



SOCIAL EVALUATION INFLUENCE ON CARDIOVASCULAR RESPONSE TO A FIXED BEHAVIORAL CHALLENGE: EFFECTS ACROSS A RANGE OF DIFFICULTY LEVELS^{1,2}

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ABSTRACT

Participants performed five memory tasks—ranging in difficulty from very low to very high—under public or private conditions. The publicity and difficulty variables interacted to determine systolic pressure and heart rate responses during performance. Where performance was public, responsiveness on the parameters increased with difficulty to a point and then dropped; where performance was private, responsiveness was relatively low at all difficulty levels. Diastolic pressure responses were configured similarly, although in that case the interaction was not reliable. Findings corroborate and extend results from a previous study, argue against some explanations of those results, and strengthen the case for a recent active coping analysis of cardiovascular audience effects. Findings also strengthen the case for a broader model of effort and cardiovascular response, which has potential for advancing our understanding of a range of phenomena and processes related to behavior and health.

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INTRODUCTION

The construct of socially-induced arousal has conceptual roots that trace back to the beginning of social psychology as a subdiscipline. In his pioneering paper on social facilitation, Triplett (1) speculated that “dynamogenic factors” in coaction settings may lead to a “freeing of nervous energy for (the actor) that he cannot of himself release” (1, p. 516). In the first experimental study into the relationship of an audience to physiological arousal, Burr (2) found that blood pressure and respiration rate among individuals who had been instructed to tell lies were higher in the presence of a large audience than in the presence of an audience of one. Following the Burr investigation, psychologists showed little interest in possible physiological concomitants of social presence until Zajonc (3) made social arousal the central construct in his well-known theory of social facilitation. Zajonc’s theory spawned numerous attempts to evaluate its premise that an observer’s mere presence induces an increase in drive. Although some studies

yielded positive social presence results, in general the case made for the premise was not strong (4–6).

Very recently, interest in the influence of others on arousal has emerged again, this time focusing on functioning in the cardiovascular (CV) system (7–10). This interest has been stimulated in part by the growing appreciation of the role social factors are likely to play in determining CV responding and CV health outcomes, such as hypertension and coronary heart disease (11,12). It also has been stimulated by the appearance of new conceptual analyses that offer fresh insights regarding the conditions under which CV audience effects should be found and, thus, fresh explanations for why audience effects have not been obtained consistently in the past (e.g. 7).

ACTIVE COPING ANALYSIS OF AUDIENCE EFFECTS

The present research was guided by a new audience analysis by Wright, Tunstall, Williams, Goodwin, and Harmon-Jones (13), which actually is an extension of a broader motivational analysis concerned with predicting effort and CV responsiveness in individuals confronted with behavioral challenges (14–16).

Model of Effort and CV Response

The broader analysis takes as its starting point the argument by Obrist (17,18) that sympathetic influence on the CV system increases with task engagement or effort (what Obrist termed “active coping”). It then uses a theory of motivational intensity by Brehm (19) to specify when individuals should be more and less task-engaged and therefore CV-responsive. In brief, Brehm’s theory proposes that intensity (engagement) does not vary directly with factors associated with the importance of success (e.g. incentive value), as most motivation formulations assume, but rather varies as a function of what individuals believe they can and must do to succeed on an instrumental task. The role of success importance, in Brehm’s view, is to set an upper bound on what individuals would be willing to do to succeed. This upper bound is referred to as the level of potential motivation. When an instrumental task is perceived as possible, engagement should be proportional to task difficulty provided that task requirements do not exceed the upper bound. If task requirements do exceed the upper bound, engagement should be low. Engagement also should be low when an instrumental task is perceived as impossible or is unavailable. Even though there might be great potential for energy expenditure in such situations, that potential should go unrealized because effort would be futile.

One notable implication of the foregoing reasoning is that the value a person places on success should moderate that person’s CV response to a possible behavioral challenge. If the value is great enough to justify what is demanded by the challenge, the person

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² Data from this study were reported previously at the 23rd meeting of the Society for Psychophysiological Research.

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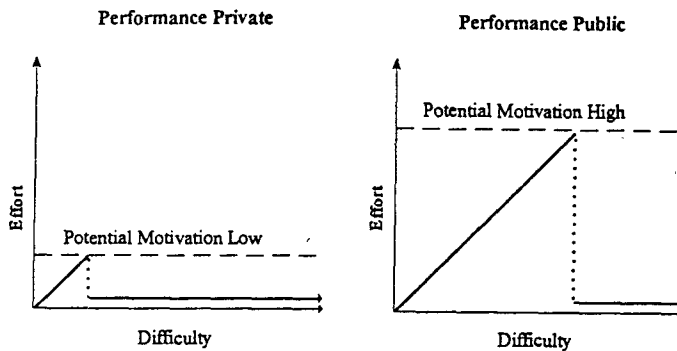


FIGURE 1: Effort as a function of difficulty under private and public conditions.

should become engaged and CV-responsive to the degree the challenge is difficult (i.e. slightly engaged and responsive if the challenge is mild and highly engaged and responsive if the challenge is substantial). On the other hand, if the value is not great enough to justify what is demanded, the person should exert little effort and manifest little CV responsivity irrespective of the degree of challenge. Another notable implication is that the subjective value of success should have no impact on a person's CV response to a challenge that is impossible. If nothing can be done to succeed, effort and responsivity should invariably be low.

Extension to Social Arousal Issue

Wright et al. (13) bring the motivational analysis to bear with respect to the social arousal issue by way of the common observation that people generally consider success on a task to be more important (valuable) when their performance is public (subject to evaluation) than when their performance is private (20–22). If this is the case, the implication is that the effect of a publicity manipulation on peoples' CV response to a challenge should generally depend on the difficulty of the challenge. When such a challenge is easy, task requirements are likely to be seen as worthwhile whether or not individuals believe their performance is, or will be, known to anyone else. Thus, CV adjustments associated with effort are likely to be minimal regardless of the potential for evaluation. On the other hand, when such a challenge is moderately difficult, requirements should sometimes be seen as justified only if the performance is or will be known, which means that CV engagement effects should sometimes be greater under evaluated than non-evaluated conditions. Finally, when such a challenge is very difficult, requirements are likely to be seen as excessive even where the performance is or will be known and may be viewed as impossible to meet. Thus, again, effort and associated CV responses should be low regardless of the potential for evaluation (see Figure 1).

RELATED RESEARCH

Some evidence in favor of the Wright et al. (13) extension comes from a group of experiments that did not involve publicity manipulations, but did cross difficulty manipulations with manipulations of other variables that should, in theory, affect the perceived importance of success and thus potential motivation. As would be expected, these indicate that CV responses are more pronounced for high- than low-potential motivation groups when difficulty is relatively high, but low for both groups when difficulty is low (16,23–26). More direct evidence for the extension comes from a study by Wright et al. that did manipulate the publicity of a

performance (Experiment 1). Participants performed an easy or moderately difficult memory task with instructions that their responses would be either private or known to the experimenter (an undergraduate assistant) and anyone else in the control room. Analysis of systolic blood pressure (SBP) responses revealed the expected interaction pattern (i.e. relatively great responsiveness only where performance was public and the task was moderately difficult) among women. Systolic responses for men were uniformly modest and thus did not conform to predictions. Although the reason for the sex difference is not certain, one possibility is that the men were less concerned with impressing the low-status assistant than were the women. If they were, their potential motivation may have been low enough that they viewed requirements of the more difficult task as unjustified. Consistent with this interpretation are data from a follow-up study (Experiment 2) that showed an audience effect for both sexes where responses were depicted as public to a high-status other.

THE PRESENT STUDY

The present study was carried out to obtain further evidence relevant to Wright et al.'s analysis and to extend their difficulty/publicity research by examining CV evaluation effects across five difficulty levels, ranging from very low to very high. Measures of SBP, diastolic blood pressure (DBP), and heart rate (HR) were taken in participants performing five versions of a recognition memory task—corresponding to the five difficulty levels—either while alone (No Audience condition) or while ostensibly being observed by others, including a relatively high-status graduate student (Audience condition). The chief prediction was that the relation between difficulty and CV responsivity would depend on whether or not participants believed their performance could be evaluated. Where performance was public, responsivity was expected to increase from the low difficulty level to a relatively high difficulty level and then drop. Where performance was private, responsivity was expected either to increase from the low difficulty level to a more modest difficulty level before dropping or be low in all difficulty conditions. Engagement effects have been observed most frequently for SBP and HR; hence, those measures were considered more likely than DBP to show the expected pattern. Because at least one observer in this case had relatively high status, the experimental variables were not expected to interact with sex in determining CV responses.

METHOD

Participants

Participants were 34 (17 male and 17 female) undergraduate volunteers who took part to receive introductory psychology class credit. Data from four individuals were excluded from analysis. Three individuals experienced a computer malfunction before data collection was complete; a fourth individual failed to follow experimental instructions. Final analyses were performed on data from 30 individuals, 16 in the Audience condition (6 men, 10 women) and 14 in the No Audience condition (9 men, 5 women).

Cardiovascular Measurement and Laboratory Set-Up

Cardiovascular measurements were made with an IBS automatic monitor (Model #SD 700A). The compressing cuff was positioned so that the mounted sensor was over the brachial artery of each participant's non-preferred arm. Determinations took about 25 seconds and were displayed in a control room adjacent to the experimental chamber. The experimental task and related instructions were presented via custom software installed on a Macintosh

SE computer, equipped with a desktop bus mouse. The computer was on a table at which participants sat throughout the session. To the front of the computer (behind the chair in which participants sat) was a video camera mounted on a tripod. Communication between the (male) experimenter (E) and the participants took place by way of a two-station intercom (Realistic). A TALK button allowed verbal communication; a CALL button produced a tone that allowed participants to signal when certain parts of the session were reached.

Baseline Measures

The study utilized a multiple baseline procedure. Initial baseline measures were taken shortly after participants signed the informed consent agreement; subsequent baseline measures were taken after each of four different work periods (the first, second, third, and fourth of a series of five). Final baselines were computed as the average of baseline values obtained in the five separate baseline periods.

In the initial baseline period, participants rested for a minimum of six minutes while pressure and HR samples were taken at one-minute intervals. If the sixth SBP sample was within 5 mmHg of the fifth SBP sample, the mean of the fifth and sixth samples was taken as the initial baseline for each CV measure. If the sixth sample was not within the 5 mmHg range, measurements continued until either two SBP samples were within the 5 mmHg range or the tenth minute was reached. In the former case, initial baseline was recorded as the mean of the last two samples for each measure; in the latter case, initial baseline was recorded as the mean of the last five samples for each measure.

Later baseline periods (those between work periods) allowed participants to rest six minutes before CV samples were taken. Sampling continued at one-minute intervals until consecutive SBP samples were within 5 mmHg of one another. (In these periods, all participants stabilized before ten minutes passed.) Baselines in all cases were taken as the average of the final two values for each measure.

Although our main analyses took as baseline the average of basal values obtained in all baseline periods, it is of note that additional analyses were performed using only basal values obtained in the initial baseline period. These additional analyses yielded results that were virtually identical to those of the main analyses.

Procedure

Participants were met individually by the E, who seated them in the experimental chamber, asked them to read and sign a consent agreement, and described the study briefly as being concerned with the way people respond when they perform different tasks under different conditions. Once the agreement was signed, the E attached the IBS cuff and began the initial baseline period. Participants were instructed to relax while baseline measures were taken; they were provided popular magazines to inspect as long as the period lasted.

When the initial baseline period was complete, the E reentered the chamber and directed participants to sit in front of the computer. He first explained that participants would be performing a series of memory tasks that would require them to scan strings of letters and later indicate whether certain letters were in the strings by pressing "yes" and "no" computer keys. Different tasks would be presented in different 40-trial work periods; what would distinguish the tasks is the number of letters presented in the strings. In the Audience condition, the E then (1) showed

participants how to use the computer keyboard, mouse, and intercom; (2) turned the video camera from a position facing away from the computer to a position that focused the lens on the computer screen and keyboard; (3) directed participants to read and follow instructions on the screen; and (4) left the room. In the No Audience condition, the E did everything the same, except that he left the camera facing away from the computer.

The first instruction screen reviewed and expanded on the information that had been presented verbally. Participants were told they would perform memory tasks in a series of 40-trial work periods. On each trial, the computer would present a string of letters (for two seconds), go blank for a period (two seconds), and then present a single letter. In response, participants were to indicate whether the letter was in the string by pressing certain keys on the computer keyboard. Instructions indicated that letters in each string would be between "A" and "Z" and would never repeat.

A second instruction screen provided information about the participants' performance goal and the publicity of their responses. It first indicated that the goal was to be correct on at least 90% of the trials in each work period and that the computer would inform participants at the end of the experiment if they attained the goal. In the Audience condition, it went on to say the investigators needed to know how well participants did, and because of this, the video camera was positioned to allow those in the control room to observe the feedback. Since the feedback would be known to the E, responses would not be recorded in the computer's memory. In the No Audience condition, the screen went on to say that the performance feedback would be known only to participants and not recorded by the computer. Instructions concluded with a brief summary and a directive for participants to press the CALL button on the intercom twice, press a key on the computer mouse, and begin the first set of trials.

Pressing the mouse key caused the first of the five work periods to begin. The procedure within each was the same except for the length of the string presented on memory trials. Depending on the period, the string included two, four, six, eight, or ten letters. The higher the number of letters, the more difficult was the task. String length in a given 40-trial series was determined by the computer software and was random except for the rule that length had to differ in each period. Response time and accuracy were recorded automatically on each trial. When the fortieth trial was completed, the computer presented questions asking participants to indicate, by pressing number keys, how difficult the preceding task was (0 = not at all, 10 = extremely) and how likely they thought it was that they succeeded at attaining the goal of being 90% correct (0 = not at all, 10 = extremely). After the fifth work period, participants also were asked to indicate the extent to which those in the control room were aware of how well they performed (0 = not at all, 10 = extremely) and how worthwhile they felt it was to perform the memory task (0 = not at all, 10 = extremely). Following the last question was a directive for participants to press CALL to signal the E that the period was concluded.

The E began sampling pressure and HR at two-minute intervals, 30 seconds after receiving the CALL signal indicating a work period had begun. This allowed a total of three sample sets in each period (measures were not taken while participants responded to questions). Upon hearing the CALL tone at the end of the first, second, third, and fourth work periods, the E told participants via the intercom to relax until they received further instructions. Six minutes later, the E began taking CV samples at one-minute intervals until the baseline criterion was met and then directed

TABLE 1
Difficulty and Likelihood of Success Ratings

Letters Per String	Two	Four	Six	Eight	Ten
Audience					
Difficulty	0.21 (0.58)	1.14 (1.61)	3.00 (2.22)	6.71 (2.16)	7.93 (2.09)
Likelihood	9.78 (0.58)	9.43 (0.65)	8.21 (1.81)	4.43 (2.85)	3.14 (2.41)
No Audience					
Difficulty	0.31 (0.60)	1.06 (1.12)	3.75 (2.52)	6.88 (2.06)	7.69 (2.15)
Likelihood	9.88 (0.34)	9.69 (0.48)	7.19 (2.46)	4.56 (2.73)	3.62 (2.45)

Note: Standard deviations are in parentheses. Higher values indicate higher difficulty and lower likelihood.

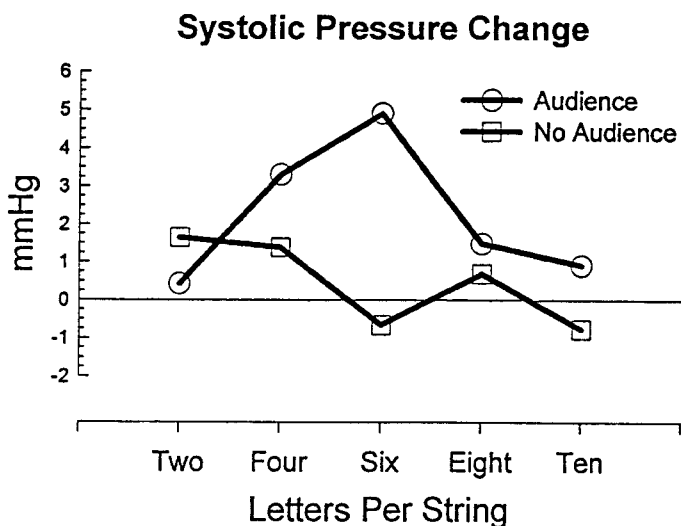


FIGURE 2: Systolic pressure change as a function of difficulty for Audience and No Audience participants.

participants to press the mouse key and begin the next work period. Upon hearing the CALL tone at the end of the fifth work period, the E returned to the chamber and conducted a thorough debriefing.

RESULTS

Analyses were performed initially including participant sex as a factor. These revealed a sex effect for DBP responsivity ($p < .006$), and tendencies toward a sex effect for baseline HR ($p < .08$), and a sex \times difficulty interaction for SBP responsivity ($p < .06$). The effect for DBP was due to higher elevations among men than women; the tendencies for HR and SBP reflected relatively faster basal rates among women than men and relatively higher pressor elevations among men than women in the four- and eight-letter conditions, but not in the other difficulty conditions. Because sex was not found to moderate the effects of interest, major analyses collapsed across levels of that variable.

Subjective Data

Mean responses to the difficulty and likelihood of success questions are in Table 1. The ratings were analyzed with 2 (audience) \times 5 (difficulty) analyses of variance (ANOVAs), in which difficulty was a repeated-measures factor. The ANOVA on

the difficulty data revealed only a difficulty main effect, $F(4,112) = 136$, $p < .001$, reflecting a steady increase in values from the lowest difficulty level (two letters) to the highest difficulty level (ten letters). Simple effects analyses indicated that all pair-wise comparisons were reliable ($ps < .004$). The ANOVA on the likelihood data also yielded only a difficulty effect, $F(4,112) = 97.56$, $p < .001$, reflecting a decrease in values from the lowest difficulty level to the highest difficulty level. Once again, all pair-wise comparisons proved reliable ($ps < .02$).

The awareness and worthwhile ratings were analyzed with one-way ANOVAs in which audience was the factor. Both ANOVAs produced audience effects ($F_s = 14.31$ and 6.80 , respectively; $ps < .02$). As expected, Audience participants indicated that those in the control room were more aware of their performance ($M = 8.06$) than did No Audience participants ($M = 3.78$); in addition, they indicated it was more worthwhile for them to perform successfully ($M = 7.61$) than did the No Audience participants ($M = 5.41$).

Cardiovascular Data

Baseline data were analyzed with one-way ANOVAs as well. There were no group differences in resting pressure; however, there was a tendency for resting HR to be higher for Audience ($M = 78.4$) than for No Audience ($M = 70.8$) participants ($p < .06$).

Cardiovascular responsivity was conceived as change from baseline. Change scores were computed by subtracting baseline values from average values obtained in each of the five work periods and analyzed in the context of 2×5 ANOVAs, in which difficulty was a repeated-measures factor. For all CV parameters, the regression of change scores onto baseline values did not approach significance; therefore, scores were not residualized (covariance-adjusted) prior to analysis.

Mean change scores for SBP are presented in Figure 2. The two-way ANOVA on the SBP data revealed an audience \times difficulty interaction, $F(4,112) = 2.55$, $p < .04$. Consistent with expectations, Audience participants showed an increase in responsivity from the two- to the six-letter condition and low responsivity in the eight- and ten-letter conditions; also consistent with expectations, No Audience participants showed low responsivity in all difficulty conditions. Pair-wise comparisons within the Audience group indicated that responses in the six-letter condition were greater than those in the two-, eight- and ten-letter conditions ($ps < .05$) and that responses in the four-letter condition tended to be greater than those in the two-letter condition ($p < .06$). By contrast, pair-wise comparisons within the No Audience group revealed no difficulty effects. Comparisons between audience groups at each difficulty level, using a pooled error, indicated an audience effect only at the six-letter level ($p < .01$).

Change score means for HR are in Figure 3. The ANOVA on these data also revealed an audience \times difficulty interaction, $F(4,112) = 3.44$, $p < .01$, reflecting a response pattern consistent with expectations. Once again, Audience participants showed a non-monotonic relation between difficulty and responsivity, with the greatest response at the six-letter level, whereas No Audience participants showed low responsivity at all difficulty levels. Comparisons within the Audience group in this case indicated that responses were greater in the four-, six-, and eight-letter conditions

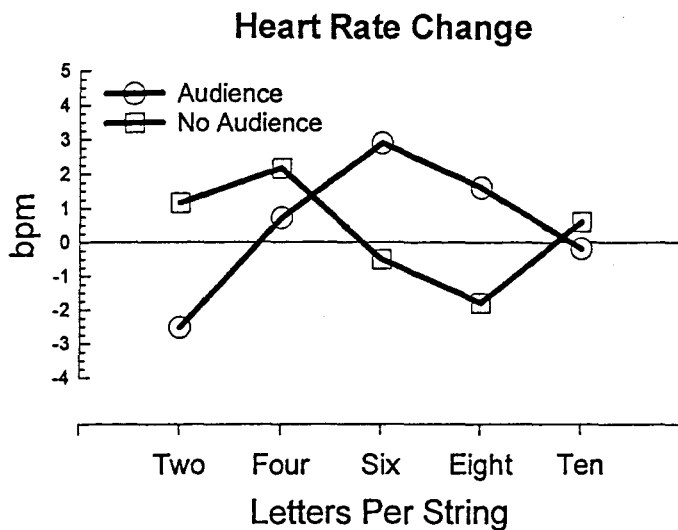


FIGURE 3: Heart rate change as a function of difficulty for Audience and No Audience participants.

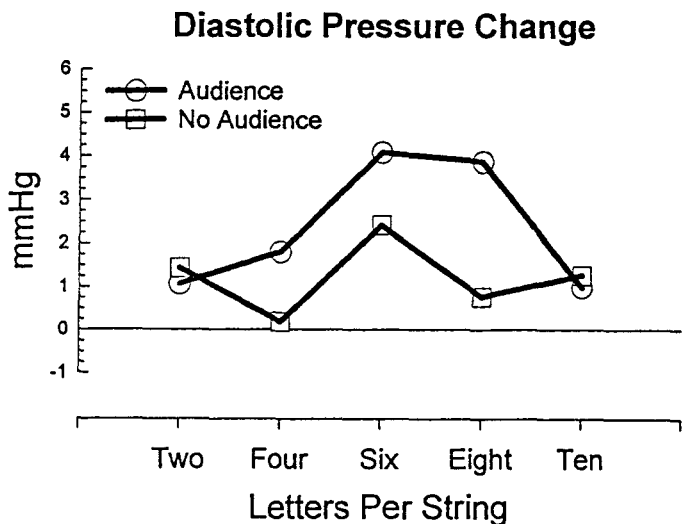


FIGURE 4: Diastolic pressure change as a function of difficulty for Audience and No Audience participants.

than in the two-letter condition ($p < .05$) and tended to be greater in the six-letter condition than in the ten-letter condition ($p < .06$). Comparisons within the No Audience group indicated only a decrease in responsivity from the four-letter condition to the eight-letter condition ($p < .05$). Examination of audience effects at each difficulty level (pooled error) revealed no effects that closely approached significance (i.e. $ps \geq .09$).

The DBP change scores are in Figure 4. Analysis of the DBP data yielded only a marginal difficulty effect, $F(4,112) = 2.31, p < .06$, reflecting a tendency for values to be greater at the six- and eight-letter difficulty levels than at the other difficulty levels. Although the audience \times difficulty interaction was not significant, the figure shows that means were in a pattern not too different from the patterns for SBP and HR change. Pair-wise comparisons indicated that Audience participants manifested greater DBP responsivity in the six-letter condition than in the two- and ten-letter conditions ($ps < .05$), whereas No Audience participants did not ($ts < 1.0$). Audience participants also tended to manifest

TABLE 2
Response Time and Accuracy (Percent Correct) Scores

Letters Per String	Two	Four	Six	Eight	Ten
Audience					
Response Time	61.3 (15.3)	65.3 (14.4)	69.3 (16.6)	78.4 (14.3)	81.1 (18.1)
Accuracy	99.1 (1.3)	98.8 (1.6)	95.2 (5.1)	84.9 (10.0)	74.8 (12.3)
No Audience					
Response Time	58.4 (12.7)	64.4 (13.7)	75.7 (12.2)	78.3 (16.9)	83.6 (18.7)
Accuracy	98.8 (2.1)	99.3 (1.5)	96.3 (3.1)	85.4 (8.3)	81.2 (7.5)

Note: Standard deviations are in parentheses. Higher values indicate slower time and higher accuracy. Response times are scaled in 1/60 second intervals.

greater DBP responsivity in the eight-letter condition than in the two- and ten-letter conditions ($ps < .07$), whereas No Audience participants did not.³

Performance Data

Response time and accuracy (percent correct) scores were computed by averaging across trials in the five work periods. Analysis revealed only difficulty effects ($ps < .001$), reflecting a steady reduction in speed and correctness as difficulty increased (see Table 2).

DISCUSSION

The Findings

Findings for the CV measures generally comported with expectations. Where performance was public, SBP and HR responsivity was non-monotonically associated with difficulty, peaking in the six-letter difficulty condition; by contrast, where performance was private, SBP and HR responsivity was low and largely dissociated with difficulty. Diastolic responses were patterned similarly, although on that measure the audience \times difficulty interaction was not significant. The CV results in the low and moderate difficulty conditions corroborate the systolic effects obtained for women in the previous difficulty/publicity study by Wright et al. (13) and provide further suggestion that the sex difference in that study was due to the observer's status. The CV results in the highest difficulty condition extend effects obtained in the previous study by documenting that responsivity will be minimal regardless of the potential for evaluation where a challenge is extremely difficult to meet.

Documentation of null CV audience effects at the highest difficulty level not only confirms a new prediction from the active coping audience analysis, but also argues against two important alternative explanations of the original Wright et al. data. One explanation would attribute the systolic effects to anxiety (27), assuming that anxiety is greater in those who are evaluated than in those who are not evaluated except where success is assured

³ An alternative strategy for analyzing the CV change data is to test the curvilinear \times audience interaction. This interaction proved reliable for all three CV variables ($ps < .04$). Follow-up analyses showed that in each case, the quadratic trend was significant where the audience was present ($ps < .02$), but not where the audience was absent.

(22,28,29). The other explanation would attribute the effects to response conflict, induced by audience distraction (30), on the assumption that an audience produces significant conflict when a challenge is difficult but minimal conflict when a challenge is easy. Although these can be applied to the original difficulty/publicity findings, they cannot be applied here because they both intimate that physiologic responsiveness should have been greater for Audience than No Audience participants during performance of the ten-letter task.

A point of ambiguity concerns the Audience participants' CV responses to the eight-letter challenge. Whereas SBP elevations were markedly reduced in the eight-letter condition relative to the six-letter condition, HR and DBP elevations were only slightly reduced, at best. Our best interpretation at present is that engagement levels were indeed lower in the eight- as compared to the six-letter condition, and the greater effort on the six-letter task was not manifested on the HR and DBP measures for underlying autonomic and hemodynamic reasons. In the case of HR, a facilitatory sympathetic effect could have been tempered by an inhibitory parasympathetic effect; in the case of DBP, the pressure-enhancing influence of constriction in some vasculature beds could have been offset by the pressure-diminishing influence of dilation in others. But other interpretations certainly are possible. One alternative view might be that engagement was relatively high in both difficulty conditions and the absence of equivalent SBP elevations was simply a statistical aberration. Another alternative view might be that engagement was modestly lower in the eight- as compared to the six-letter condition, and this modest difference was somehow manifested in terms of the number of CV parameters on which sizable elevations were observed. Adding to the complexity of the situation is the strong chance that there was variation within the Audience group with respect to the exact point of effort withdrawal. That is, some Audience participants may have disengaged at the eight-letter level, while others may have done so only when confronted with the ten-letter challenge. If a portion of the Audience participants expended relatively great energy on the eight-letter task and a portion did not, a mixed CV response pattern could have resulted.

Analysis of the subjective data indicated that the manipulations were effective and that the publicity manipulation affected success importance appraisals in the expected manner. Analysis of the performance data revealed difficulty effects, but no interactions, and thus indicated a general dissociation between response latency and accuracy on the one hand and CV responsiveness on the other. The dissociation between the performance and CV response measures could be viewed as contrary to an active coping account of the overall CV response pattern. However, it is not necessarily because of the limited relation that exists between performance and effort (31,32). Effort increases may sometimes be associated with corresponding changes in performance speed or quality (23), but they plainly are not always (33). Until there is greater understanding of when and how effort affects performance, performance outcomes should, at maximum, be construed as imperfect engagement indices.

Theoretical Caveats

Together, the present experiment and the related Wright et al. experiment provide good support for the interactional implication of the active coping audience analysis. However, in evaluating these studies readers should bear in mind several cautionary points.

Effect of an Audience on Potential Motivation: One point is that, although the audience analysis assumes that potential motiva-

tion generally is higher under public conditions than under private conditions, it does not contend that potential motivation always is. There certainly are circumstances in which little or nothing will be gained by impressing an audience. Possible examples would be where observers have low status, have no ability to reward a good performance, or have unqualified regard for the performer. Where benefits made available by an audience are of little to no value, then the audience's presence should have little to no impact on perceived success importance and thus the level of potential motivation.

There also are situations in which an audience may actually reduce potential motivation. One way an audience could do this is by causing performers to cognitively frame performance benefits unrelated to evaluation in such a way that they appear less valuable than they would under private performance conditions. By way of example, consider a research scientist striving to make a grant deadline in the presence of her husband and children. If the scientist has been able to spend precious little time with her family in recent years, the family's presence could cause her to frame the non-evaluative benefit of career advancement in terms of broader life goals and values and, as a result, view success on the proposal as less important than she would have if she were working alone.

Another way an audience could reduce potential motivation is by lowering directly the value of benefits unrelated to evaluation. An example of this might be seen in the case of a conservative Christian minister who has the opportunity to view an X-rated film by walking eight blocks to an adult theater. The minister might judge the film to be well worth the eight-block effort if he can make the walk anonymously (e.g. alone, wearing an overcoat, dark glasses, and a hat). But he is likely to judge the film to be worth no effort at all if he has to make the walk openly, with colleagues, congregation members, and reporters from a local newspaper in tow. Whereas attainment of the attractive outcome (the film) could be a substantial benefit if performance was private, it would be a trivial benefit if performance was public.

An interesting variation on the preceding framing and value effect themes could be where an audience reduces potential motivation not by lowering in some way the value of non-evaluative performance benefits, but rather by lowering the value of performance benefits associated with another observer. In this regard, it may be useful to consider some recent studies concerned with the influence of social support on CV responsivity (e.g. 9,10). The studies indicate that under conditions of high social threat—which commonly is operationalized as high evaluation by a critical authority figure—the presence of a supportive companion lowers CV responses induced by a difficult performance challenge. It has been suggested that this "affiliation" effect may occur because social threats are less motivating, and hence impactful on CV responses related to effort, when they are confronted with a friend than when they are confronted alone.

We agree with the motivational analysis of the affiliation effect. However, we would expand on it in a couple of ways. First, we would note that study participants working under high social threat conditions clearly have the chance to benefit by doing well. Specifically, the participants can gain the authority figure's approval (and any positive outcome that may accompany it) and avoid the authority figure's disapproval (and any aversive outcome that may accompany it). Second, we would note that a friend's presence could alter the magnitude of the benefit associated with the authority figure as an evaluator, either directly or through framing. A direct effect on benefit value would be seen if socially-supported participants tended to discredit the authority's

opinion, say because it was based on a small sample of behavior and the friend's presence reminded them of this. A framing effect would be seen if socially-supported performers tended to think especially broadly and, as a result, saw the opinion of a stranger as unimportant in the larger scheme. The less significance performers assign to an outside observer's opinion and the less credible they consider that opinion to be, the less likely they should be to expend the effort required to meet a difficult challenge and to show the corresponding CV response.

Irrespective of whether an audience causes a decrement in non-evaluative performance benefits or a decrement in performance benefits associated with another observer, there should be a net reduction in potential motivation only where the induced decrement exceeds any performance benefit increment that might be associated with the audience. Thus, for example, even where a supportive companion reduces concern about an outsider's opinion, the companion could still increase potential motivation by giving performers something else to be concerned about—the companion's opinion (7). To predict the CV impact of a given audience in a given situation, one must take into account not only the impact the audience is likely to have on motives already in the performance environment, but also the number and strength of motives the audience is likely to introduce to that environment.

Individual Differences: A second cautionary point readers should bear in mind in evaluating these studies is that although the active coping audience analysis assumes that people generally respond to evaluation with an increase in potential motivation, it does not contend that they all do so to the same degree or that they become equally engaged as a result of the increase. Two individual difference factors that might well mediate potential motivation responses are need for approval and fear of failure (20,23). People low on these dimensions could show smaller increases in response to evaluation than people high on these dimensions, at least under some conditions. If so, the implication is that dimension status should combine with difficulty to determine effort and CV responsivity in public situations.

An individual difference factor that is likely to predict engagement apart from potential motivation is perceived ability with regard to the observed task (15,34–36). Low-ability people should appraise the task as more difficult than high-ability people do (37). As a result, they should show greater effort and CV responsivity than high-ability people so long as both groups view success as possible and worthwhile. Low-ability people also should withdraw their effort more readily than high-ability people, because they should conclude at a lower objective difficulty level that success is impossible or too costly, given its benefit. Thus, where a task is objectively demanding, ability perceptions should sometimes be inversely related to effort and CV responsivity.

Consideration of possible individual differences naturally complicates CV predictions. But it is necessary, since volitional outcomes such as effort are determined both by objective features of a situation and the meaning of those features to the people involved (38).

Nature of the Challenge: A final cautionary point is that, although we have not discussed it in this article, the motivation model that underlies the active coping audience analysis—and thus the audience analysis itself—makes a crucial distinction between behavioral challenges that are fixed and behavioral challenges that are not fixed. Fixed challenges are like those in this and the other difficulty/publicity study. They provide people the opportunity to benefit to a certain degree (e.g. gain a certain amount of money or

social approval) by attaining a specific performance standard. Unfixed challenges, by contrast, provide people the opportunity to benefit to different degrees by attaining different performance standards. The difference is illustrated by the situations of two men, one offered fifty dollars for moving a certain number of bricks in an hour (fixed challenge) and the other offered a dollar for every brick moved in an hour (unfixed challenge). Broadly speaking, people confronted with unfixed challenges should respond by selecting a performance standard and then becoming engaged to the degree the selected standard is difficult to meet. However, the exact prediction of engagement (and CV responsivity) is no simple matter, because standard selection should depend on the benefit that may be accrued by attaining different standards, and that will vary from situation to situation. It is beyond our purpose to delve into details of this issue here. But we would be remiss not to note that the present interactional findings should be generalized only within the fixed challenge realm.

OTHER IMPLICATIONS OF THE EFFORT/CV-RESPONSE MODEL

We might conclude by noting that the present findings strengthen not only the case for the active coping audience analysis, but also the case for the broader model that underlies it, and by emphasizing that implications of the underlying conception are by no means confined to the realm of social evaluation. Regarding the latter, the effort/CV-response model can, in fact, serve as a framework for understanding any number of issues related to behavior and health. Three examples are the conditions under which anger will lead to enhanced CV responsivity (e.g. 39), the role optimism may play in determining CV responsiveness (e.g. 40), and sex and race (Black/White) differences in CV response to behavioral challenge (41,42). An anger analysis might begin with the observation that anger derives from the perception of injustice and instigates action oriented toward restoring a just state (43). Theoretically, the greater the perceived injustice, the greater should be the anger and potential motivation to carry out restorative behavior. However, the amount of effort and CV responsiveness engendered should depend on the difficulty of restorative behavior. Where restoration is viewed as possible and warranted, effort and CV responsivity should be proportional to difficulty; where restoration is viewed as impossible or unwarranted, effort and CV responsivity should be low.

The role of optimism can be analyzed in two ways. One way is in terms of optimism's impact on potential motivation. That is, where the linkage between success and benefit is not certain, increased optimism may lead to enhanced outcome expectancies (expectancies that success will yield desired outcomes [e.g. see 32]). Increased outcomes expectancies, in turn, should lead to increased appraisals of success importance and thus a greater willingness to expend energy. If the requirements of success are relatively substantial, the greater willingness should sometimes produce more pronounced effort and CV responses than would be present under less optimistic conditions. On the other hand, if success requirements are either low or extreme, the greater willingness generally should have no impact on effort and CV responsivity. The other way optimism effects can be analyzed is in terms of optimism's impact on individuals' perceived capacity to perform. Where performance capacity is unclear, optimism could induce enhanced ability appraisals in the same way it could sometimes induce enhanced outcome expectancies. To the extent that it does, optimism should yield response outcomes that accord

with the ability predictions described in the individual differences portion of the subsection above.

Sex and race differences can be analyzed in potential motivation and perceived ability terms as well. Specifically, as a result of their different social experiences, the sexes and races could have highly specialized perceptions of (1) the linkage between successful task performance and benefit (i.e. outcome expectancies) in different performance contexts, (2) the value of success (i.e. incentive value appraisals) in different performance contexts, and (3) perceptions of what they are able to do (i.e. ability appraisals) in different performance contexts (e.g. see 44). Group differences in outcome expectancy and incentive value appraisals should be associated with corresponding group differences in success importance appraisals and, thus, the willingness to expend energy. Group differences in perceived ability should not be related to what performers are willing to do, but they should be related to (1) the magnitude of effort and CV responsiveness that occurs when the groups are task-engaged, and (2) the objective difficulty level at which the groups withdraw their effort and display minimal CV responsivity. This reasoning, of course, does not rule out the possibility that sex and race differences are, in part, constitutionally based. However, it does intimate that the differences may have a substantial—and highly complex—psychological component.

SUMMARY AND CONCLUSIONS

Male and female undergraduates performed computer memory tasks varying in difficulty from very low to very high, with instructions that people in another room would or would not know how well they did. As expected, SBP and HR responses increased with task difficulty up to a point among those whose performance would be known, but were relatively low regardless of difficulty among those whose performance would not be known. Diastolic pressure responses were similar to SBP and HR responses; however, in that case the audience \times difficulty interaction was not reliable. The CV findings corroborate and extend results from a previous experiment, argue against some interpretations of the previous results, and, in general, strengthen the case for a recent active coping analysis of CV evaluation effects. The findings also strengthen the case for a broader model of effort and CV response that has potential for advancing our understanding of a range of phenomena and processes related to behavior and health.

REFERENCES

- (1) Triplett N: The dynamogenic factors in pacemaking and competition. *American Journal of Psychology*. 1898, 9:507-533.
- (2) Burt HE: The inspiration-expiration ratio during truth and falsehood. *Journal of Experimental Psychology*. 1921, 4:1-21.
- (3) Zajonc RB: Social facilitation. *Science*. 1965, 149:269-274.
- (4) Bond CF, Titus LJ: Social facilitation: A meta-analysis of 241 studies. *Psychological Bulletin*. 1983, 94:264-292.
- (5) Geen RG, Bushman BJ: The arousing effects of social presence. In Wagner H, Manstead A (eds), *Handbook of Social Psychophysiology*. London: Wiley, 1989, 261-281.
- (6) Moore DL, Baron RS: Social facilitation: A psychophysiological analysis. In Cacioppo J, Petty R (eds), *Social Psychophysiology: A Sourcebook*. New York: Guilford Press, 1983, 434-466.
- (7) Allen KM, Blascovich J, Tomaka J, Kelsey RM: Presence of human friends and pet dogs as moderators of autonomic responses to stress in women. *Journal of Personality and Social Psychology*. 1991, 61:582-589.
- (8) Cacioppo JT, Rourke PA, Marshall-Goodell BS, Tassinary LG, Baron RS: Rudimentary physiological effects of mere observation. *Psychophysiology*. 1990, 27:177-186.
- (9) Gerin W, Milner D, Chawla S, Pickering TG: Social support as a moderator of cardiovascular reactivity in women: A test of the direct effects and buffering hypotheses. *Psychosomatic Medicine*. 1995, 57:16-22.
- (10) Kamarck TW, Annunziato B, Amateau LM: Affiliation moderates the effects of social threat on stress-related cardiovascular responses: Boundary conditions for a laboratory model of social support. *Psychosomatic Medicine*. 1995, 58:183-194.
- (11) Brown PC, Smith TW: Social influence, marriage, and the heart: Cardiovascular consequences of interpersonal control in husbands and wives. *Health Psychology*. 1992, 11:88-96.
- (12) Smith TW, Nealey JB, Kircher JC, Limon J: Social determinants of cardiovascular reactivity: Effects of incentive to exert influence and evaluative threat. *Psychophysiology*. 1997, 34:65-73.
- (13) Wright RA, Tunstall AM, Williams BJ, Goodwin JS, Harmon-Jones E: Social evaluation and cardiovascular response: An active coping approach. *Journal of Personality and Social Psychology*. 1995, 69:530-543.
- (14) Wright RA: Brehm's theory of motivation as a model of effort and cardiovascular response. In Gollwitzer PM, Bargh JA (eds), *The Psychology of Action: Linking Cognition and Motivation and Behavior*. New York: Guilford, 1996, 424-453.
- (15) Wright RA, Dill JC: Blood pressure responses and incentive appraisals as a function of perceived ability and objective task demand. *Psychophysiology*. 1993, 30:152-160.
- (16) Wright RA, Williams BJ, Dill JC: Interactive effects of difficulty and instrumentality of avoidant behavior on cardiovascular reactivity. *Psychophysiology*. 1992, 29:677-689.
- (17) Obrist PA: The cardiovascular-behavioral interaction as it appears today. *Psychophysiology*. 1976, 13:95-107.
- (18) Obrist PA: *Cardiovascular Psychophysiology: A Perspective*. New York: Plenum Press, 1981.
- (19) Brehm JW, Self E: The intensity of motivation. In Rozenweig MR, Porter LW (eds), *Annual Review of Psychology*. Palo Alto, CA: Annual Reviews, 1989, 40:109-131.
- (20) Baumeister RF: A self-presentational view of social phenomena. *Psychological Bulletin*. 1982, 91:656-662.
- (21) Geen RG: Social motivation. In Rozenweig MR, Porter LW (eds), *Annual Review of Psychology*. Palo Alto, CA: Annual Reviews, 1991, 42:377-399.
- (22) Seta JJ, Seta CE: The impact of personal equity processes on performance in a group setting. In Paulus PB (ed), *Basic Group Processes*. New York: Springer-Verlag, 1983, 121-147.
- (23) Murray JB, Wright RA, Williams BJ: Difficulty as a determinant of cardiovascular response: Moderating effect of instrumentality in an alleviation paradigm. *International Journal of Psychophysiology*. 1993, 15:135-145.
- (24) Storey PL, Wright RA, Williams BJ: Need as a moderator of the difficulty-cardiovascular response relation: The case of fluid deprivation. *Journal of Psychophysiology*. 1996, 10:228-238.
- (25) Wright RA, Shaw LL, Jones CR: Task demand and cardiovascular response magnitude: Further evidence of the mediating role of success importance. *Journal of Personality and Social Psychology*. 1990, 59:1250-1260.
- (26) Manuck SB, Harvey SH, Lechleiter SL, Neal KS: Effects of coping on blood pressure responses to threat of aversive stimulation. *Psychophysiology*. 1978, 15:544-549.
- (27) Cottrell NB, Wack DL, Sekerak GJ, Rittle RH: Social facilitation of dominant responses by the presence of an audience and the mere presence of others. *Journal of Personality and Social Psychology*. 1968, 9:245-250.
- (28) Bond CF: Social facilitation: A self-presentational view. *Journal of Personality and Social Psychology*. 1982, 42:1042-1050.
- (29) Paulus PB: Group influence on individual task performance. In Paulus PB (ed), *Basic Group Processes*. New York: Springer-Verlag, 1983, 97-120.

- (30) Sanders GS, Baron RS, Moore DL: Distraction and social comparison as mediators of social facilitation effects. *Journal of Experimental and Social Psychology*. 1978, 14:291-303.
- (31) Geen RG: Human motivation: A social psychological approach. Pacific Grove, CA: Brooks-Cole, 1995.
- (32) Heckhausen H: *Motivation and Action*. Berlin, Germany: Springer-Verlag, 1991.
- (33) Heckhausen H, Strang H: Efficiency under record performance demands: Exertion control—An individual difference variable? *Journal of Personality and Social Psychology*. 1988, 55:489-498.
- (34) Geen RG: The effects of being observed on learning following success and failure experiences. *Motivation and Emotion*. 1979, 3:355-371.
- (35) Wright RA, Dismukes A: Cardiovascular effects of experimentally induced efficacy (ability) appraisals at low and high levels of avoidant task demand. *Psychophysiology*. 1995, 32:172-176.
- (36) Wright RA: Ability perception and cardiovascular response to behavioral challenge. In Kofta M, Weary G, Sedek G (eds), *Personal Control in Action: Cognitive and Motivational Mechanisms*. New York: Plenum Press, 1998, 197-232.
- (37) Kukla A: Foundations of an attributional theory of performance. *Psychological Review*. 1972, 79:454-470.
- (38) Locke EA, Kristof AL: Volitional choices in the goal achievement process. In Gollwitzer PM, Bargh JA (eds), *The Psychology of Action: Linking Cognition and Motivation to Behavior*. New York: Guilford Press, 1996, 365-384.
- (39) Smith TW, Christensen AJ: Life-style and hostility. In Friedman HS (ed), *Hostility, Coping, and Health*. Washington, DC: American Psychological Association, 1992, 33-48.
- (40) Scheier MF, Carver CS: Optimism, coping, and health: Assessment and implications of generalized outcome expectancies. *Health Psychology*. 1985, 4:219-247.
- (41) Stoney CM, Davis MC, Matthews KA: Sex differences in physiological responses to stress and in coronary disease: A causal link? *Psychophysiology*. 1987, 24:127-131.
- (42) Anderson NB, McNeilly M, Myers H: A biosocial model of race differences in vascular reactivity. In Blascovich J, Katkin ES (eds), *Cardiovascular Reactivity to Psychological Stress and Disease*. Washington, DC: American Psychological Association, 1993, 83-108.
- (43) Brehm JW, Brummett BH: The emotional control of behavior. In Kofta M, Weary G, Sedek G (eds), *Personal Control in Action: Cognitive and Motivational Mechanisms*. New York: Plenum Press, 1998, 133-154.
- (44) Wright RA, Murray JB, Storey PL, Williams BJ: Ability analysis of gender relevance and sex differences in cardiovascular response to behavioral challenge. *Journal of Personality and Social Psychology*. 1997, 73:405-417.