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An experimental study

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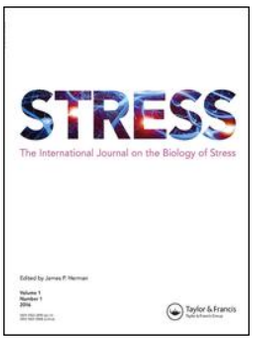

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ORIGINAL RESEARCH REPORT

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Are psychophysiological arousal and self-reported emotional stress during an oncological consultation related to memory of medical information? An experimental study

Leonie N. C. Visser[a], Marieke S. Tollenaar[b], Jos A. Bosch[c], Lorenz J. P. van Doornen[d], Hanneke C. J. M. de Haes[a] and Ellen M. A. Smets[a]

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ABSTRACT

Patients forget 20–80% of information provided during medical consultations. The emotional stress often experienced by patients during consultations could be one of the mechanisms that lead to limited recall. The current experimental study therefore investigated the associations between (analog) patients' psychophysiological arousal, self-reported emotional stress and their (long term) memory of information provided by the physician. One hundred and eighty one cancer-naïve individuals acted as so-called analog patients (APs), i.e. they were instructed to watch a scripted video-recoding of an oncological bad news consultation while imagining themselves being in the patient's situation. Electrodermal and cardiovascular activity (e.g. skin conductance level and heart rate) were recorded during watching. Self-reported emotional stress was assessed before and after watching, using the STAI-State and seven Visual Analog Scales. Memory, both free recall and recognition, was assessed after 24–28 h. Watching the consultation evoked significant psychophysiological and self-reported stress responses. However, investigating the associations between 24 psychophysiological arousal measures, eight self-reported stress measures and free recall and recognition of information resulted in one significant, small (partial) correlation ($r = 0.19$). Considering multiple testing, this significant result was probably due to chance. Alternative analytical methods yielded identical results, strengthening our conclusion that no evidence was found for relationships between variables of interest. These null-findings are highly relevant, as they may be considered to refute the long-standing, but yet untested assumption that a relationship between stress and memory exists within this context. Moreover, these findings suggest that lowering patients' stress levels during the consultation would probably not be sufficient to raise memory of information to an optimal level. Alternative explanations for these findings are discussed.

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Lay summary

High levels of emotional stress experienced by patients during medical consultations might explain why they forget 20–80% of information provided by their physician. Although we were able to induce emotional stress in the participants of this experimental study, no evidence was found for a relationship between stress levels and memory of medical information. These results suggest that to improve patients' memory more is needed than lowering patients' stress levels only.

Introduction

Patients forget 20–80% of medical information provided by their physician during consultations (Anderson et al., 1979; Gabrijel et al., 2008; Jansen et al., 2008a,b; Kessels, 2003; Ley, 1979). When patients do not remember information, they are less likely to cope with the disease, make well-informed decision and adhere to treatment and medical advice (Andersson et al., 2015; Linn et al., 2013; Mill & Sullivan, 1999). Moreover, most patients prefer to be fully informed about their medical situation (Langewitz et al., 2015). To improve patients' information recall, discovering the mechanisms that lead to limited memory is a prerequisite.

The emotional stress often experienced by patients during medical consultations, especially when involving a potentially fatal disease such as cancer (Lienard et al., 2006; Mager & Andrykowski, 2002), could be one of the mechanisms that contribute to patients' limited information memory. The relationship between stress levels and memory performance has been investigated since the early twentieth century (Diamond et al., 2007; Yerkes & Dodson, 1908). Evidence from animal studies suggests an inverted u-shaped relationship, in which

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memory increases with stress to an optimal point and beyond this point memory performance decreases with higher stress levels (Salehi et al., 2010). Findings from a recent experimental study in humans also indicate that learning under stress impairs long term memory; free recall as well as recognition of information (Schwabe & Wolf, 2010). This all fits with the finding that, in patients, receiving a poorer prognosis leads to a worse overall recall of information (Jansen et al., 2008a). Yet, the relationship between stress and memory is complex (Schwabe et al., 2010, 2012) and this relationship has not been adequately investigated within the field of medical communication.

An experimental video-vignettes methodology is highly suitable to investigate these potential associations. A video vignette is a video recording of a situation in which actors mimic a scripted doctor–patient consultation (Hillen et al., 2013; van Vliet et al., 2013). In such a design, participants are called analog patients (APs) and they can be either disease-naïve participants or (former) patients, instructed to watch the video vignette while imagining themselves in the video patients' situation (Visser et al., 2016b). A video-vignette design allows for standardization of the consultation and therefore provides the possibility for an objectively scored memory test. The video-vignette design using APs was found to be a valid method to investigate patients' perspective on medical communication (Blanch-Hartigan et al., 2013; van Vliet et al., 2013). Moreover, a positive coherence was found between participants' physiological arousal during medical interaction and their arousal when watching the interaction on video (Verheul et al., 2011), providing evidence that the vicarious experience of watching a medical consultation on video may be validly used to model actual experience. In a previous video-vignette study, watching a bad news consultation evoked significant responses on various emotional stress measures (though not on salivary cortisol), with modest overlap between psychophysiological and self-reported stress parameters (Visser et al., 2016b). Psychophysiological and self-reported measures of emotional stress also appear to affect memory performance independently (Pearman & Lachman, 2010; Wright et al., 2005). Therefore, both responses are preferably assessed and related to patients' memory of information.

The experimental video-vignette study presented here therefore explored the associations between APs' psychophysiological arousal and self-reported stress during an oncological consultation and their (long term) memory of information provided in the consultation.

Materials and methods

Participants

Table 1 shows characteristics of the sample. A previous video-vignette study showed that APs' psychophysiological stress response to the video vignette was not dependent on APs being either disease-naïve individuals or cancer patients (Visser et al., 2016b). Therefore, 181 APs were recruited among university students enrolled in a psychology and a communication science research program of the University of Amsterdam. By using students as APs, it was feasible to recruit a relatively large sample, while minimizing the influence of possible confounding variables with regard to information memory, such as educational level, age and prior experience with cancer. APs were not eligible if they: (1) were younger than 18 or older than 40 years old; (2) were using medication related to hypertension or cardiovascular disease (to prevent interference with psychophysiological assessments); (3) were unable to understand and/or write Dutch; (4) had prior experience with oncological physician–patient consultations, regarding themselves or someone else. The Ethics Committee of the department of Communication Science at the University of Amsterdam approved the study protocol (2014-CW-30).

Table 1. Sample characteristics ($N = 181$).

	N	%
Gender		
Female	126	69.6
	M	SD
Age in years (range)	23 (18–40)	4.0
Body mass index	21.9	2.5
Health literacy[a]		
Functional	1.6	0.5
Communicative	1.9	0.5
Video engagement[b]	4.8	1.0
Perceived credibility[b]		
Video vignette	5.5	1.1
Video patient	5.0	1.4
Video physician	5.5	1.2

[a]Possible range: 1–4; higher is poorer.
[b]Possible range: 1–7; higher is more.

The experimental design

Experimental procedures

Once written informed consent was obtained, APs completed a digital questionnaire (T0) on characteristics and their emotional state (see "Measures" for details on measures). They were then attached to the psychophysiological equipment by a trained researcher and signals were optimized. APs first watched a calm nature documentary on a computer screen for 11 min: an 8-min acclimation period and a 3-min period to determine resting psychophysiological baseline values. Next, the video vignette, including a brief introduction, was shown. Psychophysiological activity was recorded continuously. Immediately after watching the video vignette (T1), APs completed a second digital questionnaire to assess emotional state, engagement and perceived credibility of the vignette. Equipment was then removed and APs received one research credit (mandatory within students' research program) or 10 euros for their participation. APs were interviewed by telephone 24–28 h after the experimental session (T2) to assess (long term) memory of the information that was provided by the physician in the video vignette. To prevent deliberate encoding, APs were kept unaware of the upcoming memory test (they were informed the interview was planned for evaluative purposes). At the end of the interview, APs were fully debriefed.

Video vignettes

For a detailed description of the development of the video vignettes used in this study (see Visser et al., 2016b). Development followed published recommendations (Hillen et al., 2013). In brief, a bad news consultation script was developed first, which involved an oncological surgeon (referred to as "the physician" in this manuscript) and a patient with advanced esophageal cancer. After adjustments based on feedback from experts on the script and an initial test video, two final video vignettes were recorded. These vignettes used identical scripts, but differed in the use of a male actor versus a female actor as video patient to optimize APs' identification with the video patient (matching their own gender). In both versions, a male actor was used as the physician. The video-vignette consultation comprised two phases: (P1) a discussion of the cancer diagnosis and prognosis (also referred to as the bad news phase, with a duration of approximately 110 s) and (P2) the provision of additional information, i.e. information about treatment options, side-effects, procedures and hospital contact (also referred to as the information phase, with a duration of approximately 270 s). An introduction (49 s) was added to the video vignettes, in which the video patient was introduced and an instruction was given ("while watching, try to imagine that you are the patient having the conversation with the surgeon"). Duration of the video vignettes including introduction, varied slightly between versions, from 416 s to 437 s, because of editing and speaking rate differences. These editing differences were a consequence of creating six variations of the total vignette as part of a separate study, varying types of introduction and camera viewpoints. The content of the video-vignette consultation was exactly identical across variations. The variations in introduction and camera perspective did not influence information recall or recognition scores (Wilks' Lambda = 0.92, $F(10, 342) = 1.48$, $p = .15$) and were therefore not further discussed in the current article.

Measures

Sample characteristics

APs reported their age, gender, height and weight (from which their body mass index (BMI) was calculated) at T0. Health literacy was also assessed at T0 by using two scales of a validated Dutch self-report measure (van der Vaart et al., 2012). Both scales contain five items informing how often APs have had trouble with: (1) reading and understanding basic health information (functional health literacy scale); (2) gathering, processing and communicating about health information (communicative health literacy scale). Items were answered on a four-point Likert scale ranging from 1="never" to 4="often". Mean scores were calculated for both scales. Critical to the ecological validity of the video-vignette design, i.e. the extent to which the experience of APs resembles the experience of patients in actual medical consultations, is that APs engage with this study's video vignette. Therefore, APs' self-reported engagement with the video vignette was assessed at T1, using the 15-item Video Engagement Scale (VES) (Visser et al., 2016a). This scale assesses the extent to which APs were emotionally involved in the video, empathized with the video patient, adopted the video-patient's identity and remained attentive to the content of the video vignette. Moreover, APs' perceived credibility of the video vignette was assessed by measuring: (1) perceived realism of the vignette (three items); (2) credibility of the video-patient (two items); and (3) credibility of the physician (two items). All items, including the VES items, were answered on a seven-point Likert scale ranging from 1="completely disagree" to 7="completely agree". For the VES and each of the perceived credibility measures, mean scores were calculated.

Memory: free recall and recognition of information

A questionnaire and a codebook were developed based on the information provided by the physician in the video vignette, and pilot tested among 15 students, e.g. to test clarity of questions and procedures, and to estimate variance in scores. This resulted in a 20-item questionnaire. The first 10 items were open ended, assessing free recall, and item scores could range from 0 (not recalled), to 1 (recalled partially), to 2 (recalled completely). After these 10 items, recognition was assessed using the same questions, but now APs were provided with three multiple-choice answers and their answers were scored as either 0 (incorrect answer) or 1 (correct answer). APs' answers were scored by two coders. If coders disagreed, they discussed until consensus was reached.

To calculate percentages of information accurately recalled and recognized, a distinction was made between items covering the highly emotional information, i.e. the cancer diagnosis and prognosis, provided during the bad news phase (two items), and items covering all additional information provided during the information phase (eight items). This distinction was made as memory is influenced by the emotionality of the information (Schwabe et al., 2010), i.e. the cancer diagnosis is often well remembered, especially when compared to additional information (Gabrijel et al., 2008). Therefore, the focus of the current study was on memory of additional information and its relationship with emotional stress (immediately) prior to and during the provision of the additional information.

Psychophysiological arousal

Electrodermal activity (EDA) was recorded at a sampling rate of 1000 Hz using two disposable electrodes attached to the index and middle finger of APs' right hand, connected to a wireless EDA module and the MP 150 system from Biopac Systems (Goleta, CA) (Dawson et al., 2007). A low-pass filter fixed at 1 Hz was used to eliminate high-frequency noise from the EDA signal. Two EDA parameters were derived: the tonic skin conductance level (SCL, in μS) and the number of skin conductance responses (SCRs), determined as phasic increases of >0.05 μS in conductance (Dawson et al., 2007).

Cardiovascular activity was recorded at a sampling rate of 1000 Hz using a Finometer Pro (Finapres Medical Systems, Amsterdam, Netherlands) connected to the Biopac system, resulting in four parameters: systolic blood pressure (SBP, in mm/Hg), diastolic blood pressure (DBP, in mm/Hg),

cardiac output (CO, in L/min) and heart rate (HR, in beats per minute (BPM). The Finometer Pro cuff was connected to the ring finger of APs' left hand. The SBP, DBP and CO signals were generated by the Finometer and filtered with a low-pass filter fixed at 35 Hz. HR was extracted from the blood pressure signal (peak detection).

Means for all six psychophysiological parameters (SCL, SCRs, SBP, DBP, CO and HR) were calculated using Acqknowledge software (Goleta, CA) for the baseline resting period (B), the bad news phase of the vignette (P1) and, the information phase of the vignette (P2). In order to explore the relationship between APs' arousal and memory thoroughly, MATLAB software was used to calculate mean arousal for two additional, more specific, intervals. First, the 30 s interval capturing the transition from P1 to P2 ("transition interval"), as APs' memory of information that was provided during P2 might be related to the level of arousal that still remains at the end of P1 (immediately prior to P2). Second, the 30 s interval in which the highest level of arousal was recorded ("peak interval").

Self-reported emotional stress

APs' anxiety levels were assessed at T0 and T1 using a Dutch six-item version of the state version of the State-Trait Anxiety Inventory (S-STAI-S), with items answered on a four-point Likert scale ranging from 1="not at all" to 4="very much so" (Marteau & Bekker, 1992; van der Bij et al., 2003). A mean S-STAI-S score was calculated. APs' emotional state was also assessed using seven Visual Analog Scales (VAS) ranging from 0 to 100 at T0 and T1 asking how: (1) depressed; (2) angry; (3) sad; (4) insecure; (5) irritated; (6) tense and (7) anxious they felt at that moment.

Data processing and statistical analysis

Three APs were missing memory data as they did not respond to the telephone call. Psychophysiological data from four APs were not recorded due to equipment failure. Electrodermal data from 50 APs (28%) and cardiovascular data from 20 APs (11%) were judged to be unreliable due to several severe signal disruptions (i.e. sudden drops in the signal or noise lasting for at least 5 s) and/or observed repeated movement, sneezing or coughing of APs, and therefore excluded from analyses. Sensitivity of correlational analyses considering the resulting sample sizes (ranging from $N = 125$ to $N = 178$) was calculated using G-power 3.1.9.2 demonstrating 80% power to detect small correlations ($r = 0.2$). All hypothetical associations between psychophysiological and self-reported response measures and memory scores were graphically displayed and visually inspected. No outliers were removed. Normality of data distributions was judged by using statistics (Kolmogorov–Smirnov's test and values of skew and kurtosis) in conjunction with visual inspection. Log_{10} or square root transformations were applied where appropriate. All analyses were performed using IBM SPSS Statistics 22 (IBM Corp., Armonk, NY). The two-tailed .05 probability level was used as a criterion of statistical significance.

Changes in psychophysiological arousal and self-reported stress were analyzed by using repeated measures MANOVAs with post hoc univariate tests to compare individual time points (B, P1 and P2, respectively; T0 and T1). Pearson's bivariate and partial correlations were used to determine the association between psychophysiological responses and self-reported emotional stress responses (calculated as difference scores (Burt & Obradovic, 2013), indicated with the symbol Δ) and both free recall and recognition of additional information. For these analyses, four Δ-scores were calculated for all six psychophysiological parameters, each comparing baseline values with physiological arousal during: (1) the bad news phase; (2) the information phase; (3) the transition interval and (4) the peak interval. In addition, self-reported stress Δ-scores were calculated for all eight emotional states, by subtracting T0 scores from T1 scores. To determine inclusion of covariates in partial correlations, sample characteristics were tested for associations with variables of interest.

To ascertain the validity of results, analyses were repeated by using non-parametric testing on original data (i.e. Friedman's test with post hoc Wilcoxon's signed rank tests and Spearman's correlation). Moreover, alternative methods to account for baseline values were explored in re-analyses, including using "residual scores" (Burt & Obradovic, 2013) instead of Δ-scores, and, in order to account for possible "law of initial values" effects (Burt & Obradovic, 2013), controlling for baseline values in analyses using Δ-scores. Quadratic regression model fit was assessed additionally, exploring the possibility of an inverted u-curve shaped relationship between emotional stress and memory.

Results

Memory of information

Table 2 shows the percentages of accurately remembered information. Recognition scores were higher than free recall scores, and bad news was recalled better than additional information, about, e.g. treatment and side-effects. In fact, 80% of APs recalled the bad news, i.e. answered the two items on cancer diagnosis and prognosis completely accurate.

Emotional stress response evoked by the vignette

Tables 3 and 4 present summary data on APs' psychophysiological arousal. Table 5 provides a summary of self-reported emotional stress data. Small positive correlations were found between self-reported tenseness in response to the vignette and APs' SCL response during the vignette, both P1 ($r = 0.21$, $p = .02$) as well as P2 ($r = 0.19$, $p = .04$). No other correlations

Table 2. Percentages of free recall and recognition of information ($N = 178$).

	Min	Max	*M*	SD
Bad news information				
Free recall	0	100	89.6	21.7
Recognition	50	100	96.3	13.0
Additional information				
Free recall	6	94	52.4	17.4
Recognition	13	100	74.4	16.7

between self-reported and psychophysiological responses to the vignette were found.

A substantial multivariate main effect was shown for electrodermal (Wilks' Lambda = 0.54, $F(4, 123) = 25.94$, $p < .001$, $\eta^2_{partial} = 0.46$) and cardiovascular parameters (Wilks' Lambda = 0.33, $F(8, 149) = 37.19$, $p < .001$, $\eta^2_{partial} = 0.67$) when comparing time points (suggested norms for partial eta-squared: small = 0.01; medium = 0.06; large = 0.14 (Cohen, 1969; Richardson, 2011)). As presented in Table 3 post hoc univariate testing showed a substantial rise in physiological arousal from baseline to watching the vignette for all psychophysiological parameters. For most psychophysiological parameters, the largest increase occurred during the bad news phase (P1 > B), followed by a significant decrease to the information phase (P1 > P2), while the response during the information phase was still large enough to be significant compared to baseline values (P2 > B). A different response pattern emerged for HR. HR continued to increase from P1 to P2 (P2 > P1) and the response as evoked by the vignette was significant between B and P2 only (P2 > B).

A substantial multivariate main effect was also shown for the self-reported stress measures (Wilks' Lambda = 0.43, $F(8, 173) = 29.19$, $p < .001$, $\eta^2_{partial} = 0.57$) when comparing T1 scores to T0 scores. As shown in Table 5, post hoc univariate tests showed that the vignette evoked an emotional response in APs with regard to all self-reported states.

Associations between sample characteristics and variables of interest

APs' engagement with the video vignette was positively correlated ($0.16 \geq r \leq 0.26$) with most self-reported stress responses to the vignette (with the exception of self-reported anger, irritation and tenseness), as expected based on the partial overlap between constructs. Subsequent analyses were aimed at identifying potentially confounding sample characteristics for inclusion as covariate in (partial-) correlation analyses. Regarding APs' age, small positive correlations ($0.17 \geq r \leq 0.25$) were found with blood pressure responses only, both during P1 and P2 ($p \leq .03$). BMI was associated with the SCRs response only, during P1 ($r = 0.20$, $p = .02$) as well as P2 ($r = 0.18$, $p = .50$). Independent *t*-tests yielded virtually no associations between APs' gender and psychophysiological arousal, self-reported stress or memory, with the exception that the CO response of women was slightly larger than men during P2 of the vignette (0.16 L/min larger; $p = .02$). Functional health literacy was correlated with free recall of information, whereby poorer health literacy was associated with lower recall scores ($r = -0.22$, $p < .01$). No other relevant significant correlations were found.

Psychophysiological arousal and memory

As shown in Table 6, correlation analyses demonstrated no significant associations between any of the psychophysiological response measures (Δ) and free recall of information ($p \geq .11$). Comparable results were found for recognition (see Table 6), with two exceptions. First, a significant positive correlation was found between the SCRs response during the transition interval and recognition ($r = 0.19$, $p = .04$), accounting for 3.6% of the variance in recognition scores. Second, a negative association was found between the HR response during the transition interval and recognition ($r = -0.16$, $p = .04$). Additional adjustment for health literacy, age and BMI, when relevant, changed the statistical significance of only one coefficient: the HR response during the transition interval was no longer related to recognition of information ($r = -0.14$, $p = .08$).

Self-reported emotional stress and memory

As shown in Table 7, correlation analyses yielded no significant associations between APs' self-reported stress responses (Δ) and free recall ($p \geq .07$) or recognition ($p \geq .20$) of information. This applied to all emotional states. Adjustment for possible confounders (i.e. health literacy) did not change these results.

Alternative analytical methods used to explore relationships

Results from alternative analytical methods are supplemented in Appendix A (Supplementary Tables A1–A10). Non-parametric testing, in order to validate parametric findings,

Table 4. Psychophysiological arousal during the 30-s intervals: means, standard deviations and mean differences compared to baseline values.

		Transition interval			Peak interval		
	N	*M*	SD	*M*Δ	*M*	SD	*M*Δ
SCL (μS)	126	4.8	3.4	1.0	5.5	3.8	1.6
SCRs (spikes/min)	126	2.0	2.8	0.8	4.2	4.0	2.9
SBP (mm/Hg)	156	122.8	17.3	4.0	129.0	17.6	10.1
DBP (mm/Hg)	156	71.6	11.8	1.8	74.6	12.2	4.8
CO (L/min)	156	5.6	1.2	0.1	6.1	1.4	0.6
HR (BPM)	160	71.3	10.1	0.2	76.3	10.9	5.3

*M*Δ: mean difference compared to baseline values.

Table 3. Psychophysiological arousal during B, P1 and P2: means, standard deviations and differences between time points.

		Baseline (B)		Bad news phase (P1)			Information phase (P2)			Mean differences between time points Univariate test results[a]
	N	*M*	SD	*M*	SD	*M*Δ	*M*	SD	*M*Δ	
SCL (μS)	127	3.9	3.0	5.1	3.6	1.2	4.7	3.4	0.8	$F = 62.87$, $p < .001$, partial eta sq. = 0.33
SCRs (spikes/min)	127	1.3	1.7	2.5	2.6	1.2	1.9	2.0	0.6	$F = 36.90$, $p < .001$, partial eta sq. = 0.23
SBP (mm/Hg)	157	118.9	15.9	124.9	17.5	6.0	121.0	16.7	2.1	$F = 79.11$, $p < .001$, partial eta sq. = 0.34
DBP (mm/Hg)	157	69.7	11.3	72.4	11.9	2.6	71.0	11.7	1.2	$F = 76.19$, $p < .001$, partial eta sq. = 0.33
CO (L/min)	157	5.5	1.2	5.7	1.3	0.2	5.6	1.2	0.1	$F = 16.53$, $p < .001$, partial eta sq. = 0.10
HR (BPM)	161	71.0	9.6	71.5	10.2	0.5	72.4	9.8	1.4	$F = 17.96$, $p < .001$, partial eta sq. = 0.10

*M*Δ: mean difference compared to baseline values.
[a]Logarithms (square roots in case of SCRs) of the original values were used in analyses.

Table 5. Self-reported stress at T0 and T1: means, standard deviations and differences between time points ($N = 181$).

	Before (T0)		After (T1)		Response to the vignette	
	M	SD	*M*	SD	*MΔ*	Univariate results[a]
S-STAI-S						
Anxiety	1.7	0.5	2.1	0.6	0.4	$F = 91.42$, $p < .001$, partial eta sq. = 0.34
VAS						
Depression	14.7	19.8	34.3	25.3	19.6	$F = 152.29$, $p < .001$, partial eta sq. = 0.46
Anger	6.8	15.1	18.9	22.7	12.1	$F = 5.03$, $p < .001$, partial eta sq. = 0.03
Sadness	11.9	19.1	31.0	26.3	19.1	$F = 83.37$, $p < .001$, partial eta sq. = 0.32
Insecurity	21.6	23.1	25.3	24.2	3.7	$F = 147.73$, $p = .03$, partial eta sq. = 0.45
Irritation	9.8	17.0	18.7	23.4	8.9	$F = 35.64$, $p < .001$, partial eta sq. = 0.17
Tenseness	20.8	24.5	30.6	24.2	9.8	$F = 43.95$, $p < .001$, partial eta sq. = 0.20
Anxiousness	8.4	15.9	23.1	24.8	14.7	$F = 105.29$, $p < .001$, partial eta sq. = 0.37

MΔ: mean difference comparing T1 to T0.
[a]Logarithms of the original values were used in analyses.

Table 6. The associations between APs' psychophysiological response to the vignette and memory of information: Pearson correlation coefficients (bivariate; two-tailed).

		Free recall		Recognition	
	N	*r*	*p*	*r*	*p*
SCL[b]					
Δ Bad news phase	126	−0.04	.68	0.05	.60
Δ Information phase	126	−0.06	.52	0.02	.79
Δ Transition epoch	125	−0.01	.92	0.07	.42
Δ Peak epoch	125	0.01	.92	0.07	.47
SCRs[c]					
Δ Bad news phase	126	0.04	.68	0.10	.27
Δ Information phase	126	0.02	.84	0.11	.21
Δ Transition epoch	125	0.09	.30	0.19[a]	.04
Δ Peak epoch	125	0.01	.88	0.05	.59
SBP[b]					
Δ Bad news phase	156	0.11	.16	0.12	.13
Δ Information phase	156	0.08	.30	0.08	.31
Δ Transition epoch	155	0.08	.34	0.09	.28
Δ Peak epoch	155	0.14	.09	0.12	.13
DBP[b]					
Δ Bad news phase	156	0.09	.28	0.10	.22
Δ Information phase	156	0.10	.21	0.07	.36
Δ Transition epoch	155	0.10	.24	0.06	.47
Δ Peak epoch	155	0.11	.11	0.06	.43
CO[b]					
Δ Bad news phase	156	−0.01	.90	0.06	.49
Δ Information phase	156	0.03	.73	0.04	.66
Δ Transition epoch	155	−0.06	.43	0.00	.98
Δ Peak epoch	155	0.05	.56	0.08	.33
HR[b]					
Δ Bad news phase	160	−0.06	.47	−0.09	.26
Δ Information phase	160	0.05	.52	−0.04	.57
Δ Transition epoch	159	−0.09	.23	−0.16[a]	.04
Δ Peak epoch	159	0.06	.47	−0.03	.75

Δ: response compared to baseline values.
[a]Significant at the .05 level.
[b]Logarithms of the original values were used in analyses.
[c]Square roots of the original values were used in analyses.

Table 7. The associations between APs' self-reported stress response to the vignette and memory of information: Pearson correlation coefficients (bivariate; two-tailed) ($N = 178$).

	Free recall		Recognition	
	r	*p*	*r*	*p*
S-STAI-S				
Δ Anxiety	0.11	.14	0.06	.39
VAS				
Δ Depression	−0.04	.59	−0.07	.32
Δ Anger	−0.04	.64	0.03	.65
Δ Sadness	0.02	.76	0.06	.45
Δ Insecurity	−0.02	.78	0.01	.91
Δ Irritation	−0.13	.07	−0.03	.70
Δ Tenseness	0.03	.70	0.08	.29
Δ Anxiousness	0.02	.84	0.10	.20

Δ: response comparing T1 to T0.

yielded identical results as reported in the results sections above. Alternative methods to account for baseline values in correlational analyses did not provide other insights either. Exploring the possibility of an inverted u-curve shaped relationship between emotional stress and memory, the significance of quadratic model fit was different from the linear fit in four occasions only. First and second, SCRs and HR during the transition interval were no longer related to recognition of information when tested in a quadratic model. Third, an u-shaped relationship was shown between APs' SCL during P2 and recognition (F (2, 123) = 3.16, $p = .046$), explaining 4.9% of the variance in information recognition scores. Fourth, an inverted u-shaped relationship was shown between self-reported anger and free recall of information (F (2, 175) = 3.83, $p = .02$), explaining 4.2% of the variance in free recall scores.

Discussion and conclusions

The present study investigated the relationships between (analog) patients' psychophysiological arousal and self-reported emotional stress during an oncological consultation and their (long term) memory of information provided by the physician. In this experimental video-vignettes study, no evidence was found for associations between these variables. In medical communication research (Kessels, 2003; Sep et al., 2014; van Osch et al., 2014) and medical (communication) practice, these relationships are often assumed to exist, whereby the characteristic inverted u-shaped is implicated to suggest that higher levels of arousal or emotional stress are associated with impairment of cognitive functioning. Therefore these null-findings may be considered to refute a long-standing, but as yet untested idea, and are therefore highly relevant.

Discussion

Several explanations for these unexpected findings warrant discussion as each of these may have implications for further research and medical practice.

The first, and most straight-forward, explanation might be that there simply are no associations between patients' psychophysiological arousal or emotional stress during a medical consultation and memory of (additional) information. The relationships between 24 measures of psychophysiological arousal and eight measures of self-reported emotional stress and both free recall and recognition of information were investigated, resulting in only one significant, small correlation. Considering multiple testing, there is a high probability that this significant result was due to chance. Validation of these results using alternative analytical methods (including the testing of an inverted U-shaped model fit) strengthens our conclusion that in our study no evidence was found for associations between the variables of interest. These null-findings fit into the evidence from previous work done in (non-clinical) fields of stress and memory, revealing that stress can enhance, impair or indeed have no effect on memory (Zoladz et al., 2011).

The emotional nature (i.e. the valence) of the to-be-remembered information and the timing of the stressful experience might provide further explanations, as these factors have been proven to influence the direction and strength of the relationship between stress and memory (Schwabe et al., 2012; Zoladz et al., 2011). Evidence suggests this relationship is most pronounced for emotional information compared to neutral information (Schwabe et al., 2010). Our focus on memory of additional information, which is relatively neutral compared to the bad news information, might therefore have contributed to our null-findings. However, arousal levels were still significantly increased during the provision of the additional information and previous research demonstrated that learning under stress impairs long term memory irrespective of the emotional nature of information (Schwabe & Wolf, 2010). Nevertheless, a comparison of relationship strength based on the emotional nature of information would have been interesting, but was hindered by a ceiling effect in bad news memory scores. With regard to timing of the "stressor", we assessed both physiological arousal *prior* to the provision of the to-be-remembered information and *during* the provision of this information (during the information phase). Nevertheless, no association between memory and arousal was found, neither with arousal prior to learning, nor with arousal during learning.

A third explanation might be that many other factors influence memory of information, or its relationship with emotional stress, and therefore the proportion of the variance in memory scores that can be explained by emotional stress is small. Factors related to the individual under investigation, such as the perceived cognitive load, health literacy, involvement (Bol et al., 2016; submitted for publication), age and perceived importance of the information (Kessels, 2003) are known to be associated to recall of medical information. These associations could have decreased the relative influence of emotional stress and therefore the chance of finding significant results, although we controlled for several of these factors. We furthermore tried to avoid alternative influences by using an experimental video-vignettes design, allowing for standardization of setting and material. Moreover, we selected a large group of cancer-naïve university students as APs, trying to limit the (confounding) influence of age, previous (disease) experience and educational level. However, in this relatively homogeneous sample, functional health literacy still proved to be a significant personal factor related to information recall, emphasizing the importance of taking other, personal factors into account in future studies.

Fourth, the levels of emotional stress as evoked in our sample of APs and by our video vignette, are likely not as high as in clinical reality. To our knowledge, no observational research exists on patients' emotional stress levels, either self-reported stress or psychophysiological arousal, during medical (bad news) consultations. Therefore, a normative comparison cannot be made. Nevertheless, when considering effect sizes (partial eta squared), the psychophysiological and self-reported emotional stress responses found in this study were substantial for most parameters. Furthermore, variance in both stress and memory scores seemed large enough to detect significant associations, independent of APs' stress levels. Yet, variance could possibly be improved in future studies by comparing multiple video-vignette conditions varying in emotional stress impact.

Related to the fourth, a fifth explanation might be that the experience of APs in a video-vignettes design does not adequately resemble the reality of actual patients, thereby negatively influencing the ecological validity of the design and the chance to detect relationships. Although engagement and perceived realism scores were comparable to previous video-vignette studies (Visser et al., 2016b) and the type of reported emotions seemed valid, a direct comparison with medical practice is difficult to make. For example, the need for information and therefore the motivation to listen carefully, process and remember information are likely to be higher for actual patients. New technologies, such as virtual reality, could improve the authenticity of APs' experience and thereby ecological validity, while preserving the advantages of an experimental design such as standardization.

Strengths and limitations

A first strength of this study is that it operationalized emotional stress by using multiple measures of physiological arousal and self-reported emotional stress, which provided the opportunity to examine sensitivity and replicability across measures. Cortisol, well-known for its association with memory, was not assessed, as previous research suggests that cortisol is less sensitive to detect changes in APs' emotional state when viewing video vignettes (Visser et al., 2016b). Moreover, when designing this study, we considered assessing parasympathetic activity, such as HR variability, beyond the scope of this study, as previous research on the relation between stress and memory performance primarily demonstrated effects of sympathetic activity. This omission precluded us to explore differential memory effects of active coping responses (characterized by an increase in sympathetic activity in conjunction with vagal withdrawal) versus passive coping responses (characterized by enhanced parasympathetic activity in conjunction with sympathetic co-activation). A second strength of the current study is the experimental, standardized design, which allowed us to

assess memory by using one, objectively scored questionnaire for all APs. In medical practice, many factors would have influenced the presentation and the content of the to be remembered information, possibly confounding the results. Moreover, the video-vignette design provided us with an ethical alternative to psychophysiological recording during medical (bad news) consultations. In addition to the limitations mentioned above, timing of the memory assessment might have influenced results. Long term memory seemed to have the most clinical relevance and therefore we decided to assess information recall and recognition 24–28 h after learning, similar to for example Schwabe and Wolf (2010). Interfering experiences, ruminations or conversations with others between the learning situation and the memory assessment might have influenced APs' information recall and recognition. Future studies should control for these factor or, additionally, measure immediate (short term) memory as well in a sub sample. Generalizability of results is another limitation, especially with regard to age of the AP sample, because, on average, (cancer) patients are older. We consciously made a tradeoff between generalizability and limiting possible confounding variables, but this means replication of our findings in a more natural, heterogeneous sample is warranted.

Conclusions

"*Most people would intuitively agree with the statement that stress influences memory* (Wolf, 2009)". Results from the present study suggest that the association between patients' emotional stress and memory of medical information in clinical practice might not be as simple as would be expected based on intuition or theory. Therefore, trying to improve memory of medical information only by lowering patients' stress levels during the consultation would probably not be sufficient to raise memory to an optimal level. Yet, more research is needed to unravel the complex mechanisms that lead to patients' limited recall. It seems important to take personal characteristics such as health literacy or perceived importance of information into account as well, as these might influence the relationship between emotional stress and (long term) memory. Moreover, other methodological approaches need to be explored, such as the use of virtual reality, to be able to evoke a more clinically relevant experience in participants while preserving the advantages of an experimental design.

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