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ABSTRACT

This study considers the galvanic skin response (GSR) of sixth-grade students (n=20) using print, video, and microcomputer segments. Subjects received all three media treatments, in randomized order. Data for analysis consisted of standardized test scores and GSR measures; a moderate positive relationship was shown between cumulative GSR and standardized test scores. The higher achieving students obtained higher GSR values. Patterns of arousal with each media were identified by analysis of variance with repeated measures; the patterns of response towards the print and microcomputer treatments were very similar, and both were dissimilar from the pattern of response for video. Video obtained the highest GSR response initially, and GSR response remained constant throughout the 21-minute data collection period. Print and microcomputer obtained relatively lower GSR responses initially, then matched the GSR response level of video after about 10 minutes, and continued to increase throughout the data collection period. Two tables provide simple correlations of GSR data for each media condition with standardized test scores, and an analysis of variance summary. Graphs show: (1) GSR averages during print, video, and microcomputer use; and (2) simple correlations of print, video, and microcomputer treatments with time. (Contains 24 references.) (Author/AEF)

Media Research with a Galvanic Skin Response Biosensor: Some kids work up a sweat!

by

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RUNNING HEAD: Physiologic Response to Media ...

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ABSTRACT

This study considers the galvanic skin response (GSR) of sixth-grade students (n=20) using print, video, and microcomputer segments. Subjects received all three media treatments, in randomized order. Data for analysis consisted of standardized test scores and GSR measures. A moderate positive relationship was shown between cumulative GSR and standardized test scores ($r \approx 0.50$). The higher achieving students obtained higher GSR values. Patterns of arousal with each media were analyzed by analysis of variance with repeated measures. The interaction of media and time was significant at the $p < .05$ level ($F(14, 266) = 1.985$). The patterns of response towards the print and microcomputer treatments were very similar, and both were quite dissimilar to the pattern of response for video. Specifically, video obtained the highest GSR response initially, and GSR response remained constant throughout the 21-minute data collection period. Print and microcomputer obtained relatively lower GSR responses initially, then matched the GSR response level of video after about 10 minutes, and continued to increase throughout the data collection period. This finding has not been previously reported and reconciles earlier conflicting findings.

Media Research with a Galvanic Skin Response Biosensor: Some kids work up a sweat!

Measurements of galvanic skin response (GSR) date from the turn of the century. In 1888, Fere reported a relationship between GSR and sensory or emotional stimulation. Ruckmick in 1933 reported GSR differences for subjects viewing comedic, conflictual, and romantic film segments (reported in Schwartz & Shapiro, 1973).

GSR is referred to variously as electrodermal activity, electrodermal response of Fere, and skin resistance response. At this time, the acronym GSR is probably most commonly known to media researchers, thus GSR will be used throughout this paper (Goodman, 1985) .

What is GSR? Biologically, Galvanic skin response ". . . is a change in the electrical resistance of the skin. It is determined by passing a weak current through the skin and measuring changes in electricity flow or by measuring the current generated by the body itself. It has been correlated with emotion, attention, and stress..." (Academic Electronic Encyclopedia, 1993). Educationally, GSR is a generalized measure of autonomic arousal (Reeves, Lang, Thorson, & Rothchild, 1989) and also a measure of attention (Prokasy & Raskin, 1973). Correlations between GSR and attitude, empathy, and social interactions, especially when associated with small group interactions, have been shown (Schwartz & Shapiro, 1973).

Physiologic Response to Media

Attention (or arousal) towards media is an important component in explaining the possible different effects of media (Salomon, 1984). Measures of physiologic response are commonly used for this purpose including secondary reaction time tasks (Murphy-

Berman & Wright, 1986), eye fixation and eye movement (Zeigler, 1970), heart rate and blood pressure (Emurian, 1993; Lang, 1990), and of course GSR.

As a measure of attention, GSR relates to learning. A number of studies summarized by Carpenter and Haddan (1966) found correlations between learning and increased GSR. Students with higher GSR measures during learning scored best on posttests. Also, intelligence level was related to higher GSR measures, with brighter children tending to be more reactive (higher GSR measures).

Obtaining physiologic data is time consuming and can be cumbersome and expensive. Why use a physiologic measure of attention to media? Such information allows the researcher to obtain a better understanding of how learners use media. For example, Beentjes and van der Voort (1991) compared the secondary reaction times of students learning from 10-minute video lessons and from written transcripts of those videos. Two stories with very different content and substantially different action sequences were both presented via print and video. Findings revealed that the video condition obtained significantly longer reaction times than print. Based on the posttest results and the physiologic reaction-time data, the authors concluded that more attention was directed towards the video lesson than towards the print lesson. Interestingly, this finding suggests that <u>attention is more related to media than to content</u>. The authors indicated that the physiologic measure provided more information and increased understanding about the learners' use of the different media.

Moving GSR out of the Laboratory

There is an extensive body of research on GSR. Most of this research has been conducted in laboratory settings with expensive devices and rigorous methodology that would be difficult to apply in typical instructional settings. Can GSR be useful in the mass education environment? E. B. Fry (1963) mentioned GSR in a text on programmed instruction. He stated:

> A form of response . . . which at the present time is more remote, consists of bioelectric responses. For example, there is a slight change in the resistance offered by the skin to the passage of electricity . . . Accurate determination of these responses is now becoming possible through the development of sensitive instruments, and at some future date, these response systems may be used in education. (p.153)

If GSR instruments that are low-cost and easy to use in naturalistic settings are shown to relate to instructional variables, then GSR can be used educationally.

Are such devices available? The current cost for some easy-to-use instruments for measuring GSR is low (i.e., about $99), but these low-cost instruments may or may not be adequate. Several studies described below used a low-cost instrument to measure GSR in naturalistic settings.

For example, Clariana (1989) described a method for collecting GSR data in the classroom using a low-cost instrument (Sunburst, 1986). The GSR measures of sixth-grade students (n=10) were collected at three-minute intervals for a 21-minute period while the students watched a science educational video. A significant positive correlation was shown between GSR and standardized achievement test scores. Higher GSR measures were obtained by the students with higher standardized test scores. Also, the higher achieving students GSR measures were less variable (i.e., more stable) than those of the low-achieving students. Interestingly, the high-achieving students' GSR measures, though already high, very gradually increased while watching the video, while the low-achieving students' GSR measures either decreased or remained constant.

Using the same instrument but a different method, Clariana (1990) observed the GSR of fifth-grade students (n = 28) working in pairs and also alone on computer-based instruction (CBI) lessons on fractions. GSR measures taken at 3-minute intervals for thirty minutes for the paired and individual learning conditions were averaged together to produce cumulative GSR values for each student for each condition. A significant gender-by-treatment interaction occurred. Females' GSR was highest when working in pairs, and males' was highest when working alone. A significant correlation was also shown between a self-report instrument of preference towards working alone or with others, and the students' actual GSR when working alone or in pairs. This finding directly confirmed results obtained by Dalton, Hannafin, and Hooper (1989) using a self-report measure.

Clariana and Schultz (1991) again used the same instrument but different methodology to consider the effects of public reports of progress on the productivity of first and second grade students (n = 72) in an integrated learning system environment. Lesson "productivity" data, GSR data, and achievement data were collected. GSR data were obtained for each of the students at one-minute intervals, for a total of five minutes as they worked individually on CBI Reading lessons. The five values were averaged together to obtain one cumulative GSR value for each student. The correlation between Iowa Test of Basic Skills Reading scores and GSR was r = 0.15 (not significant). Further, GSR did not relate to lesson productivity. Probably the methodology used was inadequate, collecting GSR data over a longer period of time is desirable. Also GSR measures may be less stable during the initial part of a lesson, altering this method to take samples later on during the lesson may produce better data. In addition, the earlier studies considered older students (i.e., from 5th and 6th grades). GSR of these younger children (i.e., from 1st and 2nd grades) may be <u>less</u> related to achievement and learning.

To summarize, physiologic responses to media provide a measure of attention and also correlate with learning and achievement. However, most physiologic research, by necessity, has been conducted in laboratory settings. But instrumentation and methodology that can allow GSR media studies to be conducted in classroom settings have been described (Clariana, 1989, 1990; Clariana & Schultz, 1991).

Purpose

The purpose of this study was to further explore the use of a low-cost, easy-to-use device for measuring GSR during media use in the classroom. Based on earlier findings, a positive correlation between cumulative GSR measures and standardized achievement test scores was expected. In addition, this study considered GSR changes through time for three different media treatments. It was anticipated that print and video would produce different GSR responses (based on Beentjes & van der Voort, 1991). Specifically, the video condition should obtain higher GSR values than the print condition. This study addressed the following questions: (a) Does GSR correlate positively with student achievement? (b) Are GSR measures for video higher than those for print? and (c) Is there a relationship between the GSR values obtained when subjects use print, video, and microcomputers.

METHOD

Sample

The study sample of students was randomly selected from the sixth-grade classes of a parochial elementary school. These students were from middle-class families (extensive demographic details available from a dissertation by Kapadia, 1987). There were thirteen females and seven males.

Materials

The three conditions in this study were reading a book, viewing a video, and working on a microcomputer. The book was selected by each student and was used for writing a book report later as a part of regular required classroom work. The video treatment used pre-recorded episodes of the "Mr. Wizard" television program. The microcomputer treatment used different portions of a reading microcomputer program developed by the World Institute for Computer-Assisted Teaching. The microcomputer lesson was the next activity in each student's predetermined standard sequence, and was not a voluntary choice but rather was "business as usual". These students had attended computer lab on a daily basis and were very familiar with the computer reading curriculum. All students were also familiar with the videotape player and of course with books. Thus external validity was increased by using typical (even optimal) forms of each media presented within the normal sequence of classroom instruction under normal teacher expectations.

Based on the study by Beentjes and van der Voort (1991), it was expected that attention is more related to media than to content. Thus, it was assumed that by randomizing the content of every presentation under every media condition, the small variance that might be obtained by the content variable would be controlled.

Instrumentation

GSR was measured by a biosensor and software developed for the Apple IIe microcomputer by Sunburst (1986). This biosensor is about the size and feel of a computer mouse. It is silent, non-obtrusive, and fairly comfortable to hold, even for small children. The software was set to the highest GSR sensitivity level.

The computer lab manager recorded GSR readings at three-minute intervals from an Apple IIe computer in an adjacent station. At the end of each three-minute interval, the next four GSR values that occurred were averaged together and rounded to the nearest whole number. This one number represented the sample GSR value for that three-minute interval. Eight observations were taken for each of the three experimental conditions for each student, for a total of 480 observations (8 observations x 3 media x 20 students).

Procedure

The purpose and procedures of the study were described to the students, who were then allowed to volunteer to participate. During a two-week period, students were called individually from their classrooms to come to the computer lab to receive one of the three media treatments.

During data collection, the computer lab manager, a teacher in the school well known to the students, demonstrated how to use the biosensor and described how the students should use each type of media. Students were instructed to use the media in their "normal" or typical fashion. Students held the device in their non-dominant hand and used their dominant hand for controlling the different media devices.

All students received all treatments, but the order of treatments was randomized to control for possible order and novelty effects. Further, students were not informed of which media type they would receive until they arrived at the testing station (except for the third session, which necessarily had to be the media type not yet used by that student).

The temperature, light, and humidity in the lab were maintained at a constant comfortable level to reduce confounding physical variables that have been shown previously to effect GSR. Also measurements were taken only in the morning to reduce possible daily fluctuations in GSR.

RESULTS

Descriptive correlations of *cumulative* GSR measures (i.e., the average of the 8 measures taken for each student for each media type) and the Iowa Test of Basic Skills (ITBS) standardized test scores were conducted (see Table 1). The correlations obtained for each media were uniformly greater for the reading standardized test scores than for mathematics. Also, the print condition obtained the lowest correlations.

Table 1

Simple Correlations of GSR Data for each Media Condition with Standardized Test Scores.

media	ITBS Reading	ITBS Mathematics
Video GSR	0.57	0.53
Print GSR	0.43	0.15
Microcomputer GSR	0.50	0.44

A special microcomputer statistics program for the analysis of repeated measures designs (Bush, 1988) was used to analyze the two "with-in" factors, media type (i.e., print, microcomputer, video) and time (measurements taken every 3-minutes). This analysis of variance revealed that the main effect for media type was not significant (Table 2). The main effect for GSR measurements through time was significant, $F(7, 133) = 5.771$, $p<.05$. In general, GSR measures increased through time.

Table 2

Analysis of Variance Summary.

source	SS	DF	MS	F.ratio	p.alpha
Subject (S)	9973821.00	19	524937.94		
Media type (M)	100.15	2	50.08	0.001	0.99
M * S	2539520.25	38	66829.48		
Time (T)	164478.17	7	23496.88	5.771	0.00 *
T * S	541488.50	133	4071.34		
M * T	124569.45	14	8897.82	1.985	0.02 *
M * T * S	11925443.38	266	4483.25		
Total	14536520.90				

The interaction for media type and time was also significant, $F(14, 266) = 1.985$, $p<.05$. Students' GSR response level at time 0 (Figure 1) shows about equal GSR values for the print and microcomputer conditions but a higher value for the video condition. GSR measures for both the print and microcomputer conditions tended to increase during the 21-minute period, while the video condition began with a moderate value (relative) and continued at about the same level throughout the sampling period. To clarify this pattern that occurred through time, simple correlations of GSR with time for each media condition are shown in Figure 2 with the regression equation of each. This figure shows that the print and microcomputer conditions have similar slopes and intercepts, while the video condition is dissimilar to either.

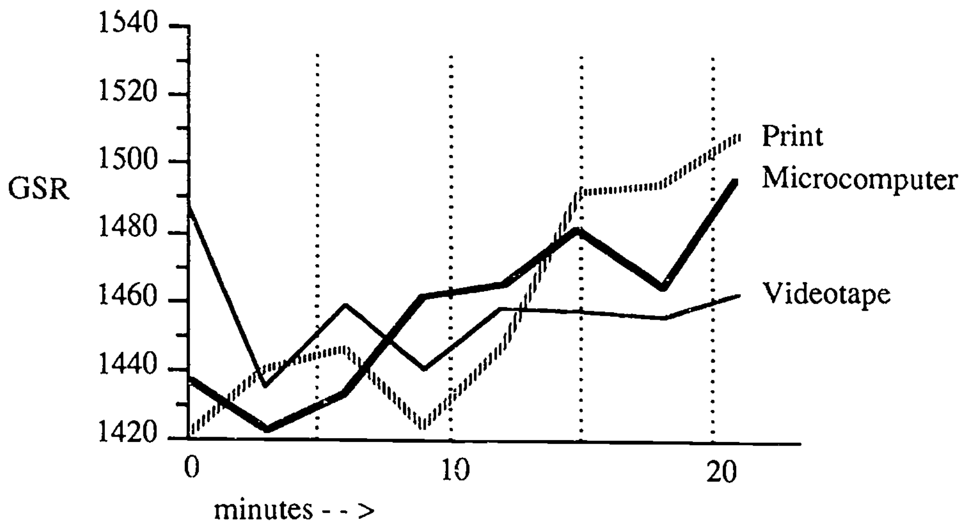

Figure 1. GSR averages during print, video, and microcomputer use.

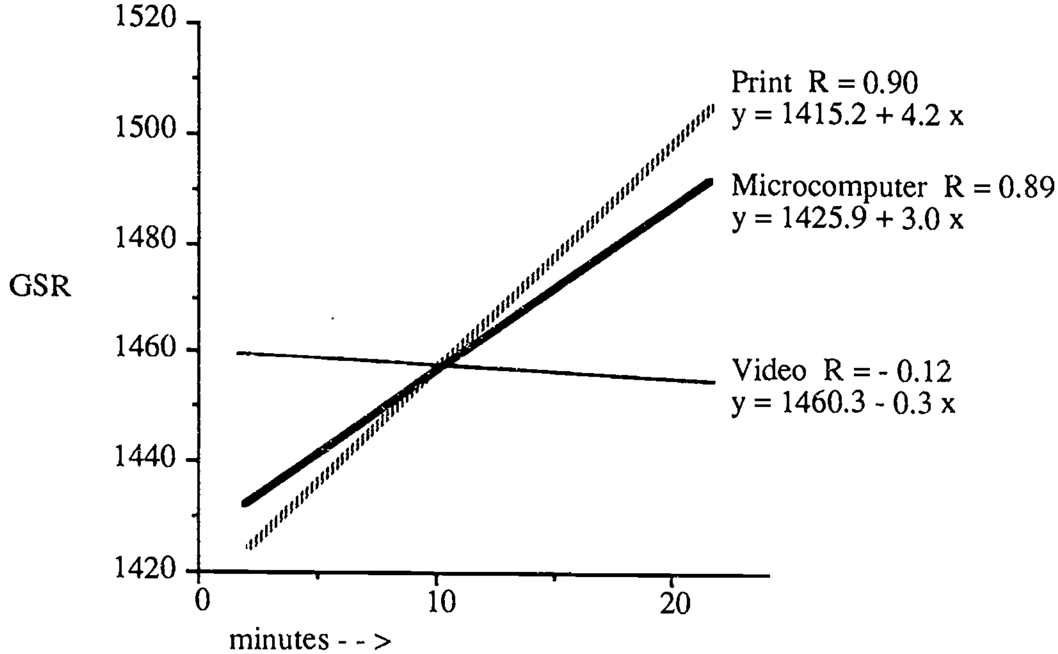

Figure 2. Simple correlations of print, video, and microcomputer treatments with time.

Consistency/reliability is of interest for this particular GSR measurement methodology and instrumentation. First, the split-half reliabilities of the GSR values taken within each 21-minute sampling period were r = 0.95 for microcomputer, r = 0.95 for print, and r = 0.96 for video.

Next, the data for each of the three media conditions taken within a two-week time period were compared. The correlations of the cumulative GSR (average of the eight measurements per medium per student) for each of the three treatments were: (a) print with microcomputer, r = 0.73, (b) print with video, r = 0.65, and (c) microcomputer with video, r = 0.72.

Finally, the consistency of these GSR measures over longer periods of time was examined. Ten students from the present study also participated in a study conducted about one year earlier (Clariana, 1990). A simple correlation between the students' cumulative GSR from that study (the average of 11 GSR measures each for the pair and the individual conditions for each student, i.e., 22 data points) compared to their cumulative GSR measures for the present study (the average of 8 GSR measures each for the microcomputer, print, and video conditions for each student, i.e., 24 data points) obtained an $r = 0.62$, $F = 4.86$, $p < 0.05$.

To summarize, the GSR measures obtained with this instrument in this way were stable within the same medium over a short time period (21 minutes) and between different media (within the two-week data collection period of this study). Also, GSR measures were fairly stable even after a long period of time (one year later and across very different media conditions).

DISCUSSION

This study confirms previous findings that GSR relates to student achievement. Further, the findings were not confirmed that GSR values observed for video would exceed those for print (from Beentjes & van der Voort, 1991). In explanation, the measurement method may have influenced the measures obtained. The Beentjes et al. study used reaction time data from an obtrusive secondary task as a measure of attention to video and print, while the present study used an unobtrusive measure (GSR). The Beentjes et al. findings also generally contradict those of Salomon that print is "tougher" than video, while the findings of the present study are in agreement with Salomon. Interestingly, the Beentjes et al. lessons lasted only ten minutes, while those of Salomon were longer. Referring to Figures 1 and 2, it should be noted that the video condition did obtain higher GSR values than print during the first ten minutes (supporting Beentjes' findings), but then print exceeded video after ten minutes (supporting Salomon's findings). Duration of study becomes a variable that reconciles the discrepancy between Beentjes' and Salomon's findings.

The microcomputer and print treatments seem very different. What may account for the highly similar response observed for these two media? The data directly supports previous studies that compare self-reports of the perceived difficulty of print, video, and microcomputers. Specifically, print and microcomputers are perceived to be more difficult than video (Krendl, 1986; Salomon, 1984). In the present study, both elicited a greater level of effort (i.e., reflected in higher GSR measures). To paraphrase Salomon (1984), viewing is "easy" and reading is "tough".

Alternately, the video though educational in nature, may have seemed more like entertainment than like instruction. It is possible that the students would have viewed the video differently if they thought the video would be followed by a test (Krendl & Watkins, 1983). Kozma (1991) in an important review of learning from print, television, and computers said of television:

> This research presents a picture of television viewers who monitor a presentation at a low level of engagement, their moment-to-moment visual response periodically attracted by salient audio cues and maintained by the meaningfulness of the material. This creates a window of cognitive engagement. Within this window, their processing is sometimes effortless, resulting in the construction of shallow, unelaborate representations of the information presented. However, when viewing with a purpose, people will attend more thoughtfully, constructing more detailed, elaborate representations and drawing more inferences from them. (p. 194)

The pattern of response to video observed in this study seems to follow somewhat with Kozma's conclusions. It should be expected that patterns of response towards instructional video will differ from that of ordinary or entertainment videos and may or may not be like the patterns observed for print in this study. Research using GSR should consider identical video conditions, with and without the expectation of a posttest.

Probably a fruitful avenue for media research utilizing GSR will involve the model of learning from media described by Salomon (1984). This model includes a construct termed the amount of invested mental effort (AIME). GSR is a likely component of AIME. Future research should consider whether GSR directly relates to the AIME construct.

Physiologic responses like GSR probably do not represent a unique construct, rather these probably account for variance in multiple constructs. As an analogy, increased heart rate may indicate either fear or love. Even though these two relate to increased heart rate, it would be absurd to say that love and fear are the same thing. But either way, additional explanatory information is obtained through physiologic response that might not otherwise be available.

Also, context is an important variable in utilizing GSR information. Even in a positive instructional environment, excessive response as well as minimal response are both likely to be detrimental to learning. Optimal rather than maximum attention should be investigated.

In conclusion, Clarke (1983) states that a useful approach for determining the effects of media influence on learning must involve "variables having to do with our attributions or beliefs about media" (p. 454). GSR has been shown to correlate with variables that are of interest in media research, and may provide some measure of an individual's "attribution" toward media. This study points towards a positive relationship between GSR and achievement, and also shows GSR as an immediately available measure of response or engagement during media use. Because it is unobtrusive (unlike reaction time data), it minimally affects the subjects normal response to media. Because it is low-cost and easy to use, it can be applied on a wide basis. Just as Fry anticipated decades ago, GSR can have prescriptive value in mass education.

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