NOCTURNAL ENURESIS AND OPTIMAL

STIMULATION THEORY

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Abstract

The present study examined the hypotheses that nocturnal enuretics would exhibit a similar general impulsive style and cortical underarousal as has been demonstrated with extraverts and children with ADHD. Thirty-two boys (16 nocturnal enuretics and 16 nonenuretics) served as subjects. They completed tasks measuring impulsivity, field-dependence, planning ability, and cortical inhibition under either a quiet or an arousal condition. One parent concurrently completed various behaviour checklists. The results showed that nocturnal enuretics performed in an impulsive and field-dependent manner in the quiet condition, thus supporting the general impulsive style hypothesis. They also tended to improve their performance in the arousal condition, thus supporting the cortical underarousal hypothesis. Differences were found on the behaviour checklists with nocturnal enuretics rated as more difficult to awaken and nonenuretics rated as more hyperactive. Treatment implications based on these results were discussed as well as potential future research directions.

Nocturnal Enuresis and Optimal Stimulation Theory

Enuresis can be broadly divided into functional versus organic etiologies (Schaefer, 1979). Functional enuresis is defined as enuresis not due to neurologic or urologic pathology and includes about 90% of all cases. Generally, sources have quoted the prevalence of organic enuresis anywhere from 1 - 10% of all cases (cf. Sorotzkin, 1984). Technically, the term enuresis refers only to those cases where the etiology is functional, while urinary incontinence is used to refer to those cases with an organic etiology. Nevertheless, approximately 5% of enuretics are later discovered to have an organic etiology.

Functional enuresis is the primary focus of the present study and is defined by the DSM-III-R as "repeated involuntary or intentional voiding of urine during the day or at night into bed or clothes after an age at which continence is expected" (American Psychiatric Association [APA], 1987, p. 84). It further specifies that there must be "at least two such events per month for children between the ages of five and six, and at least once a month for older children" (p. 84). Other sources have cited varying age criterion. For example, Pierce (1980) quoted an age criterion of only three years of age. Similarly, Forsythe and Redmond (1974) have cited that the majority of enuretics have an age of onset from three to ten years of age. Verhulst et al. (1985) have argued that the age criterion should be eight for boys and five for girls. They examined the frequency of wetting of boys and girls between the ages of four and sixteen and found that boys and girls have an approximately equal wetting frequency when boys are eight and girls are five.

The prevalence of enuresis markedly decreases with age. The rates differ somewhat, but approximately 15% of five year olds are enuretic, 5% of ten year olds, and 1% of fifteen year olds (Bindelglas, 1975; Burke & Stickler, 1980; Motta, 1979; Sorotzkin, 1984; Wagner, 1987; Wagner & Geffken, 1986). The spontaneous remission rate of enuresis has been cited to be about 15% per annum (Bindelglas, 1975; Forsythe & Redmond, 1974). Typically, twice as many boys are enuretic as girls (cf. Burke & Stickler, 1980; Moilanen, Järvelin, Vikeväinen-Tervonen, & Huttunen, 1987; Motta, 1979; Sorotzkin, 1984).

There are three types of enuresis: nocturnal, diurnal, and mixed. Nocturnal enuresis refers to bed wetting only. Diurnal enuresis refers to wetting during the daytime, usually in clothing. Mixed enuresis is characterized by a combination of the above two. The prevalence rates of each of these types is approximately 80% nocturnal, 5% diurnal, and 15% mixed (Berg, 1979; Burke & Stickler, 1980; Sorotzkin, 1984). There are approximately twice as many male nocturnal enuretics than female, and about one and a half times more female diurnal and mixed enuretics than male (Berg, 1979; Moilanen et al., 1987).

Each of the three types of enuresis can be further divided into primary or secondary onset. Enuresis with a primary onset includes those children who have never achieved an extended period of continence. Secondary onset refers to those children who have had a period of continence for at least one year (APA, 1987). Approximately 75 - 80% of enuretics fall into the primary onset type, while about 20 - 25% are of the secondary type (Berg, 1979; Moilanen et al., 1987; Sorotzkin, 1984).

Etiological Theories of Nocturnal Enuresis

Theories about the etiology of enuresis can be broadly divided into three groups: psychological, behavioural/learning, and organic. Each of these three areas will be discussed next.

A traditional conception of the etiology of enuresis can be found in the psychoanalytic or psychodynamic views (Mountjoy, Ruben, & Bradford, 1984; Mowrer & Mowrer, 1938). Any behaviour problem, according to the psychoanalytic view, is seen as an external manifestation of intrapsychic conflict (Sorotzkin, 1984). The child is seen as unable to differentiate between micturition and the pleasurable, sexual feelings that this produces. Because our society and culture are generally more sexually repressed than others, enuresis can, thus, be seen as a safe way to express these conflictual, pleasurable feelings. Alternatively, enuresis can be seen as a hysterical manifestation where anxiety is converted into a physical symptom, or as disguised hostility toward parents. Other psychodynamic etiological postulations include the desire to regress to a more infantile state, the repression of masturbation, and disturbed parent-child relations. Research supporting the psychoanalytic and psychodynamic hypotheses has been varied because it is extremely difficult to empirically test and manipulate these hypotheses (cf. Sorotzkin, 1984).

Numerous investigators have explored the relationship between enuresis and emotional and/or behavioural problems (cf. Berg, 1979, 1981; Kaffman & Elizur, 1977; Moilanen et al., 1987; Sorotzkin, 1984; Wagner, 1987; Wagner & Geffken, 1986; Wagner, Smith, & Norris, 1988). The usual method of obtaining this type of information has been to administer questionnaires to the parent(s) and/or child.

Wagner and Geffken (1986) found that their sample of nocturnal enuretics were normally adjusted according to various parental and self-report measures. Wagner et al. (1988) compared the psychological adjustment of nocturnal and mixed enuretics. They also used parental and various self-report measures and found that the mixed enuretics reported lower self-concepts and self-esteem than nocturnal enuretics.

The parental reports showed no difference between the two types other than the finding that the parents of the mixed enuretics thought that the wetting was much more of a nuisance than did the parents of the nocturnal enuretics.

Moilanen et al. (1987) interviewed only the parents of enuretic children and found that the parents reported that enuretics were generally more anxious, labile, and careless than children without enuresis. Primary nocturnal enuretics were reportedly the most anxious among the enuretic group which consisted of nocturnal and diurnal enuretics. They were also described as fitful, impatient, careless, and fearful, and characterized as "having little ability to control themselves" (Moilanen et al., 1987, p. 60). In this light it sounds as if nocturnal enuretic children tend to be rather impulsive. The diurnal enuretics, on the other hand, were described as suffering from feelings of inferiority, fears, and low self-confidence. Shaffer's (1973) review on the relationship between enuresis and emotional disorders concluded that there is a definite association between the two, especially in females and those who are mixed enuretics. The question of cause and effect arises with these types of studies. Correlational studies automatically suffer from this type of problem.

Kaffman and Elizur (1977) carried out a longitudinal study which followed 161 children in a kibbutz from two to eight years of age. They found what they labelled as an "enuretic personality pattern" (specifically referring to nocturnal enuresis) which consists of aggressive behaviour, motor hyperactivity, low frustration tolerance, and a negative response to new situations. Furthermore, 20 of the 161 children were labelled as hyperactive and 14 of these later became nocturnal enuretics. In other words, they found an increased tendency for these hyperactive children to later become enuretic than the nonhyperactive children. This study has established some antecedent, and thus potentially causal, personality characteristics of nocturnal enuretic children. The interesting connection between nocturnal enuresis and hyperactivity is also noteworthy.

Environmental stress is an additional factor which has been postulated as an etiological component of enuresis (cf. Sorotzkin, 1984; Trombini, Rossi, Umilta, & Baccarani, 1982). It is suggested that stressors during a sensitive stage (age two to four) such as hospitalization or birth of a sibling can cause enuresis. The mechanism by which the stress causes the enuresis is only speculative. The stress could interfere with the child's learning to control micturition. It has also been postulated that stress may be more related to enuresis of secondary onset than primary onset (e.g., Werry, 1967). Sorotzkin

(1984) noted that enuresis is higher in populations where stressors are higher (e.g., in homes where the family has been separated, lower SES families, and institutionalized children). Additionally, enuresis is known to occur less frequently in supposedly non-stressful situations such as sleep-overs. One interesting study found that functional enuretics responded to experimentally induced stress with bladder contractions while those with organic etiologies did not (Trombini et al., 1982).

The behavioural or learning perspective views enuresis as a form of deficient learning (Wagner, 1987). Normal children learn to attend to bladder signals and then to associate these with appropriate micturition relief sites. Mowrer and Mowrer (1938) view enuresis as a deficient habit-formation sequence where the enuretic has much the same sequence as the infantile micturition reflex. The nocturnal enuretic is seen as unable to inhibit this infantile automatic micturition reflex during sleep. Because enuresis is viewed simply as deficient learning, the focus of this approach has generally leaned towards treatment rather than further defining or supporting their perspective. Conditioning of nocturnal enuresis can be dated back at least to Mowrer and Mowrer (1938). Conditioning treatment has been widely accepted and utilized but suffers from a high relapse rate of about 40% (Lovibond, 1963; Motta, 1979; Street & Broughton, 1990; Wagner, 1987).

As previously mentioned, urinary incontinence with an organic etiology does not technically qualify as enuresis. There are instances, however, when the organic pathology is hypothesized but is not or cannot be physically supported through a neurologic or urologic examination. Some of the hypothesized etiologies include maturational lag (Burke & Stickler, 1980; Sorotzkin, 1984; Wagner, 1987), functional bladder capacity (Kaffman & Elizur, 1977; Sorotzkin, 1984; Wagner, 1987), bladder infection (Sorotzkin, 1984), heritability (Burke & Stickler, 1980; Moilanen et al., 1987; Sorotzkin, 1984), deep sleep (Kaffman & Elizur, 1977; Krupnova, 1987; Wagner, 1987), and arousability or arousal threshold (Fielding, 1982; Finley & Perry, 1973; Finley & Wansley, 1977; Kaffman & Elizur, 1977).

Maturational lag is defined as a delay in the neurological development involved in micturition control. The delay can be caused by the bladder anatomy, hormones, or nervous system, among others. Functional bladder capacity (FBC) is defined as the volume of urine necessary to produce bladder signals. This FBC has been found to be smaller in enuretics (Kaffman & Elizur, 1977). Bladder infection has been found in a small number of enuretics but is thought to be an effect of enuresis rather than a cause of it (cf. Sorotzkin, 1984).

Enuresis has been shown to have twice as high a concordance rate in monozygotic than in dizygotic twins (Burke & Stickler, 1980; Sorotzkin, 1984). Furthermore, the risk of becoming enuretic is increased eleven fold if both parents wet the bed or clothes after four years of age (Moilanen et al., 1987).

Nocturnal enuretic children have long been thought to sleep more deeply than nonenuretic children (cf. Walker, Kenning, & Faust-Campanile, 1989). This excessively deep sleep is said to result in relaxation, including relaxation of the sphincter muscle, which then results in bedwetting. Sleep studies have shown varied results, however. For example, it would follow from this hypothesis that bedwetters would wet only during deep sleep, but studies have found that wetting actually occurs in other, more superficial sleep stages as well (e.g., Ditman & Blinn, 1955; Inoue et al., 1987; Kaffman & Elizur, 1977).

If this sleep hypothesis is extended somewhat, the hypothesis of a sleep-arousal defect is possible (Finley & Perry, 1973; Finley & Wansley, 1977). This hypothesis postulates that the arousal threshold of nocturnal enuretics is elevated during sleep such that the bladder signals are not sufficient to awaken the child. It follows, then, from the arousal threshold hypothesis that these children would be more difficult to arouse from sleep than nonenuretics. The findings here have been varied and are difficult to interpret because it is the parents who are usually asked to assess the arousability of their child. The consequences of arousing an enuretic child are likely to be more unpleasant due to its association with wetting the bed. That is, awakening the enuretic child is often associated with a negative response from the caregiver. The occurrences of a parent arousing a nonenuretic child, however, are likely to be rare, if at all, and generally do not carry the same negative associations as with the enuretics. Nevertheless, parents of nocturnal enuretics typically report that their child is extremely difficult to awaken (e.g., Walker et al., 1989).

Others, however, have found equal arousability (Kaffman & Elizur, 1977). The method of assessing arousability by Kaffman and Elizur (1977) is rather problematic. They first tried to assess arousability using taped music, but the full volume did not awaken either the enuretic or the nonenuretic children. They then tried shaking the children slightly on the shoulder while calling their name and recording the amount of time elapsed before the child was awake. They found no difference in the amount of time elapsed before the child was fully awake. They did not, however, define what "awake" meant or how it was assessed. This subjectiveness is a general problem in the arousability hypothesis and research. It is important to note that one of the major problems with the conditioning treatment of nocturnal enuresis is not only the high relapse rate but also the high likelihood that the child is not awakened by the buzzer or alarm (Morgan, 1978).

In summary, according to the psychological conceptualizations and research, nocturnal enuretics may be characterized as being hyperactive (Kaffman & Elizur, 1977), impatient, and careless (Moilanen et al., 1987). These sound very much like some of the characteristics of Attention-deficit Hyperactivity Disorder (ADHD) of which impulsivity is one of the cardinal symptoms (e.g., Barratt & Patton,1983).

Nocturnal Enuresis and ADHD

Kinsbourne and Caplan (1979) postulated that there may exist a common general impulsive temperament between enuresis and ADHD. They, as well as Shapiro (1965), characterize the impulsive temperament as an underfocused cognitive style. Impulsives focus on the most salient or most obvious stimuli in the environment rather than the most critical with a resultant overdependence on the entire stimulus field to the sacrifice of its individual parts (Kinsbourne & Caplan, 1979; Shapiro, 1965). This, then, results in carelessness and distractibility. Impulsives also do not learn as well through punishment paradigms as they do from reinforcement, and they have low frustration tolerance (Kinsbourne & Caplan, 1979).

At this point, the characteristics of ADHD and the Optimal

Stimulation Theory will be further delineated for the purpose of clarifying the similarities between nocturnal enuresis and ADHD. The arousal threshold hypothesis of Finley will then be extended using Eysenck's theory relating introversion-extraversion and cortical arousal (Eysenck, 1967).

Approximately 4 - 10% of children are diagnosed as ADHD and the majority of these cases are boys (Ollendick & Hersen, 1983; Rosenthal & Allen, 1978). Children who are diagnosed as ADHD are typically characterized as inattentive, impulsive, hyperactive, and easily frustrated (e.g., Werry, Elkind, & Reeves, 1987). The disorder more specifically relates to deficient sustained attention and to defective inhibitory processes; the latter referring to the inability to inhibit impulsive responses (Douglas & Peters, 1979). These children with ADHD are also generally unable to delay gratification and condition differently than children who do not have ADHD (Rosenthal & Allen, 1978). Specifically, ADHD children do not condition well on an intermittent reinforcement schedule.

Four cognitive patterns are often associated with ADHD children: impulsivity, field-dependence, constricted control, and weak automatization (Cohen, Weiss, & Minde, 1972; Ross & Ross, 1976). Children with ADHD typically perform poorly on tasks that require reflection and field-independence. The poor performance has been shown to occur even with the effects of intelligence partialled out (Cohen et al., 1972; Rosenthal & Allen, 1978, 1980; Stoner & Glynn, 1987; Werry et al., 1987; Zentall, 1975).

The Matching Familiar Figures Test (MFFT) was developed by Kagan to measure reflection versus impulsivity (Kagan, 1966). This test presents items consisting of one familiar stimulus on one page, and five slight variations and one stimulus which is identical to the original stimulus on the opposite page. The child is required to select from the six test stimuli the one that is identical to the original stimulus. Children with ADHD typically respond much faster and make more errors than children who do not have ADHD (Barratt & Patton, 1983; Borden, Brown, Wynne, & Schlesser, 1987; Ross & Ross, 1976; Stoner & Glynn, 1987; Werry et al., 1987).

Additional measures of impulsivity include the Porteus Maze Test, or the Mazes subtest on the Wechsler Intelligence Scale for Children - Revised (WISC-R). The Mazes subtest on the WISC-R is a task which requires not only visual-spatial skills but also planning ability (Groth-Marnat, 1984). The child's task entails tracing a course from a starting point to an ending point without lifting the pencil. They are penalized for taking the wrong path and for cutting corners. Generally speaking, ADHD children do not perform well on tasks which require planning since impulsivity and planning are negatively related (Barratt & Patton, 1983; Douglas & Peters, 1979; Kinsbourne & Caplan, 1979; Ross & Ross, 1976).

The Children's Embedded Figures Test (CEFT) measures field independence versus dependence. The child is required to detect and identify a figure that is embedded, or hidden, within another figure. The ADHD child has more difficulty finding the embedded figure than the child who does not have ADHD because the ADHD child relies more heavily on the visual field embedding the object than being able to analyze the picture into its individual components. The tendency for the ADHD child to focus on the picture as a whole is indicative of their relative field-dependence (Cohen et al., 1989; Ross & Ross, 1976; Stoner & Glynn, 1987).

Optimal Stimulation Theory and ADHD

The Optimal Stimulation Theory postulates that ADHD children are "deficient in cortical and autonomic arousal" (Rosenthal & Allen, 1978, p. 691). The theory was originally proposed by Zentall (1975) and further explored by Zentall and Meyer (1987). Briefly, it states that the hyperactive behaviour of ADHD children serves the purpose of optimizing their stimulation or arousal level. In other words, the ADHD child is either cortically underaroused or has a higher arousal threshold than the child who does not have ADHD. The slower EEG recordings of ADHD children give support for the former postulation; that is, ADHD children are cortically underaroused (Ellis, 1987; Rosenthal & Allen , 1978). Kahneman (1973) suggests that a moderate level of arousal is most pleasurable and, therefore, children either seek or avoid stimulation to produce this optimal level.

The Optimal Stimulation Theory accounts for much of the seemingly paradoxical research findings on ADHD. For example, an old theory of ADHD thought that these children were overly aroused, or stimulated, and that the method of intervention in the classroom should, therefore, be to reduce stimulus input as much as possible. Research, however, found that the activity level of ADHD children increased rather than decreased with reduced stimulus input (Steinkamp, 1980; Zentall, 1975). Other studies have found that the performance of ADHD children actually improves with task irrelevant stimulation such as music or other noise, compared to their performance with task relevant stimulation (Douglas & Peters, 1979; Eysenck, 1981; Matthews, 1986; Rosenthal & Allen, 1980; Wachtel, 1967; Zentall, 1975). The task irrelevant stimulation (e.g., music or classroom noise) is thought to increase the arousal level of the ADHD children such that it is closer to the optimal level of arousal for performance. This finding clearly fits with the Optimal Stimulation Theory.

Another well known finding is that amphetamines actually decrease the activity level and increase the attention span of ADHD children (Zentall, 1975). Additionally, it has been found that ADHD children's performance improves on the Matching Familiar Figures Test when administered stimulants (Douglas & Peters, 1979). Again, this finding is clearly understandable according to Zentall's theory.

The similarities between nocturnal enuresis and ADHD are notable. For example, both are more prevalent in boys, both have impulsivity as a central characteristic, and both have been hypothesized to be due to an arousal deficit.

Eysenck's Theory of Extraversion-Introversion

Impulsivity is also basic to the concept of extraversion (Eysenck, 1981). Along with impulsivity, extraversion also includes the characteristics of sociability, impatience, activity, liveliness, and excitability (Eysenck, 1967). Impulsivity can be further divided into four factors: 'narrow' impulsivity, risk-taking, nonplanning, and liveliness (Barratt, Pritchard, Faulk, & Brandt, 1987; Eysenck, 1983, 1987; O'Gorman & Lloyd, 1987). These factors were determined on the basis of factor analyses of the Eysenck Personality Questionnaire which was developed by Eysenck and Eysenck in 1976 (Revelle, Anderson, & Humphreys, 1987). Four major traits were assessed using this instrument: extraversion-introversion (E), neuroticism (N), psychoticism (P), and a lie scale (L). The Eysenck Personality Inventory was developed in 1964 and measured only the three traits of E, N, and L (Eysenck, 1967). In 1965, Sybil Eysenck developed a Junior version of the Eysenck Personality Inventory (JEPI). The Junior Eysenck Personality Inventory is appropriate for ages 7 to 16 and contains 60 items. The validity for this instrument is not high and, therefore, it is primarily recommended to be used for research purposes only (Eysenck, 1965).

Eysenck utilized the Yerkes-Dodson law, or the inverted U function, to explain the relationship between extraversion-introversion, cortical arousal and performance (Eysenck, 1967). "Arousal...denotes the extent to which an individual is in a chronic state of low to high cortical activation" (Nelson & Shapiro, 1987, p. 153). Specifically, extraverts are cortically underaroused and are hypothesized to perform better with increased external stimulation (Matthews, 1986, 1987). Frith (1967), for example, found that extraverts improved their performance on a critical flicker fusion task in a noisy condition compared to a quiet condition. In contrast, introverts are cortically overaroused and are hypothesized to perform better under conditions of decreased external stimulation (Revelle et al., 1987). Studies have supported the hypothesis of the relationship between cortical arousal and extraversion-introversion (cf. Revelle et al., 1987). For example, Savage (1964) found increased cortical arousal in introverts compared to extraverts as measured by EEG recordings. Green (1984) showed that if a group of extraverts and a group of introverts are given the choice of stimulation level, the former chooses significantly more intense noise levels than the latter. Furthermore, given a learning task, each group learns most effectively at their chosen level of arousal, or at a level chosen by someone in their same personality group, indicating optimal learning at a self-selected optimal level of arousal. Daoussis and McKelvie (1986) also found a relationship between arousal and extraversion-introversion. They studied the effect of playing music (a Rolling Stones tape at 50 db) on a reading retention task and found that the music differentially affected performance between extraverts and introverts. Specifically, the introverts exhibited significantly poorer performance under the music condition, and, although the extraverts improved their performance somewhat with music, this difference was not statistically significant.

In terms of excitation and inhibition, extraverts have lower cortical excitability (arousability) and higher cortical inhibition than introverts

(Stelmack, 1981). Extraverts, therefore, have been found to condition less easily, extinguish faster, and build up inhibition faster than introverts (Boddy, Carver, & Rowley, 1986; Cooper & Brebner, 1987; Eysenck, 1967, 1981; Eysenck & Levey, 1972). Extraverts condition better than introverts under conditions of increased arousal (e.g., with noise and light as reinforcers), with continuous reinforcement, a long conditioned stimulus (CS)-unconditioned stimulus (UCS) interval, and a strong UCS (Eysenck, 1967; Eysenck & Levey, 1972).

The build up of cortical inhibition in extraverts versus introverts has been observed using a tapping task (Eysenck, 1964). The tapping task entailed tapping a metal board with a metal stylus as fast as possible for a one minute period. The number of involuntary rest pauses (IRPs), defined as pauses in between taps greater than three standard deviations above the mean, were measured. The extraverts were found to have significantly more Involuntary Rest Pauses than introverts, presumably because the rest allows time for the extravert to dissipate cortical inhibition.

The impulsivity component of introversion-extraversion has been claimed to be the major factor associated with the aforementioned individual differences in cortical arousal and conditioning (Campbell & Heller, 1987; Eysenck & Levey, 1972; Nelson & Shapiro, 1987; Revelle et al., 1987). Support of the important role of impulsivity with respect to arousal is observed with boys who were administered the Matching Familiar Figures Test. It was found that the more reflective boys had higher levels of arousal, as assessed using the sweat bottle method which is a measure of skin resistance change, while impulsive boys had lower arousal levels (Nelson & Shapiro, 1987).

In summary, extraverts are characterized as cortically underaroused. Extraverts are found to perform better under conditions of high arousal than low arousal. Impulsivity is one of the major components of extraversion and is claimed to account for the observed conditioning differences. The parallels between Eysenck's notion of extraversion and the aforementioned characteristics of ADHD are numerous. This is not surprising since impulsivity is one of the major components of ADHD. Notably, both are hypothesized to be cortically underaroused and both improve performance with increased external stimulation. Interestingly, extraverts are underreactive to both internal and external stimuli and, therefore, tend to be more "sleep efficient" in that they fall asleep faster and stay asleep better than introverts (Cooper & Brebner, 1987; Zuckerman, 1987). The connection between extraversion and ADHD with nocturnal enuresis is suggestive.

Nocturnal Enuresis and Cortical Underarousal

If nocturnal enuretics are also cortically underaroused, as has been demonstrated with extraversion and ADHD, then it follows that their sleep would be more efficient (as stated above) and that they would, therefore, be less easily awakened by bladder signals. This hypothesis differs from the deep sleep hypothesis in that it does not specify that enuretics sleep any deeper than children without enuresis or that wetting occurs solely in the deep sleep stages. According to the cortical underarousal hypothesis, nocturnal enuretics would be pervasively underaroused both during the day and night. Wetting does not occur during the daytime because the child is able to increase cortical arousal by other means (e.g., learned postures that are associated with the need to micturate such as pressing the thighs together, shifting stance from foot to foot, or tapping the feet; Fielding, 1982). Wetting occurs only during the night because no other stimulation exists when asleep and, therefore, the bladder signals are not sufficient to awaken the child.

Hypotheses

It is hypothesized that nocturnal enuretics have the same general impulsive style as ADHD and extraverted children. They, therefore, are predicted to respond on tests of impulsivity, such as the Matching Familiar Figures Test and the Mazes subtest, in an impulsive manner, similar to ADHD children. It is also expected that they will obtain higher scores on the Extraversion scale of the Junior Eysenck Personality Inventory than children who do not wet the bed. Further, they are predicted to respond like ADHD children on other tasks, such as the Children's Embedded Figures Test, in a field-dependent manner.

It is also hypothesized that nocturnal enuretics are cortically underaroused, much as is exhibited with ADHD children and extraverts. Cortical inhibition builds up faster in extraverts, and, therefore, it is hypothesized that nocturnal enuretics, too, will build up more cortical inhibition resulting in more Involuntary Rest Pauses on a finger tapping task. Nocturnal enuretics are predicted to respond differently to an aspiration condition than children who are not enuretic. Specifically, it is hypothesized that when nocturnal enuretics are confronted with a statement indicating that they did not perform as well as another subject and then asked how well they think they could do next time, these children would not be affected as much by such a statement due to the the relative ineffectiveness of punishment paradigms, as cited previously. Therefore, the nocturnal enuretics are predicted to perform better on the second trial. Children who do not wet the bed, however, would be affected more negatively by such a statement and, therefore, would perform less well on the second trial.

According to the Optimal Stimulation Theory, nocturnal enuretics are hypothesized to respond to an increase in arousal (external stimulation) with an improvement in performance. This hypothesis is based on the aforementioned research showing that ADHD children improve their performance with task irrelevant stimulation such as classroom noise or music. This hypothesis is also based on the Yerkes-Dodson law and the assumption that nocturnal enuretics are cortically underaroused, and that they, therefore, would perform better if their arousal level was elevated to an optimal level. Conversely, then, nonenuretics are hypothesized to experience a decrease in their level of performance with an increased level of arousal. The latter prediction is based on the assumption that the control group children typically operate at an optimal arousal level, and that an increase in the external level of stimulation would overarouse these children resulting in a decrement in performance.

The parental report information obtained from the Child Behavior Checklist and the Attention Deficit Disorders Evaluation Scale was utilized to examine whether any behavioural differences were present between the enuretics and nonenuretics. No specific hypotheses regarding these measures were made.

The items completed by the parents on the Information

Questionnaire served the purpose of verifying the presence of nocturnal enuresis according to the DSM-III-R criteria for the clinical group, and verifying that the control group was free from such symptomology. Items were also included on the Information Questionnaire for the parents to rate their child's ease or difficulty level of arousability in the night, and to rate their child's sleep onset time. Based on the aforementioned observation that cortically underaroused children are more "sleep efficient," it is hypothesized that nocturnal enuretics will tend to be rated as more difficult to awaken in the night, and that they will exhibit faster sleep onset times.

Method

Subjects

Thirty-two boys between the ages of 7 and 11 served as subjects for the present study. Sixteen of them met the DSM-III-R criteria for nocturnal enuresis. Thirteen of these were primary nocturnal enuretics and three were of the secondary type. The remaining sixteen boys were not bedwetters and did not have a history of enuresis. All of the nocturnal enuretics were referrals from The Children's Hospital of Alabama, Urology Clinic or from local pediatricians. The control group subjects were referrals from local schools and acquaintances. All subjects were prescreened to rule out the presence of ADHD. The group of 16 nocturnal enuretics were obtained from a group of approximately 35 potential subjects. The reasons for choosing not to participate in the study were varied and included being determined ineligible due to diagnosis or the presence of ADHD, and not being able to work around work schedules or having enough time. The control group children were selected from a group of approximately 20 potential subjects and the reasons for being unable to participate were similar to those previously mentioned. Participation in the present study was on a voluntary basis.

Materials

All boys were administered the Junior Eysenck Personality Inventory, Children's Embedded Figures Test, Matching Familiar Figures Test, Mazes subtest from the WISC-R, and a finger tapping task. The finger tapping task was performed on a microcomputer. A tape of popular music (Hooked by Great White) was used to artificially produce the arousal condition for half of the subjects in each group during the Children's Embedded Figures Test, Matching Familiar Figures Test, Mazes, and finger tapping tasks. The parents were given the Child Behavior Checklist, Attention Deficit Disorders Evaluation Scale, and an Information Questionnaire (see Appendix A) to complete.

Design and Procedure

Each child was tested individually. All subjects were administered the Junior Eysenck Personality Inventory orally so that potential reading difficulties were avoided. The Inventory was read under quiet office conditions. Subsequently, the Children's Embedded Figures Test, Matching Familiar Figures Test, Mazes, and the finger tapping task were given in either the quiet office (quiet condition) or with music playing in the background (arousal condition). The music was played by tape from a portable General Electric Stereo Radio Cassette Recorder (Model No. 3-5623A) which sat approximately four feet from the subject. The volume was set at slightly less than normal speaking level (about 55 db) with a setting of 6 on a scale from 1 - 11, and the tone was set at 4 on a similar scale. The Children's Embedded Figures Test, Matching Familiar Figures Test, and Mazes subtest were given according to standardized procedures.

The finger tapping task was presented with instructions for the subject to tap the space bar on the computer as fast as they could. The subjects did this until they tapped 200 times, at which point the total time it took them to tap that many times appeared on the computer screen. The present finger tapping program tabulated the number of Involuntary Rest Pauses as a sum across both trials, regardless of time differences between subjects. Therefore, in order to adjust and control for the differences in total finger tapping time, the number of Involuntary Rest Pauses was transformed into a time-based score by first dividing the total time into a base unit of 120 seconds and then multiplying this number by the total number of Involuntary Rest Pauses. Then a second finger tapping trial was administered after fictitiously telling the subject that other subjects tapped faster than they did. After this statement the subject was asked how fast they thought they could do it if they did it again. The subject's prediction was then recorded as their aspiration level for finger tapping trial # 2. After the second trial the subjects were debriefed about the fictitious nature of the aforementioned statement indicating that another subject tapped faster than they did.

While the child was being tested, one parent simultaneously completed the Child Behavior Checklist, Attention Deficit Disorders Evaluation Scale, and an Information Questionnaire. The Child Behavior Checklist was primarily utilized for the behavioural index section and contained eight separate scales. The Attention Deficit Disorders Evaluation Scale contained several behavioural items across three scales. The Information Questionnaire was primarily used to establish the validity of the nocturnal enuretic diagnosis for one group and to establish the absence of a present or past diagnosis with the control group. Additional information included some ratings from the parents of the child's sleep and arousability patterns. Each parent was also asked about some basic academic information (e.g., grade level) regarding their child in order to obtain a very basic impression or approximation of the child's cognitive ability level.

Variables and Derivation of Test Scores

The independent variables for the set of procedures followed with the children were: group (children who wet the bed versus those who do not), and condition (quiet versus arousal). The dependent measures obtained from each child included the Junior Eysenck Personality Inventory - Extraversion score, Children's Embedded Figures Test score (e.g., the number correct), the number of errors made on the Matching Familiar Figures Test, the mean response latency until the first answer on the Matching Familiar Figures Test, the Scaled score on the Mazes subtest, the number of Involuntary Rest Pauses during both trials of the finger tapping task, and the aspiration level of each subject for the second finger tapping trial.

The Junior Eysenck Personality Inventory was scored with templates resulting in raw scores for each of the three scales (Extraversion, Neuroticism, and a Lie scale) from which only the Extraversion score was used in the present analysis. A higher score here indicated more characteristics of the measured personality trait. The Children's Embedded Figures Test raw score was obtained by summing the number of correct responses such that the higher the score the better the child was able to identify the embedded figure. Two separate Matching Familiar Figures Test scores were obtained. The first was a sum of the number of errors made before the correct match was found, and the second was the mean response latency until the first response, regardless of accuracy. The Mazes subtest from the WISC-R was scored according to the directions in the WISC-R manual. The score obtained from the finger tapping task was the time-based total number of Involuntary Rest Pauses summed across two trials for each subject. Involuntary Rest Pauses were specifically defined as the number of intertrial intervals, or pauses, between taps which were greater than three standard deviations above the mean for each individual subject.

The Extraversion, Children's Embedded Figures Test, and the two Matching Familiar Figures Test scores were then transformed into Standard scores with a Mean of 10 and a standard deviation of 3 such that these scores could be directly comparable without the confound of age differences. The Mazes subtest score was already in standard score form with a Mean of 10 and a standard deviation of 3. The adjusted total number of Involuntary Rest Pauses was transformed into a time-based score, as previously described, such that the influence of different total tapping times between subjects could be controlled. The aspiration level for each child was scored on a scale from 1 - 4 with a 1 indicating that they predicted they would tap slower on trial # 2, a 2 indicating that they predicted they would do about the same, a 3 indicating they thought they could tap a little faster (i.e., up to 5 sec faster), and a 4 indicating that they predicted a much faster time for trial 2 (i.e., more than 5 sec faster).

The independent variable on the measures obtained from the parents was whether their child was a bedwetter or not. The dependent variables included eight scales from the Child Behavior Checklist, three scales from the Attention Deficit Disorders Evaluation Scale, and two measures taken from the Information Questionnaire indicating the level of difficulty in awakening their child in the middle of the night, and the typical amount of time taken for their child to fall asleep at night (i.e., sleep onset). The parent's assessment of their child's grades was also recorded. The behavioural indexes obtained from the Child Behavior Checklist and the Attention Deficit Disorders Evaluation Scale were intended to assess whether any such differences were present between the nocturnal enuretics and the control group. The Information

Questionnaire provided verification of the existence or nonexistence of bedwetting, and also provided some basic ratings by the parents on the ease/difficulty of arousing their child in the night, and the typical sleep onset time.

The Child Behavior Checklist responses were scored according to the 1991 computerized profile analysis which resulted in eight scales with standardized T scores. The resultant Child Behavior Checklist profile yields T scores ranging from a possible minimum of 50 to a possible maximum of 100 with a score above 70 indicating clinical significance. The Attention Deficit Disorders Evaluation Scale was scored according to the manual into three separate scales: Inattentive, Impulsive, and Hyperactive, resulting in three standard scores with a Mean of 10 and a standard deviation of 3, with scores below 7 indicating clinical significance. The measures utilized from the Information Questionnaire included an index of the parent's perception of how difficult it is to awaken their child in the middle of the night, and the parent's perception of how quickly their child falls asleep. Each of these measures was assessed with a 5-point Likert scale with a 1 indicating a relative ease in awakening their child and a relatively fast sleep onset, and a 5 indicating relative difficulty awakening their child and a relatively slow sleep onset. The parents rated the general academic level of their child on a 3-point scale (i.e., below average, average, above average) on the Child Behavior Checklist.

Results and Discussion

Child Measures

A 2x2 between-subjects multivariate analysis of variance (MANOVA) was performed on the following dependent variables obtained from the children: the Children's Embedded Figures Test score, the number of errors and the mean response latencies on the Matching Familiar Figures Test, the Mazes Scaled score, the number of Involuntary Rest Pauses, and the aspiration level. The independent variables were group (i.e., bedwetters versus controls), and condition (i.e., quiet versus arousal). The Extraversion score from the Junior Eysenck Personality Inventory was included in the analysis to follow due to the fact that this measure was not obtained under differing conditions of arousal. The SAS GLM procedure was utilized for this analysis.

Wilks' Lambda indicated that the combined dependent variables were not significantly affected by either group or condition, but were significantly affected by the interaction of group and condition (see Table 1). A stepdown analysis was then performed to investigate the impact of the interaction across the individual dependent variables. Significant group by condition interactions were found with the score from the

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Insert Table 1 about here

Children's Embedded Figures Test, the number of errors made on the Matching Familiar Figures Test, the mean response latency on the Matching Familiar Figures Test, and the Scaled score on the Mazes subtest (see Table 1). No significant group by condition interactions were observed with the number of Involuntary Rest Pauses or aspiration level, nor did they approach significance in either case (see Table 1).

In other words, the hypothesis that the nocturnal enuretics would respond in a similar general impulsive style as demonstrated in children with ADHD was supported. Specifically, the bedwetters performed in a field-dependent, impulsive manner, and with less planning ability than the control group in the quiet condition. Additionally, the cortical underarousal hypothesis for nocturnal enuretics was supported by the observation that they tended to perform better under a more arousing condition, whereas, the control group's performance tended to decline in the arousal condition. The number of Involuntary Rest Pauses did not significantly differ between groups. Therefore, the hypothesis that nocturnal enuretics would build up more cortical inhibition was not supported. Perhaps the assumed association between Involuntary Rest

Pauses and cortical inhibition, as noted in the literature, may more accurately be a reflection of reactive inhibition. Therefore, with this possibility, the measure of Involuntary Rest Pauses would not clearly be related to the present hypothesis regarding cortical underarousal. Additionally, the aspiration level did not differ between groups. The hypothesis, therefore, was not supported that bedwetters would be less adversely affected by the negative statement preceding the second finger tapping trial which told the subjects that other children tapped faster than they did.

Analyses of simple effects of the significant interactions were performed by analyzing subsets of the data using four separate MANOVAs. Each MANOVA suppressed one level at a time of the independent variables. Specifically, the first of these MANOVAs involved analyzing the data of both groups (i.e., bedwetters versus non-bedwetters), and only the data from the first condition (i.e., quiet condition) while the data from the arousal condition was suppressed. The second MANOVA examined the data from both groups and the arousal condition while the data from the quiet condition was suppressed. The third and fourth MANOVAs analyzed the data from both the quiet and arousal conditions across the groups. This was done first across the bedwetter group with the control group data suppressed and then across the control group with the bedwetter data suppressed.

The stepdown analyses performed on each of these MANOVAs examined the sources of significance within each of the aforementioned significant interactions. Specifically, the Children's Embedded Figures Test score differed significantly between groups in the quiet condition where nonenuretics obtained higher scores than the nocturnal enuretics, but did not differ significantly between groups in the arousal condition. The score did not differ significantly between conditions in the bedwetters or the control group, although the latter result did approach significance (see Figure 1).

Insert Figure 1 about here

The number of errors produced on the Matching Familiar Figures Test differed significantly across groups in the quiet condition where the bedwetters made more errors than nonenuretics, and in the arousal condition where the bedwetters made fewer errors than nonenuretics. The number of errors, however, did not differ significantly between conditions for the bedwetters, but was significantly different between conditions for the control group where fewer errors were observed in the quiet condition (see Figure 2).

Insert Figure 2 about here

The mean response latency on the Matching Familiar Figures Test showed significance between groups in the quiet condition such that the bedwetters responded faster than the control group, but no difference was found in the arousal condition. The mean response latency did not differ significantly between conditions for the bedwetters, however, a significant difference was found between conditions with the control subjects where slower response latencies were observed in the quiet condition (see Figure 3).

Insert Figure 3 about here

The Scaled score on the Mazes subtest was significantly different between groups in the quiet condition where bedwetters scored lower than the control group, however, no difference was seen between groups in the arousal condition. The Scaled score differed significantly between conditions in both groups where bedwetters obtained higher scores in the arousal condition, and the control group obtained higher scores in the quiet condition (see Figure 4).

Insert Figure 4 about here

The analyses of simple effects, therefore, generally indicated that the major portion of the aforementioned significant interactions was attributable to significant differences observed between the groups within the quiet condition, and to significant differences observed between conditions within the control group. The trend, however, did exist that the nocturnal enuretics improved their performance under the arousal condition.

Therefore, to reiterate, the hypothesis that nocturnal enuretics would respond in a general impulsive style was supported by the significant differences found between groups within the quiet condition. The cortical underarousal hypothesis of nocturnal enuresis was supported by the trend of the results where the bedwetters tended to perform better under the arousal condition, even though these differences were not all statistically significant. It is possible that the music utilized to artificially arouse the subjects was not loud enough to produce an optimal level of arousal and significant effects within the nocturnal enuretics.

A two-factor mixed ANOVA was performed on the finger tapping data for the total tapping times of trial # 1 and trial # 2. The between-subjects factors included the variables of group and condition. The repeated-measures variable was the finger tapping times for trials # 1 and # 2. The results indicated no between-subject effects for group, condition, or group by condition. A within-subjects main effect was observed with the finger tapping variable, $F(1,28) = 14.63$, $p < .001$, where the finger tapping time for trial # 2 was significantly faster (M = 40.96, s = 79.98) than trial # 1 (M = 44.88, s = 88.87). No significant within-subjects interactions were found. Therefore, the hypotheses that the nocturnal enuretics would aspire to tap faster and indeed tap faster than the nonenuretics in the second trial were not supported.

Child and Parent Questionnaire Measures

A one-way MANOVA was performed on the Extraversion score obtained from the children as well as the dependent variables obtained from the parents including the scores from the eight Child Behavior Checklist scales: Withdrawn, Somatic complaints, Anxious/Depressed, Social problems, Thought problems, Attention problems, Delinquent behavior, and Aggressive behavior; the scores from the three scales from the Attention Deficit Disorders Evaluation Scale: Inattentive, Impulsive, and Hyperactive; and the two Likert scale measures from the Information Questionnaire: difficulty awakening the child in the night and sleep onset. The independent variable was group (bedwetters versus controls). The SAS GLM procedure was again utilized for this analysis.

Wilks' Lambda indicated that the combined dependent variables were significantly affected by group, $F(14,17) = 33.73$, $p < .01$. A stepdown analysis then was performed which indicated that only two variables contributed to this significance. The Attention Deficit Disorders Evaluation Scale - Hyperactive score showed that bedwetters obtained a higher mean score (indicating less hyperactivity) than the control group, $F(1,30) = 6.54$, $p < .05$. The difficulty awakening variable showed that bedwetters were rated as much more difficult to awaken than the control group children, $F(1,30) = 17.64$, $p < .0005$. The latter significant finding supported the hypothesis that nocturnal enuretics, due to being cortically underaroused, would be less easily aroused by either internal or external stimulation. The former finding, however, that the control group was rated higher in terms of hyperactivity was not expected. Notably, though, both groups obtained scores on this measure that were within the average range which, although statistically significant, may have debatable clinical significance. Furthermore, the previously delineated similarities between nocturnal enuretics and children with ADHD were more specifically referring to internal similarities such as cortical underarousal and a general impulsive style and not to external behavioural similarities. It could very well be that these similar cognitive styles are expressed quite differently behaviourally. For example, in some children who are cortically underaroused it may be expressed through ADHD-like behaviours, while in others it may be expressed through nocturnal enuresis, and in still others it may be expressed both ways.

None of the other dependent variables even approached significance (see Appendix B). One specific measure which was hypothesized to differ between groups but did not was the Extraversion score on the Junior Eysenck Personality Inventory. As previously noted, however, it may be that the internal indexes of cortical underarousal and general impulsive style do not exhibit themselves externally, or behaviourally, such as in terms of extraversion.

The parental perceptions of the academic achievement level of the nocturnal enuretics showed that 9/16 were rated as above average, 6/16 were average, and 1/16 was below average. The parental perceptions of the control group children showed that 9/16 were rated as above average, and 7/16 were average. It appears, therefore, that the groups were quite similar in academic achievement indicating that it does not seem likely that any of the aforementioned significant results could be attributed to differences in academic ability.

Results Summary of Major Hypotheses

In summary, the results obtained from the children supported the hypothesis that the nocturnal enuretics would tend to perform in a more general impulsive style (i.e., in a more field-dependent, impulsive manner with less planning ability) than the nonenuretics under quiet office conditions. The results also showed a trend in the expected direction under the arousal condition. Specifically, it was found that the enuretics generally improved their performance with increased levels of external arousal and the nonenuretics tended to respond in a more field-dependent and impulsive manner with increased levels of arousal. Therefore, the cortical underarousal hypothesis which predicted that the nocturnal enuretics would perform better under a more optimal, and higher, level of arousal was given preliminary support.

Treatment Implications

The significant results have some important implications for the conditions under which optimal learning occurs. Specifically, as has been shown in children with ADHD and extraverted persons, it may also be presumed that bedwetters would condition better with a more powerful urine alarm, and under circumstances which increase their level of arousal to one which is more optimal. Punishment paradigms would not be as effective with bedwetters as would reinforcement paradigms, and bedwetters would respond better on a continuous reinforcement schedule as opposed to intermittent reinforcement. These differential learning patterns have some potentially valuable significance in the successful implementation of the traditional behaviourally-based conditioning treatment methods such as the bell and pad.

For example, using a more powerful urine alarm may include multiple stimuli such as a bell in addition to a buzzer and a light. The level of cortical arousal in bedwetters might be able to be elevated to a more optimal level during sleep by external manipulation such as medication. Specifically, stimulants have been hypothesized to be so successful with children with ADHD due to its arousing effects. It would, therefore, be quite interesting to observe whether such arousing effects might help to obtain a more optimal arousal level in nocturnal enuretics while they sleep such that they would then be more responsive to bladder signals as well as external stimulation such as the urine alarm.

The bell and pad procedure is sometimes utilized on an intermittent schedule and it is hypothesized here that nocturnal enuretics would learn better with a continuous schedule. The latter schedule could be managed by utilizing the bell and pad every night, as opposed to using it some nights and not others. It would be equally important to make sure that the child is aroused for every wetting episode (i.e., on a continuous schedule), because sometimes with these methods the child sleeps right through the alarm or even unplugs the device. Nocturnal enuretics are also hypothesized to condition better under reinforcement as opposed to punishment paradigms. This might be achieved by training the parents to not be verbally punishing when such episodes occur and by allowing the child to gain reinforcers such as special treats or events after "dry" nights.

Future Research Directions

There are several potential future directions of research that can be derived from the present study. The bedwetters did perform better in the arousal condition, however, the difference was only significant for one measure. It would be interesting to test the hypothesis of cortical underarousal further in order to determine if an increased level of external arousal would produce more of the expected differences between bedwetters and control subjects.

The present study utilized both primary and secondary nocturnal enuretics. The sample size from the latter type, however, was quite small which made comparisons difficult between the two. Therefore, future research may be interested in observing whether there are cortical arousal and/or performance differences between these two types of nocturnal enuresis.

The hypothesis that bedwetters tend to respond in a general impulsive style was supported in the present study and several implications were suggested for optimal learning. Therefore, it would seem appropriate to implement and study some of these differential learning conditions with the traditional behaviourally-based bell and pad treatment methods.

Future research might also study in what other ways that nocturnal enuretics differ from control group children. For example, do bedwetters respond differently to certain medications? The most compelling comparison would be to examine whether nocturnal enuretics respond similarly during the night while on stimulants as do children with ADHD during the day. It would also be very interesting to utilize measures which could more directly support the cortical underarousal hypothesis. Specifically, future research may measure arousal, such as through the sweat bottle method, finger temperature, or some such other method, during performance on tasks under differing levels of arousal. Additional indexes measuring direct differences in cortical underarousal could include electroencephalogram recordings.

References

American Psychiatric Association, (1987). Diagnostic and statistical manual of mental disorders (3rd ed. rev.). Washington, DC: Author.

Barratt, E. S., & Patton, J. H. (1983). Impulsivity: Cognitive, behavioral, and psychophysiological correlates. In M. Zuckerman (Ed.), Biological bases of sensation seeking, impulsivity, and anxiety (pp. 77-122). Hillsdale, NJ: Lawrence Erlbaum Assoc, Inc.

Barratt, E. S., Pritchard, W. S., Faulk, D. M., & Brandt, M. E. (1987). The relationship between impulsiveness subtraits, trait anxiety, and visual N100 augmenting/reducing: A topographic analysis. Personality & Individual Differences, 8, 43-51.

Berg, I. (1979). Day wetting in children. Journal of Child Psychology & Psychiatry & Allied Disciplines, 20, 167-173.

Berg, I. (1981). Child psychiatry and enuresis. British Journal of Psychiatry, 139, 247-248.

Bindelglas, P. H. (1975). The enuretic child. The Journal of Family Practice, 2, 375-380.

Boddy, J., Carver, A., & Rowley, K. (1986). Effects of positive and negative verbal reinforcement of performance as a function of extraversion-introversion: Some tests of Gray's theory. Personality & Individual Differences, 7, 81-88.

Borden, K. A., Brown, R. T., Wynne, M. E., & Schlesser, R. (1987). Piagetian conservation and response to cognitive therapy in attention deficit disordered children. Journal of Child Psychology & Psychiatry & Allied Disciplines, 28, 755-764.

Burke, E. C., & Stickler, G. B. (1980). Enuresis - is it being overtreated? Mayo Clinic Proceedings, 55, 118-119.

Campbell, J. B., & Heller, J. F. (1987). Correlations of extraversion, impulsivity and sociability with sensation seeking and MBTI-introversion. Personality & Individual Differences, 8, 133-136.

Cohen, N. J., Weiss, G., & Minde, K. (1972). Cognitive styles in adolescents previously diagnosed as hyperactive. Journal of Child Psychology & Psychiatry & Allied Disciplines, 13, 203-209.

Cooper, C., & Brebner, J. (1987). Excitation-inhibition and arousal as explanatory concepts for extraversion. In J. Strelau & H. J. Eysenck (Eds.), Personality dimensions and arousal (pp. 37-57). New York: Plenum Press.

Daoussis, L., & McKelvie, S. J. (1986). Musical preferences and effects of music on a reading comprehension test for extraverts and introverts. Perceptual and Motor Skills, 62, 283-289.

Ditman, K. S., & Blinn, K. A. (1955). Sleep levels in enuresis. American Journal of Psychiatry, 111, 913-920.

Douglas, V. I., & Peters, K. G. (1979). Toward a clearer definition of the attentional deficit of hyperactive children. In G. A. Hale & M. Lewis (Eds.), Attention and cognitive development (pp. 173-247). New York: Plenum Press.

Ellis, L. (1987). Relationships of criminality and psychopathy with eight other apparent behavioral manifestations of sub-optimal arousal. Personality & Individual Differences, 8, 905-925.

Eysenck, H. J. (1964). Involuntary rest pauses in tapping as a function of drive and personality. Perceptual & Motor Skills, 18, 173-174.

Eysenck, H. J. (1967). The biological basis of personality. Springfield, IL: Charles C Thomas.

Eysenck, H. J. (1981). General features of the model. In H. J. Eysenck (Ed.), A model for personality (pp. 1-37). Berlin: Springer-Verlag.

Eysenck, H. J. (1983). A biometrical-genetical analysis of impulsive and sensation seeking behavior. In M. Zuckerman (Ed.), Biological bases of sensation seeking, impulsivity, and anxiety (pp. 1-36). Hillsdale, NJ: Lawrence Erlbaum Assoc, Inc.

Eysenck, H. J. (1987). Arousal and personality: The origins of a theory. In J. Strelau & H. J. Eysenck (Eds.), Personality dimensions and arousal (pp. 1-13). New York: Plenum Press.

Eysenck, H. J., & Levey, A. (1972). Conditioning, introversion-extraversion and the strength of the nervous system. In V. D. Nebylitsyn & J. A. Gray (Eds.), Biological bases of individual behavior (pp. 206-220). New York: Academic Press.

Eysenck, S. B. G. (1965). A new scale for personality measurements in children. British Journal of Educational Psychology, 35, 362-367.

Fielding, D. (1982). An analysis of the behavior of day- and night-wetting children: Towards a model of micturition control. Behaviour Research & Therapy, 20, 49-60.

Finley, W. W., & Perry, R. R. (1973). Relationship of EEG findings to enuresis nocturna in children with psychiatric disorders. Clinical Electroencephalography, 4, 62-69.

Finley, W. W., & Wansley, R. A. (1977). Auditory intensity as a variable in the conditioning treatment of enuresis nocturna. Behaviour Research & Therapy, 15, 181-185.

Forsythe, W. I., & Redmond, A. (1974). Enuresis and spontaneous cure rate. Archives of Disease in Childhood, 49, 259-263.

Frith, C. D. (1967). The interaction of noise and personality with critical fusion performance. British Journal of Personality, 50, 127-131.

Groth-Marnat, G. (1984). Handbook of psychological assessment. New York: Van Nostrand Reinhold Co.

Green, R. G. (1984). Preferred stimulation levels in introverts and extraverts: Effects of arousal and performance. Journal of Personality & Social Psychology, 46, 1303-1312.

Inoue, M., Shimojima, H., Chiba, H., Tsukahara, N., Tajika, Y., & Taka, K. (1987). Rhythmic slow wave observed on nocturnal sleep encephalogram in children with idiopathic nocturnal enuresis. Sleep, 10(6), 570-579.

Kaffman, M., & Elizur, E. (1977). Infants who become enuretics: A longitudinal study of 161 kibbutz children. Monographs of the Society for Research in Child Development, 42, 1-53.

Kagan, J. (1966). Reflection-impulsivity: The generality and dynamics of conceptual tempo. Journal of Abnormal Psychology, 71, 17-24.

Kahneman, D. (1973). Attention and effort. Englewood Cliffs, NJ: Prentice-Hall.

Kinsbourne, H., & Caplan, P. J. (1979). Children's learning and attention problems. Boston, MA: Little, Brown & Co.

Krupnova, M. S. (1987). Clinical aspects and treatment of nocturnal urinary incontinence in children. Soviet Neurology & Psychiatry, 20, 72-78.

Lovibond, S. H. (1963). The mechanism of conditioning treatment of enuresis. Behaviour Research & Therapy, 1, 17-21.

Matthews, G. (1986). The interactive effects of extraversion and arousal on performance: Are creativity tests anomalous? Personality & Individual Differences, 7, 751-761.

Matthews, G. (1987). Personality and multidimensional arousal: A study of two dimensions of extraversion. Personality & Individual Differences, 8, 9-16.

Moilanen, I., Järvelin, H. R., Vikeväinen-Tervonen, L., & Huttunen, N. P. (1987). Personality and family characteristics of enuretic children. Psychiatria Fennica, 18, 53-61.

Morgan, R. T. T. (1978). Relapse and therapeutic response in the conditioning treatment of enuresis: A review of recent findings on intermittent reinforcement, overlearning and stimulus intensity. Behaviour Research & Therapy, 16, 273-279.

Motta, R. W. (1979). Factors related to the efficacy of treatment of enuresis. Psychological Reports, 44, 1183-1188.

Mountjoy, P. T., Ruben, D. H., & Bradford, T. S. (1984). Recent technological advancements in the treatment of enuresis. Behavior Modification, 8, 291-315.

Mowrer, O. H., & Mowrer, W. H. (1938). Enuresis - A method for its study and treatment. The American Journal of Orthopsychiatry, 8, 436-459.

Nelson, J. G., & Shapiro, J. (1987). The role of arousal in predicting impulsive and reflective children. Personality & Individual Differences, 8, 153-155.

O'Gorman, J. G., & Lloyd, J. E. M. (1987). Extraversion, impulsiveness, and EEG alpha activity. Personality & Individual Differences, 8, 169-174.

Ollendick, T. H., & Hersen, M. (Eds.). (1983). Handbook of child psychopathology. New York: Plenum Press.

Pierce, C. M. (1980). Enuresis. In H. I. Kaplan, A. M. Friedman, & B. J. Sadock (Eds.), Comprehensive textbook of psychiatry, (3rd ed.). (Vol. 3, pp. 2780-2788). Baltimore, MD: The Williams and Wilkins Co.

Revelle, W., Anderson, K. J., & Humphreys, M. S. (1987). Empirical tests and theoretical extensions of arousal-based theories of personality. In J. Strelau & H. J. Eysenck (Eds.), Personality dimensions and arousal (pp. 17-36). New York: Plenum Press.

Rosenthal, R. H., & Allen, T. W. (1978). An examination of attention, arousal, and learning dysfunction of hyperkinetic children. Psychological Bulletin, 85, 689-715.

Rosenthal, R. H., & Allen, T. W. (1980). Intratask distractibility in hyperkinetic and nonhyperkinetic children. Journal of Abnormal Child Psychology, 8, 175-187.

Ross, D. M., & Ross, S. A. (1976). Hyperactivity: Research, theory, and action. New York: John Wiley & Sons, Inc.

Savage, R. D. (1964). Electro-cerebral activity, extraversion and neuroticism. British Journal of Psychiatry, 110, 98-110.

Schaefer, C. E. (1979). Childhood encopresis and enuresis: Causes and therapy. New York: Van Nostrand Reinhold Co.

Shaffer, D. (1973). The association between enuresis and emotional disorder: A review of the literature. In I. Kolvin, R. C. MacKeith, & S. R. Meadow (Eds.), Bladder control and enuresis (pp. 118-136). Philadelphia, PA: Lippincott.

Shapiro, D. (1965). Neurotic styles. NY: Basic Books.

Sorotzkin, B. (1984). Nocturnal enuresis: Current perspectives. Clinical Psychology Review, 4, 293-316.

Steinkamp, H. W. (1980). Relationships between environmental distractions and task performance of hyperactive and normal children. Journal of Learning Disabilities, 13, 40-45.

Stelmack, R. M. (1981). The psychophysiology of extraversion and neuroticism. In H. J. Eysenck (Ed.), A model for personality (pp.38-64). Berlin: Springer-Verlag.

Stoner, S. B., & Glynn, M. A. (1987). Cognitive styles of school-age children showing attention deficit disorders with hyperactivity. Psychological Reports, 61, 119-125.

Street, E., & Broughton, L. (1990). The treatment of childhood nocturnal enuresis in the community. Child: Care, Health and Development, 16, 365-372.

Trombini, G., Rossi, N., Umilta, C., & Baccarani, C. P. (1982). Experimental stress and cystomanometric recordings of patients with primary enuresis, A preliminary report. Perceptual & Motor Skills, 54, 771-777.

Verhulst, F. C., van der Lee, J. H., Akkerhuis, G. W., Sanders-Woudstra, J. A. R., Timmer, F. C., & Donkhorst, I. D. (1985). The prevalence of nocturnal enuresis: Do DSM-III-R criteria need to be changed? A brief research report. Journal of Child Psychology & Psychiatry & Allied Disciplines, 26, 989-993.

Wachtel, P. L. (1967). Conceptions of broad and narrow attention. Psychological Bulletin, 68, 417-429.

Wagner, W. G. (1987). The behavioral treatment of childhood nocturnal enuresis. Journal of Counseling & Development, 65, 262-265.

Wagner, W. G., & Geffken, G. (1986). Enuretic children: How they view their wetting behavior. Child Study Journal, 16, 13-18.

Wagner, W. G., Smith, D., & Norris, W. R. (1988). The psychological adjustment of enuretic children: A comparison of two types. Journal of Pediatric Psychology, 13, 33-38.

Walker, C. E., Kenning, M., & Faust-Campanile, J. (1989). Enuresis and encopresis. In E. J. Mash & R. A. Barkley (Eds.), Treatment of childhood disorders (pp. 423-448). New York: The Guilford Press.

Werry, J. S. (1967). Is enuresis a psychosomatic entity? Canadian Medical Association Journal, 97, 319-327.

Werry, J. S., Elkind, G. S., & Reeves, J. C. (1987). Attention deficit, conduct, oppositional, and anxiety disorders in children: III. Laboratory differences. Journal of Abnormal Child Psychology, 15, 409-428.

Zentall, S. (1975). Optimal stimulation as theoretical basis of hyperactivity. American Journal of Orthopsychiatry, 45, 549-563.

Zentall, S. S., & Meyer, M. J. (1987). Self-regulation of stimulation for ADD-H children during reading and vigilance task performance. Journal of Abnormal Child Psychology, 15, 519-536.

Zuckerman, M. (1987). A critical look at three arousal constructs in personality theories: Optimal levels of arousal, strength of the nervous system, and sensitivities to signals of reward and punishment. In J. Strelau & H. J. Eysenck (Eds.), Personality dimensions and arousal (pp. 217-231). New York: Plenum Press.

Appendix A

Information Questionnaire

I. Child Identifying Information:

1. Age:___ Date of birth:__/__/__

2. Child lives with: __natural parents

__parent and step-parent

__adoptive parents

__single parent

__relative(s)

__other, specify_____________

II. Toilet Training History:

1. Does your child currently wet during the day or night, both, or neither:

____

*if neither, go to question # 2.

*if your child wets, go to question # 3.

2. A. When did your child first stay dry throughout the day:____________

night:________________

B. Did your child ever start wetting during the day or night since dryness was first attained:_______________

If yes, when:_________________

was it during the day or night or both:____________

how frequent was the wetting:______________

how long was it until the next dry time:____________

3. A. Has your child ever been dry throughout the day:_____________

night:_______________

B. If any dry period was attained, <u>when</u> was it and <u>how long</u> did it last:

____

C. Since what age has your child been wetting:_________________

D. How often does he wet:____________________________

E. Has your child been checked by a urologist or neurologist for his wetting:______________________________

If yes, what was the result?________________________

F. Have you tried treatment for the wetting:_____________________

G. What treatment methods have you tried:_____________________

____

how successful were they:__________________________

for how long:______________________________

H. Has any other relative had a history of wetting:____________

If yes, who:______________________________

III. Arousability/Sleep

1. How easy is it to awaken your child in the middle of the night:

___very easy

___easy

___about average

___difficult

___very difficult

2. How quickly does your child fall asleep:

___1-5 minutes

___6-15 minutes

___16-30 minutes

___31-60 minutes

___60 minutes or more

3. Does your child have any sleep disturbances:

___wakes up often throughout night

___trouble falling asleep

___nightmares

___restless during sleep

___other, specify:____________________

Appendix B

Table B - 1.

Mean Scores between Bedwetters and Control Children from Parent Measures and Child Report of Extraversion

Dependent measures	Bedwetters	Control
CBCL-WDRN	56.2	54.5
CBCL-SOM	57.8	55.6
CBCL-ANXD	56.8	56.4
CBCL-SOC	55.4	53.2
CBCL-THOT	54.4	53.7
CBCL-ATTN	54.1	55.6
CBCL-DELQ	51.7	51.4
CBCL-AGGR	52.1	53.4
ADDES-INATT	10.7	9.8
ADDES-IMP	11.5	10.4
ADDES-HYP	12.2	10.2*
Awakening	4.3	3.0**

Dependent measures	Bedwetters	Control
Sleep onset	2.5	2.4
JEPI-E	11.5	12.5

Note. CBCL = Child Behavior Checklist; CBCL Scales are as follows: WDRN = Withdrawn, SOM = Somatic Complaints, ANXD = Anxious/Depressed, SOC = Social problems, THOT = Thought problems, ATTN = Attention problems, DELQ = Delinquent behaviour, AGGR = Aggressive behaviour; ADDES = Attention Deficit Disorders Evaluation Scale; ADDES Scales are as follows: INATT = Inattentive, IMP = Impulsive, HYP = Hyperactive; Awakening = parent rating of ease/difficulty level of awakening their child in the night; Sleep onset = parent rating of how long it takes their child to fall asleep at night; JEPI-E = Extraversion scale from the Junior Eysenck Personality Inventory.

*$p < .05$

**$p < .0005$

Table 1

F values, df, and p levels for the 2x2 MANOVA Child Measure Results

Factors	F	df(num,den)	p
Full analysis			
Group	1.31	6,23	>.10
Condition	.36	6,23	>.10
Group x Condition	5.40	6,23	<.005
Stepdown analysis (interactions)			
CEFT	5.03	1,28	<.05
MTE	8.85	1,28	<.01
MTRL	8.92	1,28	<.01
Mazes	11.92	1,28	<.005
IRP	1.39	1,28	>.10
ASP	.12	1,28	>.10

Note. CEFT = Children's Embedded Figures Test; MTE = errors on the Matching Familiar Figures Test; MTRL = mean response latencies on the Matching Familiar Figures Test; IRP = Involuntary Rest Pauses; ASP = aspiration level for finger tapping trial # 2.

Figure Captions

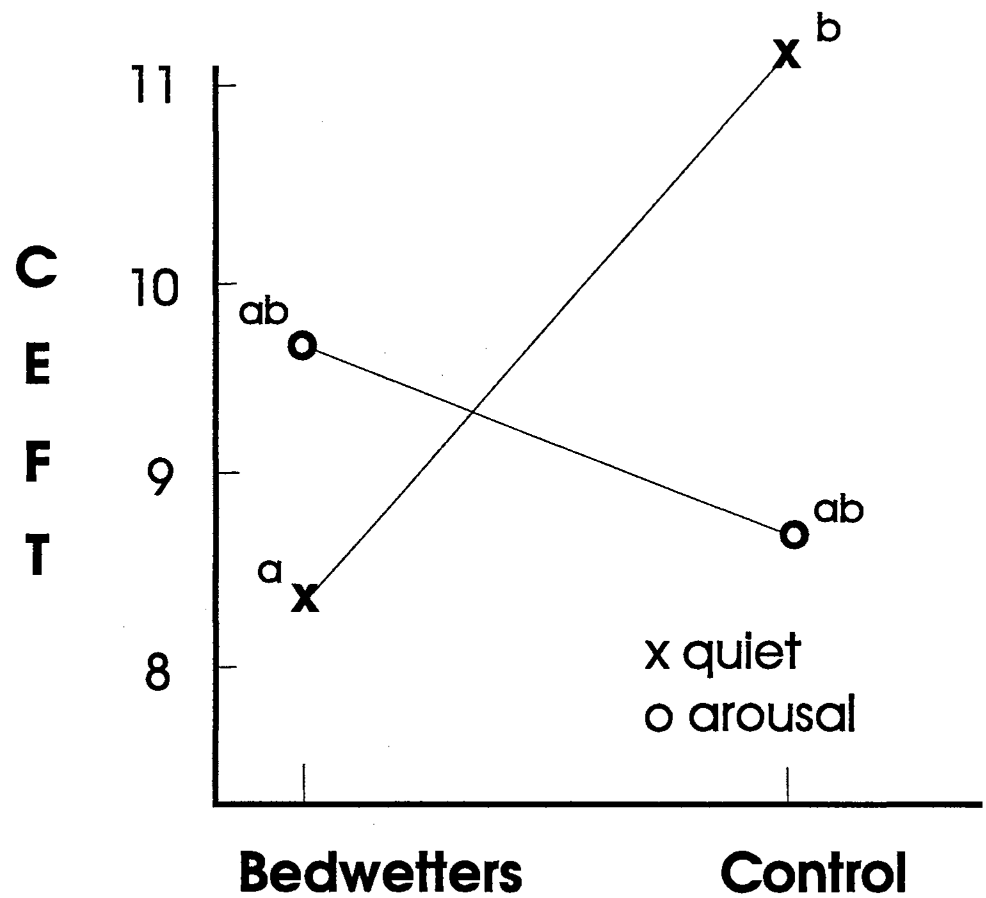
Figure 1. Children's Embedded Figures Test (CEFT) scores between bedwetters and the control group in quiet versus arousal conditions.

Figure 2. Errors on the Matching Familiar Figures Test (MTE) between bedwetters and the control group in quiet versus arousal conditions.

Figure 3. Mean response latency on the Matching Familiar Figures Test (MTRL) between bedwetters and the control group in quiet versus arousal conditions.

Figure 4. Scores on the Mazes subtest between bedwetters and the control group in quiet versus arousal conditions.

Note. Mean points sharing the same superscript (i.e., letters a - d) are not significantly different at $p < .05$.



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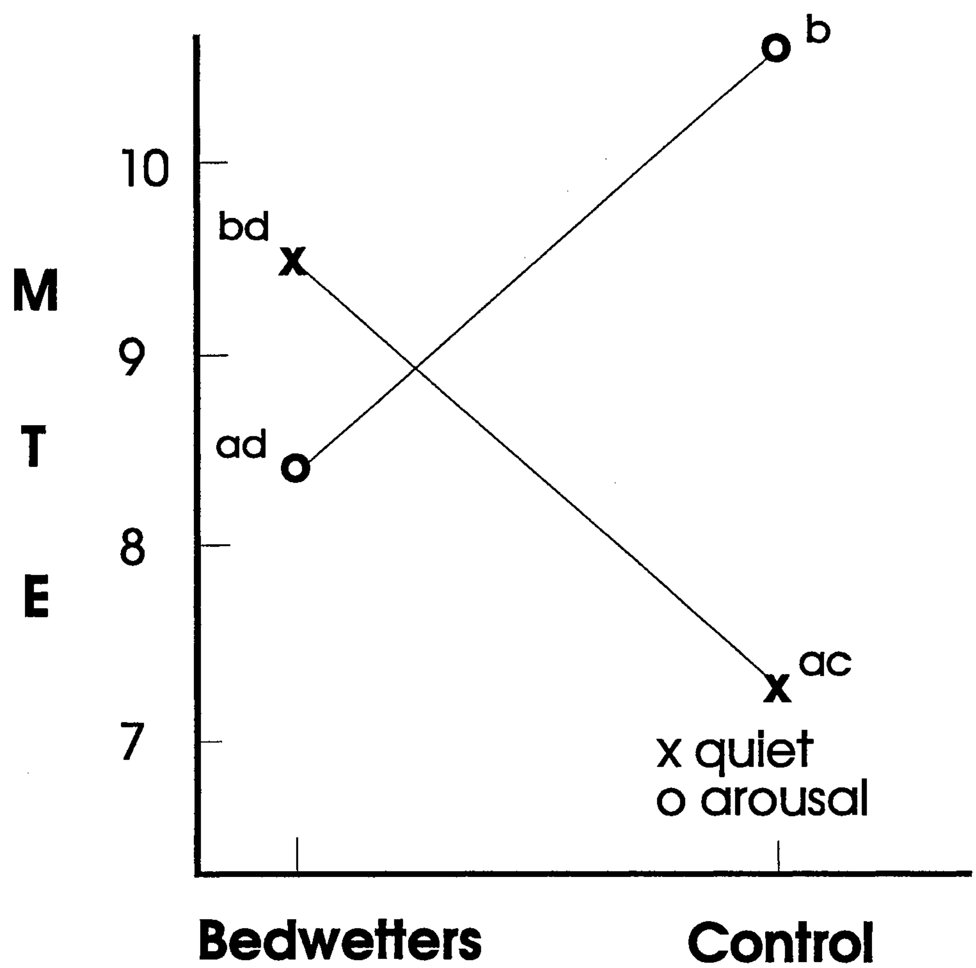

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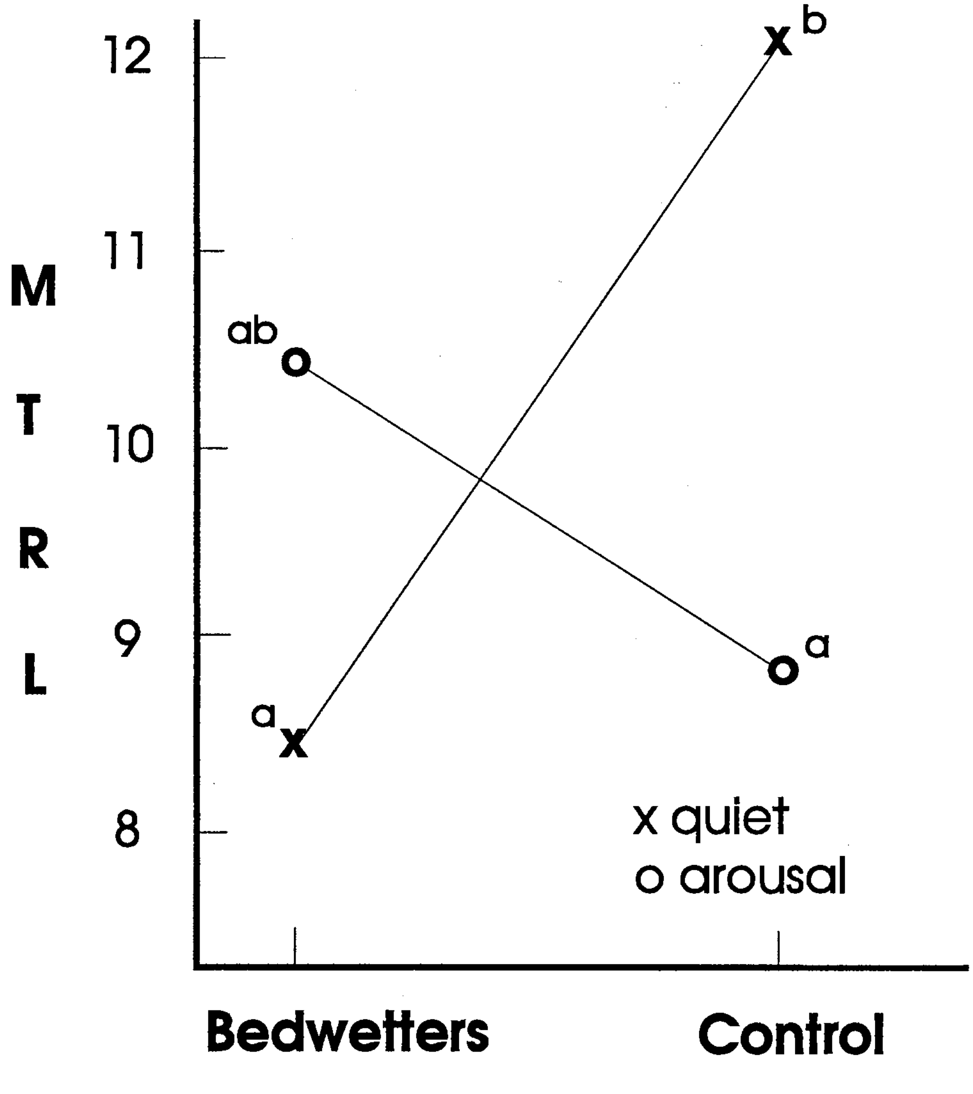

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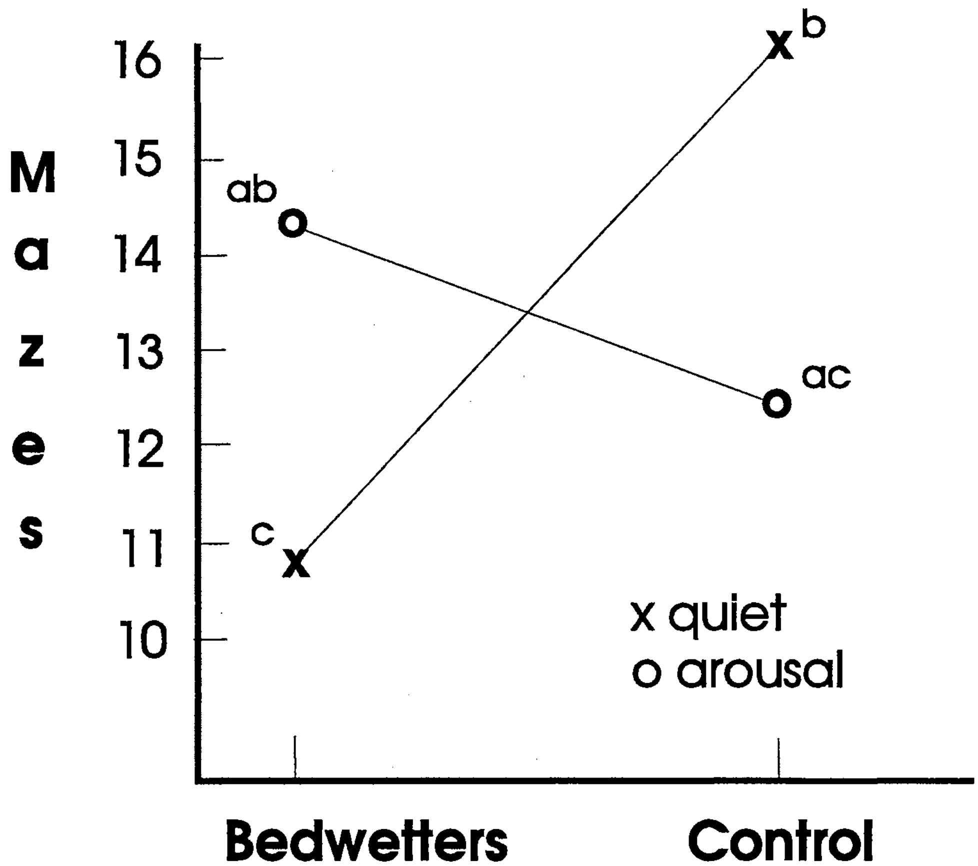
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