In H. L. Roediger, III (Ed.), *Cognitive Psychology of Memory. Vol. [2]* of Learning and Memory: A Comprehensive Reference, 4 vols. (J.Byrne Editor), pp. [759-772] Oxford: Elsevier.

Learning in Autism

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ABSTRACT This review summarizes a range of historical, current, and emerging proposals about autistic learning, covering accounts of learning in the autism intervention research, including the applied behavior analysis framework, and accounts of autistic learning in the cognitive and savant literatures. We conclude that learning in autism is characterized both by spontaneous—sometimes exceptional—mastering of complex material and an apparent resistance to learning in conventional ways. Learning that appears to be implicit seems to be important in autism, but autistics' implicit learning may not map directly onto non-autistics' implicit learning or be governed by the same constraints.

2.39.1. Introduction

Learning in autism is not a topic characterized by consensus. For example, the ability of autistics[1] to learn is considered nonexistent in the typical everyday environment (Lovaas and Smith, 2003) and fundamentally impaired (Klinger et al., 2006), but so astounding that the cognitive literature as a whole is insufficient to explain it (Atkin and Lorch, 2006). Autistic learning is recognized as distinctive (Volkmar et al., 2004) and singled out as subhuman (Tomasello et al., 2005), but is also considered unremarkable compared to non-autistic learning (Thioux et al., 2006). These apparently disparate accounts may be the result of autistic learning, in contrast to autistic perception, attention, and memory, being investigated in a piecemeal, *ad hoc* manner. This review will summarize a range of current and emerging proposals about autistic learning, examining each proposal's empirical basis and adding historical and thematic perspectives.

2.39.2. Autism: Classification and Description

Autism is a neurodevelopmental difference, classified as a pervasive developmental disorder in the DSM-IV (APA, 1994) and diagnosed by atypical social interaction (e.g., "a lack of spontaneous seeking to share . . . achievements with other people," APA, 1994, p. 70), atypical communication (e.g., difficulty "sustain[ing] a conversation," APA, 1994, p. 70), focused interests (e.g., "persistent preoccupation with parts of objects," APA, 1994, p. 70), and atypical body mannerisms (e.g., "hand or finger flapping" APA, 1994, p. 70). While autism is innate, the overt behaviors used to diagnose autism may not appear until the second year of life, but always appear before age three. Autism is polygenic (with as yet no agreed upon loci) and highly heritable, with a male:female ratio of ~4:1 and a prevalence of ~20/10,000. Two less well-defined pervasive developmental disorders are considered, with autism, to form the autistic spectrum. The first is Asperger syndrome (AS), which shares the behavioral characteristics of autism but presents with a different developmental trajectory, featuring no delay in the onset of speech and measured intelligence in the normal range (Szatmari et al., 2000). The second is Pervasive Developmental Disorder, Not Otherwise Specified (PDD-NOS), defined as a subthreshold presentation of the behaviors used to diagnose autism. Prevalence across the autistic spectrum is ~60/10,000, and has been shown to be stable over time, as has autism prevalence (Chakrabarti and Fombonne, 2001, 2005). This review will concentrate on autism itself, as the bulk of the relevant research concerns this specific diagnosis.

In research, autistics are often divided into high- and low-functioning subgroups, based on a snapshot measurement of intelligence or developmental level. While this division is an efficient shorthand to denote whether participants fall into the range of diagnosable mental retardation, instruments normed for the non-autistic population are potentially misleading when applied to autistics (e.g., Mottron, 2004), and individuals' measured IQs may change dramatically over time, particularly before age six (Eaves and Ho, 2004; Gernsbacher, 2004). Autistics' average scores on intelligence test batteries (e.g., Wechsler scales) mask widely scattered subtest scores, raising the question of whether level of functioning can definitively be assigned even at any single point in time. The difficulty of assessing autistic intelligence is illustrated by recent epidemiology: the percentage of autistics who also meet current day criteria for mental retardation is reported as anywhere from 25% to 70% (Baird et al., 2000; Chakrabarti and Fombonne, 2001; Honda et al., 1996; Kielinen et al., 2000). The difficulty of assessing autistic intelligence is also illustrated via a speed of processing task known to be correlated with intelligence: autistics assumed to be high- or low-functioning perform equally well, and as well as non-autistics with Weschler IQs more than two or three standard deviations higher, respectively (Scheuffgen et al., 2000). Similarly, autistics' performance on Raven's Progressive Matrices, the preeminent measure of fluid intelligence, may significantly exceed their performance on Wechsler scales, suggesting that the high- versus low-functioning division is of questionable validity (Dawson et al., in press).

Autism has no known etiology in the majority of cases, but in a minority of cases, an associated syndrome can be identified (e.g., tuberous sclerosis, West syndrome). In research, such syndromes are frequently cited as exclusion criteria or possible confounds, and the distinction between etiological autism (associated with such syndromes) and idiopathic autism (not associated with such syndromes) has been important in ascertaining whether epilepsy is associated with autism or with other conditions associated with autism. Indeed, evidence points to epilepsy not being associated with idiopathic autism (Pavone et al., 2004; Battaglia and Carey, 2006).

Another division is often drawn between savant autistics, whose uneven profile of abilities encompasses exceptional expertise in one or more characteristic areas (e.g., calendar calculation, drawing in perspective), and non-savant autistics, whose uneven profile of abilities has not progressed to that level of atypical expertise. Savant abilities are far more prevalent in the autistic than in the non-autistic population (1 in 10 versus 1 in 2000; Hill, 1977; Rimland, 1978), and are consistently linked with autistic traits (Heaton and Wallace, 2004). Savant abilities and their significance for the study of autistic learning will be explored in later sections.

Few aspects of neurology have not been proposed as being atypical in autism. For example, regions of reported neurofunctional atypicalities range from the brainstem to the inferior frontal gyrus, while reported neuroanatomical atypicalities range from increased white and gray matter volume (e.g., Hazlett et al., 2005) to more densely packed cells and increased numbers of cortical minicolumns (Casanova et al., 2002). Neurofunctional connectivity has been suggested to be atypical (e.g., Just et al., 2004), and neural resources may be atypically allocated or rededicated (e.g., Koshino et al., 2005; Turkeltaub et al., 2004). Virtually every fundamental human cognitive and affective process, singly or as part of an overarching model, has been proposed to be dysfunctional or absent in autism, while persistent findings of superior performances by autistics are often interpreted as evidence of neurological and cognitive pathology (e.g., Beversdorf et al., 2000; Chawarska et al., 2003; Heaton et al., 1998; Just et al., 2004; Langdell, 1978; Ropar and Mitchell, 2002; Shah and Frith, 1983, 1993; Toichi et al., 2002; for analysis and perspective, see Baron-Cohen, 2005; Gernsbacher et al., 2006; Mottron et al., 2006; Mottron et al., in press). Thus, autism has been prolifically studied but remains poorly understood.

2.39.3. History and Background: Accounts of Autistic Learning

Accounts of recognizably autistic learning date back more than a century and precede the establishment of autism as a diagnosis. There are reports of individuals with an incongruous repertoire of abilities: apparently general cognitive impairment coupled with outstanding performance in specific areas, such as music, drawing, calculation, and memory (see Treffert, 1988, for a review). The branding of these individuals as "idiot savants," a practice that endured until recently, is evidence of how autistic learning has been and may still be conceptualized.

Kanner (1943) first proposed autism as a distinct condition. His landmark description of 11 autistic children included observations about their unusual pattern of learning, evident from early development. The children precociously acquired quantities of specific information, from the names of objects, people, and presidents; to numbers and the alphabet; to fine discriminations between musical compositions; to the texts of psalms, poems, and nursery rhymes (sometimes in several languages); to lists of plants and animals as well as "long and unusual words"; to the contents of encyclopedias. Kanner characterized much of this learning, particularly in 2- and 3-year old children, as a "valueless" obstacle to genuine communication, but also reported excellent abilities in reading, spelling, and vocabulary. There were no difficulties with plurals, tenses, and grammar; an early reversal of pronouns (e.g., using *you* for *I)* became less evident over time. The children were characterized as having strong and independent interests; one child "displayed astounding purposefulness in the pursuit of self-selected goals."

Kanner observed that mute autistic children, a minority in his original sample, had "astounded their parents by uttering well-formed sentences in emergency situations"; he concluded that mute autistic children may demonstrate that they have, while apparently silent, accumulated a "considerable store" of information about language (Kanner, 1949). In a later paper, Kanner observed that autistic children were extremely difficult to teach in conventional ways: they "learn while they resist being taught." For example, they remained unimpressed with persistent attempts to prompt them to walk, then spontaneously walked when this was "least expected." One autistic boy's parents undertook strenuous efforts, involving many hours per day, to teach and exhort him to speak. These efforts failed, but "at about 2 ½ years of age, he spoke up and said 'Overalls,' a word which was decidedly not part of the teaching repertoire" (Kanner, 1951).

Independently of Kanner, Asperger (1944, translated 1991) also proposed autism as a distinct condition. In his seminal paper, Asperger recorded observations about autistic learning that were strikingly similar to Kanner's. Autistic children, some of whom were described as learning to read "particularly easily," were "almost impossible" to teach and could not learn from adults in "conventional ways" or "assimilate the ready-made knowledge and skill that others present." These children were poor in what Asperger called "mechanical learning," or learning to do as others do automatically. However, they excelled in a kind of original thinking that Asperger called "autistic intelligence." Asperger described an autistic child who spontaneously learned basic principles of geometry by age three, and cubic roots shortly thereafter, but "learnt or did not learn as the whim took him," with unfortunate results in school.

Both Kanner's and Asperger's accounts resonate with earlier reports of "idiot savants." In 1945, Scheerer and colleagues discussed Kanner's observations (1943) within an extensive descriptive and empirical account of a child, L., who today would be considered an autistic savant. Alongside apparently comprehensive limitations in behavior and intelligence, L. had excellent abilities in calendar calculation and music, as well as in learning and recall of words, events, facts, and numbers. Interest in these areas first appeared when L. was three years old. L. was reported to be incapable of learning by instruction; he had "an inherent difficulty in learning by following instructions and explanations in a systematic way" and "never absorbed or learned in a normal fashion." He had absolute pitch and enjoyed playing the piano "for hours without being taught." His unusual range of abilities was hypothesized to arise from impaired abstraction, which resulted in "abnormal concreteness" and a facility in acquiring and manipulating information that typical individuals would judge as "senseless or peripheral or irrelevant" (Scheerer et al., 1945).

Kanner considered that the atypical strengths and not the obvious difficulties of autistic children reflected their true potential, but Kanner provided limited empirical evidence to support his position, which has accumulated opposition over the years. For example, Klin et al. (1997) contended that autistics' "splinter skills" overestimated their true abilities, had little relevance to real life, and existed against a context of pervasive deficiency (see also DeMyer et al., 1974; Prior, 1979; Volkmar and Klin, 2005). Similarly, focused abilities and interests have been characterized primarily as interfering with learning in autism and Asperger syndrome, rather than representing it (Klin et al., 2005; Volkmar and Klin, 2000). Distinctly autistic learning and intelligence have thus been considered pathological, misleading, and uninformative, if not mythical (e.g., Epstein et al., 1985; Green, 1999; Shah and Frith, 1993). This judgment leaves no plausible explanation for the conspicuous success of some autistics (e.g., a child who "did phenomenally well in mathematics, was sent to an accelerated school, and is now finishing the eleventh grade with top marks," Kanner and Eisenberg, 1956).

Specific traits investigated in follow-up studies (e.g., speech fluency or measured intelligence) have not been consistently predictive of outcomes (Howlin, 2005) or explanatory of why some autistics have done notably well (Asperger, 1944; Kanner, 1973; Szatmari et al., 1989). Indeed, both Kanner (1973) and Szatmari et al. (1989) reported that fortunate outcomes were unexpected; they could not have been predicted from early presentation or development. The success in university, including one MBA, of half of Szatmari et al.'s sample (less than 70% of whom had useful speech before age 5) was achieved by individuals who, like the successful autistics reported by Kanner, grew up before the era of early intervention programs. Similarly, an individual who Asperger (1944) followed for 30 years was "grossly autistic" throughout his life, with "impossible behaviors," failure and ineptness in multiple areas (language, daily life, social behavior). This individual pursued his early interest in mathematics and rapidly became a successful, if unusual, academic. Like Asperger, Kanner (1973) underlined the importance of focused interests and abilities through development as the means by which autistics could participate in and contribute to society.

Less fortunate autistics were placed in institutions, denied education, subject to useless and harmful treatments (e.g., "tranquilizers… pushed to the point of toxicity," Kanner, 1971), and were found to have poor outcomes (Kanner, 1971, 1973; Lockyer and Rutter, 1969; Rutter et al., 1967). In Rutter's (1966, 1970) sample, 56% of the 63 children had fewer than two years of school, and many had none at all, regardless of their measured abilities. More than half were institutionalized, and many endured deleterious or spurious treatments (e.g., E.C.T., insulin coma, prefrontal lobotomy, "prolonged" psychoanalysis; Rutter et al., 1967). Against this hazardous backdrop, many in Rutter's sample acquired reading abilities, several were employed, and some had academic achievements (e.g., in the areas of music and computers). DeMyer et al. (1973) observed in their sample, 44% of whom were institutionalized, that a decrease over time in the performance IQs of poor-outcome autistics was related to an observed loss of their "splinter skills."

Descriptive and empirical accounts of autistics learning in unusual and successful ways have sporadically appeared and remained unexplained throughout the history of autism research. Autistics are no longer routinely institutionalized and are entitled to public education, but there continues to be a dearth of data linking early autism interventions to adult outcomes. Instead, there are data indicating that currently popular interventions may be unrelated to child outcomes (Eaves and Ho, 2004; Gernsbacher, 2003; Lord et al., 2006). The educational and psychosocial intervention literature in autism, despite undeniable quantity and prominence, has failed to produce "a clear direct relationship between any particular intervention and children's progress" (NRC, 2001).

2.39.4. Learning in the Autism Intervention Research

Comprehensive early intervention programs in autism have borrowed extensively from each other and have become progressively more similar (Dawson and Osterling, 1997; Kasari, 2006; NRC, 2001). A typical curriculum may, at the outset, involve series of trials for training eye contact ("look at me"), commands ("sit down," "stand up," "come here," "turn around"), motor imitation ("do this …"), followed by commands to point ("point to the …"), match, verbally imitate, and verbally label (Maurice et al., 1996). Comprehensive programs vary in their use of settings and structure (e.g., highly structured trials versus more naturalistic approaches), in their use of procedures and techniques (e.g., prompting, reinforcement), in their incorporation of developmental and other theoretical considerations, and in other ways (Rogers and Ozonoff, 2006). Apart from their intensity (usually, more than 20 hours per week) and their ideal of intervening as early as possible, they share the premise that autism represents a harmful deviation from (or multiple deviations from) typical development. They also share the goal of achieving, to the greatest extent possible, a typical developmental trajectory encompassing typical social, communicative, and adaptive behaviors. Failing to address presumed deviations or delays in early development is believed to result in autistics falling farther and farther behind, as autistic traits and abilities, which are seen as inadequate, inappropriate, or maladaptive, become entrenched obstacles to achieving the ideal typical trajectory. The promise that very early intervention will interrupt, reverse, prevent, and stop autism "in its tracks" is avidly pursued (Cecil, 2004).

The effectiveness of comprehensive early intervention programs is judged against autism's presumed poor prognosis, and according to the extent to which typical skills have successfully been acquired and atypical autistic behaviors have successfully been extinguished (Handleman and Harris, 2001; Smith, 1999). The possibility that a typical developmental trajectory and repertoire of behaviors may not be adaptive for autistics or beneficial for autistic learning has not yet been considered. Researchers have "studied the effectiveness of programs, not the appropriateness of various goals" (NRC, 2001), while as yet providing no empirical foundation for the popular contention that intensive early interventions result in successful, independent typical adults. The best adult outcomes in the peer-reviewed literature belong to autistics whose early development predates the availability of these interventions and was in no way typical (e.g., Kanner et al., 1972). Indeed, in Szatmari et al. (1989), all children retrospectively judged as only "probable" for a diagnosis of autism had poor outcomes as adults, while many children whose diagnosis—according to the strictest criteria for autism ever devised—was not in doubt went on to considerable achievement: "severity of early autistic behavior was a poor predictor of outcome."

Early interventions have been widely speculated both to prevent atypical brain activity in autism and to promote desirable typical activity (e.g., Howard et al., 2005; Lovaas and Smith, 1989; Mundy and Crowson, 1997; Perry et al., 1995; Smith and Lovaas, 1998). This speculation is as yet unsupported by studies involving measures of neural activity. The promotion of very early interventions to exploit neural plasticity in the developing brain (Dawson and Zanolli, 2003) appears to be supported solely by a report of a very early (starting at 14 months) applied behavior analysis-based intervention involving a child considered "at risk" for autism (Green et al., 2002). However, such a young age (2 years) has been cited as an explanation for why other autistic participants failed, rather than succeeded, in another intervention study and why such young participants could not continue in an optimal applied behavior analysis-based intervention (Howard et al., 2005). Thus, promises that autistic brain activity and development can be altered by early interventions in controlled and predictable ways appear to be highly premature.

Training programs that involve older autistics (school-aged children, adolescents, and adults) and that target what are presumed to be core deficits in autism have also been speculated to correct faulty autistic neural mechanisms (Tanaka et al., 2005). However, the only empirical investigation to date found that autistics acquired the specific trained behaviors (labeling pictures expressing facial affect), but did so without producing the desired neurofunctional changes (increased task-related activity in the fusiform gyrus, Bölte et al., 2006). Demonstrations that untrained autistics display this desired brain activity when previous oversights in experimental design are addressed (e.g., Hadjikhani et al., 2004; Pierce et al., 2004) raise questions about the foundations of interventions that target core deficits and exploit task-related brain activity as outcomes.

A common finding arising from both targeted and comprehensive intervention studies is that autistics, when explicitly taught typical skills, fail to generalize those skills across contexts or to related typical skills (e.g., Hwang and Hughes, 2000; Lovaas et al., 1973; Lovaas and Smith, 1989; Ozonoff and Miller, 1995). This failure to generalize is widely regarded as an autistic learning deficit, but such a failure cannot always be attributed to specifically autistic limitations. Young "feminine boys" who underwent early intensive behavioral interventions to impose stereotypically male behaviors also demonstrated a failure to generalize (Rekers and Lovaas, 1974; Rekers et al., 1974). Thus, the explicit teaching of typical behaviors may result in a failure to generalize in atypical individuals. Accordingly, autistics who fully understand typical, expected social behaviors (e.g., behaviors associated with pretend play or joint attention) may not spontaneously display these behaviors, which are adaptive for non-autistics but may not necessarily be adaptive for autistics (e.g., Boucher, 1989; Klin et al., 2002). Regulation of atypical autistic visual and auditory perception (Mottron et al., 2006; Samson et al., 2006) is currently the most plausible explanation for characteristic autistic behaviors (e.g., in the areas of eye contact, Gernsbacher & Frymiare, 2006; joint attention, Gernsbacher et al., in press; and orienting to stimuli, Mottron et al., 2007); therefore, attempts to train typical but less adaptive behaviors may not easily generalize. Further, Szatmari (2004) has argued that autistics' enhanced perception results in independent, spontaneous learning of which non-autistics are incapable.

2.39.5. Applied Behavior Analysis and Autistic Learning

The first reports of operant conditioning in autism in the early 1960s (e.g., Ferster and DeMyer, 1961) are considered by behavior analysts as the first demonstrations that autistics could learn (Schreibman and Ingersoll, 2005). Behavior analysts henceforth characterized autistics as being governed by the same laws of learning as all other organisms, while being distinguished by failing to learn from the typical, every-day environment (e.g., Lovaas, 1987; Green, 1996; Smith and Lovaas, 1998; Lovaas and Smith, 2003; Koegel et al., 2001). Applied behavior analysis (ABA), summarized by Green (1996) as employing procedures derived from the principles of behavior to "build socially useful repertoires" of observable behaviors and reduce or extinguish socially "problematic ones," has become the basis for an extensive autism intervention literature and service industry. The behavior analytic literature in autism presents autistics as having an extremely restricted behavioral repertoire that is not recognizably human, as lacking in human experience to the point of being *tabula rasa*, as requiring the explicit teaching of virtually every human behavior, and therefore as being an ideal proving ground for interventions based on learning theory (Lovaas et al., 1967; Lovaas, 1977; Lovaas and Newsom, 1976; Lovaas and Smith, 1989; Lovaas, 1993; Smith, 1999; Lovaas, 2003; Schreibman, 2005).

Stimulus over-selectivity, wherein autistics "respond to only part of a relevant cue or even to a minor often irrelevant feature of the environment," has been identified by behavior analysts as underlying autistics' failure to learn and generalize (Lovaas et al., 1979; see also Schreibman, 1996). However, demonstrations of over-selectivity in autistics (e.g., Lovaas et al., 1971a; Lovaas and Schreibman, 1971) exist alongside findings showing over-selectivity in non-autistics, as well as the absence of over-selectivity in autistics (e.g., Koegel and Wilhelm, 1973; Schover and Newsom, 1976; Litrownick et al., 1978; Gersten, 1983). An apparent failure of autistics to attend to and therefore learn from relevant social information using dolls as stimuli (Schreibman and Lovaas, 1973) contrasts with the empirical finding that autistic children (IQ ~60) perform better than age-matched typical controls in recognizing their classmates' faces (Langdell, 1978). Moreover, Lovaas et al.'s (1971, 1979) over-selectivity based prediction that classical conditioning would be impaired in autism, with a consequent failure to acquire conditioned reinforcers, was found to be incorrect. In a classical eye-blink conditioning paradigm, autistics more rapidly learned an association between multimodal contiguous stimuli than did non-autistics (Sears et al., 1994). Regardless, over-selectivity's enduring theoretical influence is demonstrated in the behavior analytic practice of breaking all skills down into small steps with each step being explicitly taught through repetition, and of minimizing and simplifying the information in an autistic's environment when teaching basic skills (Maurice et al., 1996; Leaf and McEachin, 1999; Lovaas, 2003).

The need to suppress the high prevalence of so-called "self-stimulatory" behaviors in autistics (e.g., rocking the torso, smelling objects) is a consistent theme across the behavior analytic literature. While it is believed that self-stimulatory behaviors interfere with learning explicitly taught behaviors (e.g., Lovaas et al., 1971b; Koegel and Covert, 1971; Lovaas et al., 1987), that is not always the case (e.g., Klier and Harris, 1977; Chock and Glahn, 1983; Dyer, 1987), and self-stimulatory interests (e.g., maps, calendars, movies) have also been used productively as reinforcement (e.g., Charlop et al., 1990). Self-stimulatory behaviors have not been consistently defined by behavior analysts; for example, immediate echolalia (repeating back what another person just said) was classified as self-stimulatory in one model (Epstein et al., 1985; Lovaas, 2003) but not in another (Gardenier et al., 2004; MacDonald et al., 2007).

Self-stimulatory behaviors are often defined as serving no "obvious" or "apparent" function (Gardenier et al., 2004; MacDonald et al., 2007), but in one extensive behavior analysis of the origin of self-stimulatory "ear covering that was reported by the [autistic] child's teachers to serve no identifiable function … the results of a descriptive analysis revealed a correlation between ear covering and another child's screaming. An analogue functional analysis showed that ear covering was emitted only when the screaming was present" (Tang et al., 2002, p. 95).

While self-stimulation has been defined as a subclass of stereotypy, characterized by its autonomy from social reinforcement (Lovaas et al., 1987), it has also been found to be socially mediated (Durand and Carr, 1987). Self-stimulation and stereotypy are sometimes regarded as interchangeable (e.g., Charlop-Christy and Haymes, 1996, in which "stereotypy," "aberrant behaviors," "obsessions," and "self-stimulation" are equivalent terms), and self-stimulatory behaviors have been expanded to encompass all autistic focused interests and abilities. Absolute pitch, calendar calculation, hyperlexia, expertise in prime numbers, "accurate drawing," and the like have been classified as self-stimulatory (Epstein et al., 1985; Lovaas, 2003); autistics' spontaneous, untrained learning (in the absence of either teaching or reinforcement) has been classified as "generative self-stimulatory behavior" (Lovaas et al., 1987). Epstein et al. (1985) described a 5-year old autistic boy in an intensive ABA program who "suddenly emerged" with excellent calendar calculation skills; this and other spontaneous "genius" behaviors were then discouraged and suppressed.

Indeed, exceptional and savant abilities are listed by behavior analysts as among autistics' abnormal behavioral deficits and excesses (e.g., Koegel and Koegel, 1996). Exceptional abilities in children who exhibit high levels of self-stimulatory behaviors, which are considered by behavior analysts to prevent autistics from learning, remain unexplained. For example, there is no explanation for how a 3-year-old autistic who "engaged in lengthy periods of self-stimulatory behavior such as lying down and sifting sand through his hands" learned to read at a grade one level (Koegel et al., 1997), or how a 4-year-old autistic, with no basal score on standardized language measures and "high levels" of "stereotypic hand flapping, finger manipulation, body rocking and noise making" learned how to "decode written words" and "discriminate numerous varieties of automobiles" (Mason et al., 1989). The behavior analytic observation that autistics have spontaneously learned various skills that they do not demonstrate on demand (e.g., Taylor and MacDonough, 1996) also remains unexplained, though the possibility that autistics' inconsistent responding in some situations results from "boredom" has been raised (Dunlap and Koegel, 1980).

In attempting to address autistics' failure to learn, behavior analysts have created environments of extreme food deprivation (Lovaas et al., 1967); electric shock (Lichstein and Schreibman, 1976) or other contingent aversives (Lovaas, 1987; Lovaas et al., 1987); and extreme repetition (e.g., 90,000 discrete trials to teach an autistic boy one verbal discrimination; Lovaas, 1977). One autistic child underwent more than 24,000 discrete trials and failed to learn any receptive language (Eikeseth and Jahr, 2001). The same child acquired language skills in fewer than 100 trials when provided with text, rather than speech or signs, but environments created by behavior analysts to train some autistics (now deemed to be "visual learners") with text have produced very limited results (Lovaas and Eikeseth, 2003). Although physical punishment within behavioral interventions became illegal in many jurisdictions and was replaced by other methods (but see Foxx, 2005), a non-randomized controlled trial that depended on contingent aversives (Lovaas, 1987; McEachin et al., 1993) continues to be cited as the primary evidence that ABA-based interventions are effective. The only randomized controlled trial of an early comprehensive ABA program reported poor short-term results (Smith et al., 2000, 2001). When unmatched variables in a non-randomized trial were accounted for, differences in outcome measures between the experimental and control groups (with the exception of classroom placement) were not significant (Cohen et al., 2006). Further, none of the few existing small-sample controlled trials, in a vast literature dominated by single subject designs, has reported a correlation between increased amount or intensity of treatment and better short-term outcome measures. Instead, data from an uncontrolled trial show that neither intensity nor quality of early ABA programs is related to short-term outcomes (Sallows and Graupner, 2005).

2.39.6. Autistic Learning in the Cognitive and Savant Literatures

The cognitive literature in autism provides few empirical findings directly related to learning, despite speculative claims about autistic learning impairments and "learning style" (see Volkmar et al. 2004, for a review). Among empirical findings, autistics have demonstrated enhanced discrimination of novel highly-similar stimuli but an absence of a typical perceptual learning effect (Plaisted et al., 1998); and non-autistics, but not autistics, showed a training effect when copying drawings of objects and non-objects, although overall performance of the two groups was equal (Mottron et al., 1999). In both cases (perception and procedural memory), procedures (e.g., repeated performance of tasks) that reliably resulted in learning in non-autistics appeared not to do so in autistics, while autistics appeared to learn in ways (e.g., apparently passive exposure to materials) that did not necessarily benefit non-autistics.

In the area of language, echolalia is common in typical development (e.g., a mother asks, “Do you want a cookie?” and a child responds, “a cookie?”), but echolalia occupies an atypical role in language acquisition in autism. Echolalia, which serves numerous functions (Prizant and Duchan, 1981; Prizant, 1983; Prizant and Rydell, 1984), is one example of how autistics atypically access the meaning of language by first learning its complex structure, the reverse of the typical pattern (Dunn and Sebastian, 2000). For example, an autistic child, quite fond of the Telletubbies show on Public Broadcasting Service, initially repeated the scripted sentence, “One day in Teletubbie land, all of the Teletubbies were very busy when suddenly a big rain cloud appeared,” and weeks later, using mitigated echolalia, stated, “One day in Bud's house, Mama and Bud were very busy when suddenly Daddy appeared” to express the construct of his father returning home. Initially, when this child wanted to play ball, he would approach his mother or father and say, “Quick, Dipsy. Help Laa Laa catch the ball.” As his spoken language developed, the syntactic structure of echolalic sentences remained intact, but he replaced the nouns (e.g., “Quick, Daddy. Help Bud catch the ball”), and he eventually isolated single words and morphemes and began generating original two-word phrases (e.g., “Daddy ball?” and “Dad, wanna play ball?”; Mom-NOS, 2006).

Hyperlexia (Silverberg and Silverberg, 1967), a spontaneous (uninstructed), precocious, interest-driven ability to decode written words is also strongly associated with autism (Grigorenko et al., 2002). Atkin and Lorch (2006) extensively tested Paul, a 4 year old autistic boy who intensively studied newspapers before age 2 and recited the alphabet and read printed words aloud by age 3. Paul’s mental age was placed at 1;5, and his comprehension of language was markedly delayed (though not absent), but he tested as having “extremely advanced decoding skills,” including a reading vocabulary exceeding that of typical 9 year olds. The authors concluded that these results “suggest the possibility of an atypical route to language acquisition” and that “existing cognitive accounts are inadequate to account for the development of literacy in this child.”

With respect to the role of categories in learning, autistics may not necessarily use concepts to organize information (Hermelin and O’Connor, 1970; Bowler, 2007, for a review), but are able to do so, including the use of basic level and more abstract superordinate categories as well as prototypes (e.g., Tager-Flusberg, 1985a, b; Ungerer and Sigman, 1987). In a test of novel category learning, Klinger and Dawson (2001) found that autistics categorized using both explicit and implicit rules, but when answering an ambiguous question, failed to show the same response to prototypes as non-autistics. Molesworth et al. (2005), who instead used a false recognition procedure, found typical learning of novel categories in autistics, including typical prototype formation. At the level of perceptual categorization, autistics demonstrated typical category formation in a categorization task, but contrary to typical controls, autistics showed no influence of categories in a discrimination task. The influence of categories may therefore be optional in autistics, while being mandatory in non-autistics (Soulières et al., 2007).

Klinger et al. (2006) have proposed a fundamental implicit learning (Reber, 1967, 1993; Frensch, 1998; Frensch and Rünger, 2003) impairment in autism based on the prototype paradigm in Klinger and Dawson (2001), and on preliminary data from two artificial grammar learning experiments. Their first study found equivalent autistic and non-autistic above-chance performance in the implicit learning of artificial grammars, while in their second study autistics with lower IQs than their non-autistic controls performed far above chance, but the non-autistic group performed significantly better. Reber (1967) reported a similar discrepancy between typical undergraduates and typical high-school students performing well above chance, without the latter being deemed impaired in implicit learning. Using a serial reaction time task (Nissen and Bullemer, 1987) involving a sequence of lighted circles, Mostofsky et al. (2000) found no evidence of implicit learning in autistics. However, using the same kind of task, Smith (2003) found robust implicit learning of a sequence of geometric figures in autistics, with response accuracy superior to typical controls. Results from Smith’s (2003) second experiment using a sequence of emotional face images suggest that the presence of social information may demand more attentional resources from autistics than non-autistics, therefore disproportionately interfering with autistics’ implicit learning of non-social material (in this case, a sequence).

Associative learning has been reported as intact in autism (e.g., Boucher and Warrington, 1976; Williams et al., 2006), but autistics were also found to associate paired stimuli more rapidly than non-autistics (Sears et al., 1994). Reviewing a wide range of evidence, Baron-Cohen (2003) posited systemizing, a form of intrinsically-reinforced associative learning, as being a strength in autism, "a condition where unusual talents abound." Systemizing requires an "exact mind" and is motivated not by extrinsic reinforcement but by a drive to understand systems. Baron-Cohen (2003) describes an autistic five-year old boy whose mother accidentally discovered that, by walking down the same street every day, he had correctly associated hundreds of houses with their occupants' hundreds of cars (parked on the street), along with the expiration dates and serial numbers of the cars' parking stickers.

In contrast, Tomasello et al (1993; 2005; see also Tomasello, 2001) posited a form of social learning — cultural learning — as the defining achievement of uniquely human cognitive abilities, which he deemed autistics, along with apes, to lack. However, despite claims that the essential uniquely human ability is the learning of intentionality, which according to Tomasello autistics lack (Tomasello et al., 1993; Tomasello, 2001), empirical studies have demonstrated robust understanding of intentions in autistic children (Aldridge et al., 2000; Carpenter et al., 2001; Russell & Hill, 2001) and adults (Sebanz et al., 2005). The current model of cultural learning and cognition (Tomasello et al., 2005) is now founded not on the learning but the sharing of intentionality, which Tomasello has argued is absent in autistics and apes. The defining of humanity according to attributes that autistics are judged to lack is a hallmark of normocentrism (Mottron et al., in press).

After a long history of reductive explanations for savant abilities (e.g., photographic or phonographic memory), the savant literature largely recognizes that these abilities represent both spontaneous learning and creative manipulation of the structures and regularities underlying complex information (e.g., music, numbers, written language, visual proportions and perspective). Experimental studies of savants have concentrated on whether and how learned information and abilities are recalled, applied, modified, transformed, or transferred (Miller, 1999; Heaton and Wallace, 2004). Therefore, while savant abilities in autistics can be considered the equivalent of expertise in non-autistics (Mottron et al., 2006), there is only indirect evidence as to how this expertise is acquired. Overtraining with specific materials may (Howe et al., 1998) or may not (e.g., Selfe, 1977; Epstein et al., 1985) be observed prior to the full manifestation of exceptional abilities, which may also be discovered by accident (Sacks, 1985).

Thioux et al. (2006) proposed that savant abilities are driven by autistic focused interests, but depend on spared areas of typical learning abilities; in this model, as in Klinger et al. (2006), savant abilities are explicitly learned, with no role for implicit learning. However, implicit learning is widely considered to play an essential role in savant abilities (e.g., Hermelin and O'Connor, 1986; O'Connor, 1989; Miller, 1989, 1999; Spitz, 1995; Heaton and Wallace, 2004; Pring, 2005; Mottron et al., 2006). Miller (1999) has related the "sophistication" found in savant abilities to both enhanced processing at the perceptual level and the implicit learning of regularities, while suggesting that extensive exposure to materials may, for savants, be more effective than typical forms of teaching or rehearsal, which in turn may impede learning in savants. He concluded that "savants may provide a special perspective on the mixture of implicit and explicit learning that produces noteworthy performance."

Treffert (2000) has argued that savant abilities should be encouraged and nurtured; this results in a broadening of focused abilities and the flourishing of previously limited social abilities. For example, Miller (1989) denied that a young musical savant could be autistic, regardless of the individual fitting the relevant criteria, on the grounds that by age five, he "showed obvious pleasure in social interaction." However, prior to the availability of a piano, the same boy was described as "not very responsive," "for a very long time, nonverbal and withdrawn" and "spending hour after hour gazing out the window." Further, autism does not preclude pleasure in social interaction, which for example is observed in autistics spontaneously sharing the same interest with each other (LeGoff, 2004).

Savant and non-savant autistics are best considered as belonging to the same group, based on multiple behavioral and cognitive similarities. The performance of savants predicts the performance of non-savant autistics in multiple areas. For example, savant musicians invariably have absolute pitch, while absolute pitch (Brown et al., 2003) and superior pitch labeling, pitch memory (Heaton et al., 1998; Heaton, 2003), and pitch discrimination and categorization (Bonnel et al., 2003) characterize non-savant autistics. In a music imitation task, non-savant autistic youths (mean IQ <70) with no musical experience performed as well as or better than age-matched controls who had considerable musical training (Applebaum et al., 1979), echoing the superior musical imitation found in savant autistics (e.g., Slodoba et al., 1985; Young and Nettlebeck, 1995). A savant draftsman (Mottron and Belleville, 1993) and non-savant autistics (Mottron et al., 1999) shared a facility in copying impossible figures and a recognizable, locally oriented drawing strategy. Savant (Park, 1984; Steel et al., 1984; Hermelin and O'Connor, 1990; Young and Nettlebeck, 1995; Anderson et al., 1999) and non-savant (Scheuffgen, 2000; Dawson et al., in press) autistics may present with exceptional performance in tests of processing speed and/or high-level abstract reasoning. Many other empirically documented similarities are available, but it is also true that regardless of being extensively studied, both autism and savant syndrome remain unexplained, as does the overlapping relationship between the two, and the learning processes underlying both.

2.39.7. Summary: Characterizing Autistic Learning

Learning in autism is characterized both by spontaneous—sometimes exceptional—mastering of complex material and an apparent resistance to learning in conventional ways. Learning that appears to be implicit seems to be important in autism, but autistics' implicit learning may not map directly onto non-autistics' implicit learning or be governed by the same constraints. An understanding of autistic learning, of how and why autistics learn well and learn poorly, may therefore require a non-normocentric approach, and an investigation of the possibility that autistic and non-autistic cognition may be complementary in learning and advancing different aspects of knowledge.

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