The Affective Auditory Verbal Learning Test: Peripheral Arousal Correlates

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The present study assessed the usefulness of the affective list alternatives to the Rey Auditory Verbal Learning Test (RAVL) in the induction of physiological arousal. It was anticipated that affective verbal learning would lead to arousal patterns characteristic of different emotions (Izard, 1977), with significant increases in blood pressure following negative list learning and significant decreases following positive list learning. Since diastolic blood pressure increased significantly following the learning of negatively valanced words and decreased significantly following the learning of positively valanced words, this was supported. Given the abundance of research on lateral asymmetries in emotional and verbal processing, the affective list alternatives to the RAVL may provide an objective means for evaluating individual differences in affective verbal learning as well as the induction of emotion. The Affective Auditory Verbal Learning Test (AAVL) may potentially provide a tool for assessment of cerebral dysfunction in the clinic or in the assessment of affective disorders.

Psychologists attempting to induce emotion in research subjects or clients have often relied on imagery or verbal descriptions of affective events. The present study assessed the utility of affective list alternatives to the Rey Auditory Verbal Learning Test (RAVL) in leading to psychophysiological patterns characteristic of the experience of emotion. Ax (1953) was one of the first researchers to demonstrate that specific autonomic nervous system (ANS) patterns might occur for specific emotions. While manipulating happiness (subjects relaxing on a bed with pleasant music), fear (threat of electric shocks), and anger (abusive polygraph operator), several peripheral measures were recorded. In sum, results suggested that fear and anger led to greater increases in respiration rate, skin conductance, and diastolic blood pressure (DBP). Other studies by Schachter (1957) and Roberts and Weerts (1982) subsequently replicated the findings of Ax (1953), with DBP and skin conductance evidencing greater increases with angry and fearful imagery scenes compared to happy imagery scenes.

Further research by Schwartz, Weinberger, and Singer (1981) addressed the question of whether these specific ANS patterns for specific emotions are augmented or reduced with the induction of ANS arousal (exercise). Subjects were instructed to imagine angry, fearful, happy, or sad scenes. After 2 minutes of baseline recording with imagery alone, subjects exercised on a step and were instructed to verbally describe the emotions associated with the imagined scene. In partial support of earlier findings, baseline DBP and heart rate (HR)
increased less during fearful, sad, or happy imagery than during angry imagery. With exercise, DBP differences were not found, potentially due to vasodilation during physical activity. However, the most important finding was that verbal descriptions were required for the specific ANS patterns reported by Ax (1953) to occur with or without exercise.

Research demonstrating specificity for patterns of ANS reactivity and recovery among the emotions use techniques whereby subjects are reciting affective words. Schwartz et al. (1981) required subjects to verbally describe emotional imagery. Weerts and Roberts (1976), as well as Izard (1977), required subjects to verbalize feelings associated with emotional events in their life. Hence, stating emotionally valenced words or verbally describing emotional imagery purportedly results in specific ANS patterns (heart rate, blood pressure, skin conductance, respiration rate, etc.) for specific emotional valences. Reciting negatively valenced words is associated with greater pulse rate and pressure reactivity, with slower recovery to baseline levels, than positive or neutral verbalizations (Izard, 1977; McNaughtan, 1989; Schwartz et al., 1981; Weerts & Roberts, 1976). Conversely, reciting positively valenced words is associated with less reactivity and faster recovery of baseline, than negative or neutral verbalizations (Izard, 1977; McNaughtan, 1989).

Since the verbalization of affectively valenced words is associated with differential pulse rate and pressure patterns, it seems reasonable to expect that attempting to learn emotionally valenced words and being prompted to recall them verbally will lead to similar ANS patterns in pulse rate and blood pressure. Listening to the experimenter read affective words, subvocally rehearsing the affective words, and then verbally recalling the affective words may produce differential ANS pulse rate and pressure patterns for specific emotions.

To evaluate the ANS correlates of affective learning, the present study measured pulse rate and pressure over the left brachial artery, before and after the administration of the original (neutral) Rey Auditory Verbal Learning Test (Rey, 1964), as well as two newly devised affective versions of the test (negative and positive). The purpose of the present study was to assess whether the affective versions of the RAVL are clinically useful in the induction of emotion, and hence, associated with specific ANS patterns characteristic of negative and positive emotions. It was hypothesized that a period (before the AAVL, after the AAVL) by list (positive, negative, neutral) interaction will occur, such that pressure and pulse rate would increase following the learning of negative words and remain stable or decrease following the learning of positive words.

**METHOD**

**Subjects**

A total of 66 right-handed male subjects were recruited from the departmental undergraduate subject pool (the average age range was between 19 years and 23 years). The research was devised in accordance with the guidelines of the Human Subjects Committee and Institutional Review Board of Virginia Polytechnic Institute and State University. All subjects received extra credit for participation and signed an Informed Consent Form. Three subjects were excluded, two for not exhibiting consistent right-handedness (see the Coran, Porac, & Duncan, 1979, scale discussed below) and one for reporting a mitral valve prolapse and irregular heartbeat condition.

**Apparatus**

Materials for the present study included self-report, affective learning, and psychophysiological measures. Self-report materials included the History Questionnaire and the Handed-
Rey Auditory Verbal Learning (RAVL; Rey, 1964). The RAVL is a well-known test frequently used by neuropsychologists and researchers to study the acquisition of verbal information, as well as primacy and recency effects (Shapiro & Harrison, 1990). Differential deficits in RAVL performance have been found for subjects with amnesia, Attention Deficit Disorder, and head injury (Mungas, 1983). In the original RAVL, a list of 15 words is read to the subjects five times. Following the reading of the list at each trial, the subject is requested to recall as many words as possible using a free recall paradigm.

Affective Auditory Verbal Learning (AAVL). Positively and negatively valenced word lists were previously developed for inclusion in the AAVL. The negative and positive word lists of the AAVL were developed using an index of word norms. Word lists were constructed using the Toglia and Batting (1978) index of word norms. From the subset of familiar words (a mean rating of 5.0 or above), 15 negatively valenced words were selected (those having the lowest pleasantness ratings) and 15 positive valenced words were selected (those having the highest pleasantness ratings).

Blood pressure (BP) and heart rate (HR). A Norelco digital pulse rate/pressure machine (model 3500) with automatic printer, inflation, and exhaust functions was used to obtain Korotkoff sounds (mmHg). An AC adapter was used to prevent cumulative changes in battery discharge from influencing the accuracy of measurement. The machine was set to inflate to 160 mmHg before deflating to measure Korotkoff sounds at the left arm as the brachial artery opened. The exhaust rate of the machine was 3 mmHg per second, which set the error variance at ±3 mmHg. The procedure and machine used in the proposed study were identical to those used by Harrison and Kelly (1987a) and follow the procedures set forth by the American Heart Association and the Association for the Advancement of Medical Instrumentation (see Harrison & Kelly, 1987a; Harrison, Gorelczenko, & Kelly, 1988).

Procedure

Subjects were tested individually throughout the day in a comfortably lit (about 1300 lx) room with ambient noise levels of about 45.00 ± 0.32 dB SPL (re. 0.002 dynes/cm², A scale). Upon arrival to the experiment, subjects were seated behind a desk in a cushioned recliner in its upright position. The experimenter sat directly opposite the subject at the other side of the table. Following a brief introduction to the purpose, procedure, and policies covered in the Informed Consent Form, subjects were asked to read and sign the form. After signing the Informed Consent Form, subjects received the History Questionnaire, a self-report measure of medical background (e.g., prescription drug use, head injuries, etc.), and the Handedness Questionnaire (Coran et al., 1979). In order to participate in the rest of the experiment, subjects were required to score ≥7 or higher, indicating consistent right-handedness.

The actual experiment began with the first measurement period of heart rate and left arm blood pressure. Subjects were asked to place their left arm on the table with left hand open and palm facing up. The left arm was supported at about the level of the heart. Legs were not crossed. The cuff was positioned over the left brachial artery. Palpation was used to determine the position of the left brachial artery about 2.5 cm superior to the left antecubital...
After turning the machine on, subjects were asked if they were ready, the start button was pushed, and then the cuff was inflated to 160 mmHg before deflating to detect Korotkoff sounds. Blood pressure and heart rate results appeared on the screen. Systolic and diastolic pressure was recorded in mmHg and pulse rate was recorded in beats per minute on the data sheet. The procedure for pressure and pulse rate measurement used in the present study was identical to the methodology used by Harrison and Kelly (1987a) and Harrison et al. (1988).

Following the first pulse rate and pressure measurement period, the cuff was removed, and the subject was given the AAVL. Twenty-one subjects received the neutral version, 21 subjects received the negative version, and 21 subjects received the positive version. The sequence of administration of the AAVL lists was varied to prevent order effects. The experimenter left the room for the administration of the AAVL and entered the adjacent observation room. The word lists were read to the subjects using a previously recorded audiotape of a male voice reading the lists at about one word per second. Instructions were also read by the male voice on the audio tape. The audio tape was played through the intercom system at about 50 dB as determined by the Metrosonic dB 307 Noise Dosimeter.

Subjects received the following instructions from the original RAVL on Trial 1: ‘‘I am going to read you a list of words. Please listen carefully. When I stop, you are to say back as many words as you can remember. Say the words in any order you remember. Just try to remember as many as you can.’’ Instructions for Trial 2 through Trial 5 were also as follows: ‘‘Now I’m going to read the same list again. When I stop again, I want you to tell me as many words as you can remember, including words you said the first time. It doesn’t matter what order you say them. Just say as many words as you can remember whether or not you said them before.’’ When the subject could no longer recall any more words, or a maximum of 3 minutes had past, the next trial began. Subject’s responses were recorded on an audio tape and later transferred to the data sheet.

With the completion of all five trials of the AAVL, the experimenter returned to the room and sat across from the subject for the second pulse rate and pressure measurement period. Pulse rate and pressure recordings occurred using the same procedure as the first measurement period.

RESULTS

The present study assessed changes in pressure and pulse rate reactivity following the learning of positive, negative, or neutral words. A period (before the AAVL, after the AAVL) by list (positive, negative, neutral) interaction was anticipated, such that pressure and pulse rate would increase following the learning of negative words, remain stable or decrease following the learning of positive words, and not change significantly following the learning of neutral words. Since the focus of the present study was on pressure and pulse changes as a function of affective list learning, the scores on the AAVL are not discussed. Subsequent analysis has shown that the AAVL scores of the present study replicate those discussed in a previous report (Snyder & Harrison, 1997).

A $3 \times 2$ (List $\times$ Period) mixed factorial MANOVA with repeated measures on measurement period was performed on the systolic pressure (mmHg), diastolic pressure (mmHg), mean arterial pressure (mmHg), and heart rate (beats per minute) measures. A significant list by period interaction was found using diastolic pressure measures, $F(2, 60) = 6.96, p = 0.0019$, mean arterial pressure measures, $F(2, 60) = 5.66, p = 0.0056$, and heart rate measures, $F(2, 60) = 3.15, p = 0.0502$, but not systolic pressure measures, $F(2, 60) = 1.82, p = 0.1710$. No main effects were found for any of the cardiovascular measures.
Post-hoc analysis using the Tukey Test revealed a significant increase in diastolic pressure and mean arterial pressure, but not heart rate, following the learning of negative words. The Tukey Test revealed that diastolic pressure after learning negative words ($M = 74.81; SD = 18.17$) was significantly greater than diastolic pressure before learning negative words ($M = 65.67; SD = 13.68$). Refer to Table 1. Similarly, the Tukey Test revealed that mean arterial pressure following the learning of negative words ($M = 96.83; SD = 14.16$) was significantly greater than mean arterial pressure before learning negative words ($M = 91.90; SD = 9.80$) (Table 1).

Post-hoc analysis also revealed a significant decrease in diastolic pressure and heart rate, but not mean arterial pressure, following the learning of positive words. The Tukey Test revealed that diastolic pressure following the learning of positive words ($M = 68.71; SD = 12.52$) was significantly less than diastolic pressure preceding the learning of positive words ($M = 73.90; SD = 16.20$) (Table 1 and Figure 1). Similarly, a Tukey Test revealed that heart rate following the learning of positive words ($M = 76.76; SD = 12.00$) was significantly less than heart rate preceding the learning of positive words ($M = 80.95; SD = 13.06$). Finally, post-hoc analysis did not reveal any significant changes in diastolic pressure, systolic pressure, mean arterial pressure, or heart rate following the learning of neutral words (see Table 1). Likewise, no list by period interaction was found using the systolic measures.

To further assess whether subjects in each list condition exhibited varying cardiovascular patterns before receiving the AAVL, a one-way MANOVA with the between subjects variable of list (positive, negative, neutral) was performed on the systolic pressure (mmHg), diastolic pressure (mmHg), mean arterial pressure (mmHg), and heart rate (beats per minute) measures for the first period. Results suggested that there was no significant difference between the positive, negative, and neutral list groups at pretest for systolic, diastolic, and mean arterial pressure measures. However, a significant main effect of list was found using heart rate measures, $F(2, 60) = 3.41, p = 0.0391$. Post-hoc analysis revealed that subjects receiving the negative list exhibited significantly lower pretest heart rates ($M = 72.62; SD = 9.16$) than subjects receiving the positive list ($M = 80.95; SD = 13.06$) or neutral list ($M = 81.48; SD = 14.19$) at pretest. Since the previous analysis revealed that heart rate did not change following the learning of negative words (see above), this finding does not necessarily mitigate the previous results.
FIGURE 1. Mean diastolic pressure as a function of list (positive, negative, neutral) and measurement period (before the AAVL, after the AAVL).

DISCUSSION

The purpose of the present study was to assess the influence of affective list learning on ANS measures of arousal (blood pressure and heart rate). Previous research (Ax, 1953; Schwartz, Weinberger, & Singer, 1981) has suggested that different ANS activity patterns are associated with different affective valences. In sum, ANS reactivity (blood pressure and heart rate) has been reported to increase following exposure to negatively valenced events (imagery, verbal descriptions) and to decrease following exposure to positively valenced events (imagery, verbal descriptions).

Hence, it was hypothesized that there would be a period (before the AAVL, after the AAVL) by list (positive, negative, neutral) interaction, whereby blood pressure and pulse rate would increase following the learning of negatively valenced words and decrease or remain stable following the learning of positively valenced words. Full support for the hypothesis was found using diastolic pressure measures, since diastolic pressure significantly increased for subjects learning negatively valenced words and significantly decreased for subjects learning positively valenced words (see Table 1 and Figure 1). Partial support for the hypothesis was also found using systolic and mean arterial pressure measures, since mean arterial pressure significantly increased for subjects learning negative words (see Table 1) and heart rate significantly decreased for subjects learning positive words.

All ANS measures (diastolic pressure, systolic pressure, mean arterial pressure, heart rate) were not equally affected. The findings of diastolic and mean arterial pressure suggest similar response patterns. However, the primary influence on diastolic pressure suggests that affective verbal learning has a greater influence on psychophysiological resistance parameters. Diastolic, but not systolic, pressure may have showed a significant increase following the learning
of negatively valenced words and significant decrease following the learning of positively valenced words because affective verbal learning influences blood pressure resistance more so than the force of left ventricular contraction. Previous research would support this interpretation since the presentation of affective stimuli has often been reported to influence diastolic but not systolic pressure. For example, both Ax (1953) and Schwartz et al. (1981) reported that exposure to affective stimuli influenced diastolic but not systolic pressure.

The finding of a significant increase in mean arterial pressure following the learning of negatively valenced words does not refute the above argument that affective verbal learning may have more of an influence on resistance pressure than the force of ventricular contraction. Since arterial pressure is nearer to the diastolic than systolic levels for a longer period throughout the cardiac cycle, mean arterial pressure does not necessarily reflect the true average pressure on the left brachial artery (Smith & Bickley, 1964). Hence, the mean arterial pressure is most likely less than that reflected by taking the average of the diastolic and systolic measures (Smith & Bickley, 1964). Hence, the significant increase in mean arterial pressure following the learning of negative words does not necessarily suggest that the force of ventricular contraction (systolic pressure) was influenced by negative list learning.

Similar to previous research using systolic pressure measures, the influence of affective stimuli on heart rate has yielded inconsistent findings. Research assessing heart rate reactivity or the magnitude of heart rate changes following exposure to affective stimuli has been inconsistent, with some studies showing significant heart rate changes following exposure to affective stimuli (Schwartz et al., 1981) and other studies not finding significance (Ax, 1953). However, research assessing the rate of recovery or return to baseline for heart rate measures following exposure to affective stimuli has led to more consistent findings, with slower recovery following exposure to negatively valenced stimuli (i.e., criticism, imagery, facial posing) in comparison to positively valenced stimuli (Funkenstein, King, & Drolette, 1957; Levenson, 1992; Schwartz et al., 1981).

The finding of significantly decreased heart rate following the learning of positively valenced words is useful, however, since this contradicts some verbal learning literature in support of emotional processing theories. Lacey and Lacey (1974), for example, demonstrated greater heart rate acceleration with more complex verbal processing tasks. In addition, Lacey and Lacey (1974) had subjects perform mental arithmetic tasks with or without concurrent or delayed verbalization and found that heart rate acceleration occurred for verbalization groups only. Hence, this verbal learning literature would predict that heart rate would increase following the learning of positive, negative, and neutral words, since this is a relatively difficult task and involves verbalization. However, the finding of a significant decrease in heart rate following the learning of positively valenced words does not support this prediction. Hence, results of the present study using heart rate provide support for the contention that learning positive and negative words in analogous to previous research on exposure to affective stimuli (i.e., Ax, 1953) and that our findings are potentially due to the induction of emotion.

In sum, results suggest that learning positively or negatively valenced words has a significant influence on diastolic pressure. If this psychophysiological correlate of exposure to affective stimuli is said to reflect the subjective experience of emotion, then it may be hesitantly inferred that the affective verbal learning test is useful for the empirical induction of emotion. A tool for the empirical induction of emotion will be useful for the basic researcher studying laterality or the theories of emotional processing as well as the clinician evaluating cerebral dysfunction or affective disorders. For example, future research may assess whether subjects higher in hostility show greater pulse and pressure reactivity following the learning of the negative list in comparison to subjects lower in hostility.

The practical and theoretical implications of the AAVL are numerous and suggest many
questions for future research. For example, to distinguish whether listening to affective words as opposed to verbally recalling affective words leads to affect induction, blood pressure and heart rate measures will need to be taken after the experimenter reads the list on each trial, as well as after the subject verbally recalls the words on each trial. Future research will include more measurement periods to separate the influence of listening/rehearsing from verbal recall as well as to assess duration and habituation of the pulse and pressure effects. Future research will also incorporate more unobtrusive measures (i.e., blood volume or skin conductance) and assess individual differences in reactivity as a function of sex, education, and/or age. For instance, older subjects have been reported to show greater pulse and pressure reactivity, as well as slower return to baseline levels (habituation) than younger subjects in response to the introduction of novel stimuli (Harrison & Kelly, 1987b). A similar response pattern may be found for older and younger subjects following the AAVL.

REFERENCES


