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Reactivity and Environmental Stimulation: Predictors of Individual Differences in Children's Motor Activity Levels

by
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ABSTRACT

Motor activity level (AL), a salient characteristic of childhood, may, in part, be the manifestation of a goal-directed process. One of the goals of AL may be the regulation of internal state. As such, a negative relation can be predicted between AL and reactivity, a temperament feature that presumably determines the characteristics of internal state (Strelau, 1983). High reactives, who are easily aroused, highly sensitive to, and have a low endurance for stimulation may minimize their activity in attempts to reduce chronic internal overarousal. Conversely, low reactives, who are less easily aroused, are relatively insensitive to, and have a high endurance for stimulation, may maximize their activity in attempts to enhance internal underarousal. The purpose of this research was to consider this link between activity and reactivity. Study 1 confirmed a predicted negative relationship using parent-rating measures of reactivity and AL; the most reactive children were rated as the least active and the least reactive, as the most active. In Study 2, this negative relationship was replicated using independent camp-supervisor AL rankings and an objective AL instrument measure. Additionally, Study 2 considered the dynamics underlying this relationship by first exploring the notion of activity as a regulator of internal state. On the assumption that transitory environmental factors influence the immediate, internal state, motor activity was assessed across play-settings that varied in the level of environmental stimulation (ES). As expected, the manipulation affected the high- and low-reactive child differently, thereby confirming a predicted interaction between reactivity level and ES level, at least for those children who were presented with low-before-high stimulation. Study 2 also addressed the notion of individual differences in the ability to suppress activity. The notion of behavioral regulation via reduction of motor activity assumes that individuals are capable of suppressing their activity levels. However, confirmation of a predicted negative relationship between a fine motor response and molar levels of activity may imply that high AL represents an inability to suppress activity. Both theoretical and practical implications of these findings are discussed, and future areas of research are identified.

Reactivity and Environmental Stimulation: Predictors of Individual Differences in Children's Motor Activity Levels

Motor activity level, a central variable in this study, is one of the most salient characteristics of childhood behavior. Activity level (AL) can be broadly defined as an individual's customary level of energy expenditure through movement (Eaton, 1983). More energy is expended by expansive movements of greater frequency, longer duration, and larger amplitude. While a definition of AL is attainable, its meaning remains elusive.

Understanding activity is of obvious value for several reasons, including its relevance to caregivers and educators and its presumed links to health and development. For example, the inclusion of extremes of motor activity/inactivity in definitions of learned helplessness, depression, and hyperactivity, suggests that activity level may be implicated in such behavior patterns. To the extent that individual differences in activity level predispose elderly individuals toward a more active or passive lifestyle, such differences may also have implications for the age-related rate of muscular and bone-density decay (Ostrow, 1983). Finally, understanding activity level may provide some insights into other phenomena, such as, the perception of control. If, as Skinner (1985) believes, a perception of control develops directly out of action, then the least active children may be at greater risk for developing a helpless rather than a mastery profile.

In an attempt to understand the etiology of AL, researchers have considered both environmental and genetic factors. The expression of activity has been shown to relate to situational factors, such as exposure to day care experience (Schwarz, Strickland & Krolick, 1974). On the other hand, greater similarity in levels of activity between monozygotic compared to dyzygotic twins (Saudino & Eaton, 1989) suggests that activity level has a genetic component. The prevailing opinion is that an individual's level of activity is related both to environment and to underlying biological factors. However, few theoretical models incorporate both factors, and most fail to provide a context within which the meaning of activity can be empirically evaluated.

The present research addresses these shortcomings by exploring the meaning of activity level within a theoretical framework that delegates a learning role to activity, while maintaining that activity is tied intimately to physiology. In Strelau's (1983) theory, action is viewed as goal-directed and as the manifestation of a learned relation between behavior and an outcome. Through experience, the organism learns that certain activities enhance internal stimulation/activation level, and, over time, these connections further develop. Action, then, is seen as a regulator of internal state. While Strelau's notion of action encompasses more than pure motion, the present work focuses on motor activity.

Activity can presumably enhance internal stimulation in various ways. First, according to Strelau (1983), many types of activity have inherent emotional connotations, and this emotion itself provides stimulation. For example, climbing a tree, which is likely to be perceived as risky, is accompanied by an emotional state that enhances internal stimulation. Second, activity can directly enhance overall physiological stimulation via the activation of muscle fibers, receptors, and higher nervous system centres. In short, if internal activation is low, increasing motor activity can enhance it; if internal activation is high, the depression of activity can reduce it. Further implied in this perspective is the notion that the high-active child is seeking a high level of arousal and the low-active child is avoiding high arousal. What explains such individual differences? Why, compared to the less active child, would the highly active child be seeking more stimulation?

A consideration of Strelau's (1983) concept of reactivity may provide some insight into these questions. Reactivity is a temperament feature that presumably determines the characteristics of internal state, including the need for stimulation.
If one of the goals of AL is the regulation of internal state, then high reactives, who are presumably overaroused may minimize their activity in an attempt to reduce their chronic internal overarousal. Conversely, low reactives, who are underaroused may maximize their activity in an attempt to enhance internal underarousal.

The purpose of this research was to assess a link between activity and reactivity. If motor activity is a regulator of internal state, and, if reactivity determines internal state, then a negative relationship between the two can be predicted. This relationship was explored in 5- to 12-year old children using multiple measures of activity and reactivity. The most reactive children were expected to be the least active, and the least reactive, the most active.

Reactivity

Because the link between reactivity and activity is the focus of this study, a more detailed introduction to the concept of reactivity is critical. Strelau's definition of reactivity grew out of the Neo-Pavlovian concept of nervous system strength, which is characterized by low sensitivity to weak stimulation and high endurance for intense stimulation. Sensitivity to and endurance for stimulation are properties that are uniformly linked for the Neo-Pavlovians: Those with high sensitivity have low endurance; those with low sensitivity have high endurance. This notion of reactivity differs from the strict definition of physiological reactivity, or the nervous system's ability to react to excitation of the receptors. Reactivity also differs from the nervous system concept in that, it is encompasses not only the properties of sensitivity and endurance to stimulation, but also, differences in arousability (Gray, 1972). High-reactive individuals are easily aroused, highly sensitive to, and have a low endurance for stimulation. Low reactives are less easily aroused, are relatively insensitive to, and have a high endurance for stimulation.

Measurement of Reactivity

While the reactivity concept has greater breadth than does the nervous system (NS) typology, laboratory methods of measuring nervous system strength are thought to capture individual differences in reactivity level. As such, NS data is sometimes interpreted within the context of reactivity. Laboratory methods of identifying nervous system characteristics (Nebylitsyn, 1972) typically involve assessing reaction time (RT) latencies to stimuli of varying intensity levels. The rationale for this methodology is based upon observations of individual differences in the law of strength. The law of strength suggests that the intensity of reaction grows, to a given point, as the intensity of the stimulus increases (Strelau, 1983, p. 86). Presumably the law operates in its purest form for strong nervous system types, i.e., for low reactives. This pattern is reflected by the steep negative curve shown in Figure 1; responses to low-intensity stimuli are relatively slower than are responses to high-intensity stimuli. Highly reactive individuals, on the other hand, conform less closely to the law of strength and are less diverse in their reactions to stimuli of varying intensity. The high-reactive pattern is therefore reflected in the slightly negative, but flatter curve shown in Figure 1.

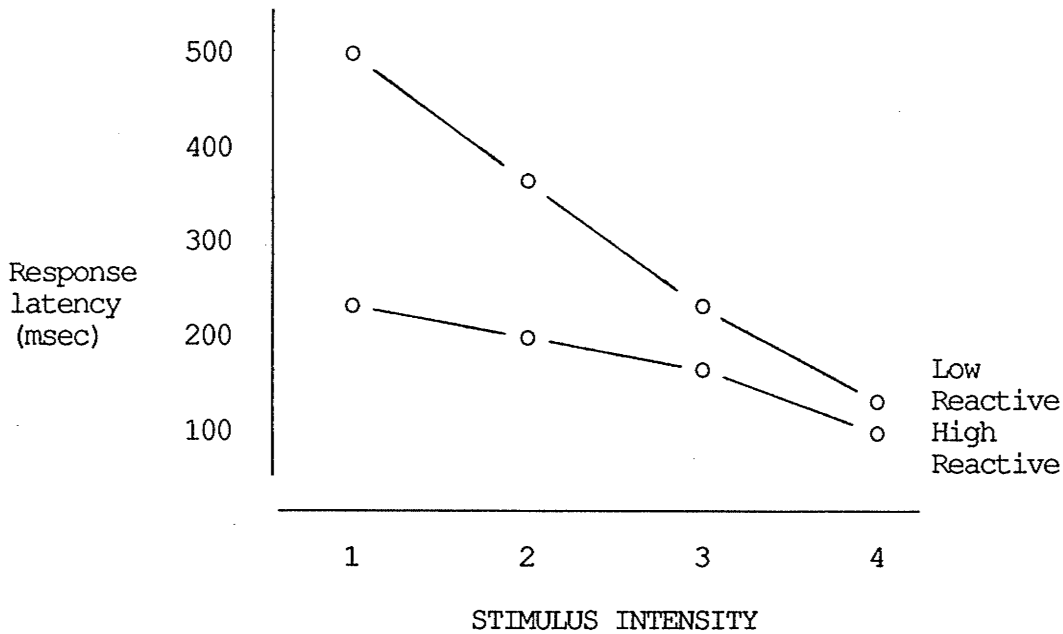

Figure 1. Hypothetical reaction-time curves for low- and high-reactive individuals.

Research based upon this "slope of the curve" measure has resulted in discrepancies in the diagnosis of reactivity and to what has become known as the partiality phenomenon. The partiality phenomenon suggests that "properties like strength of the nervous system or, in broader terms, arousability may differ somewhat by specific modality and task" (Kohn, 1987, p. 246). Strelau has reported that discrepancies are related to intraindividual differences in the type of reaction (motor versus verbal), the kind of stimuli (e.g., verbal versus non-verbal) and the modality used in RT tests (Strelau, 1983).

Strelau (1983) proposed abandoning laboratory measures of nervous system strength in favour of behavioral-observational methods. In doing so, he suggested that he "psychologicalized" Pavlov's nervous system typology by reinterpreting temperament within the context of human behavior. Reactivity at the behavioral level is thought to be reflected in an individual's characteristic intensity or magnitude of response to stimuli or situations (Strelau, 1983). High reactives respond with great intensity; low-reactives respond more mildly. Behavioral reactivity is viewed as strictly respondent behavior; reactions occur in response to some cue. For example, one person may react to a loud bang with startled movements, while another will simply glance at the source of the noise. Such behavioral differences presumably reflect underlying unobservable differences in sensitivity, endurance and arousability, or more generally, in internal state.

Reactivity at this molar behavioral level has been measured using both the Strength of Excitation Scale, a component of the Strelau Temperament Inventory (STI) and the Kohn Reactivity Scale (Kohn, 1985). Recently, a teacher-rating measure of child reactivity has also been developed (Friedensberg & Strelau, 1982) to assess children's typical behavioral reactions to everyday experiences. The items on this latter scale are intended to capture interindividual differences in endurance and sensitivity, particularly with regard to stressful situations. For example, one item asks parents whether or not, when "encountering an obstacle, child becomes discouraged and abandons performance of current activity." Items from this child measure formed the basis for the reactivity measure used in the current study.

Relationships have been found between the behavioral and laboratory measures of reactivity. Specifically, significant correlations have been reported for scores on the STI strength of excitation scale and reaction-time latencies under repeatedly applied stimuli (e.g., Strelau, 1983, p. 134). However, nonsignificant relationships have also been reported. Kohn's Reactivity Measure did not correlate with reaction latencies to stimuli (both visual and auditory) varying in intensity (Kohn, Cowles, & Lafreniere, 1987). Further comparisons of behavioral and laboratory measures of reactivity are needed to clarify the relation between these measurement approaches.

The present research used both a behavioral and a laboratory measure of reactivity and evaluated the correspondence between them. The behavioral reactivity measure was derived from a parent-rated questionnaire that assessed children's reactions to everyday events. Additionally, the questionnaire included items to evaluate parents' perceptions of their children's sensitivity to stimulation. Past research has not addressed the possible links between reactivity at the molar behavioral level and sensory sensitivity. Based upon the theoretical connection between behavioral reactivity and sensory sensitivity, it was anticipated that these items should form one conceptual unit. This issue was explored by examining associations between behavioral reactivity and sensory sensitivity.

<u>Processes Underlying Reactivity</u>

While it is not the purpose of this work to explore the processes that underlie reactivity, a brief account of these processes follows. As shown in Figure 2, the processes underlying reactivity begin with a complex set of anatomical and physiological systems. These systems presumably include all of those responsible for the accumulation and release of stored energy (Strelau, 1983). The combined influence of these systems results in a complexity and uniqueness of individual profiles. This uniqueness has been referred to as "neuroendocrine individuality". Strelau includes, as possible contributors to neuroendocrine individuality: the reticulocortical arousal loop hypothesized by Eysenck (1967); Gray's (1981) hypothesized components of the "behavioral activation system," (i.e., the lateral septal area, the medial forebrain bundle, and the lateral hypothalamus); and Zuckerman's (1987) limbic system neurotransmitters.

Figure 2 shows how some combination of such systems in turn influences a mechanism that transforms stimulus intensity from the physical into the physiological form. Differences in the transformation process presumably cause some individuals to perceive the intensity of a given stimulus as weak (low reactives) and others, to perceive the same stimuli as intense (high

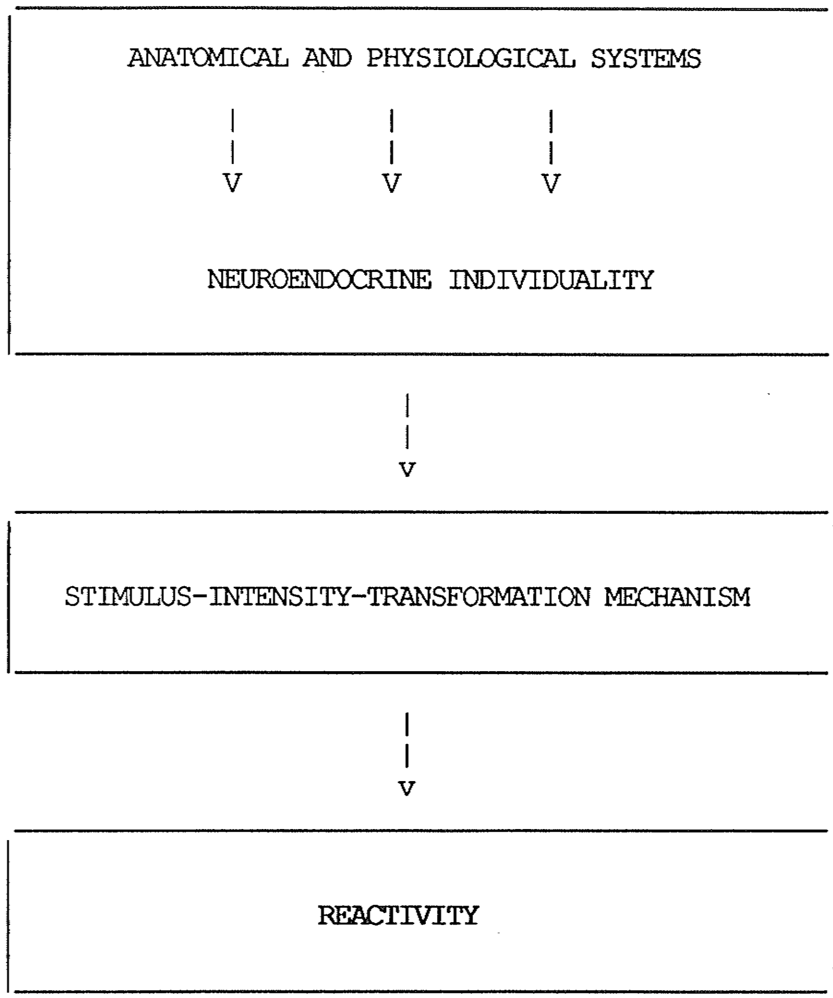

Figure 2. Hypothetical model showing the underlying processes of reactivity.

reactives). The former will be less sensitive to and have a higher endurance and need for stimulation than will the latter. Thus, Matysiak's hypothetical stimulus-intensity-transformation mechanism (Matysiak 1980, cited in Strelau, 1983) explains individual differences in internal state.

The stimulus-intensity-transformation mechanism, which is similar to Petrie's (1967) hypothesized central stimulus intensity control mechanism, either **augments** (magnifies) or **reduces** (dampens) the intensity of the stimulus. Interindividual differences in stimulus-property judgments have been found using the Kinesthetic Figural Aftereffect (KFA) task. This task involves subjective estimations of block size following the physical manipulation of blocks while blindfolded. Petrie (1967) reported over- and under-estimations of up to 50% of the actual block size, an overestimation presumably implying augmenting, and an underestimation, implying reducing.

There is some empirical support for the notion that individual differences in reactivity are related to differences in the way people perceive incoming stimulation. Reactivity, as measured by response latencies to stimuli of varying intensities, has been found to relate significantly to scores on Petrie's KFA task ($\underline{r}$=.52). Reducers were found to be relatively insensitive and augmenters, relatively sensitive to incoming auditory stimulation (Sales & Throop, 1972). A similar finding was reported by Kohn, Cowles and Lafreniere's (1987) study of 53 undergraduate students.

They measured reactivity using the Kohn Reactivity Scale and stimulus modulation using the Vando Reducer-Augmenter Scale (Vando, 1970), which has been shown to be a valid and reliable measure of stimulus modulation (Barnes, 1985). Reactivity covaried with stimulus modulation (r=.66) such that high reactives were augmenters and low reactives, reducers.

The stimulus-intensity-transformation process presumably leads to interindividual differences in the features of sensitivity, endurance and arousability. These features of reactivity (see Figure 3) presumably translate into differences in the internal state. Low reactives, who are relatively insensitive, have a high endurance, and are not easily arousable, will require high levels of stimulation to offset a below-optimal level of arousal. In contrast, high reactives, because of their characteristics, will have an above-optimal level of internal arousal and will require a lower amount of stimulation.

<u>Behavioral Implications of Reactivity</u>

The behavioral analysis of molar reactions to events and situations has broad implications within the context of temperament. Strelau's notion of temperament focuses on the "formal aspects of behavior" (Strelau, 1983, p. 172), or the form in which a behavior is manifest. This description of temperament shares some similarity with Thomas and Chess' notion of temperament as "behavioral style" (Thomas & Chess, 1977, p. 9). However, while Thomas and Chess distinguish between various temperamental traits,

FEATURES OF REACTIVITY

LOW REACTIVES		HIGH REACTIVES
LOW	SENSITIVITY	HIGH
HIGH	ENDURANCE	LOW
LOW	AROUSABILITY	HIGH

| V | V

INTERNAL STATE

BELOW OPTIMAL	AROUSAL LEVEL	ABOVE OPTIMAL
HIGH NEED	STIMULATION REQUIREMENTS	LOW NEED

| ^
v |

BEHAVIOR

Figure 3. The relations between the characteristics and internal state of reactivity and behavior.

Strelau focuses on intensity of response, or reactivity, as the main temperamental feature that guides the development of other personality factors.

Internal state and behavior. To understand the behavioral implications of individual differences in reactivity, it is necessary to consider the link between internal state and behavior. Strelau and others (e.g., Hebb, 1955; Leuba, 1965) regard optimal-arousal or optimal-stimulation as a critical aspect of internal state. These theorists assume that an optimal level of arousal or activation exists: "...individuals in the same situation and under approximately equal psychophysiological conditions do differ in the amount of stimulation needed to maintain an optimal level of activation" (Strelau, 1983, p. 187). Moreover, it is generally accepted that such differences are manifest behaviorally. "People vary in their probability of becoming either underaroused or overaroused and, therefore, differ also in how they typically pursue optimum arousal" (Kohn, 1987, p. 234). Sensation seeking may reflect attempts to accommodate to a high need for stimulation, which implies that the internal state directs behavior.

According to Strelau, behaviors can also function to regulate internal state, which suggests that the internal state is directed by behavior. It is quite possible that behavior is both a reflection of, and a regulator of, internal state, implying that a bidirectional relation exists between the internal state and behavior (Figure 3). Specifically, the suppression of behavior by an individual with a low need for stimulation reflects the low stimulation requirements, but the behavioral suppression, in turn, regulates the internal state by minimizing the level of arousal. The regulative role of action on internal state is a key concept in the present work. The centrality of this notion is exemplified by the "regulative" in the title of Strelau's theory, the Regulative Theory of Temperament. Other researchers are also emphasizing the role of behavior in self-regulation of states and emotions (e.g., Derryberry & Rothbart, 1988; Thayer, 1989).

Because concepts such as optimal arousal and needs for stimulation can not be directly monitored, the notion of self-regulation is difficult to assess. However, Strelau's theory has generated research and support for negative associations between reactivity and various types of behavior thought to regulate internal state. In a recent review, negative correlations were reported for sensation-seeking behavior and reactivity, as measured both by inventory and sensory threshold data (Strelau, 1985). Likewise, sensation-seeking behavior has been found to relate negatively to strength of the nervous system measures (Sales, Guydosh, & Iacono, 1974; Sales & Throop, 1972). For example, Sales et al. identified individuals with weak and strong nervous systems and found that strong nervous system types (low reactives) sought more stimulation by pressing a button to acquire complex visual stimulation. Another study by Kozlowski (1977) measured reactivity using Strelau's Temperament Inventory (STI) and risk preferences using behavioral observations during games, (e.g., cards and roulette). A greater proportion of high-risk persons was found among low than among high reactives. The low-reactive individual's preference for risky activities may reflect both an attempt to enhance internal arousal and to accommodate to a high need for internal stimulation.

Reactivity and motor activity level. Based upon Strelau's theory, pure physical movement may also be used to regulate internal state. If so, the underaroused, low-reactive individual, who is presumably seeking stimulation, should engage in motor behavior to enhance arousal. Using the same logic, the overaroused, high-reactive individual should generally avoid high levels of motor behavior in an attempt to minimize arousal and acquire an internal state more commensurate with a low need for stimulation. Other theories incorporate concepts similar to reactivity and activity (e.g., Thomas & Chess, 1977); however, Strelau focuses on reactivity as the main temperament feature and describes how and why activity should be linked to it.

The results from a study by Petrie (1967) provide indirect support for this relationship between reactivity and activity. To the extent that reactivity is a function of a process akin to stimulus reducing, Petrie's (1967) findings suggest that low reactives (reducers) are more likely to seek stimulation via high activity than are high reactives (augmenters). In her study, delinquent male teenagers between the ages of 13 and 17 were identified as reducers or augmenters by their performance on the Petrie KFA task, and counselors who had constant contact with the boys provided behavioral assessments. Counselors described those boys that were classified as reducers as engaging in more activities than those classified as augmenters. Augmenters, in contrast, were described as avoiding activities, being quiet and inactive. This finding is consistent with the notion that the high reactives' (augmenters') inactivity is a regulatory reaction to high internal activation and that the low reactives' (reducers') high activity is a regulatory reaction to low internal activation and the corresponding high need for stimulation.

No direct attempts have been made to examine the plausibility of the potential connection between reactivity and motor activity level per se. This absence is rather surprising given the centrality of motor AL in temperament theories (e.g., Buss & Plomin, 1984; Thomas & Chess, 1977) and the relative simplicity of its measurement. The present research represents the first direct evaluation of a link between reactivity and motor activity level and is one of only a few attempts (e.g., Grodner, 1973, cited in Strelau, 1983; Sales et al. 1974) to study reactivity during childhood.

The evaluation of the connection between reactivity and activity was undertaken in an attempt to explore the meaning of individual differences in activity level. However, the demonstration of a link between these two variables could be valuable for other reasons. For example, the combined influences of high inactivity and high reactivity may pose a health risk. As previously indicated, individual differences in activity level may be implicated in certain health-related problems; and reactivity, which has been described as "the most important individual difference construct in understanding stress reactions", has been linked to health problems such as duodenum ulcers (Strelau, 1988). Knowledge that promotes the identification of high risk populations is critical in the prevention of disease, and the relationship between reactivity and activity may provide a basis for the exploration of further health-related issues.

Overview of Research

Based upon the assumptions that reactivity determines an individual's characteristic internal state and that activity is a reaction to the internal state, the broad goal of the present research was to explore a potential negative relationship between reactivity and activity level. Multiple measures of child activity level and reactivity were taken across two studies. The first study involved the development and evaluation of a parent-rating reactivity measure and the assessment of the tenability of the reactivity-AL association. The second study attempted to replicate this association and further extended the work on reactivity and activity level. In particular, two issues were explored: (a) the notion of activity as a regulator of internal state and (b) potential individual differences in the ability to suppress activity, differences which would have implications for the ability to use activity suppression as a regulator of internal state.

STUDY 1

Study 1 was designed to assess a predicted negative relationship between child reactivity and activity level. Both measures were derived from parent ratings of child characteristics. Subjective impressions of child activity have been found to be reliable across raters and to relate to more objective AL measures (Eaton, 1983). Subjective measures of child reactivity, such as Friedensberg and Strelau's (1982) teacher-rating reactivity scale, are supported by demonstrations of inter-item consistency, retest reliability, and interobserver reliability. Because no parent-rating measure of child reactivity exists, a questionnaire was developed to measure parent-ratings of child reactivity.

The item pool for the questionnaire construction included items from various sources. The reactivity items were taken from Friedensberg and Strelau's teacher-rating scale. These items assessed typical behavioral reactions to everyday settings and were intended to measure tolerance to stressful situations or the capacity to endure strong stimuli. The present questionnaire also incorporated items to assess parents' perceptions of their children's domain-specific (i.e., visual, auditory, olfactory, and tactile) sensitivity to sensory stimulation. Finally, five items were included to measure child activity level.

The primary goal of Study 1 was to consider reactivity's value in predicting children's levels of activity. Along with reactivity, the influence of age and sex were also considered. Based upon empirical evidence, Eaton and Yu (1989) suggest that there is a decline in AL in the later preschool and elementary school years. Therefore, it was expected, in the present study, that younger children would be more active than older children. Finally, boys were expected to be more active than girls, as was reported in a meta-analysis (Eaton & Enns, 1986) involving results from 90 studies and 127 independent female-male comparisons.

A secondary goal of this study was to assess the relation between behavioral reactivity and sensitivity to stimulation. In particular, relationships between reactivity and domain-specific sensitivity were examined. If the sensitivity thought to characterize high reactivity is actually modality specific, this evaluation may provide some insight into past discrepant findings across tasks that use different modalities (Strelau, 1983). Due to the exploratory nature of the analysis of the parent-rating items, predictions about the associations between reactivity and domain-specific sensitivity were not made.

Method

Subjects

The participants in this study were 130 5- to 12-year-old children attending a summer program. The two-week program was offered at a campus of a major Canadian university and focused on recreation and education. This sample of 76 boys and 51 girls[1] was probably not representative of the general population of same-aged children on a number of dimensions. Details on SES and parental education were not collected because of the negative response that often accompanies such inquiries. However, because parents with some connection to the university are more likely to be aware of the recreational program, and because registration carries a fee, the background of these children may be characterized by relatively high levels of parental education and socioeconomic status.

Measures

Reactivity/sensitivity. A parental questionnaire (see Appendix A) was constructed to attain child measures of behavioral reactivity and sensitivity to domain-specific (visual, auditory, tactile, and olfactory) stimuli. Items were selected from two reactivity scales, Friedensberg and Strelau's Teacher-Rating Scale (1982) and Kohn's (1985) Self-Rating Scale; and from two other sources, Thomas and Chess' (1977) Parental Questionnaire and

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[1]In three cases, parents failed to identify their child on the questionnaire, thus descriptive information on gender, etc. was not available. These three subjects were included in the item analyses, but because they could not subsequently be linked with data in Study 2, they were excluded from further evaluations.

White's Sensitivity Scale [see Dragutinovich (1987) for details on White's unpublished Sensitivity Scale]. For various reasons, items have been modified or rephrased. For example, self-report items from Kohn's Scale and teacher-rated items from Friedensberg and Strelau's Scale were rephrased so that they were appropriate for completion by parents. Other items from White's and Kohn's scales are directed at an older population; thus, they were rephrased to be more age-appropriate.

Parents scored each item on a scale from hardly ever (1) to almost always (7). For the protrait items, high scores represented high values on the reactivity trait. However, in an attempt to deal with response bias, six of the items were expressed in the contrait form. That is, these items were worded so that a high score represented the opposite of the reactivity trait.

Items were subjected to a three-step process. First, internal consistency was assessed for all items combined. Second, items were categorized into distinct subgroupings. This categorization began using a logical-grouping strategy. For example, items that corresponded to auditory stimulation were categorized into an auditory domain-specific subset, and all of those items measuring behavioral reactivity were categorized into a reactivity subset. Next, a statistical approach, described below, was used to refine the subsets, i.e., to delete poor items. Third, internal consistency was evaluated for each subset.

Activity level (AL). The child's typical level of activity, or customary energy expenditure, was measured by parent ratings of their children's AL on 5 items (items 5, 10, 14, 18, 27) embedded within the questionnaire. For example, one item asks if the child "is off and running when he or she wakes up in the morning". These 5 items were taken from Buss and Plomin's (1984) and Thomas and Chess' (1977) temperament scales. Scores of 7 on three items, and scores of 1 on two items, reflected high activity.

Procedure

Parents of 250 children attending the university summer camp were asked permission for their child's participation in the research study. Parents who agreed completed a questionnaire consisting of the 30 items to assess reactivity, domain-specific sensitivity, and activity level. Either the mother or the father completed the questionnaire at his or her convenience and returned it to the experimenter by mail. Over 50% (130/250) of the parents receiving the questionnaire responded, which provided .85 power to detect a correlation of .30 at alpha=.01 (Cohen & Cohen, 1975). While parental association with the university may restrict the generalizability of results, it also likely contributed to higher than average parental cooperation in this study.

Restatement of Predictions

The main hypotheses in Study 1 involved an assessment of the predictive value of reactivity, age, and sex for parent ratings of activity. The direction and significance of *t* values corresponding to *b* weights from a regression analysis were evaluated to test the following hypotheses:

1. Children with the highest parent-rated reactivity (R_RATE) scores should have the lowest parent-rated activity level (AL_RATE) scores, and children with the lowest parent-rated reactivity scores should have the highest parent-rated activity level scores.
   (t R_RATE,AL_RATE) < 0.

2. Parent-rated activity should be negatively related to AGE.
   (t AL_RATE,AGE) < 0.

3. Activity should be related to SEX such that boys are rated by parents as more active than girls.
   (t AL_RATE,SEX) < 0, where boys=1 and girls=2.

Results

Prior to presenting the results of the main reactivity-activity analyses, various psychometric issues were considered to establish the viability of the parental questionnaire as a measure of reactivity.

Psychometric Analysis

Before conducting any analyses, the contrait items were reverse coded so that high scores on the 25 reactivity/sensitivity (R/S) and on the 5 activity items represented high reactivity and activity respectively. Using several approaches to item analysis, correlations were examined for: the two halves of the questionnaire (split-half procedure); the individual items and the whole (item-whole correlation); and the mean of all items (mean inter-item correlation). As well, alpha coefficients were assessed to consider the interconnectedness of items within a specific subscale.

Split-half reliability. The 25 R/S items were split into two groupings, each consisting of alternate questions (*M*s = 50.51 and 46.82, *SD*s = 8.85 and 8.36, respectively). As suggested by Cronbach (1970), the Spearman Brown correction was applied to the correlation between these sets. The corrected coefficient was .83, which supports the reliability of the R/S items. Because there were only 5 activity items, they were not subjected to the split-half procedure.

Item-whole correlations. Correlations between each item and the total were examined both for the R/S and for the AL items. The item-whole correlations for the five AL items were high, ranging from .70 to .86; thus, all of these activity items were retained. One of the reactivity/sensitivity items (item 7) was deleted because it was not significantly related to the R/S total, $r(128) = .12$, $p > .05$. The item-whole correlations for the remaining 24 items were significant, ranging from .22 to .58. Because the lower than expected item-whole correlations implied that it may be misleading to evaluate these items as one conceptual unit, a more fine-grained item analysis was performed for the R/S items.

Mean inter-item correlations/alpha coefficients. This further evaluation of the R/S items was undertaken to create subgroups of items. The first step in this evaluation involved identifying subgroups of items by classifying then into one of seven subsets. The subsets corresponded to logically derived groupings and included: four domain-specific sensitivity groupings (auditory, visual, olfactory, and tactile domains); two previously undefined groupings within the Friedensberg and Strelau reactivity measure (task-related distress/endurance and social distress/endurance); and finally, activity level.

Following the logical classification, a statistical approach was used to refine the subsets. For the domain-specific subsets this involved the assessment of changes in both the mean inter-item correlation and the alpha coefficient when individual items were removed. Independent considerations of item consistency were made for these subsets by excluding items, one at time, from the group. An item was dropped from the subset, if, upon it's exclusion, the mean inter-item correlation for the remaining items increased without reducing the alpha, or, if the alpha increased without reducing the mean inter-item correlation. The analysis led to the exclusion of 3 items. Item 20 was removed from the visual subset because its exclusion resulted in an increase both in the mean inter-item correlation (.25 to .34) and, in the alpha (.57 to .61). Similar changes led to the exclusion of item 2 from the tactile subset. These latter changes[2] were observed after further regrouping items into two smaller subsets, one corresponding to temperature sensitivity (items 12 and 21) and the other, to basic tactile sensitivity (items 26 and 29)[3]. The exclusion of item 19 from the auditory subset increased both the alpha and the mean inter-item correlation. Finally, adding item 11, which did not logically fall into any of the groupings to the auditory subset, left the inter-item correlation unchanged, while the overall alpha increased from .50 to .55. The original and final sets of items included in each of the subsets can be found in Appendix B.

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[2] Removing item 2 from the temperature sensitivity subset increased the mean inter-item correlation from .26 to .47 and the alpha, from .51 to .64. Likewise, its removal from the basic tactile sensitivity items increased the mean inter-item correlation from .15 to .30 and the alpha, from .34 to .47.

[3]This regrouping was done because the removal of more than one item from the original subset resulted in large changes in the mean inter-item correlation.

The alpha coefficients for each of the final subsets are shown in Table 1. The alpha reliability is a function of the number of items and the mean inter-item correlation for those items (Altemeyer, 1981). The rather low alpha coefficients for the domain-specific sensitivity subsets are difficult to interpret because they reflect the small number of items (2-4) in each subset. In contrast, the mean inter-item correlations for these subsets compare favorably to psychometric assessments of other behavioral scales. For example, Altemeyer (1981) reports mean inter-item correlations in the range of .08 to .23 for scales measuring authoritarianism.

Two reactivity groupings were also formed and were later compared in various analyses. First, the two smaller subsets based upon the Friedensberg and Strelau items[4] (i.e., task and social distress) were combined to create a **core reactivity** subset with item-whole correlations ranging from .40 to .72. This provided a measure of behavioral reactivity comparable to the teacher-rating measure developed by Friedensberg and Strelau (1982). Of the two core reactivity component subsets, the items corresponding to task

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[4]Item 19, like Friedensberg and Strelau's item 1, assesses concentrated attention; however, the present content of this item differs from Friedensberg and Strelau's by asking about noise distractions from concentrated attention.

Table 1

Number of Items, Mean Inter-item Correlations and Alpha Values for Subsets of Questionnaire Items

Subset type	n	Mean inter-item correlation	Alpha
Reactivity			
Social distress	4	.21	.52
Task distress	5	.42	.78
Core reactivity[a]	9	.22	.72
Composite reactivity[b]	15	.18	.76
Domain-specific Sensitivity			
Auditory	4	.24	.55
Visual	3	.25	.57
Temperature	2	.47	.64
Tactile	2	.30	.47
Olfactory	2	.24	.38
Activity	5	.48	.82

[a]Core reactivity includes only those items taken from Friedensberg and Strelau Reactivity Scale. [b]Composite reactivity includes the former items, as well as related sensitivity items.

distress showed greater internal consistency than did those corresponding to social distress.

Second, a **composite reactivity** grouping was formed to include the sensitivity items that were related to the behavioral core reactivity items. The items for this composite subset were identified by adding them, one at a time, to the core reactivity subset and assessing the changes in mean inter-item correlations and alpha coefficients. Items were retained if, when added, the mean inter-item correlation did not fall below .18 and, if there was no accompanying decline in the alpha value. The mean inter-item correlation and alpha value for the 15 items[5] comprising the composite reactivity subset are shown in Table 1. The item-whole correlations for these 15 were slightly lower than those found for the core score, ranging from .30 to .66.

A score on each of the subsets was created for each subject by summing parent responses on the relevant items. For example, the composite reactivity score was derived by summing each child's scores on the 15 items that comprised this subset. Table 2 provides means and standard deviations for each subset score. Because the composite reactivity score distribution was skewed, a LOG transformation was applied. After removing one outlier, the overall mean composite reactivity score for 129 subjects was 1.70 and the standard deviation, 0.10.

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[5]Item 20, which was deleted from the visual subset, was included in the 15 items comprising the composite reactivity score.

Table 2

Number of Items, Means, and Standard Deviations for Parent Ratings of Child Reactivity, Sensitivity, and Activity Subsets

Subset type	n	M	SD
Reactivity			
Social distress	4	2.87	1.59
Task distress	5	3.50	1.71
Core reactivity	9	3.22	1.65
Composite reactivity/sensitivity	15	3.43	1.71
Domain-specific Sensitivity			
Auditory	4	3.85	1.85
Visual	3	4.12	1.79
Olfactory	2	5.05	1.63
Temperature	2	4.17	1.71
Tactile	2	3.71	1.76
Activity	5	4.74	1.54

Note. Values presented are those calculated before the application of transformations and the exclusion of outliers.

Correlations among subsets. As can be seen from Table 3, most of the sensory domain-specific subsets were significantly related to each other. However, the scores for the sensory-domain subsets did not necessarily relate either to the core reactivity score or to its

Table 3

Correlations among Reactivity and Sensitivity Subset Scores

	2	3	4	5	6	7	8
1 Core reactivity	a	a	.20*	.02	.07	.04	.37***
2 Social distress		.27**	.26**	.03	-.01	.09	.34***
3 Task distress			.09	.01	-.11	.11	.28**
4 Auditory				.39***	.19*	.18*	.34***
5 Visual					.24*	.25**	.22*
6 Olfactory						-.41***	.11
7 Temperature							.10
8 Tactile							

[a]Correlations are not reported among core reactivity (1) and either social distress (2) or task distress (3) because the former score is a combination of the latter two scores.
* $p < .05$. ** $p < .005$. *** $p < .0005$.

component subsets (i.e., task and social distress). Of note are the significant correlations among the tactile and the core reactivity scores, $r(127)=.37$, $p < .0005$, and among the auditory and the core reactivity scores, $r(127)=.20$, $p < .05$. It also appears that while tactile sensitivity is related to both the social- and task-distress components of the core reactivity measure, auditory sensitivity is related only to the social-distress component.

Summary of psychometric assessment. The item-whole correlations among the entire set of individual R/S items was lower than expected. Moreover, reactivity was not related to sensitivity in the visual, olfactory, and temperature domains. Taken together, these findings may imply that behavioral reactivity, as conceived of by Strelau, is unrelated to, and should be evaluated separately from, sensitivity in some domains. However, with only two items remaining in each of three of the domain-specific subsets (tactile, temperature sensitivity and olfactory), these findings should be interpreted cautiously. An expanded version of the present questionnaire may provide a more meaningful analysis of the relationship between reactivity and domain-specific sensitivity.

Results regarding the measurement properties of the two reactivity subsets (i.e., core and composite reactivity) support the reliability of the parent-ratings for the measurement of child reactivity. The inter-item correlations and alpha values for reactivity subsets were generally acceptable. The item-whole correlations for the 9-item core reactivity measure compared favorably to, although were slightly lower than were those reported for Friedensberg and Strelau's (1982) teacher-rated version of the reactivity scale. Both reactivity measures had acceptable mean inter-item correlations and alpha values, further supporting the interconnectedness of items.

Activity and Reactivity Analyses

Two separate regression models were constructed to examine the relation between parent-rated reactivity and activity. In Model 1, the core reactivity measure was used as a predictor of AL, and in Model 2, the composite reactivity measure was the predictor. Along with reactivity, age and sex were entered as predictors of activity level. In both models, parent-rated reactivity was found to be a significant predictor of activity level (Table 4). Children who were rated as the most reactive were also rated as the least active, and those rated as the least reactive were rated as the most active. Age was also a significant predictor of activity, with older children being rated as less active than younger children. Sex however, did not predict parent-rated activity; boys were viewed as no more active (M = 23.99) than were girls (M = 23.27).

A further stepwise analysis with age, sex and the two reactivity scores as predictors of AL was done for two reasons. First, this provided an indication of the magnitude of the relationship between reactivity and activity; and second, it allowed for a comparison of the two reactivity measures. Age explained the greatest amount (9%) of variance in the AL scores, and beyond age, composite reactivity explained an additional 7% of the variance. The core reactivity measure did not explain any additional variance in the AL scores; thus, the composite reactivity score appeared to be superior to the core reactivity score in the prediction of parent-rated activity. This may imply that the inclusion of some sensitivity items can enhance the predictive ability of the parent-rated reactivity measure, at least in accounting for AL variance.

Table 4

Predictors of Parent-rated Activity Level using Two Separate Reactivity Measures in Two Regression Models

Predictors	b	t	p
Model 1: Composite reactivity			
Age	−0.81	−3.65	.00
Sex	−0.44	−0.44	.66
Composite Reactivity	−15.34	−3.23	.00
Model 2: Core reactivity measure			
Age	−0.82	−3.67	.00
Sex	−0.85	−0.83	.41
Core Reactivity	−0.17	−2.80	.01

Conclusions

This first evaluation of a relationship between child reactivity and motor activity level confirmed the predicted negative association. Children who were rated by parents as the most reactive, were also rated as the least active. This association fits with the premise that underlying differences in reactivity may explain individual differences in motor activity level. Anticipated age differences also emerged, with older children being rated as less active than younger children. However, the anticipated sex differences were not found. These results are further reviewed in the final discussion.

A limitation in Study 1 must be addressed. The relationship that emerged between reactivity and activity was based solely on subjective measures that were not independent of one another. As a consequence, this relationship could reflect the fact that the constructs are linked through a third variable, such as, the structure of language. The link between reactivity and activity could be due to some feature or image common to both types of items. For example, an "active" image is common to the AL items as well as to some of the reactivity items. Study 2 avoided this problem by employing independent and objective measures of both activity and reactivity.

STUDY 2

Study 2 was designed for two reasons, the first being an attempt to replicate the negative association between reactivity and activity and the second, involving a consideration of two dynamics critical to this relationship: the potential role of activity as a regulator of internal state and the possibility of individual differences in the ability to suppress activity.

Replication

The replication of the negative relationship between reactivity and activity was critical because of the dependence of these two measures used in Study 1. In this second study, the relationship was again evaluated, but this time, using independent measures. Reactivity was measured using the "slope of the curve" index, which was determined from individual response patterns to visual stimuli of varying intensity levels. A single score, which reflected the pattern of responses was calculated for each subject. Low reactivity corresponded to a score that represented a strong negative slope as were shown in Figure 1, and high reactivity corresponded to a score that represented a flatter slope.

While the evidence is not conclusive, there is support for the validity of RT as a measure of behavioral reactivity. Correlations in the range of .54 to .86 have been reported between Strelau's behavioral reactivity measure (i.e., the Strength of the Nervous System Scale from the Strelau Temperament Inventory) and RT, as measured by "change in simple reaction time under repeated stimulation" (Strelau 1983, p. 135). Nonsignificant correlations have also been reported for reaction time profiles and reactivity, as measured by the Kohn Reactivity Scale (Kohn, Cowles, & Lafreniere, 1987). Differences across these studies in the measurement of reactivity make comparisons of these findings difficult. However, it is possible, as Kohn et al. suggest, that a restricted range of intensities on the RT task may have contributed to unreliability in the measurement of the slope of the curve.

There is a dispute over the use of laboratory measures of reactivity because of their presumed inability to capture the complexity of individual profiles in underlying physiology. However, there are various reasons why this measure is potentially useful, and rejection of RT as a measure of reactivity seems unwarranted. First, it is not evident that behavioral measures are any more superior in capturing the full essence of reactivity than are laboratory measures. Second, there is some support for the validity of an objective laboratory measures.' Third, the objective measure avoids potential language-related problems inherent in paper-and-pencil tests. A'relationship based solely on subjective tests could reflect the possibility that the constructs are linked through the structure of language. Furthermore, Strelau and others continue to interpret RT studies within the context of behavioral reactivity, suggesting a continued acceptance of such reaction time measures as meaningful indices of reactivity.

If the slope of the curve measure (SLOPE) reliably captures stable individual differences in reactivity, then an association between SLOPE measures across test and retest sessions should be found. Frearson, Barrett, and Eysenck's (1988) results provide support for the stability of reaction-time measures. They found, not only day-to-day stability, but stability from two weeks to nine months. These findings however, were based, not upon reaction latencies to stimuli of varying intensity, but upon simple reaction time. In the present study, stability of the pattern of response was examined to consider the reliability of the SLOPE measure. Establishing some assurance that the slope of the curve measure captures typical reactions is also important because, according to Strelau, typical reactions can be influenced by situational factors such as the meaning of the stimuli and current arousal and motivational levels (Strelau, 1983).

The independent measures of child activity in this second study included a subjective measure - supervisor rankings - and an objective instrument measure - an actometer. The relationship between reactivity and activity was examined by assessing the associations between the slope of the curve reactivity measure and both supervisor rankings and actometer readings of AL. In addition, associations among the parent-rating reactivity score from Study 1 and each of the Study 2 activity measures were also explored.

<u>Activity as a Regulator of Internal State</u>

As well as examining the replicability of the reactivity-AL relationship, Study 2 was designed to consider the role of activity as a regulator of internal state. This was accomplished by assessing activity under conditions that were assumed to influence internal state. The premise of this evaluation is that the internal level of arousal and the immediate need for stimulation can be influenced by transitory events such as the level of environmental stimulation. Internal state then, is presumably a reflection of the constant influence of temperament differences (reactivity) and the transitory influence of environmental factors such as stimulation level (see Figure 4).

<u>Environmental stimulation, internal state, and activity</u>. While reactivity can not be manipulated, stimulation level can, and this provides a way to assess whether the expected changes in activity occur with changes in internal state. In other words, this provides an indirect test of the notion of behavioral regulation via motor activity. Activity should generally increase under lower levels of environmental stimulation because these conditions presumably reduce internal arousal and increase the immediate need for stimulation. On the other hand, under higher levels of environmental stimulation that presumably increase internal arousal and reduce the needs for stimulation, activity should generally decrease.

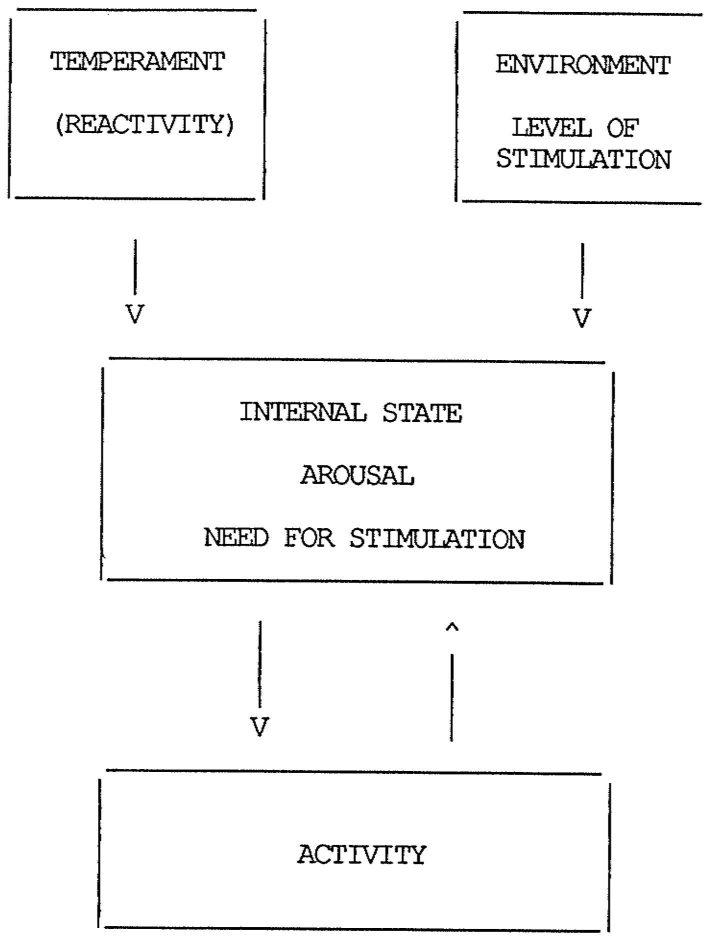

Figure 4. Factors influencing internal state.

The results from a study by Koester and Farley (1982) are consistent with the notion that behavioral regulation operates to redress the heightened need for stimulation assumed to exist under low levels of environmental stimulation. Koester and Farley studied arousal and sensation seeking in six first-grade classrooms that were thought to differ in environmental stimulation level: three classrooms were open (stimulating), and three were traditional (less stimulating). Various physiological measures, such as mean pulse-rate were taken, and sensation seeking was measured by a paper and pencil test referred to as the pyramid-maze test (Domino, 1965). On the first of two visits, Koester and Farley found that children's sensation seeking scores were higher in the traditional classroom that presumably provided lower levels of environmental stimulation than did the open classrooms. Sensation-seeking behavior, then, may have been a reaction to a lack of stimulation. Because environmental stimulation level per se was not measured in Koester and Farley's study, other competing interpretations are also plausible.

Like sensation seeking, motor activity may increase under low levels of environmental stimulation and decrease under high levels of environmental stimulation. If transitory environmental factors affect the internal climate, and if activity is used to regulate internal state, then activity should vary as a function of the level of environmental stimulation. However, the activity patterns across levels of environmental stimulation may be dependent upon individual differences in reactivity.

Reactivity, environmental stimulation, and activity. The extent to which children modify their levels of motor activity in response to changes in environmental stimulation may be mediated by individual differences in reactivity. The amount of environmental stimulation that is required for optimal levels of internal excitation likely differs for high and low reactive individuals; thus, a different pattern of activity over levels of high- and low-environmental stimulation was expected for high and low reactives. As shown in Figure 5, high reactive's will reach their optimal level with a lower amount of Environmental Stimulation (ES) than will low reactives. In general then, increasing environmental stimulation should have a greater impact upon high- than upon low-reactive individuals. Under high stimulation, the former, who are typically overaroused, are more likely than are the latter to resort to behavioral regulation of internal state via activity suppression. This logic is consistent with Eliasz's (1987) notion of a wider "band" of optimal level of activation for low- compared to high-reactive individuals and with Strelau's (1983) conclusion that intensification of stimulation may evoke symptoms of overload for the high reactive, but not for the low reactive.

High reactives presumably reach an above optimal-level with little stimulation, thus the stimulation levels in this study were regarded as sufficient to test the plausibility of behavioral

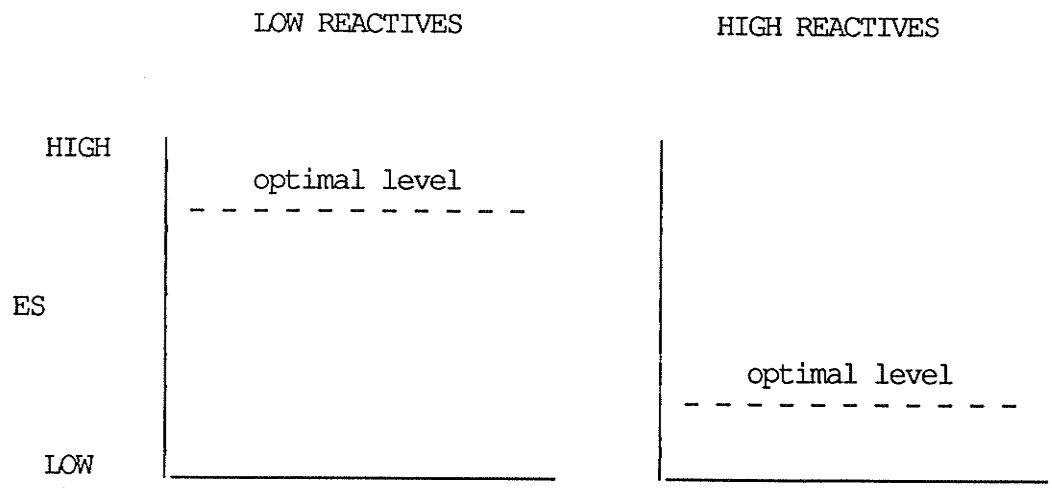

Figure 5. Relation between level of Environmental Stimulation (ES) and internal state for Low and High Reactives.

regulation of internal state. High reactives were expected to resort to behavioral regulation in the form of minimizing activity under high stimulation. Thus, for high reactives, motor activity was expected to be lower under high- compared to low-stimulation. This theoretically-derived expectation is consistent with empirical findings from two previous studies that considered the notion of physical output (Eliasz, 1980; Grodner, cited in Strelau, 1983). It is important, however, to note that neither Eliasz nor Grodner evaluated the concept of motor activity level as it is defined in the present work.

First, a study of motor proficiency provides evidence of behavioral regulation by high reactives under conditions of high stimulation. While the original report of these results is unavailable in English, the main findings are reviewed by Strelau (Grodner, cited in Strelau 1983). Motor proficiency, defined by the distance a child could push a 2 kg. ball with both hands, was evaluated for high and low reactive 12- to 15-year-old boys in a gym lesson. This approach allowed for an assessment of changes in motor proficiency across levels of low and high stimulation. Stimulation level was manipulated by imposing competition, and multiple measures of motor proficiency were taken across competitive (high stimulative value) and noncompetitive (low stimulative value) conditions.

The results indicate that low and high reactives respond differently to changes in the level of stimulation provided. Under stimulating conditions, performance improved for low reactives and declined for high reactives. The decline in motor proficiency (i.e., the decrease in distances) for high reactives under the stimulating, compared to the less stimulating conditions, is consistent with the notion that high reactives may reduce physical exertion in an attempt to dampen environmentally-enhanced internal arousal.

A second study by Eliasz (1980) assessed "stimulative activities" for high- and low-reactive adolescents living in areas of three large industrial cities that varied in levels of stimulation. Stimulative activities, or "activities resulting in intensified stimulation from outside and/or from the subjects' own activity" were identified during an interview with the subject. Subjects were classified as high or low on stimulative activity using a median-split procedure, and the frequency of high- and low-reactive children that scored either high or low on stimulative activity was calculated within each of the different "macroenvironments." The reader is referred to the original report for a full description of these findings; for the present purposes, only two findings will be discussed.

For high reactives living in the most stimulating environments (i.e., high stimulation, high density), the frequency of those scoring low on stimulative activity was greater than the frequency of those scoring high (15:6). Although Eliasz's conclusion differs, lower levels of stimulative activity under highly stimulating living conditions could reflect a reaction to overload from the living environment. There are, however, many interpretations for the finding, and the correlational nature of this research restricts conclusions.

Eliasz and Grodner both found that, for low reactives, increasing levels of stimulation were associated with heightened behavior. Eliasz reported that low reactives, living under highly stimulating living conditions, tended to be <u>more</u>, rather than less involved in stimulative activities. Likewise, Grodner found that, under highly stimulating competitive conditions, low reactives demonstrated higher levels of motor proficiency.

These findings of enhanced activity for low reactives under high stimulation are incongruent with the present theoretical framework. Presumably, high levels of stimulation lead to enhancement of the internal state, which should result in lower, not higher, activity. It is possible that brief exposures to high environmental stimulation may actually provide optimal levels of stimulation for the low reactive; and that, rather than attempting to reduce the environmentally-produced internal stimulation, low reactives attempt to further enhance the rewarding stimulation by becoming even more active.

Another possible explanation for the low reactives' increasing levels of activity levels with heightened environmental stimulation is provided by the notion of a curvilinear relation between arousal and performance (Yerkes & Dodson, 1908). According to the Yerkes-Dodson law, performance increases with increasing arousal - up to an optimal level of arousal, at which time performance declines. If, like performance, activity can be enhanced by high levels of stimulation, the low reactives' responses to high stimulation may be more consistent with the Yerkes-Dodson law than with Strelau's theory.

The Yerkes-Dodson law refers to performance, and it may be quite applicable to Grodner's assessment of motor proficiency. However, performance variables are likely quite different from the activity level variable being assessed in the present study. Therefore, the present prediction for the influence of environmental stimulation on the low reactive's AL was based upon theoretically-driven expectations from Strelau's theory. Because, according to the theory, the low reactive typically seeks stimulation, activity should not decline unless the stimulation level is sufficiently high to "push" arousal beyond an optimal level. Thus, the environmental-stimulation manipulation in the present study was expected to have very little effect for low reactives. Under the present stimulation conditions then, the expectation was one of stability in AL over different conditions of stimulation.

Assessing the low reactives' behavioral regulation would require exposure to stimulation levels of a magnitude high enough to produce an above-optimal level. Such levels were not used in the present study because they could be extremely uncomfortable for highly reactive children. Thus, the high level of stimulation in the present study was actually less extreme than the "high" label would imply.

With the present levels and duration of environmental stimulation, behavioral regulation of internal arousal was expected to operate only for the highly reactive child. Across environmental stimulation conditions, a decline was expected for high reactives. In contrast, low reactives were expected to demonstrate relative stability in AL across levels of environmental stimulation. Taken together, these expectations led to the prediction of an interaction between reactivity and environmental stimulation. Figure 6 shows the predicted situationally-induced AL pattern of decline for high, and stability for low reactives.

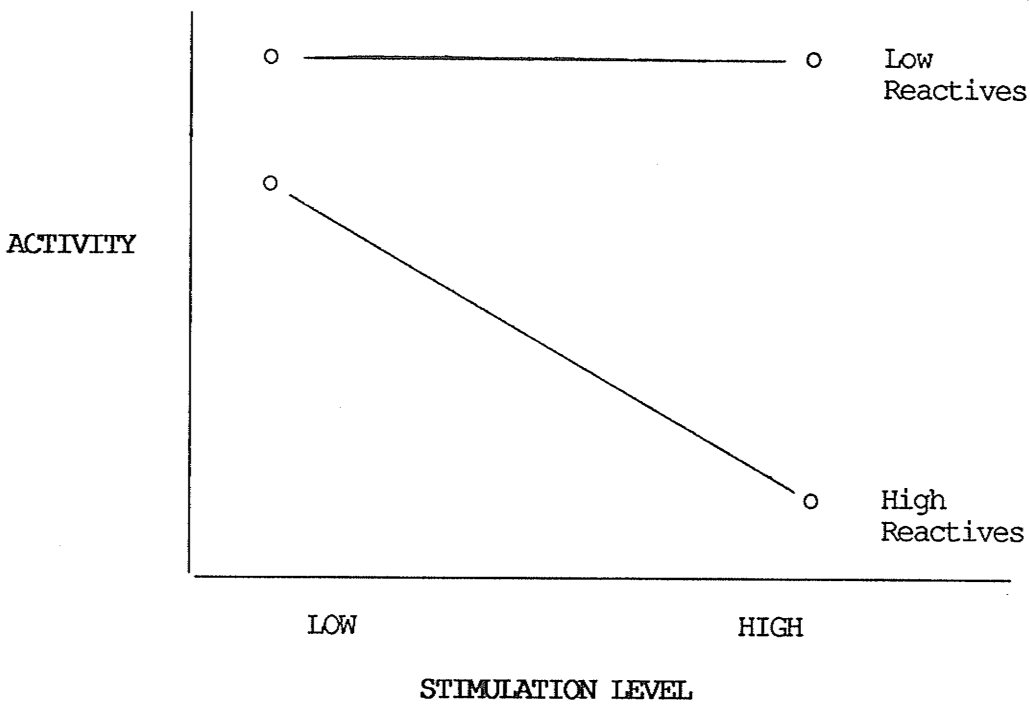

Figure 6. Predicted activity scores as a function of an interaction between reactivity and environmental stimulation.

Individual Differences in the Ability to Suppress Activity

The reduced AL expected for the high reactives under highly stimulating conditions is presumed to result from the suppression of activity. Thus, Study 2 was designed to consider the possibility of individual differences in the ability to suppress activity. Customarily high levels of activity may represent an inability to suppress motoric levels of activity, and this would have serious implications for the notion of activity as a regulator of internal state. In other words, an inability to suppress activity would interfere with the potential for regulating internal state.

While it is unclear whether there are individual differences in the ability to suppress overall levels of motor activity, common expressions like "he can't seem to sit still" imply that some children have difficulty suppressing gross motor behavior. Research on "behavioral inhibition" may also imply that some children are better able to suppress levels of motor activity (Kagan, Reznick, Clarke, Snidman, & Garcia-Coll, 1984; Garcia-Coll, Kagan, & Reznick, 1984). The children who respond to unfamiliar settings with behavioral inhibition may be those who have the highest ability to suppress motor activity level.

Strelau's (1983) notion of "strength of inhibition" - another nervous system property - may be compared to the present notion of "motor response suppression." Strength of inhibition, which is defined as "the functional capacity of the nervous system for conditioned inhibition," is evaluated using a molar, behavioral approach. Strength of inhibition is presumably manifest in restraining from reaction and delaying and/or interrupting action (Strelau, 1983, p. 126). This concept, which grew out of the earlier Neo-Pavlovian research, is measured via questionnaire items that ask about the ability to restrain molar behaviors. For example, one item asks about the capacity to restrain from doing something until given the signal to do it (Strelau, 1983, p. 123).

The behavioral unit of analysis in Strelau's broad molar approach differs markedly from the fine, motor responses assessed in the present work. To the extent that suppression of fine motor responses is directed by the same process that inhibits broad behavioral responses, a parallel between motor response suppression and Strelau's concept of inhibition may be appropriate. However, the fine motor responses in the present evaluation have more in common with the behavioral units explored in Neo-Pavlovian laboratory research than with Strelau's molar responses.

Because of substantial differences in procedures, the Neo-Pavlovian meaning of inhibition must not be equated with the present meaning of suppression of response. Neo-Pavlovian laboratory measures of inhibition include the conditioning of a response prior to the evaluation of strength of inhibition. Unlike traditional laboratory measures of inhibition, conditioned responses were not evaluated in the present study; thus, it would be inaccurate to interpret the outcomes from the current laboratory task as conditioned inhibition. Reference to the Pavlovian notion of inhibition is further avoided due to the general confusion surrounding the notion. As noted by Strelau, "Pavlov's views on the strength of inhibition were unclear and confused .., causing considerable reluctance among Pavlov's students and followers to investigate this property" (Strelau, 1983, p. 7). To avoid further confusion, the term "motor response suppression" is used instead of "inhibition".

Motor response suppression and activity level. This research did not directly assess the ability to suppress motor activity level. Rather, the ability to suppress fine motor responses was measured. The ability to suppress motor responses has been evaluated in various ways, such as, by the Draw-a-Line-Slowly Test (Maccoby, Dowley, Hagen, & Dagerman, 1965). This consists of measuring the length of time it takes for a child to draw a line as slowly as possible between two points. Another method exposes individuals to multiple presentations of stimuli that on some occasions require a response and on others, require no response (e.g., Logan, Cowan & Davis, 1984). Using the latter method, the present work evaluated the suppression of a motor response and its relationship to motor AL.

Prior research has found individual differences in the ability to suppress motor responses (e.g., Loo, 1978), but a link between suppression of simple motor responses and gross motor activity has not been addressed. It seems intuitively appealing that the most active children should have the greatest difficulty suppressing simple motor responses; thus, the prediction in the present work was that the less, compared to the more motorically active children, would demonstrate a greater ability to suppress simple motor responses. If the ability to suppress a simple motor response is related negatively to motor activity level, low levels of motor activity may represent successful attempts to suppress activity, while high levels may represent an inability to suppress activity. This might further imply that the children unable to suppress activity, (i.e., highly active children) are also unable to use activity suppression as a means of regulating their internal arousal.

Overview of Analytic Approach and Research Design

Correlational techniques were used to evaluate the replicability of the Study 1 relationship between reactivity and activity and the hypothesized response suppression-activity relationship. The analysis of the latter relationship involved the statistical control of various potentially confounding variables. In addition, the design of this study allowed for the direct examination of changes in high- and low-reactive children's levels of activity under two levels of environmental stimulation. In a counterbalanced design, each child's level of activity was assessed in two free-play settings, one consisting of high environmental stimulation, the other consisting of low stimulation. Activity level changes were assessed in a reactivity (low, high) by environmental stimulation (low, high) split plot ANOVA design. This analysis allowed for an empirical test of how AL varies both as a function of reactivity and of environmentally-produced changes in internal state.

Methodological issues. The methodology in this study has a number of strengths which facilitated the evaluation and interpretation of the reactivity-activity relationship. First, the within-subjects design provided information on the same child under two conditions. Second, environmental stimulation was manipulated, allowing for a direct test of the hypothesized interaction. Third, AL was monitored continuously throughout the manipulation. These methodological features address the shortcomings of earlier research which, according to Gale and Edwards (1983), exhibit an over-reliance on simple correlations and a failure to examine processes during the experiment.

Due to certain methodological features of this study, the potential influence of several variables on activity had to be considered. First, prior to the activity evaluation, some children participated in phase 1 of the study (a computerized tasks) while other did not; therefore, potential experimental-task-composition effects on AL were evaluated (i.e., RT task completion versus no RT task). Second, because the reading of actometers was done by multiple research assistants and activity scores could be related to systematic reading differences between assistants, reader effects were evaluated. Finally, despite counterbalancing for order of environmental stimulation condition, order effects seemed particularly plausible in this study.

Order effects could be salient in this study for two reasons. First, regardless of environmental stimulation, it seemed that the novelty of the first setting could either enhance or depress activity. While on the one hand, it seemed that the novelty of the toys and the play situation could enhance activity, research also suggests that some children respond to unfamiliarity with behavioral inhibition (Garcia-Coll, Kagan & Reznick, 1984; Kagan, Reznick, Clarke, & Snidman, 1984).

Second, carry-over effects might operate for highly-reactive children only, a phenomenon which could work against the predicted interaction of environmental stimulation and reactivity. For example, if the high-reactive child's exposure to high levels of stimulation enhances activation of the internal state, this arousal could carry-over to the second room, leading to similar levels of behavior across the conditions. Continued attempts to regulate environmentally-induced internal activation/arousal caused by the first setting could be manifest in continued suppression of activity in the second room. That is, when exposed to high-before-low stimulation, the high reactives' pattern may be more stable, and thus appear more similar to the expected low reactives' stable pattern.

Summary and Predictions

Study 2 attempted to replicate the findings from Study 1 and to further explore two issues. The notion of activity level as a regulator of internal state was examined, and a relationship between motor-response suppression and general activity level was considered. Finally, because it is important to link paper-and-pencil tests to more objective measures, correlations among multiple measures of both activity and reactivity were examined. The various measures of reactivity and activity level were expected to be positively related, both within and across studies. Specifically, the main hypotheses were:

1. Reactivity scores derived from the slope of the curve on the reaction time task in Study 2 were expected to be positively correlated with both the core and composite parental-reactivity scores from Study 1.

2. Positive correlations were predicted among the Study 2 actometer and supervisor-AL-ranking scores and among each of these and the Study 1 parental AL rating scores.

3. Activity measures from Study 2 were expected to relate negatively to both parent-rated and experimental SLOPE reactivity measures.

4. Children who had the greatest difficulty suppressing a motor response were expected to be most active in a play setting.

5. Differences in activity across levels of environmental stimulation (ES) were expected to relate to reactivity, with activity differences being greater for high- than for low-reactive children.

Method

Subjects

The subjects in this study consisted of 241 5- to 12-year-old children from the University-recreational program described in Study 1. Some of these children had also participated in Study 1, while others had not. Parental permission was obtained for all children (see Appendix C). After dropping the data for one child because of an outlying activity score, 137 boys and 103 girls remained. To minimize potential feelings of being excluded, children who did not have parental permission to participate in the study either participated in another "mock experiment" or were told that they had been randomly divided into groups and would be involved in different activities for awhile.

Overview of Setting and Materials

Children, in groups of two to eight, participated in experimental sessions conducted on the university campus. An objective reactivity measure was obtained from a reaction-time task that was administered in a computer laboratory containing 20 workstations. Activity scores were then collected using a mechanical motion recorder, known as an actometer, for which complete details are provided later. These AL measures were taken in two classrooms identical in all characteristics, with the exception that the level of environmental stimulation varied. Play items in the two rooms were identical and included: balloons, plastic beach balls, plastic bowling pins, miniature basketball hoops, and bubble makers. This variety of play materials was used to reduce the chances of boredom during the experimental sessions. The play materials were selected on the basis of their low required skill level, their lack of required previous experience, and their absence of sex-stereotyped properties. Items were also chosen to encourage rather than to discourage physical movement.

Variables

An overview of the chronological sequencing of events in the study follows a description of the variables. The key independent variables were the manipulated environmental stimulation level (low, high), the temperament measure of reactivity, and the measure of motor response suppression. The dependent variable was activity level.

Environmental stimulation. Environmental stimulation was defined by variation in the visual and auditory characteristics of the room. In the high-stimulation environment, loud, quick tempo, classical music was played on a tape recorder, all available lighting was used, and the walls and ceiling were covered with bright colorful panels of tissue paper, wall paper, posters, and multicolored streamers. Three fans were also positioned around the room to add to the overall noise level and to provide motion in the streamers. The low-stimulation environment was dimly-lit with no extraneous noise or wallcoverings.

Reactivity. The "slope of the curve" index, which was determined from individual response patterns to stimuli of varying levels of intensity was used as a measures of reactivity. Stimuli were presented on a computer in a succession of displays. The four displays presented during a single trial of the reaction-time task[6] are illustrated in a flowchart in Figure 7.

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[6]All programming for the computer tasks was done in GWBASIC. Level of intensity was varied by emulating the monochrome color mode and producing various shades. In order to attain more than two shades, it was necessary to replace the standard Hercules (compatible) Graphics Cards with ATI EGA Wonder boards. Based upon a visual inspection of perceived intensity, four shades were selected from the possible 16 that were available. These 16 shades corresponded to the 16 potential colors that would be available using a color rather than a monochrome mode. However, using a monochrome mode, the manipulation of shades was within a single hue; thus, the shade was not confounded with hue. The intensity (i.e., luminosity) of each of these four shades was then measured by placing a LitMate System 500 Photometer approximately 16 inches from the screen and taking two readings of each. The luminosity values and colors names that corresponded to the shades chosen for the present study were: 1.4 (cyan), 3.1 (light cyan), 3.7 (brown) and 58.45 (high intensity white).

The first display was a 5-second warning stimulus (i.e., a set of arrows) that appeared on the left side of the screen, which indicated to the subject that the response stimulus was to follow. The second display consisted of a blank screen which remained for 1.5 - 2.5 sec. The third display was the response stimulus, a square, which was terminated either by a response (i.e., a depression of the space bar) or, if no response occurred, by a 2 sec lag. The termination of the stimulus was followed by the final blank display, which represented an interstimulus interval of 10 seconds.

A different level of intensity was randomly applied to each subsequent presentations of the response stimulus (i.e., the square) across a block of four trials. That is, the level of stimulus intensity was randomly varied within four completions of the loop shown in Figure 7. This resulted in a total of 6 trials of each of four intensities, for a total of 24 trials[7].

The procedure for the present study was computerized and thus differs from the Neo-Pavlovian research. Stimulus intensity was determined by luminosity, or candelas/meters squared (cd/m^2), rather than by the traditional measure of illuminance (i.e., lux values). The Neo-Pavlovian procedure involved projections of light onto a screen and measurements of the illuminance, or the amount of

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[7]The initial RT program contained 40 presentations of stimuli, which took approximately 20 minutes. Pretesting of this program revealed that the task was too long for children of this age group; thus, the number of presentations was reduced to 24.

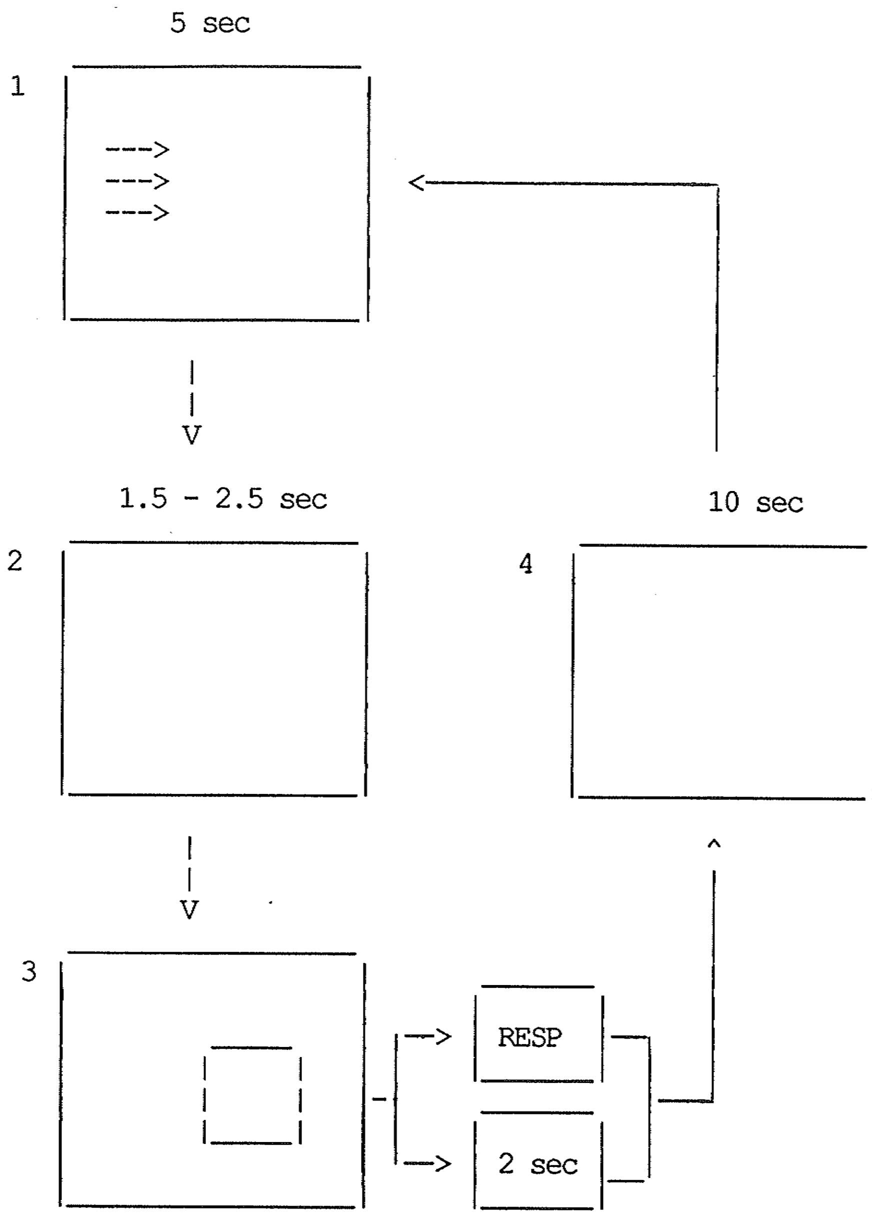

Figure 7. Flowchart illustrating the computer displays presented during a single trial of the computerized reaction-time task.

light falling on the surface. Luminosity has been used by others (e.g., Grice, Nullmeyer, & Schnizlein, 1979) in simple reaction-time tasks and is the appropriate measure of intensity for the computerized task. Values of 1.4, 3.1, 3.7, 58.45 cd/m^2 were selected to attain a range of intensities for the task; however, both the lower and upper values may be somewhat less extreme than the traditional values of .02 and 2000 lux.

Because eight different computers were used and some variation in the speed of computers is to be expected, possible differences between computers were considered. Also, equality in luminosity for each of the four intensity levels was somewhat variable across the computers, despite attempts to calibrate the computers (see Appendix D for description of calibration procedure). While luminosity values for one intensity level achieved equivalence across computers, the luminosity values were not necessarily equivalent across computers for the other intensity levels. These computer differences were examined statistically to determine potential computer effects.

To consider the reliability of reaction time as an individual difference predictor, 35 subjects returned to the laboratory for retesting on the reaction-time task. The instructions and the practice trials were repeated before the task began. Because the recreational-camp coordinators scheduled each group's experimental participation times, neither the length of time between test and retest sessions, nor the time of day, were under the experimenter's control. Length varied from one to five days, and with the exception of one group, the time of day differed from the initial to the second visit.

Motor response suppression. A motor response suppression score was calculated on the basis of children's responses on 14 additional trials that were administered following the RT task. During these trials, children were asked to continue responding as quickly as possible to the presence of the square. Except on some trials, called no-response trials, or STOP trials they were asked to refrain from responding. No-response trials were simply trials on which the word STOP appeared below the square. The STOP instruction was assigned within the 14 trials based upon the randomized sequencing of intensity levels in the previous RT task. The number of appearances of these STOP trials varied between 1 and 8 across subjects. Subsequent analyses excluded children who received fewer than 3 STOP trials, because scores based upon only a couple of trials were likely to be unreliable.

The probability of responding on STOP trials was calculated for each child, and took into account, both the number of responses on STOP trials and the number of stop trials presented. First, the presence or absence of responses on no-response trials was determined. Then, each child's percentage of response on STOP trials was calculated by dividing the number of trials in which a response to a STOP trial occurred by the total number of STOP trials a child received and multiplying by 100 (M = 34.34, SD =

24.77). This provided a measure of the percentage of responding on stop trials, such that 100% represented a high percentage of responding on STOP trials, and 0% represented a low percentage.

In further discussion of this measure, the term response suppression is used rather than probability of responding. High scores on response suppression should logically indicate a strong ability to suppress a response, and low scores, a weak ability. However, this is opposite to the scoring on the percentage of response measure where high scores indicate an inability to suppress responses. For the sake of clarity, this percentage of response score was reversed so that high scores represented a strong ability to suppress responses, and low scores, a weak ability. The response suppression score was thus created by reversing the probability of response measure so that high scores reflected a high ability to suppress responses. This reversal was done by multiplying the probability score by -1.

Activity level: actometers. Two activity measures were obtained in this study. First, a mechanical instrument, known as a Kaulins and Willis Model 101 Motion Recorder was used for a measure of situation AL. These motion recorders, or actometers, physically resemble and function much the same as does a traditional wristwatch. The conventional watch movement however, is modified so that any motion or tipping of the instrument induces the advancement of the second, minute, and hour hands. Therefore, the hands of the watch advance to physical motion rather than to time.

The placement of the actometer hands are typically recorded at the beginning and end of session, and each elapsed second on the instrument represents an activity unit (AU). The differences between the beginning and end actometer readings then, provide an objective measure of the number of AUs that elapse.

The AU scores in the present study were calculated by taking the difference between the beginning and end readings for each limb. Further details on actometer limb placement, etc. are presented under the procedure chronology section. Descriptive statistics for AL measures are presented in the Results section.

Actometers have been shown to be both valid and reliable (Eaton, McKeen & Lam, 1988; Buss, Block & Block, 1980; Halverson & Waldrop, 1973), the reliability increasing as the number of actometers used increases (Eaton, 1983). Eaton demonstrated a 50% increase in reliability of actometer measurement by aggregating data and using composite measures. The reliability of preschoolers' activity, as measured by a single actometer reading was .33, while the reliability of aggregated multiple readings and a composite score was .88.

An attempt to enhance reliability of the actometer AL measure was undertaken in the present study by using two actometers per child, one worn on the wrist, and one, on the ankle. In addition, because errors in reading can occur, and because several research assistants were involved, there was an attempt to ensure that readings were conducted accurately. Research assistants were trained in the reading of actometers using a standard procedure for recording the instrument times. The inter-reader reliability was also assessed periodically throughout the study. This involved both assistants providing readings on all actometers after a play session. Following a session, each assistant would first record the initial reading for each actometer, then, would reread the actometer and take an adjusted reading. Comparisons of these adjusted readings where used in calculations of reader reliability.

Activity level: supervisor rankings. Camp-supervisor rankings of children's AL were also obtained by supervisors after they had been with the children for two weeks. The procedure for supervisor rankings is similar to one used by Eaton, Chipperfield, and Singbeil (1989). Specifically, supervisors were given a set of stickers, each including a child's name, and they were asked to rank the children's activity levels (see instructions in Appendix E). This involved constructing a ranked list based upon all of the children within a group. Supervisors affixed the sticker for the least active child at the top and the sticker for the most active child, at the bottom. While all children were initially ranked by supervisors, only the relative ranking scores for 54 of these children, who had parental permission to participate, were used. Using a similar ranking method, Eaton et al. (1989) found a median correlation of .65 across multiple caregivers from multiple centers, a finding that supports the reliability of this method.

Covariates. Due to characteristics of the present design, the procedures, and the limitations of the subject pool, several variables could not be experimentally controlled. Consequently, a statistical approach was used to assess potential covariates in the various analyses of this study. Variables that require no explanation include: the order of stimulation level presentation (low-high, high-low); actometer readers (1-7); group size (2-8); the child's sex and age; and the number of STOP trials on the response suppression task. Other variables that do require explanation include: familiarity with other peers (1-10), fatigue level, and experimental task composition.

An index of peer familiarity was provided by the number of days the child had been in the recreational program. This was only a crude index of peer familiarity, since some of the children may have know each other prior to the summer camp. Nonetheless, many of the children had not known the members of the camp group prior to the summer camp.

A fatigue level score was derived from information about prior events during the day of the experiment. This information consisted of the senior recreational program coordinator's ratings of each the daily event. Specifically, the coordinator was asked to rate each event on the amount of (a) sitting, (b) arm movement, and (c) leg movement involved. Each of these features were rated on a three-point scale, then an exertion level value was calculated for each daily event. The exertion level score for an event was the sum of the ratings for the amount of arm and leg movement minus the rating for the amount of sitting involved. Finally, for each child, a fatigue level score was created by summing the exertion level scores over all events the child had participated in on the day of the experiment.

Finally, an experimental-task composition designator was created to identify children who had been exposed to the computer task prior to the activity assessment. Because scheduling difficulties precluded some children from participating in Phase 1 (i.e., the computerized tasks), the exposure to Phase 1 may have influenced activity. To examine this issue, children were identified either as having been previously exposed, or not having been exposed to the computer task.

Procedure Chronology

The chronological events of this study are summarized in Figure 8 and are further described below.

Phase 1. The first phase of this study involved the completion of the two computerized tasks. Children were brought to a computer laboratory by camp supervisors. Because the camp group sizes differed, and because not all children had permission to participate in the study, the experimental group size varied from two to eight children. The children were seated individually, approximately 36 cm in front of an IBM-compatible computer screen. Dividers surrounding the individual work stations helped to minimize group effects as did instructing the children to be

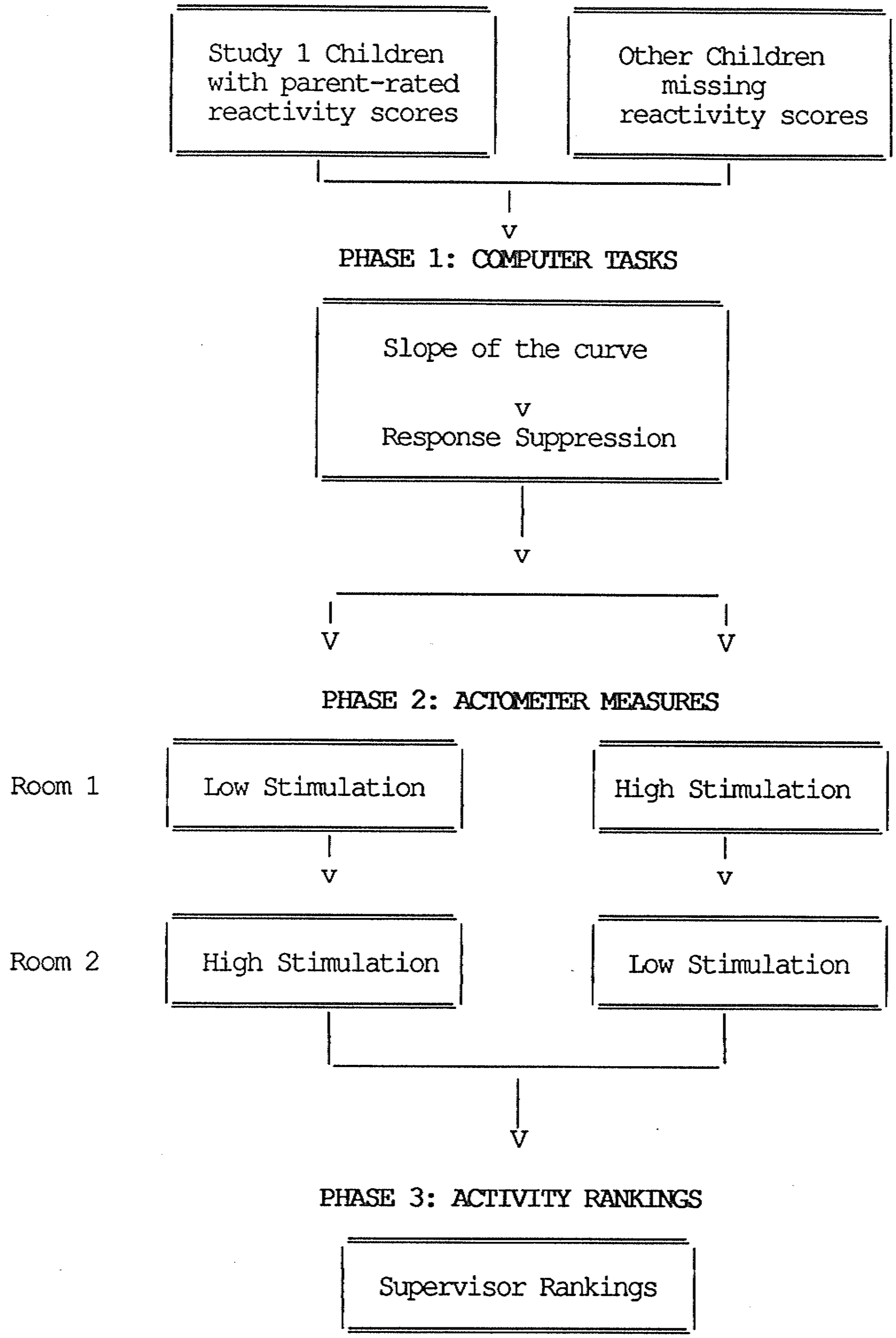

Figure 8. Chronological sequencing of research events.

as quiet as possible while in the computer room. To try to reduce arousal, children were told that the task was very easy and that itwould not begin until everyone understood what to do. The task was simplified by marking the space bar with three black stickers and the enter key with a red sticker. During the instructions for the task (Appendix F, part A), children could then be directed easily to the approriate keys.

The first task was a reaction-time task, which provided the reactivity measure in this study. Children were simply asked to press the space bar as soon as a square appeared on the screen. Before beginning the task, two practice trials were provided and children were instructed to wait quietly when finished the task (Appendix F, part B).

When all children had finished the RT task, the response-suppression task was administered. Children were told that now, on some occasions, along with the square, the word STOP would appear on the screen and that when this happened they should <u>not</u> press the space bar. During the computer tasks, the supervisors were asked to wait at the back of the laboratory. Including the instructions, demonstrations, and completion of the two tasks, the total time for phase 1 was approximately 20 mins.

<u>Phase 2</u>. After the computer tasks (see Figure 8), the children were escorted to another room by the camp supervisor and the researcher. The supervisor was asked to sit just outside the door and to record the names of children who had to leave the room

during the session. Half of the children were taken first to the low-stimulation room, and half, to the high-stimulation room. Prior to the session, a chart for recording activity (Appendix G) was prepared for each child. This involved filling in the child's name and recording the start readings for two actometers.

Upon entering this room, which is subsequently referred to as Room 1, each child was instructed to sit on the floor by his or her chart and asked not to touch the attached watches. Once seated, the children were told that they were to wear the "special watches." They were told that the watches did not really measure time, but rather movement, and they were then discouraged from shaking their arms and legs. Using Velcro fasteners, two actometers were strapped onto each child. One actometer was placed as a wristwatch would be, on the dominant wrist; the other was fastened on the lateral side of the opposite ankle. Once attached, the children were asked to try to forget that they were wearing the watches, and then they were told that they could play with any of the materials in the room.

At the end of a 15-min interval, a timer sounded to mark the end of the first play session. Children were again asked to form a circle and to remain seated while the researcher removed the watches. Children were allowed to play in the this room while an assistant recorded the end readings for Room 1 and the estimated start readings for the second play session. The start reading for the second play session was estimated by adding 4 AU's to the recorded end reading for Room 1. Four AU's were added because this was the average number of units that elapsed during the movement of the watches to the second room.

Children were next taken to the second room of alternative stimulative value, which is subsequently referred to as Room 2. In this room they were again asked to sit by their chart and the watches were again attached. After another 15-min play period, actometers were removed and clipped onto the child's chart. Each child was then individually taken aside, thanked for his or her participation, given a piece of bubble gum, and asked a question (see Appendix G) to determine whether he or she had perceived the differences between the two rooms. After the children left, the Room 2 session-end actometer readings were recorded.

Phase 3. The third phase of this study consisted of the supervisors' rankings of children's levels of activity. The supervisors were asked to rank, from the least to the most active, all of the children within their group. The rankings were to be based, not upon single observations of activity, but upon a more general perception of the children's typical levels of activity. Although there was no control over the conditions under which this task was completed, the supervisors were asked specifically to do this on one of the last two days of the camp. Rankings were requested from 24 supervisors and received from half of these.

Missing data. Scheduling difficulties precluded some children from participating in all parts of the Study 2. First, not all children participated in Phase 1 (i.e., the computer tasks). Those that did not, were brought directly from their usual events and entered Study 2 at the second phase. Second, not all children were assessed in the two separate rooms in Phase 2. Third, rankings in Phase 3 were provided only by a small number of supervisors. Because of missing data, the sample sizes for the various analyses in this study vary depending on the size of the particular subsample.

Restatement of Predictions

The predictions regarding the correlations among the various measures of reactivity and activity level were as follows:

1. Positive correlations were predicted for the Study 2 actometer (AL_ACT) and ranking (AL_RANK) scores and for each of these with the Study 1 parental AL rating (AL_RATE) score:

   $(r_{\text{AL\_ACT,AL\_RANK}} > 0)$;

   $(r_{\text{AL\_ACT,AL\_RATE}} > 0)$;

   $(r_{\text{AL\_RANK,AL\_RATE}} > 0)$.

2. The Study 2 slope of the curve (R_SLOPE) reactivity score was expected to relate positively to both the core (R_CORE) and the composite (R_COMP) reactivity ratings from Study 1:

   $(r_{\text{R\_CORE,R\_SLOPE}} > 0)$;

   $(r_{\text{R\_COMP,R\_SLOPE}} > 0)$.

The predicted negative relationship between reactivity and AL was tested by assessing the significance of correlations and/or the significance and direction of $\underline{t}$ statistics corresponding to $\underline{b}$ values from a regression analysis. The $\underline{t}$ statistics were again evaluated to consider the hypothesis regarding response suppression. Finally, the significance of the $\underline{F}$ statistic from a repeated measures ANOVA was examined to test the interaction between reactivity and environmental stimulation. These three sets of hypotheses are summarized as follows:

1. Study 2 activity measures (AL_RANK, AL_ACT) were expected to relate negatively to both parent-rated reactivity (R_RATE) and experimental slope of the curve reactivity (R_SLOPE) measures:
   ($\underline{r}$ AL_ACT,R_RATE < 0);
   ($\underline{r}$ AL_ACT,R_SLOPE < 0);
   ($\underline{t}$ AL_RANK,R_RATE < 0);
   ($\underline{r}$ AL_RANK,R_SLOPE < 0).

2. Children the least able to suppress a motor response (SUPPRESS) were expected to be the most active:
   ($\underline{t}$ SUPPRESS,AL_ACT) < 0).

3. Differences in activity (AL_ACT) across levels of environmental stimulation hES) were expected to relate to reactivity (REACT):
   [$\underline{F}$ AL_ACT(REACT*ES) > 0].

Results

The main analyses in this second study addressed the potential replication of the reported reactivity-activity relation from the first study and two issues underlying this linkage: (a) the plausibility of activity level as a regulator of internal state, and (b) the assessment of a relationship between motor activity level and motor response suppression. However, before reporting the results of these analyses, some information is provided on various measurement issues. Reported are the intermediate analyses for determining scores for the measures of reactivity and activity, followed, in each case, by reports of psychometric properties.

Measurement Issues

(SLOPE) reactivity score creation. Three steps were involved in creating the laboratory reactivity score, which is referred to as the slope of the curve, or the Nebylitsyn Index (Strelau, 1983). First, each subject responded six times to each of four stimulus intensity levels, thus a mean latency value was calculated for each of these four intensity levels. Only viable scores - those that were neither to fast nor too slow - were retained for further analyses. In keeping with prior conventions (Ulrich, & Stapf, 1984), very fast response latencies of less than 70 msecs, or very slow latencies of greater than 450 msecs were excluded. Very fast responses presumably indicate anticipatory responses, while slow responses likely reflect inattentiveness or a lack of motivation. For seven subjects, a mean for at least one intensity level could not be calculated because there were fewer than two viable latency scores. These seven subjects were excluded from further analyses because nonmissing values for all four means were required for the next step.

The second step involved the calculation of four ratios, one for each intensity level. Ratios, which were based upon the mean latency values were constructed using the following formula:

$$\frac{\text{mean RT to intensity level}_n}{\text{mean RT to highest intensity stimuli.}}$$

A nonstandardized estimate (i.e., b, from the simple regression equation y=a+bx) was then calculated for each of 160 subjects by conducting a regression analysis with ratio regressed on level of stimulus intensity. The resulting coefficient quantitatively reflects the slope of the subject's RT curve over stimulus intensity level. Low reactives are identified by a large negative coefficient that corresponds to a steep negative slope, and high reactives, by a small, but still negative coefficient that corresponds to a flatter negative slope. To be consistent with the parent-rating reactivity measures from Study 1, these coefficients were reversed so that high scores reflected high reactivity and low scores, low reactivity.

From the 160 regression coefficients, two outliers (i.e., extremely negative values) were first excluded. For 49 children, the reactivity profile was opposite to what is expected from the law of strength. That is, rather than a decrease in simple RT that occurs with increasing stimulus intensity (Strelau, 1983 p.86), an increase in simple RT was found. As a consequence, these scores could not be logically categorized as either high or low reactivity.

One possible explanation for the positive slopes found in this study is that they represent "transmarginal inhibition." Transmarginal inhibition refers to the lowering of the level of response under prolonged, repeated stimulation. Under monotonous conditions, high reactives are more prone to a greater reduction in the level of response to high intensity stimuli than are low reactives, Thus, a positive slope may be expected for high reactives. However, high reactives, as defined by their high scores on the parent-rating measure, were not found to be any more likely to have positive slopes than were low reactives. Of those children with positive slopes, 54% were low reactives and 46% were high reactives. Thus, transmarginal inhibition can not explain the positive slopes in this study.

Other possible reasons for differences between these children with a positive and negative slope were considered by examining correlations among slope (0=negative, 1=positive) and various other variables: age, sex, group size, peer familiarity, time of day, and fatigue level. No significant correlations were found, and reasons for this positive slope remain unclear. Because these subjects could not logically be classified as high or low reactives, they were excluded from further analyses.

Finally, a square root transformation was applied to the skewed distribution. As a result of this transformation, tests of mean differences become tests of median differences (Tabachnick & Fidell, 1983, p. 84). However, in this case, the median and mean in the transformed reactivity distribution were identical ($\underline{M}$ = -.28, $\underline{SD}$ = .13).

Test-retest reliability of SLOPE scores. Thirty-five children returned to the laboratory for a second reaction-time test. Two of these children were deleted from the reliability assessment because they did not have viable latency scores (i.e., scores between 70 and 450 msecs) in the initial session. A nonsignificant correlation for the remaining 33 children, $\underline{r}(33) = .05$, $\underline{p} > .05$, suggests instability in the slope of the curve across the test-retest interval.

Convergent validity: SLOPE and parent ratings. Despite the instability of the SLOPE measure, the SLOPE score was positively related to both parent-rated reactivity scores from Study 1. That is, the SLOPE measure was associated with the core reactivity score, $\underline{r}(51)=.30$, $\underline{p} < .05$, which consisted of revised behavioral items taken from Friedensberg and Strelau's (1982) teacher-rating scale and with the composite reactivity score, $\underline{r}(51)=.34$, $\underline{p} < .05$, which consisted of the core items plus related sensitivity items.

Summary of SLOPE measure. The convergent validity of the slope of the curve measure was only weakly supported by its correlation with the parent-rating reactivity measure. Test-retest data also indicated that there was no consistency over time in the SLOPE measure. Moreover, there was a preponderance of positive slopes, which are meaningless from the present theoretical perspective. Taken together, these findings threaten the viability of the SLOPE of the curve measure of reactivity.

Activity level score creation. Activity level scores were created for the two activity measures in this study - supervisor rankings and actometers. A supervisor-ranked AL score was derived using the rank order standardization procedure (see RANK procedure [SAS Institute], p. 649), which converts the rectangular distribution of a ranking to a normal distribution. Scores for all of the children in 12 of the camp groups were included in the initial rank order standardization procedure. The standardized rank scores for only those children who had permission to participate in the study (N = 54) ranged from -1.93 to 2.54 (M = -.05, SD = 1.04).

Of the 214 children who participated in the actometer phase of the study, data for one was dropped from further analyses because the arm actometer score in the Room 1 play setting was an extreme outlier. Seven other activity scores were deleted because of invalid scores for at least one of the limb scores. Invalid scores resulted when one limb reading was missing, or when the subtraction of the Room 2 reading from the Room 1 reading produced a negative value. Negative values were interpreted a misreadings, since the hands on the actometers move in a clockwise direction, and the reading from the second play setting should always be greater than the reading from the first.

Table 5 provides means and standard deviations for various actometer scores. Room 1 and Room 2 activity scores were the sums of the limb actometer scores within that particular room. The total activity score was the sum of all valid actometer readings for all limb scores across both rooms. Late arrivals at the experiment precluded the evaluation of many experimental groups in the second play session. Activity was assessed for 98 children[7] who had actometer readings for both rooms. Total activity scores were calculated only for these children having scores from both room, and were available for all but three of these children, each of who had an invalid activity score. Prior to analyses, a log transformation was applied to each of the available activity scores.

Actometers: interobserver reliability. Interobserver reliability was assessed using the adjusted actometer readings that were periodically taken by both assistants during the experiment. Because actometers had to be moved between the readers during this process, agreement was defined by readings that were within 2 secs of each other. Interrater reliability for the various actometer readers was assessed for these adjusted readings using the standard formula: agreements/agreements + disagreements x 100. As can be

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[7]In total, 99 children were assessed in both rooms; however, one child's data was deleted because the AL score was an extreme outlier.

Table 5

Descriptive Statistics for Actometer Scores Within and Across Rooms

Actometer measure	n	M	SD
Within Room 1			
Arm	208	226.64	122.50
Leg	206	445.77	240.44
Total Room 1	206	672.57	329.02
Within Room 2			
Arm	98	243.79	123.93
Leg	98	398.45	219.16
Total Room 2	98	642.24	306.76
Across Rooms			
Combined Arm scores	97	484.32	214.20
Combined Leg scores	95	923.53	407.32
Total activity score	95	1411.03	581.26

Note. Values presented are those calculated before the application of transformations. The combined limb scores included only those children who had two valid limb scores, one from each room. The total activity score included only those who had valid scores on all limb scores across both rooms.

seen from Table 6, the mean interrater reliability between pairs of raters was 82% with a range from 64% to 100%. Because each assistant was not paired with every other one, it was not possible to evaluate reliability for every pair of readers. Thus, while the reliability was generally high for those who were assessed, possible reader effects were further considered in an analysis described under the heading of reader effects.

Table 6

Interobserver Reliability for Seven Pairs of Actometer Readers

Pairs of Readers	Agreements	Disagreement	Reliability
A	8	0	100
B	3	1	75
C	9	5	64
D	8	2	80
E	20	3	87
F	11	3	79
G	19	3	86
Total	78	17	82

Actometer reliability/validity. On the final day of the study, an evaluation of the actometers was done using a procedure reported by Eaton, Mckeen, and Lam (1988). The instruments were strapped onto the racks of a Blue M Model MSB-1122A-1 Chemical Shaker. Uniform agitation of the racks provided a constant movement of 2.5 cm per oscillation, with an oscillation rate of approximately 245 cycles per min. The 30 actometer used throughtout the study were thereby exposed to identical amounts of movement. Three independent trials were conducted by activating the shaker for 5, 10, and 15 mins. Prior to, and following each trial, actometer times were recorded and these values were subjected to a 3 X 30 trials by actometer ANOVA.

The actometer validity, or sensitivity to amount of movement was confirmed by an expected trials effect, $F(2,58) = 694.35$, $p < .0005$. In other words, trials of longer duration resulted in higher AU units; the 15-min trial produced the highest mean number of AU units, followed by the 10 min trial and then the 5-min trial. The actometer reliability, or the interchangeability of the instruments was also confirmed by the expected nonsignificance of the actometer effect. Furthermore, the intraclass coefficient (Shrout & Fleiss, 1979), which provides an estimate of the correlation between measurements by different actometers was .97. Additional support for the reliability of actometers is suggested by the significant correlation among wrist and ankle actometer scores $r(206) = .60$, $p < .0001$ and among total Room 1 and Room 2 actometer scores $r(95) = .50$, $p < .0005$.

Convergent validity: actometers and subjective AL measures. Actometer readings have previously been found to be reliable and valid (e.g., Eaton, 1983; Eaton, et al. 1988); thus, they were compared to the other AL measures from Study 1. Specifically, the Room 1 AL scores (i.e., combined limb scores) from the first 15-min session and the Room 2 AL scores from the second 15-min play session were compared to the more subjective supervisor-ranked measure and to the parent-rated activity level measure. A significant positive relationship was found for the parent-rating and the Room 2 actometer measure, $r(52) = .30$, $p < .05$, but not for the parent rating and Room 1 actometer measure, $r(100) = .03$, $p = .79$. The Room 2 actometer measure also correlated more highly with the supervisor-ranking measure of activity, $r(11) = .34$, than did the Room 1 measure, $r(26) = .02$, although neither correlation was significant in this small sample. Half of the children who were ranked by instructors were not rated on activity by parents, and the correlation between these two subjective AL measures, $r(27) = .33$, $p < .10$, failed to reach significance in this small sample.

Replication of Reactivity-Activity Relationship

The first major concern in this study was the replicability of the reactivity-activity relationship. This analysis was initially performed using the slope of the curve (SLOPE) reactivity measure and subsequently, using the parent-rated (PARENT) reactivity measure from Study 1. Results from both analyses are presented.

<u>SLOPE reactivity and activity level</u>. Prior to assessing the replicability of the reactivity-activity linkage, correlations were examined to identify variables that may relate to the slope of the curve and thereby lead to misinterpretations. No significant correlations were found for slope of the curve with i) time of day, ii) fatigue level, iii) group size, iv) peer familiarity, v) age, or vi) sex. However, an ANOVA revealed a significant computer effect, $F(7,108) = 3.02$, $p < .005$ indicating that the slope of the curve scores varied across computers. The mean SLOPE scores across computers ranged from -.15 to -.42. Further exploration of this computer effect indicated that much of the variation was due to two of the eight computers. With the removal of data based on these two computers, the significant effect disappeared, $F(5,100) = 1.92$, $p > .05$. Fortunately, these two computers were used infrequently (i.e., only eight times) during the experiment, and further analyses of the SLOPE measure omitted their data. The mean SLOPE scores across the remaining computers ranged from -.23 to -.31.

To consider the replicability of the reactivity-activity linkage, the significance of the association between the SLOPE of the curve reactivity measure and each of the activity level measures was assessed. The slope of the curve was not significantly related to the any of the activity measures from

Study 1 or Study 2 [parent-rated activity, $r(49) = -.18$, $p = .22$; supervisor-ranked activity, $r(31) = .06$, $p = .75$, activity in Room 1, $r(96) = -.02$, $p = .86$, and activity in Room 2, $r(56) = -.19$, $p = .16$]. For this reason, the slope of the curve was abandoned in further explorations of the reactivity-activity analysis. Rather, further evaluation relied on the parent-rated reactivity measures from Study 1.

PARENT reactivity and supervisor-ranked activity. The replicability of the reactivity-activity link was next evaluated using the parent-rated reactivity and supervisor-ranked activity measures. The results for this analysis, which included only 27 children with both measures are shown in Table 7 and parallel those found in Study 1 for the parent-rated AL and reactivity ratings. Both the core and the composite reactivity measures predicted supervisor-ranked activity. Once again, children who were rated as more reactive were the least active. This finding, based upon independent measures of reactivity and activity, replicates the Study 1 results.

Table 7

Predictors of Supervisor-ranked Activity using Two Reactivity Scores in Two Separate Regression Models

Predictors	b	t	p
Model 1			
Age	0.15	2.48	.02
Sex	-1.15	-4.73	.00
Composite Reactivity	-2.47	-2.28	.04
Model 2			
Age	0.15	2.51	.02
Sex	-1.23	-5.24	.00
Core reactivity	-0.03	-2.80	.01

Unlike the consistency in the reactivity effect across Study 1 and the present analysis; age, although again being a significant predictor of activity, was related in a direction opposite to that found in Study 1. Older children were ranked by supervisors as more active than younger children. Sex effects, which were not significant in Study 1, did emerge in Study 2 with boys being ranked as more active than girls.

PARENT reactivity and actometer AL. A final test of the replicability of the reactivity-activity relationship involved the examination of parent-rated reactivity and actometer AL measures. Again, the direction and significance of correlations between these measures were examined. Actometer scores were negatively correlated with the parent-rated CORE reactivity score in the second play setting, $r(51) = -.36$, $p < .01$, once more confirming the negative association. The correlation in the first room, however, was not significant, $r(96) = -.08$, $p < .05$.

Activity as a Regulator of Internal State

As well as assessing the replicability of the reactivity-activity relationship, a main goal of Study 2 was to evaluate the plausibility of the role of activity as a regulator of internal state. Prior to this evaluation, preliminary analyses were conducted to consider four specific issues. First, a manipulation check was performed to ensure that children could perceive differences across stimulation levels. Second, assessments were made to examine the possibility of reader effects on activity scores. Third, an analysis was conducted to examine possible order effects. Finally, a comparison of the predictive ability of the core and composite reactivity measures was conducted.

Manipulation check. A manipulation check was performed by comparing the expected and observed frequencies of children who were able and unable to detect the manipulation. The viability of the environmental stimulation manipulation involved the analysis of responses to a question that asked which room had more things to see. A chi square statistic was calculated based upon the 99 children who were exposed to both stimulation conditions. It was predicted that the observed frequency of children recognizing the manipulation would differ significantly from chance. The observed frequency of those recognizing the manipulation (73/99) was significantly larger than would be expected by chance (i.e., by 50%), χ^2 (1, n = 99) = 22.1, $p < .001$; thus, the manipulation was assumed successful.

Reader effects. Interobserver reliability for actometer readers was substantial; however, reader effects were further assessed because not all pairs of readers were available for the interobserver reliability assessments. Activity units were calculated for each case where the same reader took both the initial and the end reading for a given room and where each assistant took a minimum of 5 readings. Data for two readers were removed from the analysis because there were 5 or fewer times when they took both beginning and end readings in a given room.

Separate ANOVA's were conducted for Room 1 and Room 2 actometer scores. Analyses tested for difference between readers' activity units on 72 readings for Room 1 and on 54 readings for Room 2. No reader effect was found in either Room 1 or Room 2 (F = 2.30, p = .07, F = 2.15, p = .11). Thus, reader effects were not included in further analyses.

Order effects. An analysis was conducted to consider the potential influence of order of stimulation level presentation on changes in activity. This analyses was performed for the 95 children who had valid actometer scores in both the rooms. Childrens' activity levels across the Low Stimulation (LS activity) and the High Stimulation (HS activity) Rooms were compared. LS activity and HS activity represent the sums of the limb scores within that level of stimulation. An interaction between order and environmental stimulation emerged, $F(1,93) = 7.09$, $p < .01$, suggesting that changes in activity over levels of environmental stimulation are related to the order of environmental stimulation presentation (see Table 8 and Figure 9).

To explore the significant interaction, the simple main effects were first tested according to the method described by Kirk (1982). Because this involves the calculation of numerous F values, the typical alpha of .05 was set at a more stringent level of .01 (i.e., alpha/2). As can be seen from Table 8, two of the simple-main effects were significant. First, the order in which the high-stimulation setting was experienced influenced activity. An

Table 8

Repeated Measures Analysis for the Effects of Order and Environmental Stimulation (ES) on Actometer Activity

Source	df	MS	F
Between Subjects			
Order	**1**	**0.481**	**6.26 ***
Error	93	0.077	
Within Subjects			
Environmental Stimulation (ES)	1	0.049	1.81
ES X Order	**1**	**0.192**	**7.09 ****
Order at LES	1	0.027	0.77
Order at HES	**1**	**0.650**	**12.33 ****
ES at Low-High	1	0.020	0.74
ES at High-Low	**1**	**0.213**	**7.88 ****
Error	93	0.027	

Note. LES = Low Environmental Stimulation, HES = High Environmental Stimulation.
* $p < .05$. ** $p < .01$.

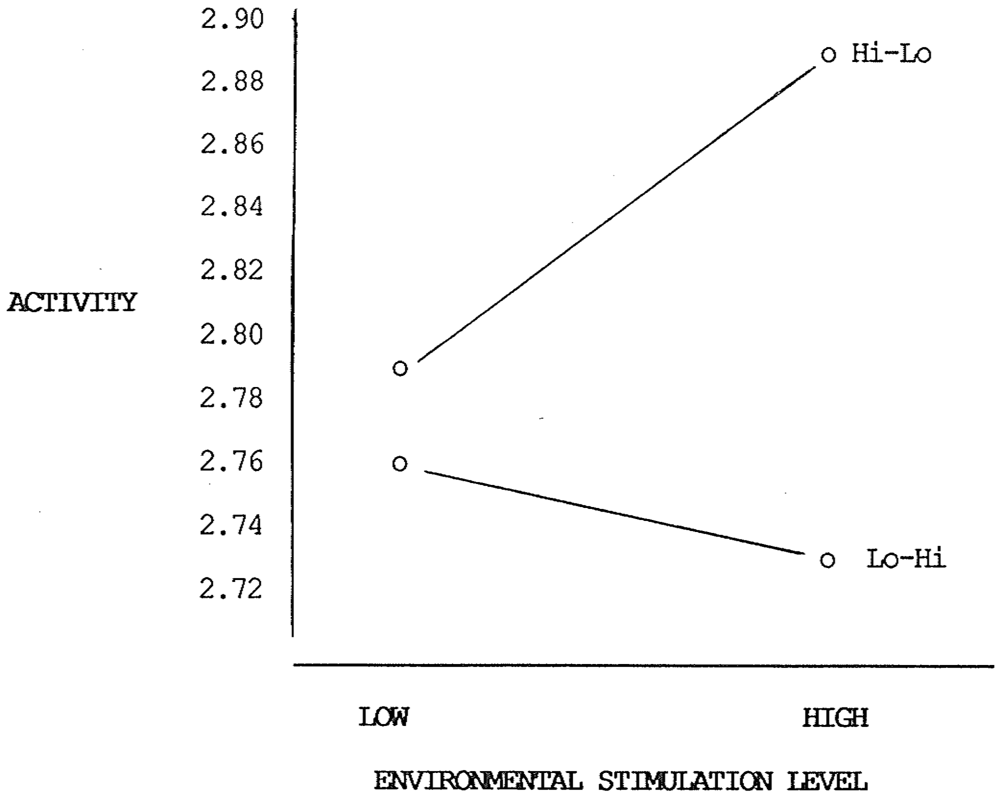

Figure 9. Order (high-before-low, low-before-high) by environmental stimulation (low, high) interaction for repeated actometer measures.

evaluation of the high stimulation settings only indicated that AL was significantly higher when the high stimulation was presented prior to, rather than following, the low stimulation. Second, a within-subject evaluation of only those children in the high-before-low stimulation condition indicated there was a significant decline in activity over high to low stimulation. This finding is opposite to what was expected and is further addressed in the discussion.

In addition to simple main effect tests, a Scheffe post hoc statistic was calculated to examine a relevant nonpairwise comparison. While Levin and Marascuilo (1973) discourage this approach, Tabachnick and Fidell (1983) suggest that, as long as conservative procedures are used and results are interpreted cautiously, it is appropriate to explore interactions in this way. In particular, AL differences were evaluated for Room 1 only, and activity was significantly higher when the level of stimulation was high, compared to low, $t(3,186)=2.86$, $p < .05$.

These findings indicate that, as expected, AL varied as a function of the level of environmental stimulation. However, they further imply that this association may be qualified by the order in which the stimulation level is experienced. As a consequence, further analyses were conducted separately for each order.

Choice of reactivity measure. The composite reactivity score explained more of the variance in parent-rated activity scores in Study 1 than did the core reactivity. However, the opposite was true in Study 2. In a stepwise regression, the core reactivity score entered first and explained 14% of the variance in the total activity score. Consequently, the core, instead of the composite parental reactivity score was used in the analysis of reactivity and changes in activity over levels of environmental stimulation. For the purpose of these subsequent analyses, the reactivity score was dichotomized using a median split procedure. High reactives were those with a score of 28 or above on the core reactivity measure; low reactives were those with a score of less than 28.

Summary of preliminary analyses. Based upon the preceding preliminary analyses, the following conclusions can be drawn. First, because AL was found to vary as a function of the order of stimulation presentation, further analyses were conducted separately for children who received low-before-high and those who received high-before-low stimulation. Second, because the parent-rated core reactivity score was superior to the composite reactivity score in predicting AL, further analyses were performed using the former. Third, the results in this study can not be attributed to children's inability to distinguish between the two levels of environmental stimulation. Finally, findings can not be attributed to systematic actometer reader errors.

Environmental stimulation, reactivity, and activity level. One of the main goals of this study was to explore the potential role of activity as a regulator of internal state. Indirect support for this notion would be gained by confirming the predicted interaction between environmental stimulation and reactivity on AL. This interaction was tested by performing a repeated measures analysis separately within each order of stimulation presentation (high-before-low, low-before-high). Activity level was expected to be influenced by a predicted interaction between environmental stimulation level (low,high), the within-subject variable and reactivity (low,high), the between-subject variable.

Only those children who had both a parent-rated core reactivity score and valid actometer scores in both rooms were included in this analysis. This resulted in a sample of 51 subjects. The mean age for the 22 children (10 girls, 12 boys) in the low-before-high order was just over 10 years, compared to approximately 9 1/2 years for the 29 children (12 girls, 17 boys) in the high-before-low condition. Means and standard deviations for the actometer scores for children in this analysis are presented in Table 9.

The predicted interaction effect between reactivity and environmental stimulation on activity was found, but only when the low stimulation preceded the high stimulation, $\underline{F}(1,20) = 5.21$, $\underline{p} < .05$ (see Table 10 and Figure 10). The meaning of the significant interaction between reactivity and environmental stimulation was first explored using tests of simple main effects (Kirk, 1982). These tests did not reveal any significant comparisons. However, the high reactives' decline in AL over environmental stimulation conditions approached significance, with AL being higher under low stimulation ($\underline{M} = 2.72$) than under high stimulation ($\underline{M} = 2.60$). This trend is consistent with the expected decline in AL for high reactives resorting to behavioral regulation. Also, in examining only the high-stimulation setting, low reactive children tended to be more active ($\underline{M} = 2.77$) than were the high reactive children ($\underline{M} = 2.60$).

Table 9

High and Low Reactives' Actometer Scores within each ORDER of Stimulation Presentation

Actometer measure	n	M	SD
Low-Before-High Stimulation			
Low Reactives			
Low Stimulation Room	12	2.70	.23
High Stimulation Room	12	2.77	.22
High Reactives			
Low Stimulation Room	10	2.72	.23
High Stimulation Room	10	2.62	.21
High-Before-Low Stimulation			
Low Reactives			
Low Stimulation Room	14	2.82	.23
High Stimulation Room	14	2.92	.25
High Reactives			
Low Stimulation Room	15	2.69	.20
High Stimulation Room	15	2.82	.23

Note. Values presented are those calculated before the application of transformations.

Table 10

Repeated Measures Analysis for the Effects of Reactivity and Environmental Stimulation (ES) on Actometer Activity

Source	df	MS	F
Between Subjects			
Reactivity	1	0.060	0.73
Error	20	0.083	
Within Subjects			
Environmental Stimulation (ES)	1	0.008	0.42
ES X Reactivity	**1**	**0.097**	**5.21 ***
ES for HR	1	0.077	4.14
ES for LR	1	0.026	1.40
Reactivity at LES	1	.004	0.08
Reactivity at HES	1	0.162	3.20
Error	20	0.018	

Note. LES = Low Environmental Stimulation, HES = High Environmental Stimulation.
* $p < .05$. ** $p < .01$.

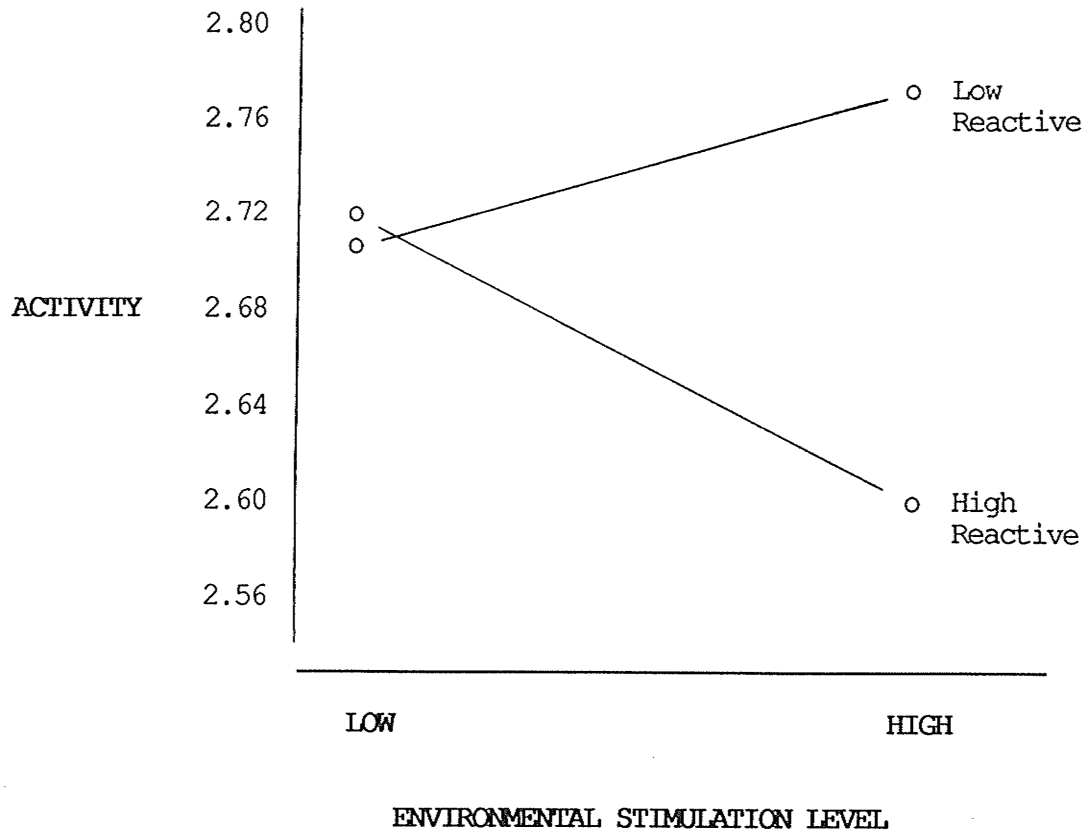

Figure 10. Reactivity by environmental stimulation interaction for repeated actometer measures in the low-high stimulation order.

Further probing of the interaction was conducted using Scheffe nonpairwise comparisons. A comparison involving a contrast of the difference between the high and low reactives' AL differences under conditions of high- versus low-stimulation level revealed that, while there was very little difference between high- and low-reactive children's AL under the initial low stimulation, there were significant differences under the second, high-stimulation setting. The variation in AL between high and low reactives was significantly greater under conditions of high compared to low stimulation, t (3,40) = 2.92, p = .05.[8], suggesting that the differences between high and low reactives' activity depended upon the level of stimulation (see Figure 10).

Potential confounding variables. Further analyses were undertaken to consider the possibility that the interaction between reactivity and environmental stimulation was due to various other confounding variables. First, a stepwise regression was conducted with several potential confounding variables entered as predictors of total actometer scores. Because arousal and fatigue likely increase over the day, time-of-day and fatigue seemed particularly likely to be associated with lower levels of activity later in the day. Also, age and sex, which were found to be related to other subjective activity measures were entered into the model, as were group size, peer familiarity, and experimental task composition. Experimental task composition (RT task, no RT task) and time of day (am, pm) were found to be significant predictors of activity level.

Covariate analysis. Experimental task composition and time of day were entered as covariates in a repeated measures ANCOVA along with the main classification variables of reactivity and environmental stimulation. For those children receiving low-before-high stimulation, the interaction between reactivity and environmental stimulation remained significant even after adjusting for time of day and experimental task composition. The similar

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[8]The critical t value for the nonpairwise comparisons was 2.92.

analysis for the children who received high-before-low stimulation revealed no effects for reactivity, stimulation, or the interaction.

Response Suppression

The final issue in Study 2 examined the notion of individual differences in response suppression. Individual differences in the ability to suppress action have implication for the ability to use activity suppression as a regulator of internal state. The goal of this evaluation was to assess the relation between differences in molar levels of activity and differences in the ability to suppress a fine motor response. This linkage was considered only after first conducting preliminary analyses.

Preliminary analyses. Because certain variables could not be experimentally controlled, an attempt was made to statistically control for variables that may have a confounding effect. To select the variables for inclusion as covariates, separate ANOVAs were conducted with each of the following as predictors of response suppression: (a) number of STOP trials [3-8], (b) computer number [1-8] (c) age [5-12], (d) group size [1-4, 5-8], (e) fatigue level, (f) time of day [am,pm], (g) peer familiarity and (h) sex [female, male]. The number of STOP trials, age, fatigue level, and peer familiarity were significantly related to response suppression (see Table 11), while other variables were not. The number of STOP trials, fatigue level, age and peer familiarity were controlled for in the subsequent final analysis, which is described following a comment regarding these covariates.

An evaluation of the intercorrelations indicated that control over suppression of motor responses related positively to the number of STOP trials and fatigue level and negatively to age and peer familiarity. Not surprisingly, the ability to suppress a motor response increased with practice at suppressing the response. However, the increase in response suppression with increasing fatigue and decreasing age was rather surprising. These unexpected findings may be a byproduct of poorer attention during the task, both for children who were more fatigued and younger. Inattention during the task could have resulted in the lack of a response on STOP trials, and this would be classified as an instance of response suppression. Finally, a negative link between response suppression and peer familiarity could also be explained by inattentiveness on the task. If the presence of unfamiliar peers reduced distractions, such as instances of talking, then attentiveness could be enhanced by the presence of unfamiliar peers. In other words, children tested with familiar peers, may have appeared less able to suppress a motor response than were those tested with unfamiliar peers because the former were more distracted and less attentive during the task.

Table 11

Analysis of Variance F Values for Predictors of Response Suppression

Predictor	F
Stop trials	**2.83 ***
Computer number	0.51
Age	**3.17 ****
Group size	2.10
Fatigue level	**5.34 ****
Time of day	0.06
Peer familiarity	**2.46 ***
Sex	0.65

Note. The F values are taken from separate ANOVA models where variables were entered as predictors of response suppression.
* $p < .05$. ** $p < .001$.

Response suppression and activity level. Each of the selected covariates (age, number of STOP trials, fatigue level, and peer familiarity) were entered - along with response suppression - into a regression analysis predicting total activity. Response suppression was a significant negative predictor of actometer activity level, $t = 1.20$, $p < .05$, even after the covariate adjustments. However, the independent variables were interrelated, and an evaluation of the collinearity diagnostics revealed that there was a problem of multicollinearity. Therefore, separate models were constructed to examine separately each covariate in combination with the response suppression as predictors of AL.

The results from these analyses (see Table 12) indicate that, even after holding constant the effect of each covariate, the ability to suppress a motor response was a significant predictor of activity in both Room 1 and Room 2. As predicted, the children who had the most difficulty inhibiting motor responses on the computerized task were the more active children in the experimental sessions. However, while the predicted negative relationship between response suppression and activity did emerge in the experimental setting with an objective measure of activity, there was no relationship between response suppression and parent-rated activity, $\underline{r}$ (78) = -.01, $\underline{p}$ = .91.

Table 12

Regression Models for the Suppression of Motor Response as a Predictor of Room 1 and Room 2 Activity Level

Predictors	b	t
Room 1 Activity		
1. Number of Stop trials	0.007	0.443
Response Suppression	-0.002	-2.438 *
2. Age	0.007	0.631
Response Suppression	-0.002	-2.177 *
3. Fatigue Level	-0.007	-0.607
Response Suppression	-0.002	-2.346 *
4. Peer Familiarity	0.005	0.756
Response Suppression	-0.002	-2.461 *
Room 2 Activity		
1. Number of Stop trials	0.014	0.740
Response Suppression	-0.002	-2.231 *
2. Age	0.008	0.493
Response Suppression	-0.002	-2.009 *
3. Fatigue Level	0.010	-0.795
Response Suppression	-0.002	-2.110 *
4. Peer Familiarity	0.018	1.695
Response Suppression	-0.003	-2.427 *

DISCUSSION

This research provides support for a negative relation between reactivity and motor activity level in children. This finding first emerged in Study 1 with parent-rated measures of reactivity and activity and was further replicated in Study 2.

Replication of the Reactivity-Activity Relationship

The Study 1 ratings of reactivity and activity were provided by the same individual in Study 1; thus, the association could have been due to bias in the parents' ratings. However, the replication of this finding using other independent activity measures in Study 2 confirms the relationship. Children who were rated by their parents as the least reactive were ranked by their supervisors as the most active and were the most active on an objective actometer measure. This negative relationship was found in the home and in both a natural and an experimental peer-group setting, indicating that the association persists across different settings.

In addition to establishing a negative relation between reactivity and activity, other results provide further insight into this linkage between reactivity and activity. First, environmental stimulation was found to be important. Under some conditions, AL differences between low and high reactives were found to vary depending on the level of environmental stimulation. Second, partial support was found for the possibility that some children may be less able than others to suppress their activity levels.

Environmental Stimulation

Differences in activity patterns for high and low reactives were anticipated because the high stimulation in the present study was assumed to be sufficient to push the highly reactive child's internal arousal beyond an optimal level, while having little effect on the low reactive child's. This assumption led to the prediction of an interaction between reactivity and environmental stimulation (ES) level, a prediction that was partly confirmed. When activity level was assessed across an initial low- and then a second, high-stimulation play setting, the predicted interaction between environmental stimulation and reactivity emerged. This interaction persisted even after covarying the effects of time of day and prior exposure to the computer task. AL differences between high- and low-reactive children were found to be greater under conditions of high than under low stimulation, with low reactive children tending to be more active under high stimulation than were the high reactive children. Moreover, a marginally significant declining pattern of AL across the low- to high-stimulation play setting was evidenced for high reactives. Taken together, these findings are consistent with the notion that activity suppression operates to dampen internal arousal for high reactives.

The present results are also consistent with two related expectations. First, the results support the idea that the present levels of high stimulation were not extreme enough to "push" the low reactives' arousal to an above-optimal level. Second, the notion that low reactives failed to resort to behavioral regulation of internal state was supported. After covarying the effects of time of day and prior exposure to the computer task, low reactives expressed similar levels of activity across the low- to high-stimulation conditions. This supports the notion that, due to a wide optimal "band" of arousal (Eliasz, 1987), small changes in stimulation level have little influence on the low-reactive child.

Implications of environmental stimulation findings. The finding that low and high reactives respond differently to varying levels of environmental stimulation has practical implications. For example, if activity differs for high and low reactives under varying levels of environmental stimulation, this would suggest the value of matching children to environments commensurate with their reactivity or temperament. A recent review of the day-care crisis in America (Zigler & Ennis, 1989) acknowledges that certain children may be overwhelmed by overstimulating day-care settings. The matching of temperament and environments could have broad application in the construction of child-care environments and in the resulting impact on social development and emotional well-being. For example, the reduction of stimulation level could facilitate social exchanges and enhance psychological well-being by minimizing the unpleasant internal overarousal typical of the highly-reactive child.

On the other hand, stimulation is a part of life that is often unavoidable, and sheltering children from its consequences may be a mistake. It may be adaptable for highly reactive children to learn to cope with high levels of stimulation. Highly reactive children could benefit by a gradual introduction to high stimulation. Assessments of these issues can only be addressed using a longitudinal analysis.

Activity level differences through life likely predispose individuals to a more active or passive lifestyle, and these lifestyle differences may influence physical fitness, which is critical for the delay of certain aging processes (Ostrow, 1984). If temperament differences in reactivity underlie individual differences in activity level, then a consideration of reactivity may also have application to the development of living environments and the design of programs for the elderly. For example, considerations of both individual differences in reactivity and environmental features may be essential in the development of fitness programs for the elderly. In contrast to the typical highly stimulating fitness setting, a quiet, relaxing atmosphere with limited environmental stimulation may promote greater activity for highly reactive elderly people.

Limitations. While activity suppression was expected for the high reactives under high, compared to low stimulation, a decline was found only for children experiencing the low prior to the high stimulation, and this trend only approached significance. There are a number of reasons to expect that the present evaluation underestimated the strength of the decline for high reactives. First, the small sample and corresponding low power in this analysis reduced the chances of finding an effect. Second, the level of "high-stimulation" may have been insufficient to motivate the high reactive to resort to behavioral regulation of the internal state. The fact that 25% of all children did not recognize the manipulation may suggest that the high-stimulation level was rather weak. On the other hand, children's failures to report differences across the rooms could have been a reflection of the type of question asked. For example, children were asked about differences in the visual features of the room, but not about the auditory features. It is possible that, if asked, a higher percentage of children would have reported differences in the auditory features. Finally, social influence from other children in the group may have promoted more activity in the high reactive, thereby contributing to the nonsignificant decline in AL. Because high reactives are more easily "steered" (Eliasz, 1980) or influenced by others than are low reactives, attempts by the low-reactive child to engage the high-reactive child in energetic activities could have contributed to a higher than expected level of activity for the high reactives.

The present examination of changes over levels of environmental stimulation was based upon very brief exposure to stimulation, and chronic exposure may provide much clearer evidence of the regulatory role of activity. Results from Koester and Farley's (1982) longitudinal study of open and traditional classrooms, while correlational, provided supportive evidence for the notion of behavioral regulation of internal stimulation. Over time, they found patterns of decreasing sensation seeking in the open, more stimulating classrooms and patterns of increasing sensation seeking in the traditional, less stimulating classrooms. With longer exposures to high stimulation, it is possible both that the high reactives' decline in motor activity would be significant and that reduced activity would also occur for low reactives.

<u>Individual Differences in Motor Response Suppression</u>

The results from this study may also imply that individual differences in response suppression are relevant to the reactivity-activity association. A predicted negative relationship between ability to suppress a motor response on the computerized task and motor activity level in the play setting was confirmed. Children who were most able to suppress motor responses were the least active in the play setting.

Some common underlying inhibitory process may influence the ability to suppress both motor responses and gross motor activity levels. Furthermore, such a process could lead to individual differences in the capacity to use reduction of motor activity as a means of regulating and controlling internal arousal levels. Some children (low motor-inhibitors) may be unable to regulate internal state by reducing overall levels of motor activity, and others (high motor-inhibitors), may be more successful in regulating internal state by reducing motor activity. If the more active children lack the inhibitory processes that allow for the suppression of activity, this could mean either that they are unable to regulate above-optimal internal activation, or, that they use avenues other than activity reduction to regulate internal state. Such individual differences in the ability to suppress activity could attenuate the relation between reactivity and activity. For example, the magnitude of the negative correlation would be reduced by higher than expected levels of activity for highly reactive children who have a low capacity to suppress activity.

Attempts to regulate the internal state by modifying levels of activity may be mediated by many factors. Individual differences in the ability to suppress motor activity are identified as one potential mediator of this relationship, but may others likely operate. Findings from the present research further suggest that the sequencing of environmental stimulation may influence AL, which would have consequences for the strength of the reactivity-activity link.

<u>Sequencing of Stimulation and the Reactivity-AL Link</u>

Three perplexing findings arose with respect to the order or sequencing of stimulation presentation. First, the magnitude of the activity level differences under high stimulation depended on the order of stimulation presentation. In general, under high stimulation, children were more active when the high stimulation was presented prior to, rather than following, the low stimulation. Second, in the analysis of order effects, children in the high-before-low stimulation condition had higher AL under the high stimulation setting, which is opposite to the theoretically derived predictions of lower AL under high levels of stimulation. Third, AL was not influenced by the predicted interaction between reactivity and environmental stimulation for children in the high-before-low condition.

Together, these finding suggest that the presentation of high stimulation prior to low stimulation produces a pattern of results that is inconsistent with the predictions in the present study. An explanation for these findings is unclear, but several potentially important factor are discussed. First, novelty of the setting; second, setting cues other than environmental stimulation; and third, the process of transmarginal inhibition may be operating to influence the pattern of AL when high stimulation precedes low stimulation.

Novelty of the setting. The novelty of the setting may have contributed to the unexpected findings in this study. Novelty, according to Berlyne's (1970), is one of the arousal-producing properties of a stimulus. If novelty produces arousal, children's arousal levels should have been at a maximum in the high stimulation setting when the setting was also novel (Room 1) compared to when it was more familiar environment (Room 2).

Furthermore, if a depression in behavior is thought to accompany arousal, it would be expected that activity would be at it's lowest when high stimulation was paired with novelty.

However, the results in the present study are incongruent with an arousal-producing or activity-suppressing view of novelty. When high stimulation was paired with novelty, children were <u>more</u> active than when high stimulation was paired with familiarity. Also, when high stimulation was paired with novelty, as it was in the high-before-low condition, activity was found to be <u>higher</u> under the high, compared to low, stimulation. Moreover, an analysis of Room 1, or the novel setting only revealed that activity was <u>higher</u> when the level of stimulation was high, compared to low. Thus, a simple novelty-inhibiting effect would not explain the AL differences in this study.

On the other hand, novelty may have an enhancing effect on behavior. The novelty of the situation may lead to a "flurry of activity" that eventually wears off as the situation becomes more familiar. Separate analysis of children exposed to a different orders of stimulation presentation, indicated that, although AL was higher in the first room for those exposed to high-before-low stimulation, this was not the case for children exposed to low-before-high stimulation. Thus, an simple novelty-enhancing effect is also inconsistent with the present findings.

While simple novelty effects are inconsistent with the present findings, novelty could interact in some way with environmental stimulation such that the combination of high stimulation and novelty reduces the likelihood of activity being used as a regulator of internal state. For example, there may be some cognitive blocking process that operates to reduce the effects of high stimulation under novel conditions. In this case, behavioral regulation would be unlikely in the first high-stimulation setting.

Novelty may further influence the awareness of stimulation, which may have contributed to the present unexpected findings. For example, the awareness, or processing of high stimulation may be impeded by novelty. Moreover, the role of novelty may differ for high and low reactives. For example, the impact of novelty could be relatively stronger for high than for low reactives and, could thereby override the influence of environmental stimulation. The nonsignificant interaction between reactivity and environmental stimulation in the high-before-low order could stem from a failure by the high reactives to perceive environmental cues when a high stimulation was immediately encountered in a novel setting. In other words, under these conditions, high reactives may not have been immediately "tuned in" to the features of the environment, that upon recognition, cause internal disequilibrium and behavioral regulation.

If the impact of novelty is relatively stronger for high than for low reactives and if novelty initially overrides the influence of environmental stimulation, then activity differences between the high and low reactives in the initial setting may have been attenuated. In particular, if high reactives failed to perceive or process high stimulation in the initial novel setting, their activity in this setting might be higher than expected, and this would mask the differences in the AL pattern for high and low reactives across the initial high- and subsequent low-stimulation conditions. While highly speculative, such factors or processes could have contributed to the similarity in high- and low-reactive children's activity patterns in the high-before-low condition. This could explain the failure to find the predicted interaction between environmental stimulation and reactivity on AL in the high-before-low condition.

This reasoning implies that, for the level of environmental stimulation to enhance internal activation, the stimulation must be perceived, and not simply present. The hypothetical process (Matysiak, 1980) which transforms the intensity of the external stimulus into its internal form (i.e., the process of reducing or augmenting) may not operate in isolation, but, in tandem with other variables, like the awareness of the environment. If the failure to cognitively register high levels of external stimulation actually operates to maintain optimal levels of arousal, cognitive regulation may operate along with behavioral regulation of internal arousal. That is, internal arousal may be dampened by volitional or automatic cognitive "blocking," In other words, under some conditions, high reactives may be capable of ignoring high environmental stimulation, which would further imply that high reactives may be able to learn to cope with stimulation overload by blocking the stimulation.

Whether or not novelty and temperament interact to mediate the perception of environmental stimulation remains to be tested. High and low reactives have, however, been found to differ in their perceptions of social content. For example, Eliasz (1987) reported that high reactives both send and receive nonverbal messages better than do low reactives. On the other hand, reactivity does not relate to Mehrabian's Stimulus Screening scale, nor does it relate to desire for novelty (Kohn, 1985). Thus, differential "novelty-producing interference" by high and low reactives remains a speculative explanation for the generally high activity in the first, highly stimulating setting and for the lack of interaction between reactivity and environmental stimulation in the high-before-low order.

Setting cues. Some activity-enhancing process operating in Room 1 - when it was highly stimulating - would be necessary to explain the present order of stimulation findings. It may be that in a novel, highly stimulating setting, activity is under the control of setting cues other than the level of environmental stimulation. For example, the initial high-stimulation setting, which included loud music and colorful streamers, may have elicited usual behaviors associated with a "party-like" atmosphere. In contrast, when the first play setting had low stimulation, it may have been perceived more like the typical classroom, and this may have elicited behavior in accordance with a classroom setting.

Transmarginal inhibition. Transmarginal inhibition is a final factor that may have increased activity in the first highly stimulating, novel setting. Transmarginal inhibition, which leads to dissipation of responses, would be reflected by the dissipation of behavioral regulation, or, by higher levels of activity. In the present research, high stimulation in the first, novel setting may have actually produced extreme stimulation, which according to Strelau (1983), leads to transmarginal inhibition. Transmarginal inhibition then, may have operated to increase AL in the setting that had extremely high stimulation (i.e., high environmental stimulation and novelty). This could explain higher AL when high stimulation was encountered in Room 1, the novel setting compared to when it when it was encoutered in Room 2, the more familiar settings.

The findings of high levels of activity under high stimulation are congruent with the notion of transmarginal inhibition. Moreover, transmarginal inhibition could explain why AL for children in the high-before-low stimulation condition was not influenced by an interaction between reactivity and environmental stimulation level. By virtue of their low endurance for stimulation, high reactives presumably succumb to transmarginal inhibition at lower levels of stimulation than do low reactives. Since transmarginal inhibition would lead to a higher level of activity, a greater degree of transmarginal inhibition by high than by low reactives in the first highly stimulating condition would lead to higher than expected levels of activity for the high reactive. Because this would result in more similar levels of activity than expected for high and low reactives, the strength of an interaction between reactivity and environmental stimulation would be attenuated.

Measurement Issues

Factors that mediate the potential for motor activity as a behavioral regulator of internal state may in turn help to explain another unanticipated finding in this research.

Activity level. The lack of association between the Room 1 actometer measure of activity and other subjective AL measures (i.e., parental ratings and supervisor rankings) could be due to factors that operated only in the first room. For example, children may not necessarily express their typical level of activity in a novel setting with access to new toys. This view would be supported by Kagan et al's (1986) work on behavioral inhibition, which would suggest that individual differences in responses to novelty or unfamiliarity (Kagan et al. 1986) may have operated in the first, but not in the second play setting. Although novelty effects in the first room may have produced atypical activity, the activity measures in Room 2 did relate significantly to parent ratings of AL from Study 1, suggesting that

Room 2 activity was more representative of the child's typical level of activity.

While lower than expected, the magnitude of correlations among activity measures do suggest that the measures are tapping some similar notion of energy expenditure. The lower than expected associations between the measures of activity across these studies may indicate that activity can vary considerably as a function of setting features, some of which have been identified in this research (e.g., environmental stimulation, time of day, and prior exposure to the RT task). The presses that operate within the experimental peer-group setting and those that operate within the home environment are clearly different, and activity within the home may be more representative of the child's customary level of energy expenditure.

Alternatively, differences in the measurement techniques may have reduced the magnitude of associations between activity measures. For example, different definition of activity employed by parents and supervisors or unreliability in the supervisor rankings may have contributed to the low associations between this measure and the other AL measures. The supervisors' two-week exposure to the children may not have qualified them as accurate judges of children's typical levels of activity. Conclusions regarding the supervisor ranking measure are restricted because reliability assessments were not possible; however, the analyses of actometer measurements provides strong evidence of instrument reliability, which is consistent with past reports (e.g., Eaton et al., 1988).

Reactivity. The association between the parent-rated reactivity and the laboratory slope of the curve measure was higher than has been found in a previous comparison (Kohn et al., 1987). This, however, could be due to differences across studies in the reactivity measures or in the populations assessed. In the present analysis of children, the SLOPE measure was significantly related to the core reactivity score ($r=.30$), which was based upon modified items from Friedensberg and Strelau's teacher rating scale and to the composite reactivity score ($r=.34$), which included these and other related domain-specific sensitivity items. Moreover, the psychometric properties of the subjective reactivity measures were generally acceptable, which supports the notion that parents, like teachers, are capable of assessing reactivity in their children.

It is likely more difficult for parents to rate their children on sensory sensitivity than on dimensions of activity and task- or social-distress. Parental ability to rate these latter characteristics seems more viable because ratings are based upon overt behaviors. Low correlations among sensitivity subsets and reactivity could be due to inaccuracy in parents' judgments of their children's sensitivity. The alpha coefficients and item-whole correlations were lower than expected for these domain-specific subsets which may indicate a problem with the reliability of parental ratings of child sensitivity. On the other hand, increasing the number of questionnaire items within each grouping could provide more reliable measures of domain-specific sensitivity. It would also be valuable to examine the validity of parent ratings by comparing parental ratings of child sensitivity to more objective measures of sensory sensitivity.

The question as to which reactivity index - the core or the composite - is better, remains unresolved. In the first study, the composite score explained more of the variance in predicting activity than did the core score; however, the reverse was true in the second study. Some sensitivity items do seem to relate with Friedensberg and Strelau's behavioral items, implying that their inclusion may add an important dimension to the measurement of reactivity. In particular, tactile and auditory sensitivity may be important in the diagnosis of reactivity.

The significant association found in Study 1 between parent-rated reactivity and auditory sensitivity may further imply that auditory assessments of SLOPE reactivity measures may be more appropriate than are visual assessments. The magnitude of the association between the SLOPE and the subjective reactivity measures may be stronger when auditory rather than visual stimulation is used. On the other hand, Kohn et al's. (1987) comparison of adults' subjective reactivity scores and SLOPE measures does not support this conclusion. With adults, auditory stimulation does not appear to be any more strongly related to reactivity than does visual stimulation.

A conclusive remark on the appropriateness of the reaction-time measure is difficult. A significant, but weak, association between the laboratory RT method and the parent-rating method of diagnosing reactivity suggests that both measures are tapping part of some underlying construct. Despite this correspondence however, there was a lack of association between the slope of the curve reactivity measure and the activity measures. Moreover, instability over time on the SLOPE measure indicates that this method of diagnosing reactivity may be unreliable, any this may imply that the SLOPE measure is an inappropriate method for detecting stable individual differences in children's reactivity. On the other hand, the reported unreliability of the measure may be a reflection of influences, such as boredom with the task during the retest session, or other uncontrolled variables (time of day, duration between test and retest sessions, computer effects) in the experimental session. The sighing and fidgeting during retest sessions did indicate that boredom may have influenced the retest responses, and reliability may be enhanced by improving the conditions under which children are tested.

Even if the SLOPE measure was found to be reliable, its inability to predict behavior would seem to limit its applicability to assessments of behavior and temperament. Although the relationships between the SLOPE and activity measures were nonsignificant, they were generally in the predicted negative direction, and the low associations in this study may have been due to unforseen difficulties in the current RT procedure. For example, inattention may have increased the error variance for this slope of the curve measure, and would imply that the real association between the present parent-rated reactivity measures and the laboratory slope of the curve measure may be stronger than reported. A measure of attentiveness on the task would allow for an analysis of only those children who were attending.

A final note should be made about the preponderance of positive curves resulting from the RT measure. These positive RT slopes are inconsistent with past evidence of how people respond to varying intensity levels (Strelau, 1983), and they may further suggest a problem on the task. The inability in the present study to isolate differences between children with positive and negative curves leaves open the obvious possibility that inattentiveness on the task contributed to the unanticipated positive curves. Again, this underscores the need to assess attention to the task when examining children's responses to such a task. Because the slope of the curve measurement of reactivity has been restricted to adult populations, little is known about how children's reactions may differ.

Response suppression. Attentiveness on the computer task was also a concern with the response-suppression measure, although this measure proved to be very useful in the diagnosis of individual differences. During the performance of the task, some children appeared not to attend to the task. For these children, the lack of response on STOP trials would have been calculated as instances of motor suppression rather than as instances of inattentiveness, which could explain a rather counterintuitive relationship between age and motor-response suppression. That is, younger children's higher ability to "suppress" responses may have reflected their inattentiveness. Errors due to attention-related miscodings would attenuate the relationship between motor-response suppression and motor activity, and improvements in this respect may lead to even stronger associations. It seems particularly likely that over-estimates of response suppression may have occurred for the highly active children because these are the children who are also likely to be more inattentive. If this were so, the relationship between activity and suppression of response would clearly be attenuated.

The association between the motor response suppression and activity was restricted to the measure of activity in the free-play laboratory setting. While children who were the least active in the laboratory setting also had the least difficulty inhibiting motor responses, no association was found for response suppression and activity, as measured by parents in the home. Children may generally be more active in the home than in a novel experimental setting, and thus, suppression of activity should be more likely in the experimental setting. This proposition also fits with the notion of behavioral inhibition in an unfamiliar environment and could help to explain why lower levels of activity in the experimental setting were more likely to relate to response suppression. Alternatively, the temporal proximity of the response suppression and the actometer measures may have also contributed to the significance of the relationship.

Other Findings

A comment should be made regarding the discrepancies across studies for relationships between activity level and both sex and age.

Sex effects. Consistent with past research (Eaton & Enns, 1986), boys were ranked by supervisors as more active than girls. This difference was quite large as demonstrated by the mean effect size in standard deviation units. The mean AL for boys was 2.07 standard deviations above the mean AL for girls. In contrast, significant sex effects were not evident for parent ratings or for either of the two actometer measures. Using these measures, boys were still more active than girls, but standard deviation effect sizes were generally small. Standard deviation effect sizes ranged from .12 for the parental ratings, to .15 for the Room 1 actometer scores, to .30 for the Room 2 actometer scores.

The strong sex effect in the camp supervisor rankings is somewhat perplexing. Most reports of behavioral problems in the camp apparently involved boys, and it may be that boys engaged in more rough play than girls. Such behavior may actually encompass high levels of motor activity, or it may be perceived by an observer as encompassing more activity.

Age effects. Study 1 found the expected decline in activity with age; but, Study 2 found the AL-age association to be opposite in direction: Activity, as ranked by supervisors increased with age. This unexpected positive association for age and AL in the camp setting may represent differences between younger and older children in their attempts to please the camp supervisors. In this study, the younger children seemed more likely than the older children to try to please the supervisors, which could translate into less activity.

Summary and Conclusions

This research provides some interesting findings, while at the same time raising some critical questions and highlighting some important methodological considerations for future research.

Future research questions. The present work identifies a number of questions and hypotheses regarding potential factors that could mediate the role of activity as a regulator of internal state. Two questions seem particularly worthy of investigation. First, are children who have difficulty inhibiting motor responses unable to regulate high levels of internal arousal by reducing their levels of motor activity? This question could be further explored by comparing activity for high and for low reactives who were also identified as either high or low motor inhibitors.

Second, does the order of stimulation influence the high-reactive child's likelihood of resorting to behavioral regulation of internal state; and if so, why? One line of speculation presented in this research is that, when confronted first with a highly stimulating setting, high reactives' use of behavioral regulation is impeded by novelty which disrupts awareness of environmental stimulation. Direct examination of awareness of environmental stimulation in novel/familiar settings and of the correponding behavior changes would assess the viability of this hypothesis.

Methodological concerns. Methodological concerns for future assessments of children's reaction time include a careful analysis of attention to the task. Likewise, an assessment of attention during the response suppression is critical. Another important issue, both methodologically and substantively, involves the peer-group setting and the potential influence of the low reactives' AL on the high reactive. Problems of interpretation arise if the low-reactive child's activity influences the high-reactive child's, and this seems likely since high reactives are more conforming. In the present study, this social influence could have contributed to the weaker than expected magnitude of the hypothesized reduction in activity by high reactives. This issue could be directly assessed by comparing patterns of AL change for high-reactive children alone, and in dyads or larger groups that consist of either high or low reactives.

A final and critical methodological concern involves the interpretation of the effects of environmental stimulation manipulations. A problem that plagues all such investigations occurs because of the presumed individual differences in how much stimulation is needed to enhance internal arousal to an above-optimal level. Such individual differences obviously mean that any constant effect for a given stimulation manipulation can not be assumed across subjects. One approach to improving the precision of stimulation manipulations would be to pretest individuals and determine a baseline level of stimulation that is believed to create above- or below-optimal arousal levels. Then, in evaluations, specific predictions could be made about the conditions under which expected behavior changes should occur. Such methods would provide meaningful and interpretable manipulations.

Conclusion. The findings in this research lend strong support for the existence of a negative relation between reactivity and motor activity level. The negative reactivity-activity association emerged in different settings and with both subjective and objective measures of AL. The present results also suggest that, in some cases, changes in environmental stimulation are responded to differently by high and low reactive children. The consistency of this finding with research in other domains, such as, motor proficiency (Grodner, cited in Strelau, 1983) suggests that the environmental stimulation-reactivity interaction can be extended to another domain, motor activity.

Further evaluations of the regulatory role of activity are required to clarify the status of activity as a regulator of internal state. While the decline in activity for high reactives across low-to-high stimulation only approached significance in this study, it does seem possible that the significance of this pattern could be established by employing larger samples and higher stimulation levels. Future evaluations would benefit by examining individual differences in the ability to suppress activity, differences which may have serious implications for the ability to use activity reduction in the regulation of internal state. Moreover, as highlighted by the present work, it is necessity to consider other possible mediating factors in behavioral regulation, such as the effects of novelty.

To the extent that activity is related to internal state, individual difference in activity level may reflect an ongoing interplay between temperament (reactivity) and environmental factors. The findings in this study support the notion that the internal state, which is presumably influenced by temperament differences in reactivity is also jointly determined by transitory environmental features. This is suggested by the finding that activity differences between high and low reactives depend, in some cases, on the level of environmental stimulation. Taken together, the present findings are consistent with the notion that individual differences in the temperament dimension of reactivity underlie individual differences in activity level. If this is true, there are implications for the place of activity in temperament theory. Individual differences in motor activity may not stem directly from biological differences present at birth; but rather, they may covary with the general underlying temperament trait of reactivity.

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Appendix A

Parental Questionnaire

The questionnaire has two parts. The first part asks some questions about your household and the second, asks about your child.

CHILD'S NAME ______________________________

Part 1. Household Information:

Number of individuals usually living in the household ________

Number of rooms in house (excluding bathrooms, laundry rooms, storage rooms)________ and/or approximate square footage of house (if known) ________.

Do you live near a noise-producing source such as a railway track, a high traffic area, a fire station, an emergency hospital ward, or an air route? yes or no ___ Please state the source ________

Think about each family setting indicated below, and circle the number that would normally best describe that setting. Rate each family setting on a scale from 1 (usually quiet/calm/lacking excitement) to 7 (usually noisy/chaotic/exiting).

Family settings:

	usually quiet						usually noisy
breakfast	1	2	3	4	5	6	7
supper/dinner	1	2	3	4	5	6	7
children's bedtime	1	2	3	4	5	6	7
car trips	1	2	3	4	5	6	7
visits from guests	1	2	3	4	5	6	7
Saturday mornings	1	2	3	4	5	6	7
festive occasions (such as birthdays)	1	2	3	4	5	6	7

Part 2: Information on child in the study

Please indicate the birth dates and relationships (sister, brother, step sister, step brother) between the child named above and the other siblings in your family. If the child has more than four siblings, please use the reverse side.

Birthdates of brothers & sisters day/month/yr	Sibling relationship
__ / __ / __	____________________
__ / __ / __	____________________
__ / __ / __	____________________

In responding to the following items, please circle the number that most accurately describes your child. You are asked to rate each item on the scale ranging from 1 to 7 (shown below the item).

The numbers 1 and 7 reflect the extremes identified by the accompanying phrases. For example, if your child is "hardly ever uncomfortable" in the presence of a less known person then, in item #1, you would circle the 1. If your child is almost always uncomfortable, you would circle the 7. The numbers 2 through 6 represent intermediate points between the extremes.

1 Child is uncomfortable in the presence of less-known persons. For example, child may act timid, avert gazes, redden, or avoid answering questions.
1 2 3 4 5 6 7
hardly ever uncomfortable almost always uncomfortable

2. Child is sensitive to differences (tightness, roughness, etc.) in the way different clothes feel.
1 2 3 4 5 6 7
hardly ever sensitive almost always sensitive

3. Upon encountering an obstacle, child becomes discouraged and abandons performance of current activity.
1 2 3 4 5 6 7
hardly ever abandons almost always abandons

4. Child enjoys the company of other persons. For example, child seeks interaction with others and enjoys being in a group of people.
1 2 3 4 5 6 7
hardly ever enjoys company almost always enjoys company

5. Child is very energetic.
1 2 3 4 5 6 7
hardly ever energetic almost always energetic

6. Child is annoyed by air pollution, such as that caused by cigarette smoke or the exhaust from gasoline or diesel engines.
1 2 3 4 5 6 7
hardly ever annoyed almost always annoyed

7. Child finds it difficult to detect odors that others can smell.
1 2 3 4 5 6 7
hardly ever has difficulty almost always has difficulty

8. Child shows tension before important task. For example, child may redden, hands may tremble, child may move or sit rigidly.
1 2 3 4 5 6 7
hardly ever tense almost always tense

9. Child avoids long, fatiguing tasks that demand problem solving and exertion.
1 2 3 4 5 6 7
hardly ever avoids tasks almost always avoids tasks

10. Child is always on the go.
1 2 3 4 5 6 7
hardly ever on the go almost always on the go

11. Child finds it easy to go to sleep after an exciting day or an emotional event.
1 2 3 4 5 6 7
hardly ever finds it easy almost always finds it easy

12. Child is aware of small changes in air temperature.
1 2 3 4 5 6 7
hardly ever aware almost always aware

13. When faced with failure, child is resistant to setbacks; he/she does not get discouraged but works harder in the future.
1 2 3 4 5 6 7
hardly ever gets discouraged almost always gets discouraged

14. Child prefers quiet, inactive games to more active ones.
1 2 3 4 5 6 7
hardly ever prefers almost always prefers

15. Child initiates organizing play or work with others. For example, he or she likes to organize and lead in decision- and rule-making.
1 2 3 4 5 6 7
hardly ever initiates almost always initiates

16. Child is aware of small noises.
1 2 3 4 5 6 7
hardly ever aware almost always aware

17. Child is prevented from easily falling asleep if there is an intermittent sound e.g., a door banging.
1 2 3 4 5 6 7
hardly ever prevented almost always prevented

18. Child is off an running as soon as he or she wakes up in the morning.
1 2 3 4 5 6 7
hardly ever off & running almost always off & running

19. Child finds it easy to concentrate on some task, like reading a book, if the radio is on.
1 2 3 4 5 6 7
hardly ever finds it easy almost always finds it easy

20. Child's ability to go to sleep in the usual way would not be disturbed if the room lighting differed from the usual level.
1 2 3 4 5 6 7
hardly ever able almost always able

21. Child is likely to comment on room being hot or cold.
1 2 3 4 5 6 7
hardly ever comments almost always comments

22. Child does not notice colors, and does not comment on how pretty or ugly they are.
1 2 3 4 5 6 7
hardly ever notices almost always comments

23. Child willingly assumes independent and responsible functions. For example, child offers to fulfill functions for which he/she alone would be solely responsible.
1 2 3 4 5 6 7
hardly ever assumes functions almost always assumes these

24. Child is not bothered by loud noises (fire alarm, siren, etc.)
1 2 3 4 5 6 7
hardly ever bothered almost always bothered

25. Child never remarks if teacher or classmates wear new clothes.
1 2 3 4 5 6 7
hardly ever remarks almost always remarks

26. Child has to be seriously hurt before he/she comments or cries about cuts or bruises.
1 2 3 4 5 6 7
when hurt, hardly ever cries almost always cries

27. When child moves about, he or she usually moves slowly.
1 2 3 4 5 6 7
hardly ever moves slowly almost always moves slowly

28. Child is very conscious of odors, he/she comments on pleasant or unpleasant smells.
1 2 3 4 5 6 7
hardly ever conscious of odors almost always conscious

29. Child doesn't react if accidently touched or lightly brushed by another child.
1 2 3 4 5 6 7
hardly ever reacts almost always reacts

30. Child is highly sensitive to changes in the brightness or dimness of light.
1 2 3 4 5 6 7
hardly ever sensitive almost always sensitive

Thank you for your cooperation!

Appendix B

Questionnaire Items for Each Subset

Subset type	Item numbers for original pool	Item numbers for final subset
Reactivity		
Social distress	1,4,8,15	1,4,8,15
Task distress	3,9,13,19,23	3,9,13,19,23
Core reactivity	1,3,4,8,9,13,15, 19,23	1,3,4,8,9,13,15 19,23
Composite reactivity	1,3,4,8,9,13,15, 19,23	1,3,4,8,9,11,13,15 17,19,20,23 26,29,30
Domain specific		
Auditory	16,17,19,24	11,16,17,24
Visual	20,22,25,30	22,25,30
Temperature	2,12,21	12,21
Tactile	2,26,29	26,29
Olfactory	6,28	6,28
Activity	5,10,14,18,18,27	5,10,14,18,18,27

Appendix C

Letter and Consent Form

July, 1988

Dear Parent:

With the hopes of improving the diversity of programming of Mini University and Sport Camp, we are conducting a research project. The primary purpose of the research is to look at childrens' levels of motor activity in two settings. The activities in the study will be fun for the children. Participation in the study would involve about an hour and a half of your child's time on one day during the camp.

Your child would be asked to wear a small wristwatch-like instrument while she or he played freely under supervision in two rooms. The watch-like instrument measures motor activity, and it has been used extensively in our prior research. Activity will be measured in one room that lacks stimulation, and in another that provides a moderate level of stimulation (music, colorful posters, etc). Children will also play a short computer game that involves pressing a key when a shape appears on the screen. We are hoping to discover if children differ in how quickly they react to the images and if these reaction differences are related to motor activity levels. Children will be supervised by the Sport Camp Instructors at all times during the study.

Mini University Camp requires that parents approve of any research. If your child is between 5 and 12 years of age, your approval and their participation would be very much appreciated. To indicate approval or disapproval, please complete the attached Parental Consent Form and return it in the postage-paid envelope provided. Children who do not have permission to participate, or those who do not wish to participate, will continue with their regularly scheduled activities. We are optimistic that the results of this research will enable us to provide better programming in the future.

If you have concerns or questions about the study, please feel free to contact the director of the Mini University and Sport Camp Program, Joyce Fromson, at 474-9143 (office) or at (home) or Judy Chipperfield at . Either of us would be happy to discuss any concerns you have. When leaving a message, be sure to indicate that you are calling about the Camp Research Study. Thank you very much for your time.

Yours truly,

Judy G. Chipperfield, M.A.
Warren O. Eaton, Professor

Parental Consent Form

Child's name: ____________________________

Child's birthdate: ____ /____ /____ Child's sex: __________
Day Month Year (M or F)

_______ I consent to my child's participation in the study to be conducted by Dr. Warren Eaton and Judy Chipperfield.

_______ I do not consent to my child's participation.

Name and signature of parent or legal guardian

Name (please print):
Signature:

______________________________ ________________________________

Date:___________________________

Please check the camp that your child is attending:

Mini University (July 4 - July 15) ______

Mini University (July 18 - July 29) ______

Fun, Sport, & Fitness (July 4 - July 15) ______

Fun, Sport, & Fitness (July 18 - July 29) ______

Feedback on Study

If you are interested in learning about the overall findings of study, please check the statement below and provide your address. This summary will be mailed to you in about 8 months.

___ I would like to receive a summary of the research findings.

My mailing address is: ______________________________

____

____

Thank your for your cooperation!

Appendix D

Calibration of Computers

The following steps were taken to calibrate computers:

1) A stimulus of the same level was displayed on each computer

2) The brightness and contrast settings were adjusted on each computers until the stimuli for that intensity level appeared approximately equal across computers.

3) Measurements of luminosity were taken by placing a LitMate System 500 Photometer approximately 16 inches from the computer screen and taking two measurements of each stimulus.

4) Further adjustments were made to the controls until luminosity measurements for that stimulus level were approximately equal across computers.

5) The previous steps were followed for each of the different intensity stimuli.

Appendix E

Supervisor Instructions for Ranking Activity Level

Children seem to vary in their characteristic levels of motor activity, which is the central variable in the study we have been conducting. We would appreciate your further cooperation in another aspect of the study. Please read the following instructions and rate the children on their characteristic levels of activity. Think about the children that you have had in your group for the past two weeks, and base your ratings on your general impression of the typical, or customary, level of activity for that child relative to the other children in the group. Each child's name has been printed on a sticker. Separate the stickers along the perforations, and lay them out on a desk or table. Arrange the stickers so that the children are ordered from the least to the most motorically active. You will probably find it difficult to place a few of the children in the ranking. Don't worry about this, but do the best you can without spending a lot of time on the task. When you have completed the ranking, please affix the stickers to the data sheet in the following manner. Affix the sticker for the least active child first on the list, i.e., beside the number 1, and the sticker for the most active child last on the list.

When you have affixed all stickers, please return the completed list of rankings to your coordinator. Thank you for your cooperation with this and other parts of the study.

Appendix F

Instructions For Computerized Task: Part A

What we are going to be doing today is very simple. I want you to watch the screen in front of you, and when you see a box I want you to try to make it disappear as fast as you can. The way you do that is by pressing the bar (space bar) with the three black dots on it. Does everyone see the bar? Before the box appears you will see some arrows which means that you are to get ready. When you see the arrows, get ready to press the bar, but don't press it until the box appears. The idea is to make the box disappear as fast as you can by pressing that bar. To make sure that everyone understands, we are going to go through 2 practices before we start. Before we begin the practices, does anyone have any questions? Ok, to begin the practice trials, press the enter key, the one with the red sticker.

Instructions For Computerized Task: Part B

Before we begin, I want to explain to you what will happen when you are finished. Some words will show up on your screen to tell you that the first part is finished. (Younger children only: You may not be able to read the words, and that doesn't matter). When you see this, please wait quietly until everyone else is done. When everyone is done, I will explain what we will do next. Does everyone understand? Do you have any questions? You can begin the first part by again pressing the enter key, the key with the red sticker on it.

Appendix G

Activity Level Data Sheet

SECTION 1

ID __ __ __

CS/SS/C#

CS = Camp Session 1 = July 11-15 2 = July 18-29
SS = Study Session 1 - 59
C# = Child Number

Child's name ______________________ Child's sex F M

Date: Mon -- Fri ________ day/ __ month __ / 1988

Research Assistant name ________ Number of researchers in room ____

Order of condition H-L L-H

Actometer description:

letter	A B C D E F	A B C D E F	A B C D E F	A B C D E F
number	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
strap color	W B	W B	W B	W B
placement	l r arm leg	l r arm leg	l r arm leg	l r arm leg

Record initial reading under SECTION 1 -- ROOM 1 START TIME.

Number on name sticker _____

SECTION 2

Actometer placement: When putting actos on, ask child which hand he/she writes with and attach an actometer to that wrist and to the opposite ankle. Try to use the black watch straps for wrists.

ROOM 1:

ARM

START TIME ____ STOP TIME ____

hours/mins/secs hours/mins/secs
___ / ___ / ___ ___ / ___ / ___
___ ___ ___ ___ ___ ___

LEG

START TIME ____ STOP TIME ____

hours/mins/secs hours/mins/secs
___ / ___ / ___ ___ / ___ / ___
___ ___ ___ ___ ___ ___

ROOM 2:

ARM

START TIME	STOP TIME
hours/mins/secs	hours/mins/secs
___ / ___ / ___	___ / ___ / ___
___ ___ ___	___ ___ ___

LEG

START TIME	STOP TIME
hours/mins/secs	hours/mins/secs
___ / ___ / ___	___ / ___ / ___
___ ___ ___	___ ___ ___

Please use this space to make a note of any unusual happenings during the sessions. Ensure that you indicate which session.

Please ask each child the following question and circle the H for high or the L for low stimulation room.

1. Do you think that one of the rooms you played in had more things to see?

   Which room, the other one or this one? H L