

# The Effect of Humor on Short-term Memory in Older Adults: A New Component for Whole-Person Wellness

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## ABSTRACT

**Context** • For older adults, the damaging effects of aging and stress can impair the ability to learn and sustain memory. Humor, with its associated mirthful laughter, can reduce stress and cortisol, a stress hormone. Chronic release of cortisol can damage hippocampus neurons, leading to impairment of learning and memory.

**Objectives** • The primary goal of this study was to determine whether watching a humorous video had an effect on short-term memory in an older population.

**Design** • The research team designed a randomized, controlled trial.

**Setting** • The study took place at Loma Linda University in Loma Linda, California.

**Participants** • The research team recruited 20 normal, healthy, older adults, 11 males and 9 females.

**Intervention** • The humor group ( $n = 10$ , mean =  $69.3 \pm 3.7$  y) self-selected 1 of 2 humorous videos—a Red Skelton comedy or a montage of *America's Funniest Home Videos*—and watched it for 20 min. A control group ( $n = 10$ , mean =  $68.7 \pm 5.5$  y) sat calmly for 20 min and were not allowed to read, sleep, or talk on a cell phone.

**Outcome Measures** • The Rey Auditory Verbal Learning Test was used to assess short-term memory—learning

ability, delayed recall, and visual recognition. Salivary cortisol levels were measured at predetermined times.

**Results** • Learning ability improved by 38.5% and 24.0% in the humor and control groups, respectively ( $P = .014$ ). Delayed recall improved by 43.6% and 20.3% in the humor and control groups, respectively ( $P = .029$ ). Within the humor group, delayed recall (43.6%) was significant compared with learning ability (38.5%) ( $P = .002$ ). At 3 predetermined time points, significant decreases in salivary cortisol were observed in the humor group ( $P = .047$ ,  $P = .046$ , and  $P = .062$ , respectively).

**Conclusion** • The study's findings suggest that humor can have clinical benefits and rehabilitative implications and can be implemented in programs that support whole-person wellness for older adults. Learning ability and delayed recall are important to these individuals for a better quality of life—considering mind, body, spirit, social, and economic aspects. Older adults may have age-associated memory deficiencies. However, medical practitioners now can offer positive, enjoyable, and beneficial humor therapies to improve these deficiencies. (*Adv Mind Body Med.* 2014;28(2):16-24.)

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Our world is encountering a rapid increase in society's aged population.<sup>1</sup> With this increase in life expectancy, an enhanced need exists for whole-person, mind-body care. Rather than merely emphasizing the cause of disease, an affirmation of a salutogenic paradigm of health care that supports overall human wellness and health promotion is needed for older adults and the young.<sup>2</sup> Short-term memory loss affects many older individuals.<sup>3,4</sup> As people become older, numerous concerns about short-term memory loss become much more prevalent,<sup>3</sup> and solutions are vital to individuals, families, and society. These age-associated memory deficits can be precursors to the progression to dementia, indicating 3 times greater risk.<sup>5</sup> Interventions related to short-term memory loss need to be addressed as an essential component of whole-person wellness for older adults.

Short-term memory deficiencies can manifest in older adults as issues with physical and behavioral compliance in individualized, home-rehabilitation treatment programs. For instance, noncompliance might exhibit as (1) a failure to perform at-home, physical therapy exercises properly; (2) inaccurate timings or dosages of medications; or (3) missed health care appointments.<sup>6</sup> Barriers that older adults face that hinder compliance might be poor memory,<sup>7</sup> anxiety, depression, or lack of self-motivation.<sup>6,8</sup> In addition to having a broad effect on society's escalating health care costs, noncompliance leads to a decrease in personal health and the efficacy of treatment.<sup>9</sup> Intervention strategies should be geared toward whole-person wellness for older adults and include precursor therapies and modalities for enhancement of memory or reduction of memory deficits (eg, humor therapy).

Several methods have been used to improve short-term memory in older adults. Studies have revealed, with measurable brain variations, that cognitive training can enhance short-term memory.<sup>10,11</sup> Furthermore, cognitive stimulation programs that incorporate the development and advancement of quality of life, self-improvement approaches, increased daily activities, and the integration of daytime naps have been shown to be beneficial.<sup>12-14</sup> A blend of multivitamin, mineral, and herbal supplements has been shown to improve short-term memory in older women.<sup>15</sup> Implementing natural interventions such as physical activity into a whole-person wellness program can reduce cognitive decline in older adults.<sup>16,17</sup>

Humor and its associated mirthful laughter affect several systems in the human body. In addition to mirthful laughter having similar physiological effects as exercise, it can also improve cognition, increase natural killer-cell activity, and stimulate circulation.<sup>18-20</sup> Humor therapy and the positive emotions that are elicited through mirthful laughter have been used widely as a complementary therapy for many conditions, including stress reduction during cardiac rehabilitation.<sup>21</sup> Additionally, humor therapy has shown benefits for vascular function<sup>22,23</sup> and can protect against the risk of disease.<sup>24,25</sup> Furthermore, humor-associated, mirthful laughter has been linked to an improvement in the quality of life of depressed older adults.<sup>26</sup>

Studies have shown that the body's physiological functions are beneficially affected by mirthful laughter.<sup>20</sup> One approach to such studies has been through psychoneuroimmunology (PNI), which focuses on processes linking communication pathways involving the brain to neuroendocrine and immune systems. The approach contributes to our understanding of the link between mirthful laughter and the salutogenic, whole-person lifestyles that support wellness.<sup>27</sup> Mirthful laughter stimulates  $\gamma$ -wave (31-40 Hz) band activity in the brain, shown through electroencephalography (EEG), which leads to enrichment of higher cognitive activity.<sup>28,29</sup> It has been shown to decrease the biomarker for cortisol, a neuroendocrine stress hormone.<sup>30</sup>

Moreover, a decrease in one's immune function can lead to a decline in cognition.<sup>31</sup> However, a positive eustress (healthy or fulfilling) experience can reduce stress.<sup>30,32</sup> Cortisol, released through the adrenal axis of the hypothalamic pituitary, can be neurotoxic to the hippocampus, the site of consolidated memory. With chronic, excess production of cortisol due to continued stressful events, individuals can damage the hippocampus, which in turn can lead to impairment in emotion, learning, memory,<sup>4,33</sup> and recall of previously stored memories.<sup>34</sup> For healthy older adults being tested on wordlist memorization, Kircher et al<sup>35</sup> have found that the anterior left hippocampus has the central function in memory encoding and recall.

A number of studies have shown the therapeutic connection of mirthful laughter and humor to physiological and behavioral aspects of humans.<sup>18,20</sup> However, no studies have shown a connection, beneficial or not, between mirthful laughter in humor and the enhancement of short-term memory in older adults. The primary focus of the current research was to determine whether watching a humorous video had any effect on short-term memory in a cohort of older adults. The research team proposed that older adults who watch a humorous video might exhibit improvement in their short-term memory—learning ability, delayed recall, and visual recognition—and also show a decrease in levels of the stress hormone cortisol at predetermined time points.

## METHODS

### Participants

Twenty healthy older adults, the initial and final sample size, were recruited and enrolled in the current study (control group,  $n = 10$ ; humor group,  $n = 10$ ). Individuals were recruited through word of mouth on the campus of Loma Linda University (LLU) in Loma Linda, California, and in neighboring communities, including faculty and staff of LLU, their spouses, and residents of a local senior center. The control group consisted of 6 males and 4 females with a mean age of  $68.7 \pm 5.5$  years. The humor group consisted of 5 males and 5 females with a mean age of  $69.3 \pm 3.7$  years.

Individuals were questioned and excluded if they had any of the following conditions: (1) impaired hearing that would prevent them from understanding a researcher's

verbal instructions, (2) cognitive impairments, (3) neurological disorders, (4) psychiatric disorders, or (5) a history of substance abuse. Furthermore, individuals were excluded if they were taking a corticosteroid. Because many older adults take medications for various conditions, medications were recorded. To screen for cognitive ability, prospective participants were given the Mini-Mental State Exam (MMSE). The MMSE is a highly validated exam that tests for cognitive ability.<sup>36</sup> It is subdivided into 5 components: (1) orientation—10 points, (2) registration—3 points, (3) attention and calculation—5 points, (4) recall—3 points, and (5) language and praxis—9 points. The exam provides a total of 30 points and has 11 questions. A score of 24 to 30 indicates that the person has no cognitive impairment, 18 to 23 shows mild cognitive impairment, and 0 to 17 indicates severe cognitive impairment. The duration of the exam is approximately 10 minutes.

For screening of prospective participants, each individual entered a private sitting area and was seated for 10 minutes prior to starting any testing to acclimatize to the room (22°C) and surroundings. The testing area was a quiet and comfortable room to preclude possible distractions, and no interruptions occurred during the process. A bottle of water was provided to each person.

At this point, the informed consent was read by all prospects and verbally explained to each individual. All questions regarding the research study were answered to each person's satisfaction. The participant then signed a statement of informed consent, and the investigator devoted a few minutes to building rapport with the individual to make him or her feel comfortable. Next, a salivary cortisol sample (prebaseline) was obtained.

Finally, the person was given the MMSE by the investigator to check for cognitive ability. All prospects were found to be free of cognitive impairments based on the administration of the MMSE. The Institutional Review Board of LLU approved all procedures.

### Intervention

If the individual's cognitive ability was intact as evidenced by the results of the MMSE, he or she was instructed to choose 1 slip of paper out of 2 from an envelope; one was marked "Control Group" and the other was marked "Humor Group." The investigators were blinded to the allocation of participants to the humor or control group.

**Humor Group: Humorous Video.** Participants in the humor group were asked to self-select 1 of 2 humorous videos: a Red Skelton comedy or a montage of *America's Funniest Home Videos*. They watched the video on a laptop, wore noise-reduction headphones, and were left alone in the room to watch the video.

Three participants in the humor group selected *America's Funniest Home Videos*, and 7 selected the Red Skelton comedy. This video was a segment from the DVD titled *Double Feature: The Lucy Show/More Red Skelton* (Vina Distributor 2002, Garden Grove, CA, USA). Each participant

watched the first 3 chapters for a total of 20 minutes: Chapter 1 had a duration of 6 minutes and 33 seconds, Chapter 2 had a duration of 2 minutes and 52 seconds, and Chapter 3 had a duration of 11 minutes and 35 seconds. This video was selected because participants were older adults and could relate to the humor from that era of comedy. The Red Skelton video was part a genre of comedy featuring the American variety show. Chapter 1 consisted of Red Skelton's monologue. Chapters 2 and 3 consisted of Red Skelton with guest stars performing comedy sketches.

*America's Funniest Home Videos* were a collection of 2 videos found on YouTube. They were entitled "100 Falling People, Part 1"—*America's Funniest Home Videos*, Part 538; and "100 Falling People, Part 2"—*America's Funniest Home Videos*, Part 540. The duration of Part 1 was 11 minutes and 11 seconds and of Part 2 was 8 minutes and 50 seconds, for a total of 19 minutes and 1 second. Both videos consisted of short clips of babies, children, and adults falling in various comical situations.

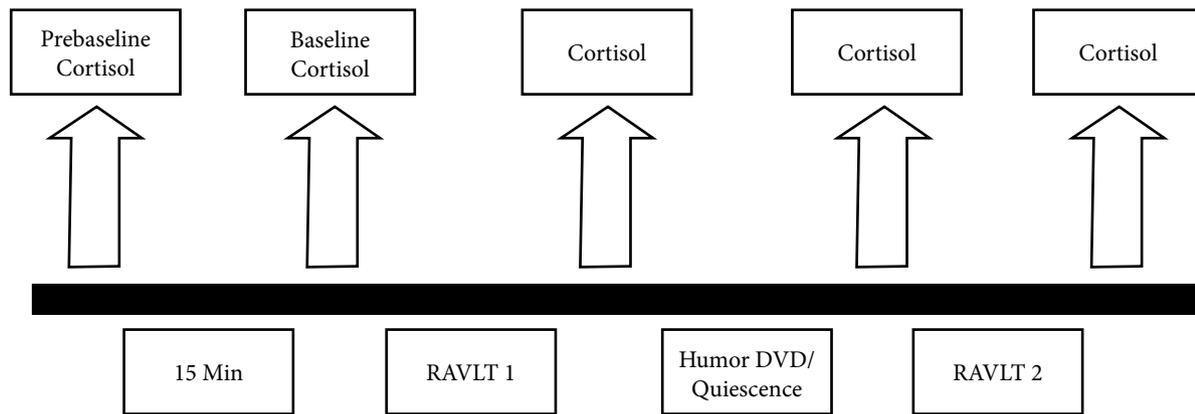
**Control Group: Quiescence.** Participants in this group were instructed to sit calmly for 20 minutes. The investigator instructed participants that they would be left alone for that period. The control group did not watch a video, and participants were not permitted to read, speak, or use cell phones.

### Outcome Measures

**Rey Auditory Verbal Learning Test.** As shown in Figure 1, the Rey Auditory Verbal Learning Test (RAVLT) was administered twice during the study. The RAVLT was used to determine learning ability, delayed-recall ability, and visual-recognition ability. The test was printed by Western Psychological Services (Torrance, CA, USA) and has been used in clinical practice and in research studies. The test is a widely used neuropsychological assessment and was developed by Andre Rey (1941, 1958). It consists of a 15-item word list that was presented 5 times. A number of studies have shown the high test-retest reliability<sup>37</sup> and validity of this test.<sup>38,39</sup> The instructions are straightforward and can be easily understood by older adults. Examples of words on List A are *drum, curtain, school, color, house, and river*. The longest word on List A is 7 letters: *curtain*. For List B, examples of words are *stove, desk, bird, shoe, and church*. *Mountain* is the longest word on List B, with 8 letters.

**Salivary Cortisol Sampling.** As shown in Figure 1, samples were taken at 5 predetermined time points throughout the study. The functioning form of cortisol in blood and saliva is in its unbound form.<sup>40</sup> Salivary flow rates do not have an effect on levels of salivary cortisol.<sup>41</sup> A strong correlation exists between levels of salivary and serum cortisol.<sup>42-44</sup> Day-of-sampling confounding variables of salivary cortisol were taken into consideration. Twenty-four hours prior to arriving at the lab, participants were instructed to abstain from eating and strenuous exercise during the 1 hour prior to their appointment times.<sup>45,46</sup> They were directed to abstain from coffee or alcohol, to abstain from smoking

**Figure 1.** Salivary Cortisol Sampling Protocol



upon awakening, and to stay awake upon awakening.<sup>47-49</sup> Upon their arrivals, verbal instructions were given to participants explaining the sampling protocol for salivary cortisol. All questions were answered to a participant's satisfaction.

When a person is faced with a stressful situation, his or her cortisol levels increase in a manner unrelated to its diurnal rhythm.<sup>50</sup> However, in deference to the diurnal rhythm of cortisol, levels were measured between 10:30 AM and 4:00 PM.<sup>46,51</sup> Products for sampling salivary cortisol were purchased from Salimetrics, LLC (State College, PA, USA). Supplies included cryostorage boxes, oral swabs, swab storage tubes, and bar-coded sample labels.

### Procedures

After the participant's assignment to either the humor or the control group when the investigator and participant were ready, the second sample of salivary cortisol was obtained and RAVLT 1 was administered to check learning ability, delayed recall, and visual recognition. Two investigators administered the test. Investigator 1 read the words aloud, while Investigator 2 kept a tally of the words repeated by the participant on a premade word-list form. Investigator 1 and the participant were seated face-to-face at a table to facilitate better hearing and understanding of the words spoken. Investigator 2 sat to the side and at a distance from the participant and Investigator 1 to prevent the participant from seeing or hearing tallying of the correctly repeated words. For reliability, the same Investigator 1 was used to speak and the same Investigator 2 was used to record throughout the study. After RAVLT 1 was administered, the third sample of salivary cortisol was obtained.

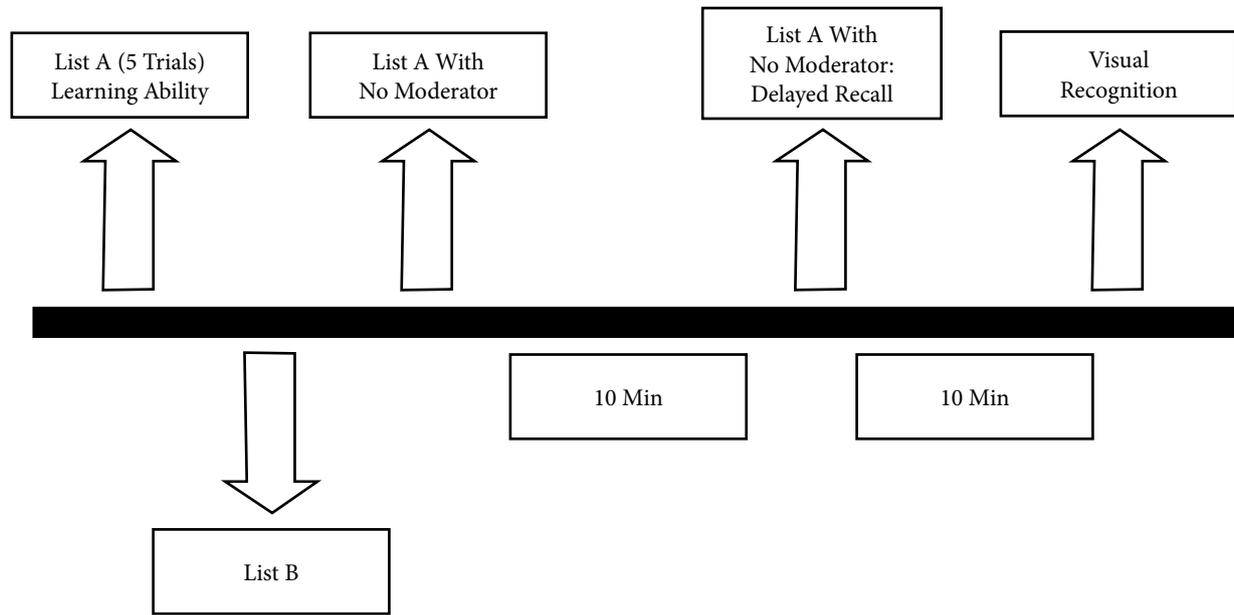
Next, the humor group watched the chosen video and the control group sat calmly for 20 minutes. The investigator then obtained the fourth sample of salivary cortisol and administered RAVLT 2, using the same words from RAVLT 1. Lastly, after RAVLT 2 was finished, the final sample of salivary cortisol was obtained.

**Measurements of Salivary Cortisol.** The oral swab was placed directly under participants' tongues by the investigator, and they were instructed to keep their mouths closed for 90 seconds, timed with a stopwatch. Subsequently, the oral swab was removed by the investigator and placed directly into an oral-swab tube, capped, and then immediately stored in a refrigerator-freezer at -20°C. After the participant completed the study and all salivary cortisol samples had been obtained, the storage tubes were immediately placed in a freezer at -80°C. Each of the storage tubes was pre-labeled by Salimetrics with a barcode representing the participant's number and the predetermined time point that the sample was taken. The same investigator obtained all salivary cortisol samples.

Participants were allowed to drink water throughout the study. However, 10 minutes before the salivary cortisol sampling occurred, participants were instructed not to take any sips of water until after the sample was made. When all experiments were completed, the samples were shipped overnight to Salimetrics for analysis. Two cortisol readings ( $\mu\text{g}/\text{dL}$ ) were analyzed per sample, and an average was reported.

**RAVLT: Learning Ability.** As shown in Figure 2, participants were instructed that Investigator 1 would read aloud the list of 15 words (List A) and that they should listen carefully and not interrupt the sequence. The speed was approximately 1 spoken word per second. When all 15 words had been read, participants were asked to repeat as many words as they could recall. The order in which participant repeated words was not of importance. To jog participants' memories, they were encouraged to repeatedly speak the words aloud once they could not recall words to any further extent. They were allowed to repeat words previously spoken. Investigator 2 used a premade list of words from List A and checked the list as words were spoken by the participant. After the participant could no longer recall any words, the same words were tested again, and in the same procedure, for a total of 5 trials. The investigators moved onto the next trial after participants stated that they could not recall any

**Figure 2.** RAVLT Protocol



additional words or until at most 1 minute of silence had occurred. No time break took place between the 5 trials.

After the fifth trial, Investigator 1 immediately read aloud a set of 15 new words from a different list (List B) and instructed participants to repeat as many of the List-B words as they could recall. Investigator 2 again tallied the correct words on a premade list. Per the RAVLT protocol, List B was given to intentionally confuse the participant.

Following the reading of List B, Investigator 1 asked the participant to repeat the words from the original list (List A). At this juncture, the imperative requirement was that Investigator 1 should not speak the words prior to having the participant recall and state the words. The participant was then given a 10-minute break. During the break, the participants were not allowed to sleep, read, or talk on their cell phones or to the investigators. When the 10-minute break concluded, delayed recall was tested.

**RAVLT: Delayed Recall.** Investigator 1 asked the participant to recall and repeat the words from List A once more. Again, prior to the participant stating the words, Investigator 1 did not read the words from List A. The participant was then given a 10-minute break. During the break, the participant again was not allowed to sleep, talk on the cell phone, talk to investigators, or read. When the 10-minute break was completed, visual recognition was tested.

**RAVLT: Visual Recognition.** Investigator 2 handed the participant a pen and a 1-page form consisting of a list of words. Participants were instructed to locate the words that were spoken to them, and learned and recalled by them from List A, and to check off only those words. Participants were told to check off a maximum of 15 words. The form contained 50 words and consisted of words from List A, List B, and

various other words. Participants were given a maximum of 3 minutes to complete this task.

### Statistical Methods

Statistical analysis was performed using the statistical package IBM SPSS for Windows version 22 (IBM, Armonk, NY, USA). Data was summarized using frequencies and means and standard deviations. The demographic characteristics of the 2 groups were compared using an independent *t* test and Fisher's exact test. The independent *t* test was also used to compare the RAVLT scores between the 2 groups, and the Kruskal-Wallis test was used to compare the change in scores within the groups. The Wilcoxon signed-ranked test was conducted to assess changes in cortisol levels as a result of the intervention. The significance level was set at  $P \leq .05$ .

### RESULTS

The demographics of all 20 participants are displayed in Table 1. No significant differences existed between the control and the humor groups in gender, age, height, weight, BMI, or MMSE score. Figure 3 shows percentage changes in learning ability, delayed recall, and visual recognition due to the 20-minute humor intervention for the humor group and the rest period the control group, as measured by the RAVLT.

Results indicated that learning ability, delayed recall, and visual recognition were enhanced in both groups. When examining the changes in scores on the RAVLT between preintervention and postintervention testing, however, a significant difference existed between the humor and control groups in scores for delayed recall ( $P = .029$ ), as shown in Figure 3. The percentage increase was more than double for the humor group, a 43.6% increase compared with a 20.3%

**Table 1.** Mean (SD) of Demographic Characteristics by Study Group (N = 20)

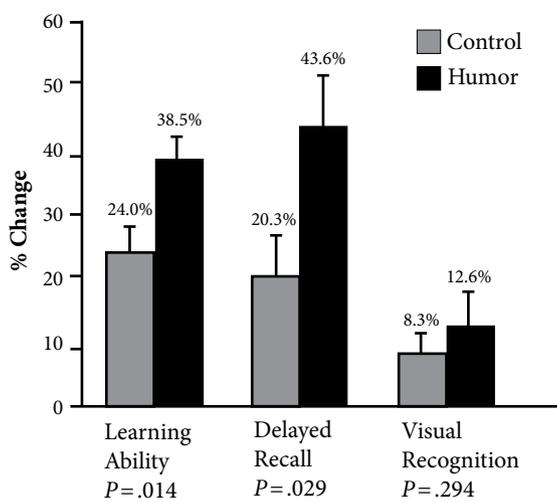
	Control Group (n = 10)	Humor Group (n = 10)	P Value
<b>Gender, %</b>			
Male	60	50	.50 <sup>a</sup>
Female	40	50	
<b>Age, y</b>	68.7 (5.5)	69.3 (3.7)	.78 <sup>b</sup>
<b>Height, cm</b>	170.5 (8.8)	168.8 (9.6)	.67 <sup>b</sup>
<b>Weight, kg</b>	76.9 (17.7)	83.9 (19.8)	.41 <sup>b</sup>
<b>BMI, kg/m<sup>2</sup></b>	26.2 (4.1)	29.5 (6.8)	.22 <sup>b</sup>
<b>MMSE</b>	29.4 (0.7)	28.7 (0.9)	.08 <sup>b</sup>

Abbreviations: SD = standard deviation; MMSE = Mini-Mental State Exam.

<sup>a</sup>Determined using Fisher’s exact test ( $\chi^2$ ).

<sup>b</sup>Determined using independent *t* tests.

**Figure 3.** Mean (SD) % Change of RAVLT Scores

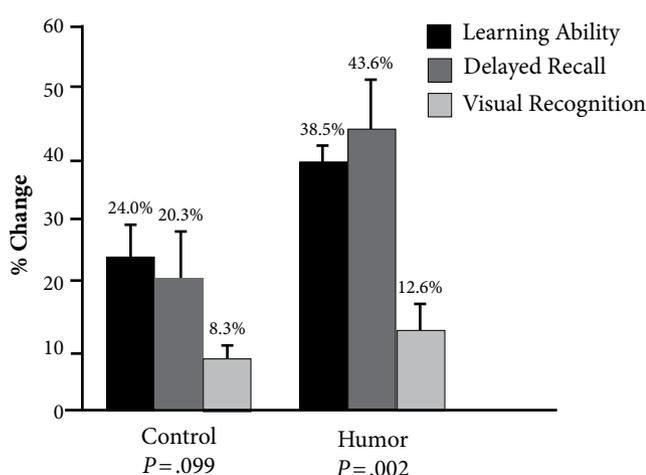


increase for the control group. This category shows the greatest improvement for the humor group, indicating that the video was most influential in improving delayed recall.

Furthermore, significant differences were found when comparing changes in learning ability between the 2 groups. As shown in Figure 3, although the control group increased their learning ability by 24.0%, the humor group had a larger increase, 38.5% ( $P = .014$ ). Although both groups experienced an increase in the percentage change in visual recognition, 8.3% in the control and 12.6% in the humor group, the difference between these increases was not significant ( $P = .294$ ).

Percentage changes within each group for the 3 parts of the RAVLT are shown in Figure 4. For the control group, the greatest percentage change was seen for learning ability versus delayed recall and visual recognition ( $P = .099$ ). The opposite was observed in the humor group. The humor group showed a greater increase in delayed recall versus learning ability and visual recognition ( $P = .002$ ).

**Figure 4.** Mean (SD) % Change of RAVLT Scores by Study Group



For the control and humor groups, Table 2 shows the levels of salivary cortisol at the 5 predetermined time points throughout the study. Table 2 illustrates the mean (SD) for the cortisol levels ( $\mu\text{g/dL}$ ) in the control and humor groups over time. One control participant’s cortisol level appeared to be an outlier. After using Grubbs’ test, it was determined to be 2.8 SD from the mean and, thus, was deleted.

Watching a humorous video significantly decreased salivary cortisol levels in the humor group. The most relevant drop in that group’s levels occurred from measurements at baseline/pre-RAVLT 1 to those immediately after watching the humorous video/post-RAVLT 2 ( $P = .046$ ). For the control group, during the same time frame, no significant change occurred in levels of salivary cortisol ( $P = .130$ ).

In addition, a significant change occurred in the levels of salivary cortisol for the humor group from baseline/pre-RAVLT 1 to immediately before watching the humorous video

**Table 2.** Cortisol Levels ( $\mu\text{g/dL}$ ) by Study Group

	Control Group Mean (SD)	<i>P</i> Value <sup>a</sup>	Humor Group Mean (SD)	<i>P</i> Value <sup>a</sup>
Prebaseline	.20 (.08)		.25 (.20)	
Baseline/pre-RAVLT 1	.20 (.08)	.257	.27 (.20)	.242
Post-RAVLT 1/prehumor or quiescence	.22 (.12)	.477	.23 (.14)	.047
Posthumor or quiescence/pre-RAVLT 2	.17 (.10)	.130	.21(.13)	.046
Post-RAVLT 2	.14 (.06)	.047	.17 (.07)	.062

Abbreviations: SD = standard deviation; RAVLT = Rey Auditory Verbal Learning Test.

<sup>a</sup>Determined using the Wilcoxon signed-rank test.

(post-RAVLT 1/prehumor quiescence) ( $P = .047$ ). Again, no significant changes in the level of salivary cortisol occurred during this same period for the control group ( $P = .477$ ). Borderline significant changes occurred in the humor group from baseline/pre-RAVLT 1 to immediately after administering the RAVLT 2 (post-RAVLT 2 or end of study) ( $P = .062$ ). In the control group, a significant change also occurred during the same time frame ( $P = .047$ ). Prebaseline measurements compared with baseline measurements were not significant for the control or the humor group ( $P = .257$  and  $P = .242$ , respectively).

## DISCUSSION

The current study examined whether short-term memory in older adults could be enhanced by watching a humorous video and also whether levels of the stress hormone cortisol could be modulated in this process. The results showed that the humor group had a substantial increase in learning ability and delayed recall when compared with the control group. In addition, the current study has shown that prebaseline levels of cortisol, measured 10 minutes before baseline measurements and before the start of RAVLT 1, were not significantly different for the humor and control groups. This result suggests that no anticipatory effect existed at the onset of the memory test. After cortisol measurements were taken at prebaseline, participants were randomly placed into 1 of the 2 groups.

The research team might ask whether individuals' anticipation that they would be watching and enjoying a humorous video could diminish the possible stress response associated with taking a memory test and, thus, affect test scores. Immediately following RAVLT 1, the humor group's cortisol levels significantly decreased. That decrease could be attributed to the humor group's anticipation that they would be in a mirthful state. However, in the control group, cortisol levels actually increased following RAVLT 1. A stressful state can be either a eustress or a distress state. Results for the humor group seem to indicate they experienced a eustress state while taking the memory test, as shown by their decreased cortisol levels. On the other hand, the control

group appears to have experienced a distress state, as shown by their increased cortisol levels.

Even though both groups were aware that RAVLT 2 was pending, cortisol levels—as predicated—did decrease during the 20-minute time frame when the humor group was watching the humorous video and the control group was sitting quietly and calmly. A previous study had shown, not surprisingly, that humor and the associated mirthful laughter decreases cortisol levels as readily as a calm meditative state.<sup>30</sup> More astonishing was the effect that humor and laughter had on modulating cortisol levels compared with baseline for the humor group (Table 2). After watching the humorous video, cortisol levels were significantly lower than participants' baseline cortisol levels. Although the control group's cortisol levels also decreased while sitting calmly for 20 minutes, the change was not significant.

The research team suggests that the hippocampus, which helps consolidate short-term memory, possibly sustained less cortisol-induced suppression overall in the humor group, potentially explaining improved cognitive outcomes for that group.<sup>4,33</sup> Throughout the study, the humor group showed a consistent decrease in cortisol levels. Moreover, at the end of the study, at completion of RAVLT 2, the humor group showed a borderline statistically significant decrease in cortisol, from baseline measurements (Table 2).

The research teams further suggests the humor group was continuously in a eustress state throughout the study, potentially accounting for the fact that the group's overall scores for memory tests were significantly higher after the humor and laughter session. However, although the cortisol levels had decreased in both groups during the 20-minute period, the increases in scores on the memory test were significantly greater in the humor group (Figure 2). The effect of watching the humorous video had the greatest influence on delayed recall in the humor group, with the percentage increase more than doubling and being significantly greater than that of the control group. Also, learning ability showed a significantly greater improvement in the humor group than in the control group.

Furthermore, throughout the study, variations occurred within the control group's cortisol levels. At this time, the research team lacks sufficient data that might suggest if this variability did or did not affect hippocampal influence over cognitive outcomes. However, although the control group showed a significant decrease in cortisol levels from baseline measurements, the results show that the decreases did not significantly affect the group's scores on the memory tests and that the control group's scores for learning ability and delayed recall were affected.

Within the humor group, delayed recall showed a more significant increase than observed for learning ability; note that delayed recall was tested after learning ability. Not surprisingly, delayed recall should increase after a session of learning. Due to the research team's view that the humor group was in a continuous eustress state, the enhancement to learning ability may have translated into better delayed recall. However, within the control group, no significant difference existed between the increases in learning ability and delayed recall, perhaps because of the continuum of distress. This finding strongly supports the claim that humor may play a role in enhancing short-term memory and, specifically, learning ability and delayed recall in older adults.

This current study has some potential limitations. First, the sample size was small. Although the sample size had over a 90% power based on results of a pilot study, a larger sample size would have allowed for better representation of an older adult population as a whole. Second, due either to the small sample size or the assay testing for salivary cortisol, more variability may have been evident in the cortisol levels. It remains to be seen whether a larger sample size will reduce this variability. Third, the participants included in this study were limited to healthy older adults. Future studies should include cohorts of older adults with diabetes and obesity. Diabetic and obese individuals should be included because poor glucose tolerance and obesity have been associated with greater risks for cognitive impairment.<sup>52,53</sup>

## CONCLUSIONS

The study's findings suggest that humor has clinical benefits and rehabilitative implications and can be implemented into salutogenic, whole-person wellness programs for older adults. Difficulties with learning ability and delayed recall become more burdensome as individuals age. Learning ability and delayed recall are important to older adults for a better quality of life—considering mind, body, spirit, social, and economic aspects. Older adults have age-associated memory deficiencies. However, health care practitioners can now offer positive, enjoyable, and beneficial humor therapies to improve these deficiencies.

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