The hyperactive spontaneously hypertensive rat learns to sit still, but not to stop bursts of responses with short interresponse times

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The spontaneously hypertensive rat (SHR) is hyperactive and has been proposed as an animal model of attention-deficit hyperactivity disorder (ADHD). Although ADHD in most cases is treated with central stimulants, behavior therapy has also been used, but with relatively limited success. The purpose of the present study was to investigate suppression of SHR hyperactivity by differentially reinforcing immobility (DRI) using a positive reinforcer. The DRI schedule required that the rat remain immobile in a particular part of an operant chamber, the target, in order to obtain the reinforcer. The time requirement, the DRI value, of these periods was increased progressively. The results showed that time spent on the target increased by increasing DRI value in both hyperactive and control rats. However, the total number of movements, on as well as outside the target, was higher for the hyperactive rats. The behavior grouped into two independent response components. One component consisted of immobility responses with durations less than 1 s, actually bursts of active responses; the other component consisted of immobility responses with durations more or less matching the DRI requirement. The reinforcement schedule modified the long-lasting immobility component in both groups. SHR received more reinforcers than WKY as long as the schedule did not require too long periods of immobility. However, the total number of movements on target was not reduced in SHR; on the contrary, it increased somewhat as the schedule requirements increased. If the behavior of ADHD children consists of two, or more, independent components similar to the ones observed in the present study,
the present results may offer an explanation of why behavior therapy has limited success in the treatment of ADHD.

KEY WORDS: rats; spontaneously hypertensive rats; hyperactivity; hyperkinesis; animal model; behavior therapy; behavior modification; immobility; differential reinforcement of immobility.

INTRODUCTION

Childhood hyperactivity, attention-deficit hyperactivity disorder (ADHD) is characterized by attention problems, distractibility, and impulsivity, as well as a profound hyperactivity (American Psychiatric Association, 1987; for a critical discussion see Conners, 1990). Although there is some disagreement (Rutter et al., 1990), it is generally believed that there is a strong genetic component in ADHD (Biederman et al., 1990). The administration of psychomotor stimulants, amphetamine and methyphenidate (Ritalin), is generally considered to be the most effective therapy for ADHD (for recent reviews see Gittelman Klein and Abikoff, 1989; Murray, 1987; Sagvolden and Archer, 1989). However, behavior therapy is another treatment strategy used with some success (for recent reviews see Gittelman Klein and Mannuzza, 1989; Rapoport, 1983; Sagvolden and Archer, 1989). An obvious advantage with behavior therapy is the total avoidance of the side effects of drug administration.

Spontaneously hypertensive rats (SHR) are hyperactive without any surgical or neurotoxic intervention (Knardahl and Sagvolden, 1979, 1982; Hendley and Ohlsson, 1991; McCarty and Kopin, 1979; Moser et al., 1988; Myers et al., 1982; Wultz et al., 1990). SHR and their normotensive progenitor strain, Wistar-Kyoto rats (WKY), were originally developed by selectively inbreeding Wistar rats for an entirely different purpose, namely, as an animal model of essential hypertension (Okamoto and Aoki, 1963). It has repeatedly been shown that there is no relation between the hyperactivity and the hypertensive traits of the SHR (Hendley et al., 1983, 1986; Sagvolden et al., 1992a).

It has been suggested that SHR may be used as an animal model of ADHD (Myers et al., 1982; Sagvolden et al., 1989; Wultz et al., 1990). SHR show a remarkable hyperactivity in the free-exploration open field (Knardahl and Sagvolden, 1979; Moser et al., 1988; Wultz et al., 1990), in operant conditioning (Sagvolden et al., 1989, 1992a,b), and also in avoidance tasks (e.g., Knardahl and Sagvolden, 1982). Further, SHR show changes in attention behavior (Sagvolden et al., 1989, 1992a,b). Thus, SHR show the two major behavioral symptoms of ADHD: hyperactivity and attention deficit. These are the main reasons why we have