Journal of the International Neuropsychological Society (2005), **11**, 367–375.

DOI: 10.1017/S135561770505040X

Evidence of utilization behavior in children with ADHD

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(RECEIVED March 15, 2004; REVISED September 10, 2004; ACCEPTED January 24, 2005)

Abstract

The purpose of this study was to investigate whether inappropriate/excessive motor activity seen in children with Attention Deficit Hyperactivity Disorder (ADHD) could be characterized as Utilization Behavior (UB). Given evidence that the neuropathology of ADHD may involve frontal-striatal systems, we investigated the possibility that children with ADHD may demonstrate "utilization behavior." Utilization Behavior (UB) is a neurobehavioral syndrome documented in individuals with damage or dysfunction in the frontal areas of the brain; patients exhibiting UB are often described as reaching out and utilizing objects in the environment in an automatic and inappropriate manner. The sample consisted of two group of children; children with ADHD ($n = 32$) and control children ($n = 31$). Children were assessed individually in a testing room where various objects, selected to elicit UB, were present. They completed cognitive tests and also were allowed to engage in an unsupervised activity. Testing sessions were videotaped and instances of physical activity (i.e., upper limb motor activity and utilization of objects) were counted by two raters. Results indicated high levels of object utilization in approximately one-half of the children with ADHD, whereas almost no such behavior was observed in controls. This behavior did not appear to be a result of generally heightened activity levels or due to instruction set, but differed according to object familiarity and object visibility. Levels of UB were statistically associated with the severity of hyperactivity, as reported by parents, of children with ADHD. This study suggests that inappropriate/excessive motor activity may, at least in part, be characterized as UB in some children with ADHD. (*JINS*, 2005, *11*, 367–375.)

Keywords: Hyperactivity, Frontal, Striatal, Motor systems, Environmental dependency, Disinhibition

INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD), Combined Type, is an externalizing disorder characterized by inattention, disinhibition, impulsivity, and excessive motor activity (Goodyear & Hynd, 1992). These motor symptoms are evident through developmentally inappropriate levels of fidgetiness, difficulties staying seated, inappropriate/excessive movement, difficulties waiting one's turn, and excessive manipulation of objects (Barkley, 1997a). Anecdotal and observational evidence indicates that children with ADHD have great difficulty restricting their behavior to conform to instructions/rules and with deferring gratification/resisting temptation (Barkley, 1997a). In addition to demonstrating higher activity levels, these children also exhibit qualitatively more inappropriate and intrusive motor behaviors (Porrino et al., 1983). Hyperactive children appear less able to inhibit their motor activity when asked to do so (Ullman et al., 1978), and demonstrate more off-task behavior, out of seat behaviors, and forbidden "touching of objects" than non-hyperactive children (Barkley, 1991, 1997a). Given the above-noted symptoms, some theorists have proposed that ADHD is uniquely characterized by overactivity and difficulties with motor regulation (Halperin et al., 1992), with these symptoms distinguishing ADHD from other psychiatric conditions.

It has been proposed that some of the challenging behaviors seen in children with ADHD closely resemble those seen in individuals with documented frontal lobe pathology (Barkley, 1997a; Chelune et al., 1986; Goodyear & Hynd, 1992). Neuropsychological investigations have supported a "frontal lobe hypothesis" of ADHD (Barkley, 1997a; Chelune et al., 1986; Gorenstein & Mammato, 1989; Grodzinsky & Diamond, 1992; LaPierre et al., 1995; Pennington & Ozonoff, 1996; Shue & Douglas, 1992). In addition, neuroimaging investigations have identified abnormal metabolism within frontal-lobe systems in children with ADHD (Sieg et al., 1995; Zametkin et al., 1990, 1993), and both

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structural and functional neuroimaging studies have suggested dysfunction within frontal-striatal systems in these children (Alexander et al., 1990; Casey et al., 1997; Casey, 2001; Cummings, 1993; Groenewegen et al., 1997; Lou et al., 1989; Roeltgen & Schneider, 1991; Tannock et al., 1989; Zametkin et al., 1993) .

Frontal-striatal circuits, including basal ganglial-thalamocortical pathways running from the prefrontal cortex through the basal ganglia and thalamic nuclei, have been associated with the voluntary control of motor activity and the suppression of inappropriate action/behavior (Kroptov & Etlinger, 1999). Statistically significant correlations between behavioral inhibition and frontal-striatal volumes have been obtained in children with ADHD (Casey, 2001), suggesting that dysfunction in these circuits could be associated with the clinical symptomatology of ADHD. While frontal-striatal networks likely influence many aspects of behavior, research suggests that they may be particularly important for controlling attention, inhibition, and motor intentional behavior (Hynd et al., 1991a). Indeed, some authors have conceptualized ADHD as a disorder specifically of neural systems subserving the regulation of motor control (Hynd et al., 1991a, 1991b; Niedermeyer & Naidu, 1997; Niedermeyer & Naidu, 1998). Associations between motor problems and ADHD have been seen in a number of studies (Tannock, 2000), including tests of fine and gross motor skills (Carte et al., 1996; Kadesjo & Gillberg, 1998), as well on tasks requiring motor control and coordination (Mariani & Barkley, 1997; Piek et al., 1999).

Given the prominence of motor regulation problems in the clinical symptomatology of ADHD and evidence for dysfunction in frontal-striatal circuits, we investigated the possibility that some of the motor disinhibition seen in this population could reflect frontal lobe UB; for a comprehensive review of the "Utilization Behavior" syndrome, see Archibald et al. (2001). UB is a phenomenon noted in individuals with dysfunction in frontal brain systems. First coined by L'hermitte (1983), the term "Utilization Behavior" refers to a neurobehavioral syndrome that reflects instrumentally correct, yet highly exaggerated and inappropriate, motor responses to environmental cues and objects (Eslinger et al., 1991; L'hermitte, 1986). Patients have been described as automatically using objects in the environment in a manner that is "object-appropriate," but that is inappropriate for the particular context. According to Eslinger (2002), these patients display "unintended and disinhibited actions that are solely triggered and compelled by objects in the environment." Furthermore, they may be unaware or unconcerned that their actions may be socially inappropriate. For example, a patient may pick up a toothbrush and begin to brush his teeth, in response to a toothbrush being placed in front of him, but in a setting in which brushing one's teeth would not be appropriate, such as in an appointment with a doctor. In a neuropsychological evaluation, a patient with UB might automatically pick up a pen and paper and begin writing something, in a situation where it is inappropriate or the patient has not been requested to do so. UB has also been described in the context of a more global "environmental dependency syndrome," which is characterized by deficits in personal control of action, and a striking over-reliance on the external social/physical environmental for guiding behavior (Eslinger, 2002; L'hermitte, 1986). Most theoretical perspectives view this syndrome as due to a loss of frontal executive controls resulting in an imbalance between frontal systems, important for internally guiding motor activity/behavior, and parietal systems, important for responding to external or environmentally based stimuli, and particularly to visual stimuli (Brazzelli et al., 1994; Eslinger, 2002; Goldberg & Podell, 1995; L'hermitte, 1986; Shallice et al., 1989). Research has suggested that the pathophysiology of UB involves dysfunction within frontal-striatal brain systems (Brazzelli et al., 1994; L'hermitte, 1983; L'hermitte, 1986; Shallice et al., 1989).

Barkley (1997b) was perhaps the first to propose that children with ADHD might be conceptualized as experiencing something like UB given their difficulty with the internal control of behavior and susceptibility to external circumstances. The primary goal of this study was to determine if ADHD is associated with UB, either as a part of or in addition to generally heightened activity levels. It was hypothesized that children with ADHD would specifically "utilize" objects in their environment versus just explore or fiddle with objects. Other questions of interest were also explored, based on the theoretical neurological underpinnings of UB (see Archibald et al., 2001). These included predicting whether instructions not to touch the objects would influence UB, and whether UB would occur more during verbal than visual (motor-free) tasks, more with objects that were familiar *versus* unfamiliar, and more in response to objects that were in sight *versus* those that were available and known to the child but not visually present.

METHODS

Participants

The sample consisted of two groups of children, recruited from local elementary schools, ranging from ages 6 to 12 years, matched by age and gender. Children were initially screened, through a telephone interview with parents, to determine their appropriateness for inclusion within this study. The initial screening interview enquired about a history of attention problems, learning challenges, and other medical/psychiatric difficulties. Only children who did not have histories of major medical problems or psychiatric difficulties were selected for more comprehensive screening for possible inclusion within the study. Participating children and their parents were compensated with a small monetary stipend.

Inclusion within the ADHD sample was based on two separate diagnostic indicators: (1) a previous diagnosis of ADHD by a qualified health care professional (physician or psychologist), and (2) a current diagnosis based on a structured interview completed by one of the investigators. The clinical sample consisted of 32 children (28 males and 4 females) all of whom met Diagnostic and Statistical Manual, 4th Edition (DSM–IV; American Psychiatric Association, 1994) criteria for ADHD, Combined Type, based on the Diagnostic Interview for Children and Adolescents (DICA; Reich et al., 1997) at the time of the study. Of children that were screened, 15 children were not included in the final ADHD sample of 32, as they did not meet full DSM–IV criteria for ADHD, Combined Type, based on the DICA. Children with ADHD were tested off their stimulant medications, after a washout period of at least 24 hr.

The control group consisted of 31 children (27 males and 4 females) without a history of significant developmental, attention, or behavioral problems. Parents of children in the control sample also completed the DICA. Children who were included in the control sample had never been diagnosed with ADHD, and did not meet current diagnostic criteria for ADHD, based on the DICA. Control participants were matched with children in the ADHD sample based on age and gender. The demographic characteristics of each participant group are outlined in Table 1.

Parents of all participants completed the "Child History Questionnaire," which requests information about the child's medical, behavioral, and educational history. The Wechsler Intelligence Scale for Children Third Edition (WISC–III) Vocabulary Subtest (Wechsler, 1991) was used to provide an estimate of verbal intelligence (VIQ). The WISC–III Vocabulary subtest is known to be a fairly reliable estimate of verbal intelligence as it correlates well ($r = .87$) with overall verbal intellectual ability (VIQ; Wechsler, 1991). The Raven's Color Matrices Test (Raven, 1947, 1995) was used as an estimate of (essentially motor-free) nonverbal intelligence (NVIQ; Spreen & Strauss, 1998). An overall estimate of intellectual ability was then calculated by averaging the estimates of IQ obtained from the WISC–III Vocabulary and the Raven's Colored Matrices. It should be noted that both the WISC–III Vocabulary and Raven's tests are thought to correlate moderately well ($r = .70$ and $r = .79$, respectively) with estimates of general intellectual ability (Spreen & Strauss, 1998; Wechsler, 1991). Although some children utilized objects during administration of cognitive (verbal) tasks, they were able to answer the questions and the administration was deemed valid. Groups were found to differ significantly on the estimate of verbal intellectual abilities, but did not differ on the estimate of nonverbal intelligence (NVIQ; see Table 1). As a consequence, the ADHD and control samples did differ significantly in estimates of overall intellectual ability. However, estimates based on the average of verbal and nonverbal abilities for both groups fell solidly within the average range (*M* ADHD = 64.08 %ile, *SD* = 19.73; *M* Control = 76.92 %ile, *SD* = 14.78). There were no children with overall estimates of intelligence below a standard score of 80. Forty-four percent of the ADHD sample had learning difficulties, *versus* none of the controls, but ADHD children with learning difficulties were not excluded due to the high co-morbidity of learning difficulties with ADHD.

Procedures

All children were tested individually at the University of Victoria. The testing room was set up to give children easy access to objects. To determine if the child's behavior was influenced by the "visual pull" of objects, objects were placed both within and outside of the child's line of sight, although all were easily within their reach. For this purpose a special table was designed, with an "opening top" similar to a child's school desk, with an 8-inch high opening in the front by 36-inches wide, allowing access to a shelf (made of a glass for videotaping from below). This was constructed to allow children access to objects "in the desk," which they could easily touch but that were not visible. At the start of each session, as children entered the testing room, the table was "open" so that children were able to look at the objects inside the table. Once the child was seated, the "opening top" of the testing table was closed, though the objects were clearly within reach through the large opening in front. Objects were just above hand level for children seated with hands in their laps.

Table 1. Description of ADHD and control samples—demographic information

	ADHD group		Control group			
Measure	*M*	*SD*	*M*	*SD*	*T*	*p*
Age in Years	9.89	1.86	10.15	1.87	.54	ns
Estimate of Verbal IQ						
WISC–III Vocabulary %ile	57.84	24.53	76.68	17.75	3.48	<.01
& Scaled Score	10.78	2.35	12.84	2.35		
Estimate of Performance IQ						
Ravens Matrices %ile	70.31	19.29	77.16	18.00	1.46	ns
& Scaled Score	12.03	2.13	12.64	2.13		
Estimate of Overall IQ %ile						
(Average of Vocab/Ravens)	64.08	19.73	76.92	14.78	2.92	<.01

Note. ns = not significant.

To investigate if instruction set/expectation influenced the children's behavior, half of the sample was randomly assigned to an "instruction condition" and asked at the beginning of the test session not to touch any of the objects in or around the table. The other half of the sample was not given any instructions or directions regarding the objects. This was the only discussion of the "objects" that occurred during the testing session.

To see if object familiarity influenced children's behavior, objects that should have been "familiar" to or commonly used by children (e.g., scissors, stapler, stopwatch, small telescope, cup, brush) and items that were "unfamiliar" or rarely used by most children (e.g., garlic press, wood working tool, clamp, wood planer (blade removed), wine bottle vacuum, ear syringe, table lamp clamp) were selected. Objects were placed in one of two locations, inside the table or on the top right-hand side of the table with an equal number of familiar and unfamiliar objects either clearly visible (i.e., on top of the table) or out of sight (i.e., inside the closed testing table). Objects were positioned in exactly the same location for all participants.

Each session was videotaped using two VHS cameras. The first camera was mounted high on a wall opposite the testing table and positioned facing the child, to record behaviors above the table. The second camera was located underneath the testing table and was angled upwards through the plate glass shelf of the table. This gave a clear view if a child put his or her hand(s) inside the table and touched or manipulated any of the objects inside the table (out of the child's view).

While sitting at the testing table, all children were administered the WISC–III Vocabulary subtest (Wechsler, 1991) and the Raven's Colored Progressive Matrices test (Raven, 1947, 1995), to compare levels of motor behavior during verbal *versus* visual (motor-free) tasks. All children also participated in an "unsupervised activity" within the same room. During this activity, participants were left on their own with instructions to complete, in 10 min, as many simple math problem sheets as possible.

Behavioral observations were the primary means of evaluating motor behaviors. Instances of object-directed behaviors (defined as touching of objects) were coded using Shallice's categorization and coding scheme (1989), when there was "use of one or more objects lasting more than 1 s, following the end of a previous instance of object use by at least 1 s." As per Shallice's coding scheme object-directed behaviors were categorized as either: "True Utilization Behavior," "Complex Toying," or "Toying."

True Utilization Behavior was defined as "a set of actions integrated in a typical fashion with respect to the relevant object(s)." Complex Toying was defined as "the use of two objects in a linked way, but in an incomplete fashion or not for the purpose for which *both* objects were designed," or "the use of an object in a *purposeful* way but not for its intended purpose."

Toying was operationally defined as "a single action in which an object is manipulated but not in any purposeful way or for its intended use." Instances of simple Toying, in which children merely fiddled with objects, were not considered examples of UB as children did not "utilize" the objects in any purposeful way.

Observations of object-directed behaviors of the participants indicated that Complex Toying was typically purposeful in relation to objects, and that it generally occurred when children were not familiar with the exact function of an object. In this case, children utilized the object in a manner that would be appropriate for a similar object with which they were familiar (e.g., using the ear syringe as if it were a pump or the table clamp as if it were a paper clip). As Complex Toying and True UB both involved purposeful manipulation of objects (i.e., children seemed to utilize objects "appropriately" for what they thought the purpose was), these two categories were considered examples of UB. They were therefore combined to yield a score called "Total UB," in keeping with the coding scheme developed by Shallice et al. (1989).

To assess general motor activity, instances of self-directed motor behaviors (Self-touching) were also recorded to rule out a general "activity level" confound. Self-touching was operationalized as "any behavior in which a child touches his/her upper body, face area, or clothing for more than 1 s following the end of a previous instance of Self-touching by at least 1 s." Occurrences of resting one's head in one's hands and/or fidgeting with one's fingers were not considered examples of Self-touching.

Object-directed (Toying, Complex Toying, and True Utilization Behavior) and self-directed (Self-touching) movements were counted over the duration of the testing session, which was the same for all participants. In this study, total behavior counts were recorded by tallying the number of object-directed (in response to each object) and self-directed motor behaviors over different activities.

Intraclass correlation coefficients, to assess reliability of behavioral coding, were obtained on a portion of the sample (20%). Inter-rater reliability coefficients ranged from .87 to .97 across the four behaviors of interest (see Table 2).

RESULTS

Analyses of Behavior

Intellectual ability was not statistically related to any of the measures, and therefore was not used as a covariate in the analyses.

Table 2. Inter-rater reliability coefficients

Behavioral measure	Intraclass coefficient (Single measure)
Object-Directed Motor Behaviors	
Toying	.8714
Complex Toying	.9935
True Utilization Behavior	.9340
Self-Directed Motor Behaviors	
Self-Touching	.9718

https://doi.org/10.1017/S135561770505040X Published online by Cambridge University Press

To explore the nature of motor behaviors observed within the testing situation, behavioral ratings of Self-touching, Toying, Complex Toying, and True UB were analyzed using a MANOVA with four behaviors as the within-subjects factor and one between-subjects factor (group). Analyses revealed a statistically significant interaction between the motor behaviors and group membership (Greenhouse-Geisser corrected $F(3,180) = 3.38$, $p = .039$) and a significant effect of behaviors (Greenhouse-Geisser corrected $F(3,180) = 28.16$, $p < .001$). See Figure 1. Further analysis of this interaction using Bonferroni corrected *post-hoc* tests revealed no significant differences between the groups on the Self-touching behaviors (M ADHD = 47.5, SD = 25.94; M Controls = 38.73, SD = 26.89; $t(1,61) = 1.31$, $p = .197$). Group differences in Toying behavior were marginally significant (M ADHD = 17.9, SD = 37.92; M Controls = .35, SD = .61; $t(1,61) = 2.47$, $p = .016$). The groups differed significantly on both Complex toying (M ADHD = 12.84, SD = 21.45; M Controls = .06, SD = .25; $t(1,61) =$ 3.32, $p = .002$) and on True UB (M ADHD = 35.38, SD = 49.82; M Controls = .26, SD = 1.44; $t(1,61) = 3.92$, $p <$ .001) Indeed only two subjects from the control sample exhibited any object-directed motor behaviors, one with eight instances of UB, and the other with one instance of Toying.

Given that the group differences in Complex Toying and in True UB were both highly significant and that both of these behaviors reflected purposeful use of at least one object in an "appropriate" manner, we used the Total UB score (Complex Toying plus True UB) for all further analyses. In addition, given the exceptionally low frequency in the control group of any behavior that was scored as UB, investigations into other dimensions of behaviors coded as UB were conducted using data from the ADHD sample only.

Results of a within-subjects paired t-test revealed that children with ADHD demonstrated significantly higher levels of Total UB (M = 48.22, SD = 63.06) than mere Toying (Toying; M = 17.19, SD = 37.92; $t(31) = 3.05$, $p < .01$). Total UB was significantly higher in response to objects that were familiar (M = 42.41, SD = 56.81) *versus* those that were unfamiliar (M = 5.81, SD = 10.28, $t(31) = 3.99$, $p < .001$; see Figure 2). Children with ADHD were much more likely to utilize objects that were within their line of sight (M = 46.03, SD = 61.22) compared with those that were out of sight (i.e., inside the testing table; M = 2.19, SD = 5.56, $t(31) = 4.14$, $p < .001$; see Figure 2). Finally, Total UB was significantly more frequent during the verbal task (Vocabulary) than during the motor-free visual task (Raven) (M Vocab = 15.78, SD = 22.50; M Ravens = 2.16, SD = 8.49; $t(1,31) = 3.30$, $p = .002$; see Figure 2).

To address concerns that object utilization may be a result of the children's misunderstanding the purpose of or "rules" with respect to objects placed in and around the testing table, levels of Total UB were compared under incidental (no instructions) and instructional (including a statement "not to touch" objects) conditions. Using independent samples t-tests, results indicated that equivalent levels of Total UB occurred when children were given instructions not to touch the objects as when they were not given any instruc-

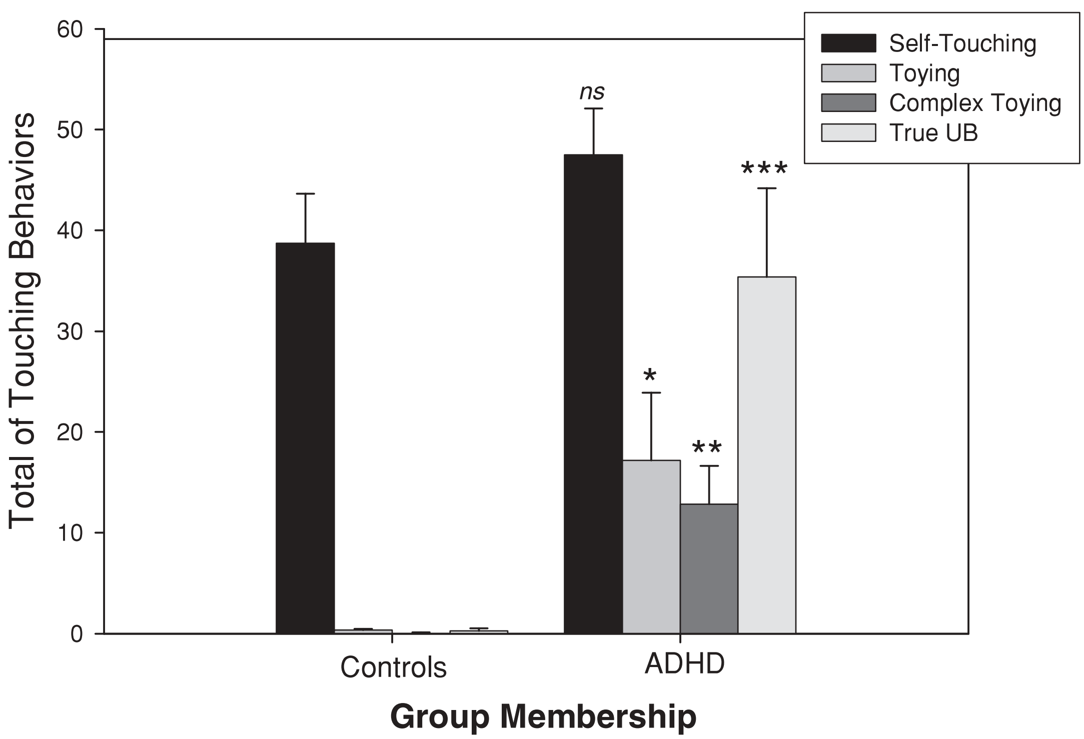

Fig. 1. Comparison of motor behaviors in ADHD and control participants. Using Bonferroni corrections for multiple comparisons; $^*p < .05$; $^{**}p < .01$; $^{***}p < .001$. Error bars are standard errors.

https://doi.org/10.1017/S135561770505040X Published online by Cambridge University Press

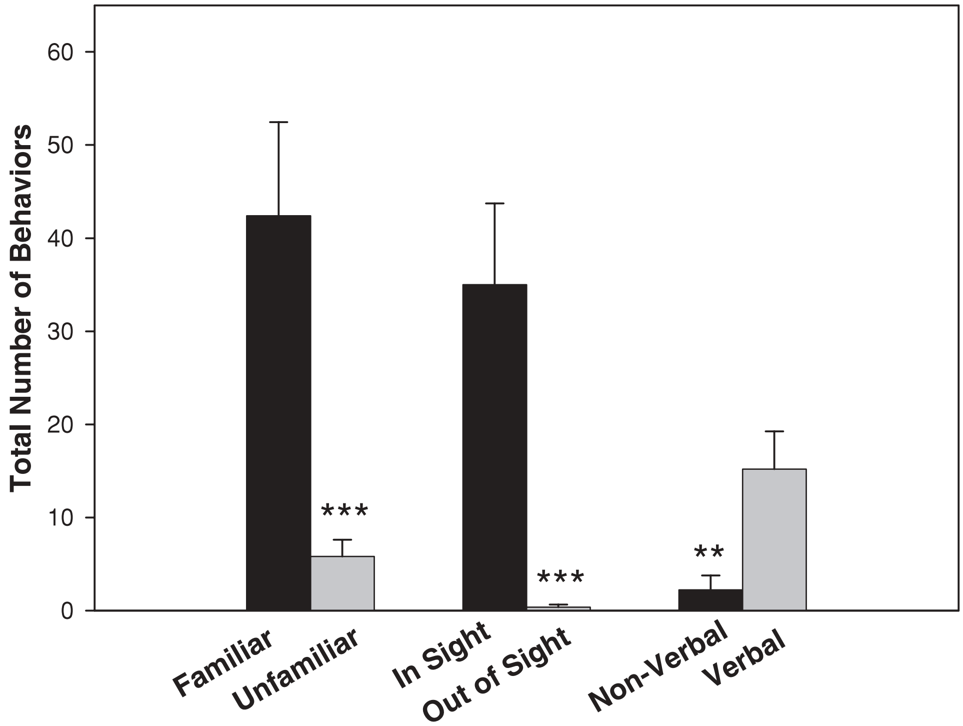

Fig. 2. Comparison of utilization behaviors in the ADHD group across conditions; $**p < .01$, $***p < .001$. Error bars are standard errors.

tions regarding the objects (*M* No Instruction = 35.57, *SD* = 52.57; *M* Instruction = 58.06, *SD* = 70.02; $t(1,31) = 1.00$, $p = .325$).

To better capture variability of UB within the ADHD group, we characterized children as "Utilizers" or "Non-Utilizers" using a cut-off criteria. Children in the ADHD sample who had a Total UB score of greater than 18 (more than twice that of the highest control subject) were categorized as "Utilizers." Using this scheme, 53.1% of the ADHD sample was so characterized, though considerable variability in the frequency of this behavior was noted even in children who did exhibit it. There were no differences between the Utilizers and the Non-Utilizers on a number of key variables including age, Vocabulary, Raven's, having a diagnosis of learning disability, or inclusion in a special behavioral classroom (see Table 3).

To explore the relation between UB and severity of ADHD symptomatology, Pearson correlations were obtained between Total UB and numbers of hyperactive and inattentive symptoms reported by parents on the DICA. Total UB was significantly correlated with number of hyperactive symptoms as reported on the DICA [$r(30) = .45$, $p = .014$], but not with number of inattentive symptoms [$r(30) = .12$, $p = .583$].

DISCUSSION

The goal of this study was to identify whether some of the inappropriate/excessive motor activity seen in children with ADHD could be characterized as UB, either as a part of or in addition to generally heightened activity levels. The literature suggests that children with ADHD have difficulty

Table 3. Comparison of ADHD "Utilizers" and "Non-Utilizers" on key variables

	Utilizers		Non-Utilizers			
Measure	*M*	*SD*	*M*	*SD*	*T*	*p*
Age in Years	9.97	1.77	9.82	2.01	.22	ns
Estimate of Verbal IQ						
WISC–III Vocabulary %ile	53.41	24.29	62.87	24.64	1.26	ns
& Scaled Score	10.29	2.17	11.33	2.50		
Estimate of Performance IQ						
Ravens Matrices %ile	69.06	18.17	71.73	21.03	.39	ns
& Scaled Score	11.88	2.00	12.20	2.34		
% of Group with Learning Disability	50.00	.52	60.00	.52	.48	ns
% of Group in a Behavior Disorder Class	25.00	.44	20.00	.42	.28	ns

Note. ns = not significant.

with self-regulation, may be less controlled by internally represented information, may be more influenced by external circumstances (Barkley, 1997b), and may manifest dysfunction in frontal-striatal systems (Casey et al., 1997).

Results indicated that children with ADHD showed significantly higher levels of Complex Toying and True UB (Total UB), and marginally significantly more Toying behaviors than did non-ADHD children. In contrast, the children with ADHD and the non-ADHD children did not differ on Self-touching behavior. These findings suggest that children with ADHD are much more likely to reach out and "use" objects in their environment than are non-ADHD children. Indeed, with the exception of one participant, children within the control sample did not engage in any complex toying or True UB, while using a control-referenced criteria, whereas approximately 53% of the ADHD sample demonstrated UB. On informal observations during testing, these children also presented as considerably more active and dysregulated than other children diagnosed with ADHD who did not display UB. Consistent with these informal observations, levels of UB within the ADHD sample were significantly and specifically correlated with the severity of hyperactivity, but not inattention, as reported by parents on the DICA.

Examination of these UB behaviors within the ADHD sample revealed that these children were much more likely to truly "utilize" objects than to fiddle aimlessly with them, or even to engage in Complex Toying. This suggests that children with ADHD may be displaying behavior consistent with True UB rather than just simply fidgeting as a result of generally heightened activity levels. Further corroboration of this was provided by the finding that children with ADHD did not demonstrate significantly higher levels of Self-touching behaviors than did non-ADHD children. Again, this argues against the suggestion that children with ADHD touch more objects simply because they are generally more active and tend to touch everything around them. Furthermore, higher levels of UB in this population did not appear to be simply due to more uncooperative behaviors or an "implicit" expectation that objects "should be" used, as has been a concern in previous studies (Shallice et al., 1989). A comparison of an "instruction condition" (in which instructions not to use the objects were provided) and a "no instruction condition" indicated that instructional set or expectation did not significantly influence the levels of UB.

Results also indicated that UB was more common in response to objects that were familiar *versus* those that were unfamiliar, again supporting the contention that this behavior is not simply due to generally heightened activity levels towards all aspects of the environment. This finding also provides support for theories suggesting that UB may result from disinhibition/release of preprogrammed parietal/lateral motor schemata, as a result of dysfunction within frontal control systems (Archibald et al., 2001; Shallice et al., 1989). If UB results from a release of familiar or "preprogrammed" action schemata, one would expect to see UB in response to objects that are familiar (for which an individual has developed a schemata), but not in response to unfamiliar objects.

Finally, some individuals have suggested that UB may result from an imbalance between a medial and lateral motor system that would result in high levels of visually driven behavior (Goldberg, 1985). The results of this study provided some support for this contention in that, first, UB within the ADHD sample occurred much more often in response to objects that were in sight (on the table), compared with those that were out of sight (inside the table). These results suggest that UB could be triggered and compelled by objects in the environment, possibly due to a release of lateral motor systems that are associated with an organism's responsiveness to the environment (Archibald et al., 2001; Eslinger, 2002). Again this supports a strong visual component to UB, as utilization of objects out of the field of vision would require some mental representation and theoretically invoke the medial system. Second, utilization behavior was more likely to occur during a verbal activity than during visual (though motor-free) activity when the lateral system was likely otherwise engaged in the task. Disinhibition of the lateral system is less likely when the visual system is occupied (Goldberg, 1985), as has been demonstrated in earlier studies of the UB Syndrome (Shallice et al., 1989). Further investigations of the association between behaviors classified as UB and performance on motor measures, which specifically assess functioning of the respective "lateral and medial" motor systems, would be useful in clarifying theoretical frameworks for UB.

In sum, the present study provided evidence that some of the inappropriate and excessive motor behavior in children with ADHD may be associated with UB. Our results are consistent with theorists such as Barkley (1997b) who has proposed that children with ADHD may be less well controlled by internally represented information and more so by external stimuli. These results are also consistent with studies suggesting a frontal-striatal basis for ADHD; evidence for UB provides additional support for a disruption of frontal motor connections in ADHD, leading to difficulties with motor control (Niedermeyer & Naidu, 1997) within this population. Our results are consistent with previous studies documenting impaired "frontal motor abilities" in children with ADHD (Grodzinsky & Diamond, 1992; Shue & Douglas, 1992) and with recent neuroimaging data suggesting that ADHD may result from frontal-motor uncoupling as a result of dysfunction within frontal-striatal circuits (Casey, 2001; Casey et al., 1997; Hynd et al., 1991a; Niedermeyer & Naidu, 1997).

It is also important to consider the clinical relevance of some of these findings. Excessive touching of objects in the environment is a frequent complaint of parents of children with ADHD, and is typically seen as "non-compliant" behavior. Given that some of the intrusive and inappropriate motor behavior seen in children with ADHD (particularly the excessive utilization of objects in the environment) could be conceptualized as due to UB, at least some of the challenging behaviors seen in this population may not be "motivationally" based. The association between hyperactivity and UB should be further investigated in future studies, as this could have implications for treatment/management of ADHD. In addition, further investigation of the difference between children with ADHD who demonstrate UB *versus* those who do not is clearly warranted. From a clinical perspective, it is important to recognize that not all children with the diagnosis of ADHD demonstrate UB, and even within those that did, there was substantial variability in the frequency of this behavior within this experimental setting. Clearly a significant portion of motor overactivity in children with ADHD cannot be accounted for as UB and caution should be exercised when labeling such behaviors.

One clear limitation of this study was the failure to rule out co-morbid diagnoses, which may also be associated with UB. In the current investigation, UB in ADHD appeared to be associated with the severity of hyperactivity and the presence of oppositional and defiant behaviors. However, it was not possible to determine whether children with "pure" Oppositional Defiant Disorder (not co-occurring with ADHD) also exhibit UB, or whether symptoms of ADHD, oppositional behaviors, and UB, constitute a distinct and more severe subtype of ADHD. Therefore, this study was not able to determine whether findings of UB in children with ADHD are indeed specific to this population. Future studies should investigate UB in children with "pure" ADHD, where other co-morbid conditions are carefully screened out, and in children with other disruptive behavior disorders (Oppositional Defiant Disorder, Conduct Disorder).

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