	15.5	37
		Post	73.5	24.7	37
	Dual tasking	Pre	85.8	12.8	37
		Post	65.4***	25.6	37
Vividness	Recall only	Pre	82.1	13.6	37
		Post	77.3	21.5	37
	Dual tasking	Pre	81.6	18.2	37
		Post	66.4***	23.8	37
Credibility	Recall only	Pre	59.7	37.1	37
		Post	57.6	37.5	37
	Dual tasking	Pre	63.1	33.6	37
		Post	49.3*	35.5	37

Note. SD = standard deviation.

* $p < .05$.

*** $p < .001$.

outcomes. As hypothesized, the results of the Time \times Condition interaction showed that post-test ratings of all outcomes were significantly lower after dual tasking than after recall only. The effect-sizes are considered large (partial eta squared >0.14).

4. Discussion

The aim of this study was to test the hypothesis that the dual tasking procedure decreases emotionality, vividness and credibility of auditory episodic memories of voice-hearing. The data confirmed this hypothesis, i.e. ratings of all outcomes showed a significantly greater decrease after dual tasking than after recall only. These findings are in line with the theory that WM taxation during retrieval of a memory reduces the emotionality, vividness (Lee and Cuijpers, 2013; Van Schie et al., 2016; Van Veen et al., 2015) and the credibility of negative beliefs associated with memories (De Jongh et al., 2010).

Our findings regarding emotionality and vividness of memories are (partly) consistent with previous research. A recently published study of Matthijssen et al. (2019) showed that emotionality of auditory memories in patients suffering from AH was reduced by dual tasking. Several studies including university students used visual and auditory (autobiographical) memories and found that emotionality and vividness of these memories were significantly reduced after a dual task compared to a control task (Baddeley and Andrade, 2000; Kemps and Tiggemann, 2007; Kristjánisdóttir and Lee, 2011). One study investigated the effect of dual tasking in patients with PTSD using both visual and auditory memories (Matthijssen et al., 2017). In contrast to our results, the latter authors found that emotionality of the memories decreased, irrespective of whether participants were exposed to a dual task (visual or auditory taxation) or a control task. A possible explanation for this might be

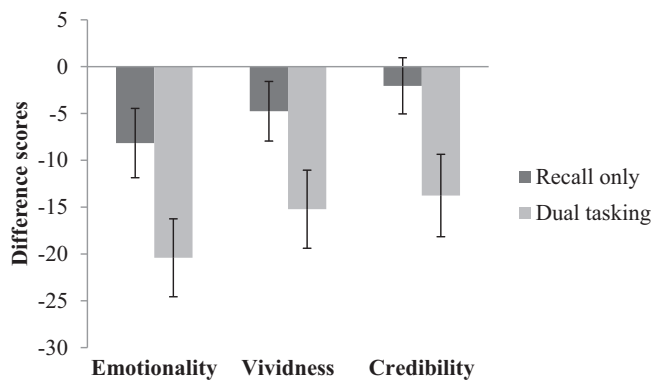


Fig. 2. Mean difference scores (post-test minus pre-test) and standard errors of recall only and dual tasking on emotional response during recall of the auditory memory, vividness of the memory, and the credibility of the content of the voice.

Table 4
Time \times Condition effects of emotionality, vividness, and credibility.

Measure	Effect	F	df	p-value	Partial Eta squared
Emotionality	Time	21.73	1, 36	<0.001	0.38
	Condition	0.45	1, 36	0.51	0.01
	Time \times Condition	6.13	1, 36	0.02	0.15
Vividness	Time	12.36	1, 36	<0.001	0.26
	Condition	2.96	1, 36	0.09	0.08
	Time \times Condition	4.80	1, 36	0.04	0.12
Credibility	Time	6.75	1, 36	0.01	0.16
	Condition	0.29	1, 36	0.59	0.01
	Time \times Condition	6.96	1, 36	0.01	0.16

that, in the latter study, the control task (which was set-up as a recall only condition) included staring at a non-moving dot while retrieving the memory. In a large trial with patients with PTSD, Sack et al. (2016) observed that patients with eye movements had no advantage compared to staring at a non-moving hand. Possibly, the fixation on a non-moving object also requires WM taxation and this could explain why the decrease in emotionality was visible in all conditions of the study of Matthijssen et al. (2017); moreover, as the researchers mentioned, their study may have been underpowered.

To our knowledge, the present study is the first to test and show that the dual tasking procedure can influence the credibility of beliefs associated with auditory memories of voice-hearing. Hearing negative voices is an unpleasant experience; however, the extent to which these experiences become distressing and invalidating depends on the credibility of what is said (Chadwick and Birchwood, 1994; Mawson et al., 2010). The credibility of the voices is an essential target in effective psychological therapies (Birchwood et al., 2014; Chadwick and Birchwood, 1994; Craig et al., 2018; Paulik et al., 2018). The present findings can be taken as proof of principle that dual tasking can also be an effective strategy to reduce the credibility of negative voice comments.

However, there are two important issues to be addressed in light of interpretability of results. First, it should be noted that the present study used a crossover design, thereby not allowing to investigate whether reductions in credibility of specific voice-statements generalized to a reduction of beliefs about the voices, associated distress, frequency of voice-hearing, or negative content of voices in daily life. Our intention was to pursue the same research procedure as the studies that investigated dual tasking in visual images, whereby researchers also started by doing similar laboratory tests (e.g. Andrade et al., 1997; Van Den Hout et al., 2001) before experimenting in clinical practice; only after effectiveness was repeatedly proven, prospective research was conducted. Since the present study suggests that the dual tasking procedure for voice-hearing statements is effective, future research should, besides replicating these results, investigate whether the reported effects also influence future voice-hearing. Promisingly, there are some indications for this. Holmes et al. (2005) found that the correspondence between memory hotspots (as was targeted in this research) and intrusions was high in a sample of PTSD patients; a voluntary recall of a traumatic moment corresponded highly with involuntary re-experiencing (a part of) a traumatic event. Also, the pre-test scores of all measurements in the present study were high; since emotionality, loudness and negative beliefs about voices all contribute to voice-hearing distress, this indicates that the targeted memories represented voice-hearing experiences that were highly disturbing in daily life. Finally, according to clinical observation, most targeted memories were voice-statements that frequently occurred and contributed possibly significantly to daily life voice-hearing distress.

Second, we did not analyse results by diagnosis but we deliberately choose to approach voice-hearing as a transdiagnostic symptom. AVHs is a common symptom in many disorders, i.e. schizophrenia (Larøi et al., 2012), bipolar disorder, depressive disorder (Baethge et al., 2005), and borderline personality disorder (Slotema et al., 2017), and

as Slotema et al. (2012) showed, the phenomenology of AVHs is similar in patients with schizophrenia and borderline personality disorder. The aetiology and underlying mechanisms of voice-hearing may be different between persons, but that seems to be unrelated to the disorder (Sommer et al., 2018); though discussion about this remains. In addition, it still would have been interesting to investigate the effectiveness of the intervention per diagnosis, but unfortunately this was not possible due to the lack of power.

The present study had several limitations. For example, in contrast to other studies (Kristjánsson et al., 2011; Matthijssen et al., 2017), we did not include a measure to rate the extent to which the memories were auditory or visual. As a result, we cannot be certain that we indeed targeted memories that were mainly auditory. However, voice-hearing is in essence an auditory experience and auditory cues were emphasized during the instruction of the experiments and during the selection of the hotspot of the memory. Nevertheless, this is a point of concern and a measure to control for should this be included in future research designs. Also, we did not measure the extent to which the dual task taxed WM; hence, we cannot state for certain that the mentioned mechanism (dual taxation of the working memory) allowed for the decrease in emotionality, vividness and credibility of the memories. Specificity of results is missing. However, this was not the aim of this study, since we primarily wanted to investigate whether the dual tasking protocol could lead to a decrease in emotionality of auditory images; future research should focus more on the involved working mechanisms. Also, other studies that did measure taxation rates showed that eye movements, counting, and playing Tetris taxed WM (Engelhard et al., 2010; Van den Hout et al., 2010; Van Veen et al., 2015). Since our results correspond to the outcomes of these studies, and since the language task that we used involves indicating how many syllables a word contains and thus requires cognitive effort, it seems plausible that the task also taxed WM. Nonetheless, the task we used was reasonably straightforward, whereas more complex tasks might be more effective. Other studies found a dose response relationship; high taxation led to less emotional and less vivid images compared to low taxation (De Jongh et al., 2013; Van Veen et al., 2015), although overtaxing possibly decreases the effects (Engelhard et al., 2011; Van den Hout et al., 2010). Therefore, measuring the extent to which the dual task taxes WM is an important subject for future study.

A strength of the present study is that it is one of the first experimental investigations of WM taxation on auditory episodic memories of voice-hearing that was performed in a clinical population. Also, standardized experimental procedures were followed, based on an existing protocol developed by experts (Van Veen et al., 2015).

The results of this study may, if replicated, be of clinical importance. Several studies have shown that dual tasking decreases emotionality and vividness of visual memories (e.g. Cuperus et al., 2016; Sack et al., 2016; Van den Hout et al., 2011). The present study provides proof of principle that the salience and credibility of the content of auditory images can be reduced by dual tasking. Future dual tasking studies without a crossover design could monitor whether future intrusions (i.e. voice hearing) also decrease. If so, dual tasking might be an important augmentation of current psychological interventions of voices (Van den Berg et al., 2013).

Contributors

AJ, SvV, MvdH, and DvdB contributed to the study protocol. AJ collected data, performed the analyses and wrote under supervision of DvdB the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

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Declaration of competing interest

The authors declare that there are no conflicts of interest.

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