An Analysis of the Characteristics of Autism Spectrum Conditions for Application to Weather
Communication Methods in the Weather Enterprise

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Abstract

This article, in an effort to foster discussion on potential implications for weather communication methods, seeks to provide for meteorologists a thorough overview and analysis of the characteristics of Autism Spectrum Conditions. ASC impacts cognitive development and communication ability, and although prevalence has increased steadily in recent years, little attention has been paid to it by the weather community in discussions to improve overall weather communication. With our analysis, we hope to communicate to meteorologists some of the challenges faced by individuals with ASC, which may affect their receipt of weather communication, and identify areas where potential research at the intersection of meteorology and ASC may occur so that the weather preparedness needs of these populations can be more effectively met. This paper argues ASC should be an important consideration for the weather enterprise as many of its characteristics suggest that those with the condition are at higher risk than others in times of dangerous weather.

Keywords: Autism Spectrum Condition, Meteorology, Theory of Mind, Central Coherence, Systemizing, Risk Communication

Introduction

Weather is important to all people, whether they realize it or not. It affects them physically and psychologically on small scales (e.g., in behavior and clothing choice), and on large scales (economies, critical infrastructure, etc.). Within this is the widespread occurrence of extreme weather threats across the United States. In response, the U.S. National Weather Service (NWS) launched the Weather-Ready Nation (WRN) initiative in 2012, in an effort to increase weather awareness and resiliency across the country. Better methods of meteorological communication and outreach are being explored within this program, and then are being disseminated and applied throughout the greater weather enterprise - the collective group (which includes meteorologists, emergency managers, mass communicators, psychologists, and others) whose individual entities work together to communicate weather information to the general public. Forecasters are working to improve the ways in which they communicate weather, while efforts are underway to improve the public's weather knowledge and corresponding ability to prepare for extreme and severe weather events. Individuals with physical disabilities are included in meteorologists' focused efforts (e.g., hurricane evacuations), and a new lightning safety campaign focused on deaf and hard-of-hearing populations was launched in June 2016 (National Weather Service, 2016a). However, "invisible" conditions - including various mental disabilities and conditions, and conditions such as blindness and color vision deficiency - remain left out of formal discussions (National Weather Service 2016b, 2016c, 2016d).

Autism, which can drastically affect cognitive development and communication ability, is one such condition. Affecting individuals neuro-developmentally, it is generally characterized by delays in communication ability, repetitive behaviors, sensory sensitivities, impairments in cognitive development and social interaction, and by the possession of a narrow range of

interests which are typically the subject of intense focus (American Psychiatric Association, 2013). The prevalence rate of the condition in the United States is 1-in-68 (U.S. Centers for Disease Control, 2014). Historically, there have been a number of individually-diagnosed autism-related conditions to fit multiple levels of severity, including classic autism, Asperger's Syndrome, and pervasive developmental disorder among others (American Psychiatric Association, 1994). These were all merged into one umbrella diagnosis (Autism Spectrum Disorder, or ASD) in 2013 (American Psychiatric Association, 2013). However, we support the notion that autism is not necessarily a disorder but rather a manifestation of individual difference along a continuous spectrum of being (Baron-Cohen, 2000; Beardon, 2007; Wing, 1988). Whereas the implication of "being disordered" is that one is somehow broken or flawed, "having a condition" is generally viewed as far less stigmatizing (Baron-Cohen, 2012a), and so, following in the footsteps of other researchers, we will hereafter refer to the aforementioned diagnoses as falling upon the autism spectrum of conditions and to individuals with these conditions as having Autism Spectrum Condition (ASC, Aylott, 2009; Baron-Cohen, Golan, Chakrabarti, & Belmonte, 2008; Bölte & Hallmayer, 2011; Clare & Woodbury-Smith, 2009; Lai, Lombardo, Chakrabarti, and Baron-Cohen, 2013 among others). ASC terminology aligns with the so-called "neurodiversity perspective," which puts forth the concept that neurological conditions are manifestations of natural variation in human functioning (e.g., Jaarsma & Welin, 2012).

People with an ASC function at many different levels. Some display more typical behavior and development, while others are severely cognitively impaired and in need of substantial living support. Regardless, each individual on the autism spectrum is limited, to some degree or other, in their respective capacities to discern and act on many types of information.

Integrated weather-society research has become a key focal point within the weather enterprise over the past decade. Topics include the public's perceptions of forecast uncertainty (e.g., Handmer & Proudley, 2007; Joslyn & Savelli, 2010; Morss, Demuth, & Lazo, 2008), general weather risks (Hoekstra et. al, 2011), the importance of weather to people on a psychological basis (Stewart, 2009; Stewart, Lazo, Morss, & Demuth, 2012), and climate change (e.g., Egan & Mullin, 2012; Hamilton & Stampone, 2013; Taylor, de Bruin, & Dessai, 2014). Others (Bolton & Blumberg, 2015; Bolton, Wise, & Blumberg, 2016a, 2016b; Bryant et al., 2014; Grant, 2015) have suggested weather communication implications exist for individuals in the arena of color perception. However, no empirical work, nor the WRN program to our knowledge, has considered autism populations in the context of weather communication. Adding to this, we have observed through discussion with those in the field that even though meteorologists may be directly affected by ASC through a family member or friend, it is not something they usually think of or see as related to their work. It is for these reasons that, even as meteorologists go to great lengths in communicating timely and accurate weather information and facilitating quality weather education to the general public, we hereby state that the weather enterprise does not do enough to accommodate populations with various neurological conditions, including ASC. We mean this with regard to community education and engagement, and the communication of potentially life-saving weather information.

We believe that the observed lack of action on behalf of those with ASC presents a problem to the weather enterprise, because the most-prime directive of the meteorologist is to protect all life and property in times of severe weather. Recent research (Bolton & Ault, 2017) has shown that knowledge of ASC facilitates acceptance for and understanding of those with the condition. Therefore, in an effort to begin a dialogue within the weather enterprise on autism

spectrum conditions and related topics, we seek to introduce to meteorologists some of the concepts relevant to understanding those with ASC, through a thorough analysis of the various characteristics of the condition. This includes a presentation of three theories which allow for a substantial understanding of some of the strengths and weaknesses that may be present in individuals with ASC, which may be encountered by the meteorologist in the course of their work. Finally, we will use the aforementioned concepts to present some possible research topics for future consideration by meteorologists and others in the weather enterprise. Overall, in providing information on some key features of ASC, we hope to spark conversation on the topic among meteorologists.

Overview of ASC Characteristics

Autism exists along a continuous spectrum (American Psychiatric Association 2013; Wing, 1988). Individuals who have less severe manifestations of ASC have fewer cognitive impairments overall, but still typically experience some social, emotional, and information-processing deficiencies. Individuals with more severe ASC, meanwhile, typically have moderate to severe deficiencies all-around. Inhibitions in the processing and integration of sensory information are most common across the spectrum; as a result, individuals with ASC may engage in self-stimulating behaviors in attempts to relieve sensory-related stressors and discomforts (Wing, 1997), or in response to intense feelings of happiness and pleasure, and due to some of the soon-to-be-described logical thinking and information-processing characteristics of ASC (Baron-Cohen, Ashwin, Ashwin, Tavassoli, & Chakrabarti, 2009). Such behaviors, informally known as "stimming" and occurring potentially all along the autism spectrum, consist of usually-uncontrollable, sudden, and/or erratic movements such as the flapping of hands and/or feet, spontaneous leg shaking, and fidgeting.

More severe manifestations of the condition may, furthermore, cause the affected individual to be exceptionally limited in verbal communication ability. Work concerning non-verbal ASC is sparse, but one relatively recent study on the prevalence of this extreme form of the condition estimated that it affects one-fourth of all individuals on the spectrum (Tager-Flusberg, Paul, & Lord, 2005). Many with severe ASC only communicate on the basis of expressing their essential needs in a very limited fashion, and require extensive therapy and intervention to potentially improve their condition. Others speak on a limited basis, but struggle to use language meaningfully (Smith, Mirenda, & Zaidman-Zait, 2007). Some non-verbal individuals with ASC communicate by way of gestures, sign language, picture cards, typed language, or augmentative and alternative communication devices (Mody, 2014).

Sensory-processing conditions, and conditions like Attention-Deficit Hyperactivity Disorder (ADHD), echolalia (wherein one repeats heard speech), and apraxia of speech, can co-occur alongside ASC, and additionally affect the individual. Apraxia of speech is a “motor-speech” condition that creates imbalances in brain functioning such that the individual has difficulty in mentally planning and coordinating the muscle movements required for speech (American Speech-Language-Hearing Association, 2016). It occurs most frequently in cases of more severe ASC (Shriberg et al., 2010). Sensory-processing conditions (affecting hearing, vision, physical function/perception, cognition, taste, and smell) co-present alongside the majority of ASC cases (O’Neil & Jones, 1997) with varying severity levels. Impairments in executive functioning (e.g., working memory, mental flexibility, planning abilities) have also been observed in ASC (Hill, 2004).

Theory of Mind

The first cognitive theory that we will discuss, Theory of Mind (ToM), is particularly relevant to the way people with ASC interpret the social world, although it is not exclusive to the condition. It is a widely accepted theory of cognition, and while its deficits are most often seen in ASC, they are also observed in schizophrenia and ADHD (Korkmaz, 2011), deafness (Lecciso, Levante, Baruffaldi, & Petrocchi, 2016), epilepsy (Giovagnoli et al., 2011), and alcoholism (Uekermann & Daum, 2008). Baron-Cohen, Frith, and Leslie introduced theory of mind to the ASC lexicon in 1985. This was in an effort to address the condition's social deficits from a cognitive perspective, independent of such factors as IQ.

ToM crosses simultaneously into the domains of conceptual theory and ability, which together work to explain the underlying cognitive mechanics of ASC. Conceptually, it is the idea that one is able to conceive of mental states. They include, for example, purpose, intention, knowledge, belief, thoughts, doubts, and likes and dislikes. As human beings, we understand, generally, that we possess these and other such psychological constructs, which comprise one piece of an overall state of mental consciousness. However, we are forever blind to the consciousness - the minds - of others. We know others have minds due to our own inner thought processes and mental experiences, but we are unable to directly access or observe them in others. As such, we are left to merely infer others' mental states and the behaviors which may result from them.

When an individual possesses the capacity to know that mental states exist, and further, when they are able to recognize the presence of these in themselves and others, it is said that the individual has a "theory," or understanding, of mind (Premack & Woodruff, 1978). Premack and Woodruff here infer "theory" to mean "understanding," because the ability to infer mental states

is a model which can be used to make predictions about the behavior of others. The dual process of role- and perspective- taking, in which one determines an appropriate social response by combining knowledge of people and behavior, and perceptions of behavior in a given situation (Flavell, Wright, Botkin, & Jarvis, 1968), is heavily involved in ToM.

Tightly interwoven with ToM is a psychological construct known as “meta-representation” (M-rep). M-rep is a “higher-order” cognitive representation process, in which “representation” refers to the process by which one conceptualizes some thing in their mind. While “first-order” representation involves self-awareness, second-order representation, with which M-rep is synonymous, involves awareness of others.

In meta-representation, one represents in one’s mind what one sees or otherwise experiences. Moreover, one also represents to oneself the mental representations (thoughts) of others. When we think about another person, and also when we think about another person thinking about us (in what is considered to be third-order representation), our M-rep abilities are engaged. M-rep is an ability considered impaired in ASC alongside ToM, which is itself a meta-representational model of cognition (Baron-Cohen et al., 1985; Leslie, 1987; Leslie & Frith, 1987; Leslie & Frith, 1988). It is through M-rep that we generate new knowledge or meaning, by mentally considering thoughts and concepts.

ToM and M-rep deficits are among the primary reasons that people with ASC can in some cases be extremely honest and loyal (Baron-Cohen, 2007), as the individual simply may not know any other way of behaving because other possibilities are entirely foreign to them on a conceptual level. To be dishonest, one must possess an inherent understanding and awareness for the existence of false beliefs. That is, it must be recognized that there can be two different perspectives or versions of an event: there is the true, reality-based version (“The vase broke

because *I* dropped it”), and the false, fictional version (“The vase broke because *Mark* dropped it”) that can be believed as true by someone else. This knowledge is not always possessed at a sufficient level when ToM is lacking (Baron-Cohen et al., 1985).

The skill/ability part of theory of mind, in which M-rep and second-order representation are crucially involved, is the sub-concept of “mentalizing.” Mentalizing is the cognitive process that occurs when mind-reading: that is, when thinking about and attributing mental states, both internally and to others, through meta-representation. This ability allows us to temporarily infer for ourselves what others are thinking, and correspondingly enables us to predict their behavior. It also facilitates the differentiating of fact from fiction - allowing one to successfully and consistently discern meaning from, and recognize, deception (Sodian, 1991), jokes and lies (Leekam & Prior, 1994), and other communication subtleties (such as sarcasm, irony, white lies, and double bluff; Happé, 1994). Theory of mind, as an overall model of cognition that includes M-rep and the ability to mentalize, is typically impaired or lacking in ASC because impairment in second-order representation prevents the autistic, to some degree, from having a proper theory of mind (Baron-Cohen et al., 1985, 1995; Dennett, 1978; Pylyshyn, 1978). ToM impairments also affect the individual's capacity for meta-cognition, which is thinking about thinking, or as Proust (2007) elaborated more technically: “all cognitive activities in which one is trying to appreciate, in retrospect, a cognitive achievement...” (e.g., thinking about whether or not one will be able to learn something new, thinking in retrospect that we were just able to recall an entire song's lyrics after having not heard the song in several years).

It is a myth that people with ASC individuals lack empathy in totality, because empathy is not all-or-none. Empathy is cognitively impaired in ASC, due to mentalizing and M-rep inhibitions, but remains affectively-functional (Baron-Cohen, 2012b; Mazza, 2014; Rogers,

Dziobek, Hassenstab, Wolf, & Convit, 2007). To fully understand what this means, it is necessary for us to briefly discuss the two underlying components that make up the overall construct of empathy (which are of cognitive and affective natures, respectively). Affective empathy drives one's ability to respond in an emotionally-appropriate way to what others are thinking and feeling. Cognitive empathy, meanwhile, is the part of empathy that allows one to understand the thoughts and feelings of others, and “put themselves in that person’s shoes,” so to speak. What this is saying is that people on the spectrum lack intuitive and unconscious awareness for differing perspectives (cognitive empathy/ToM) but not the ability to respond appropriately to others’ emotions (e.g., responding with concern and a desire to help when they notice someone is hurt).

In short, cognitive empathy is theory of mind (Baron-Cohen, 2012b), but it is important to not confuse them. They are interchangeable terms insofar as they both relate to how people understand the thoughts of others (in reference to the ability mentalize), but ultimately diverge because ToM is an altogether more complex process which incorporates cognitive representations on a more in-depth level.

Rather, they lack the cognitive component of empathy (which is essentially ToM on a lower level, to the point it concerns perspective-taking), while retaining their capacity for affective empathy, which allows for appropriate responses to others’ emotions (e.g., feeling the need to help someone who is hurt). Many autistic individuals report feeling high levels of affective concern for others in contrast to their inhibitions in cognitive empathy.

The social skill and emotional inhibitions in ASC are thought to largely stem from ToM-related impairments in inference and mental state understanding (though it is important to note that individuals on the spectrum can still be socially competent due to intact factors outside of

the ability to infer mental states - see Baron-Cohen et al., 1985, and Montgomery et al., 2016). The individual might close themselves off from others (Frith, 2003), mentally "shut/melt down" due to an inability to appropriately process their emotions and related sensory information from the world around them (Mazefsky et al., 2013), engage in self-harm (a behavior estimated to be present in as many as 28% of autistic children in two recent studies - see Soke et al., 2016a and 2016b) or try to harm others, if, for example, they are unable to properly process and feel cognitively overloaded by certain emotions. These responses could be coping mechanisms to sensory feedback and environmental stimuli, or they may result, more simply, because the individual has little to no experience in the particular situation at hand.

Because individuals on the autism spectrum often lack appropriate unconscious awareness and understanding of mental states and others' thoughts, they may appear to show little concern for others. They may ask questions repetitively, and/or in inappropriate situations and contexts; they may say rude/inappropriate things at times, or be overly candid, not realizing their inappropriateness until it has been pointed out. Further, they may ask a question over and over, even if they know the answer. In these cases, they ask not in an attempt to learn or impart new information, but merely to confirm (in an if-then manner) some factual pattern or question that interests them (S. Baron-Cohen, 2015 [interview](#)). These questions are not necessarily born in intentional rudeness or social inconsideration on the part of the individual with ASC but, rather, are manifestation of a natural driver of behavior (which we will discuss shortly) working in conjunction with communication impairments. ToM impairments cause the individual to frequently misunderstand correct social cue usage, because they are often unable to properly infer a response appropriate to the situation. The potential behavior exhibited by the person with ASC as a result of this scenario can be disruptive to others, especially considering that the co-

occurrence of social anxiety is common in ASC (Kussikko et al., 2008, among others). ToM deficits could induce, and then feed into and off of, social anxiety, and majorly affect the individual's ability to socialize.

Empathizing-Systemizing Theory

One piece of theoretical evidence that supports the relationship between ToM and anxiety is that people with ASC can be strong "systemizers." Whereas the process of empathizing involves the natural drive and ability to identify and relate to the emotions of others, systemizing is the drive and ability to construct and identify rules/patterns in "systems," which can be anything that takes an input and produces a correlated output (Baron-Cohen, 2009). Systemizing is an if-then process in which one observes some detail (variable) of a system and then monitors it for change and variance. Systemizing occurs naturally from passive observation, and also when one purposely manipulates a given variable, in the framework of "if I do *X*, *A* changes to *B*. If *Z* occurs, *P* changes to *Q*" (Baron-Cohen, 2008).

In a 2014 study examining the relationship between empathizing, systemizing, and anxiety, Strutt, Campbell, and Burke reported that people who scored highly on a particular measure of systemizing traits correspondingly scored lower on a measure of empathizing (ToM) traits. This same group scored highly on measures which examined participants' levels of anxiety and autistic traits. A positive correlation was found between participants' levels of anxiety and systemizing, such that participants who expressed higher levels of systemizing also exhibited higher levels of anxiety. A propensity for systemizing may therefore predispose one to exhibit higher levels of anxiety.

The Empathizing-Systemizing theory was formulated to account for the social and non-social behaviors of ASC, including the possession of narrow interests, a need for sameness, and attention to detail (Baron-Cohen, 2009). It has been posited that systemizing is a cognitive style of ASC, and that its purpose is to seek truth - which can be hereafter defined as "precise, reliable, consistent, or lawful patterns or structure in [some kind of] data" (Baron-Cohen, 2008). This search for logic and accompanying predictability and control is evidenced by the frequent repetitive behaviors seen in ASC (e.g., self-stimulating behaviors, young children spinning wheels on toy cars, fascination with dates, tendency to arrange objects in sequence, repetitive question asking, need for routine, structure, and sameness of schedule) and the tendency for these individuals to largely be disinterested in socializing. It also explains how social and other anxiety could so easily be introduced to the individual with ASC if that predictability is unable to be found.

As a cognitive style, systemizing interprets autistic difficulty related to empathy and socializing as a consequence of minds which seek truth and certainty in the domain of emotions. Human behavior, being inherently fluid, is lawful only to a certain degree. It therefore cannot be systemized with certainty. Anxiety can result for the individual affected by ASC in many different ways, but one theoretical example is that it occurs when they attempt to apply another individual's conflicting words and behaviors to the systemizing model. Systemizing would expect the person the ASC individual is interacting with to behave, with unerring consistency, in a way that correlates with their words. When their behavior does not match their words, cognitive dissonance - a mental state of psychological discomfort in which the affected individual holds two or more conflicting and irreconcilable beliefs (Festinger, 1957) - and social anxiety are introduced. The person with ASC is subsequently confused by their peer's ability and

willingness to say *X* (to which they expect a corresponding result *Y*) but do *B*, instead (recall that mentalizing deficits induce an inability to consistently detect deception, and other communication subtleties which may be recognized as benign were the individual able to mentalize). In an attempt to alleviate their dissonance and anxiety while lacking a theory of mind which could help them resolve the situation, the individual with ASC may unintentionally engage in further systemizing behavior, by repetitively questioning their peer about their behavior.

Systemizing sees the minds of people on the autism spectrum as naturally driven for if-then details and related pattern-based thinking, which contradicts and is naturally opposed to empathizing's drive to affectively understand the minds of others. Basically, this theory suggests that, in ASC, there is generally a net increase in logical and analytical thinking, and a net decrease in emotional understanding and social responsivity/reciprocity to others. The result of this, however, is that people with the condition may be predisposed for talent in science and other fields (Baron-Cohen, 2008; Baron-Cohen et al., 2009).

Psychologists have indeed observed a link between ASC incidence and individuals interested in science, which features disciplines heavily-rooted in observable data and predictability. A good deal of work has linked ASC to mathematics, engineering, physics, and technology-related fields such as IT and computer science (Baron-Cohen et al., 1998; Baron-Cohen, Wheelwright, Stone & Rutherford, 1999; Wheelwright & Baron-Cohen, 2001; Baron-Cohen, Wheelwright, Burtenshaw, & Hobson, 2007; Roelfsema et al., 2011; Baron-Cohen, 2015). Notably, Baron-Cohen and colleagues have found in multiple studies (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001; Baron-Cohen et. al., 1998, 2007) that ASC traits, and diagnosed occurrences, are more common among the physical sciences - families of

engineers, physics, and mathematicians - compared to control groups in the social sciences and humanities, and also disciplines (i.e., medicine and law) which could be considered to require a similarly strong drive for systemizing.

Interestingly, anecdotal evidence, noted by these authors while working within the weather enterprise, would seem to suggest that individuals with ASC may have higher-than-normal interests in meteorology. Working as weather educators at various education events, and elsewhere, we have observed numerous individuals who have exhibited noticeable levels of autistic traits, some of whom have self-disclosed themselves as autistic. In addition to our anecdotal findings, news outlets have also observed cases in which a child or other individual with ASC has a meteorological or other science-related inclination (e.g., CBC News, 2013; *New York Times*, 2014; *Tampa Bay Times*, 2014; WRIC-TV, 2015).

Mental illness (schizophrenia, bipolar disorder, manic depression, and others) seems to be linked to artistic creativity (e.g., Kyaga et al., 2013; Sussman, 2007; Popova, 2014; Cancer, Manzoli, & Antonietti, 2016). Considering this, perhaps the opposite might be true of certain other conditions: that, instead of predisposing one for creative outlets, particular conditions might calibrate an individual for science through an innate attention for detail and desire for logic, and, therefore, act as a benefit where weather communication is concerned.

Central Coherence Theory

Cognitive psychology involves many different internal processes of the mind, including those by which information is gathered and interpreted. Information is broadly processed in two ways: from the top, down; and, from the bottom, up. “*Top-down*” processing occurs when one forms perceptions and impressions - of concepts and ideas, of people, and so on - by starting

with the larger picture and moving “down” to the specific details. Put another way, it is thinking “from the general to the specific.” Contrast this framework with “*bottom-up*” processing, which is thinking “from the specific to the general.” Bottom-up processing occurs when perceptions are formed by starting with specific details, moving “up,” or outwards, towards the larger picture. Grandin (2013) established that bottom-up processing is what generally happens in the brain of someone with ASC, whereas those without the condition generally possess the capacity for both top-down and bottom-up processing in fairly balanced amounts. Together, top-down and bottom-up processing comprise one’s capacity for “central coherence,” the process by which information is gathered from a wide array of sources and then centrally assimilated together in a cohesive manner. Central coherence theory, the last theory in our review, puts forth the idea that one of the core components of ASC is an inability to integrate and process information at different levels of cognition (Frith, 1989; Frith & Happé, 1994).

This inherent inability in people with ASC, which gives way to bottom-up information processing, exists, precisely, in one's ability to interpret information locally (pertaining to individual details) and infer it globally (with regard to the “big picture” and overall mass of details). The ability to take information from one level of cognition (i.e., that concerning small, local, pieces of information) to another (that concerning large pieces) is biased in ASC towards local information processing, so that one who has the condition is considered to have “weak” central coherence (WCC). To make a meteorological analogy, when one has WCC, that person most naturally sees and processes concepts at the microscale, and not on a synoptic scale, level.

WCC has been pointed to as an explanation for some aspects of savantism - a condition in which one has high skill or knowledge in a very particular area, but potentially severe impairment elsewhere. Treffert (2009) reported that although there is study-to-study variability,

savantism is generally thought to be present in as many as 1-in-10 people on the autism spectrum - more than in any other group observed to date. Evidence for WCC-linked savantism has been reported over the years (e.g., Heavey, Pring, & Hermelin, 1999; Heavey, Hermelin, Crane, & Pring, 2012; Wallace, Happé, & Giedd, 2009). In studies examining numerical processing in relation to long-term memory retrieval, for example, Heavey and colleagues observed that weak central coherence may bestow strong skills in mentally calculating dates and numbers. Long strings of numbers and other information are essentially broken down into manageable pieces; hence, some people with ASC can easily repeat facts and figures.

It has been established that WCC is a detail-focused cognitive style, with psychologists consistently finding that individuals with ASC have small-scale information-processing skills that are superior to those observed in those without ASC (Happé, 1999; Happé & Frith, 2006). Notable studies which have furthered this conclusion include work by Shah and Frith (1983, 1993), Jolliffe and Baron-Cohen (2001), O'Riordan, Plaisted, Driver, and Baron-Cohen (2001), and Mottron, Burack, Iarocci, Belleville, and Enns (2003). Taken together, the existing body of work on central coherence has garnered widespread acceptance for the belief that central coherence theory centers around concepts that exist not as overall negatives and pure deficiencies in global processing, but rather as a manifestation of local processing skill and attention to detail.

Discussion

There are a myriad of contexts where knowledge of the characteristics and cognitive theories of ASC could benefit meteorologists and others in the weather enterprise. Sensory-processing deficiencies and differences can potentially lead to behavioral meltdowns and/or temper tantrums, and other behaviors which may otherwise seem odd to those lacking knowledge

of ASC, at public weather events where meteorologists may be present. Knowledge of the fact that individuals with ASC may be more sensitive to and perceptive of changes in the weather (given proof of the sensory-integration issues in ASC, see, among others: Blakemore et al., 2006; Tavassoli, Miller, Schoen, Nielsen, & Baron-Cohen, 2014), and this coupled with knowledge of these individuals' need for routine and structure in scheduling, could have implications for meteorologists, emergency managers, and others. Consideration of this information could allow for enhanced messaging to individuals with ASC in times of needed evacuation. For example, in the time before a tropical cyclone landfall, when planning and preparation may be needed for more severely impaired individuals with ASC who live in group homes or under other intensive supervision, and even those without extreme impairment who nonetheless may struggle with issues related to anxiety and the need for sameness.

Mentalizing inhibitions, meanwhile, could cause the individual with ASC to behave outside of normally-observed social conventions. For example, they may respond inappropriately or otherwise improperly in conversation with a meteorologist because they are unable to infer the consequences of their behavior and how it may be interpreted. Due in part to mentalizing weaknesses, systemizing could induce a situation in which the individual becomes fixated on some (perhaps situationally-inappropriate) question or thing. Finally, the individual with ASC, unable to properly mentally assimilate and conceptualize thoughts because of WCC and M-rep deficits, also may not understand concepts or information presented to them on a meaningful level. All of these issues may potentially hinder meteorologists in providing quality weather communication and education to individuals who fall along the autism spectrum.

Potential Areas of Focus for ASC-Meteorology Research

We have identified multiple integrated weather-society avenues professionals across the weather enterprise may take in exploring research topics related to autism spectrum conditions. It is possible that the co-occurrence of ASC and sensory-processing conditions forebodes potential trouble where weather is concerned. Impacting factors which could affect the individual with ASC include noise (thunder), light sensitivity (lightning), and imagery (i.e., visualizing flooding, tornadoes, and other phenomena leading to cognitive and/or sensory overload through an amplified sense of anxiety, fear, and perseveration on said fear). Neil, Olsson, and Pellicano (2016) found anxiety to be present in as many as 84% of the sampled children with ASC. These high levels of anxiety were found to be correlated with an inherently poor tolerance of uncertainty. Considering this linkage, and that extreme/severe weather phobia is already a problem for many people in the general population (Coleman, Newby, Multon, & Taylor, 2014; Westfield, 1996), it should be considered a possibility that extreme-weather-centered phobias could readily develop for individuals with ASC.

Another relevant research area is that involving social perceptions of those with disabilities and mental conditions such as ASC. Much of the work conducted in this area (see, for example, Gordon, Feldman, Tantillo, and Perrone, 2004; Karnilowicz, Sparrow, and Shinkfield, 1994; Nowicki, 2006; Thomas, 2000; and Tringo, 1970) has found that people (children and adolescents as well as adults) seek distance from those with mental illness and disability more so than they do individuals with physical disability. Meanwhile, reports by journalistic outlets reports (e.g., ABC News, 2017; *Lincoln Star Journal*, 2016; *The Guardian*, 2015; WABC-TV, 2016; WSB-TV, 2016; Good Morning America, 2016, among others) suggest widespread poor treatment of those with mental illnesses and disabilities. These social injustices lend themselves

to the idea of “stigma,” which has been defined as a feature “which majorly discredits the [affected] individual” and reduces him or her “from a whole and usual person to a tainted, discounted one” (Goffman, 1963, p. 3, as cited in Major & O’Brien, 2005). Mental illness stigma and bias can potentially lead to strained familial relationships (Lefley, 1989), employment discrimination (Farina, Felner, & Boudreau, 1973), and general social rejection and lower quality-of-life overall (Corrigan, Edwards, Green, Diwan, & Penn, 2001). The overall stigma surrounding mental health and disability topics has been shown to result in people on the autism spectrum forming fewer friendships, and maintaining an altogether smaller social support group than their without the condition. Subsequently, it has been reported that people with ASC have lower self-esteem and other negative self-directed perceptions that ultimately lead to lower quality-of-life (Nevill & White, 2011).

Considering this, it may be beneficial to investigate the consequences of social isolation that may result for individuals with ASC, and whether or not these also forebode trouble regarding the receipt of critical weather information from meteorologists. There is much support in the literatureⁱ including Aguirre, Wenger, & Vigo, 1998; Anderson, Keaton, Saarinen, & Wells, Jr., 1984; Baker, 1979, Christensen & Ruch, 1980; Riad, Norris, & Ruback, 1999; and Bateman & Edwards, 2002) for the social behavior phenomenon that sees people confirm weather warnings and phenomena like tornadoes through friends and wider social networks before taking action themselves (this is part of the warning-response process. See *Communication of emergency public warnings: A social science perspective and state-of-the-art assessment*, Mileti & Sorensen, 1990, for more information). With potentially fewer meaningful interpersonal relationships, and therefore smaller social support networks, individuals with ASC may have fewer ways to receive and verify life-saving weather information.

The ways in which weak central coherence may work within the framework of television weather broadcasts (commonly known as “weathercasts”) also warrant research. Weathercasts are most often split into “packages,” each of which makes up a different aspect of the forecast. Within an overall news program, there are numerous weather package cut-ins, with many opportunities for the meteorologist to complete the entire forecast. Most individual broadcast packages last roughly two minutes and, within that time, the meteorologist must deliver the forecast, warning, or other update in a clear and concise manner. Graphic design, tone of voice, camera angles and transitions, and non-verbal delivery (i.e., body language) must all be considered. Severe weather situations may at times warrant wall-to-wall, commercial-free coverage, which features prolonged and comprehensive tracking and broadcast of storm information. These events can be fast-paced, and often lead to what may seem to be chaotic reporting. Related to this, another potentially-confusing element of weathercasts is that, in some severe weather situations (e.g., a landfalling tropical cyclone), there may be many different news anchors and field reporters providing supplementary coverage to the meteorologist. The many aspects of weathercasts, as well as constant changes in some event coverage, may be difficult for the individual with ASC to follow, as they are affected by inhibitions in their capacity for attention-switching (e.g., Charman, 2003; Reed & McCarthy, 2012; Swettenham et al., 1998) as well as the aforementioned WCC-linked imbalance in global-local information processing.

Furthermore, some broadcast television vendors program their weather graphics software in such a way as to only allow particular colors to be used in certain graphical elements (B. McClure, 2016, personal communication). A station, therefore, could be forced into using two different colors to represent the same watch/warning product, both of which may be seen on-screen at the same time. Someone with ASC could see a certain color used in one part of the

broadcast and infer meaning from it, even though the watch/warning product in question is used elsewhere in the broadcast in a different color.

Visual fixation and systemizing behaviors may potentially negatively affect the message ASC-affected individuals receive during weathercasts. Frey, Molholm, Lalor, Russo, and Foxe (2013) noted that eye- and gaze- tracking (“the ability to keep the eyes on target when looking from one object to another, moving the eyes along a printed page, or following a moving object like a thrown ball,” American Optometric Association, 2016) is often observed as impaired in ASC. They reported poor mapping of visual space within the cerebral cortex section of the brain as the likely cause of this. It has been suggested in psychology literature that eye-tracking differences cause people with autism to focus more on their surroundings and inanimate objects therein, and less on people, in social settings (e.g., Klin, Jones, Schultz, Volkmar, & Cohen, 2002; Rice, Moriuchi, Jones, & Klin, 2011). We postulate that the results from these studies may apply when individuals with ASC watch weathercasts. The major concern here is that the weathercast might essentially be processed by the ASC-affected viewer in a manner similar to a social interaction. In addition, there are often extra computer monitors, TV screens, weather data visualizations, and other details on-screen, especially during wide-angle camera shots. Such distractions may be more easily systemized. The viewer with ASC could be predisposed to focus/fixate not on what is intended to be the focus (e.g., the meteorologist and green screen or TV monitor), but on extraneous details in the margins of the shot, as they are caught up in systemizing. These issues and those mentioned in the preceding paragraphs, with regard to weak central coherence, could potentially expose those with ASC to a greater level of weather-related risk than that seen in other populations, and warrant investigation, with specialized methods focused on identification of the problem and potential interventions, to mitigate that risk.

Yet other weather dissemination channels, including traditional radio, NOAA Weather Radio, and computer-based information, as well as mobile weather applications, may introduce other inconsistencies and issues with regard to WCC and M-rep deficits. Radio broadcasts are not accompanied by imagery, while mobile apps may have inconsistencies in their information when compared with other sources due to the preponderance of computer-generated weather data and its potential conflicts with human-produced forecasts. So, with regard to these outlets, the individual with ASC may have trouble mentally conceptualizing content without the prompts provided by complementary graphics, and, furthermore, may be confused when presented with conflicting information. We are currently investigating uses and sources of weather information in people with ASC.

Summary

Given the lack of meteorology-ASC literature, this article attempts to define, for the first time, Autism Spectrum Condition as an important topic of concern faced by the weather enterprise in delivering weather information. Toward this end, we have thoroughly reviewed aspects of ASC with which we feel meteorologically-focused professionals should be familiar. We examined three models of cognition that exist within ASC. Theory of mind (essentially, the ability to infer thoughts and mental states in oneself and others) was reviewed first. Secondly, we discussed central coherence theory (deficiency in large-scale information processing, but strength in small-scale processing). In closing our theoretical review, we discussed the Empathizing-Systemizing theory (which posits that people on the autism spectrum are impaired in empathizing because of ToM impairments, but have a strength in analytical, if/then-type thinking in contrast). Thereafter, we outlined areas of research which could be pursued by

meteorologists, in efforts to improve weather communication methods to better account for individuals on the autism spectrum. We hope this will spark future communication around autism-related topics in the weather enterprise, and that meteorologists and others active in the field will take the information provided here into consideration in the course of their future work.

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References

- ABC News. (2017, January 6). What we know about the alleged Chicago hate crime streamed live on Facebook. Retrieved from <http://abcnews.go.com/US/alleged-chicago-hate-crime-streamed-live-facebook/story?id=44596745>
- Aguirre, B. E., Wenger, D., & Vigo, G. (1998). A test of the emergent norm theory of collective behavior. *Sociological Forum*, 13(2), 301-320.
- American Optometric Association. (2016). Vision skills needed for school success. Retrieved from <http://www.aoa.org/patients-and-public/good-vision-throughout-life/childrens-vision/school-aged-vision-6-to-18-years-of-age?sso=y>
- American Psychiatric Association. (1994). *DSM-IV diagnostic and statistical manual of mental disorders, 4th edition*. Washington, DC: American Psychiatric Association.
- American Psychiatric Association. (2013). Autism spectrum disorder. In *Diagnostic and statistical manual of mental disorders: DSM-5*. Washington, D.C: American Psychiatric Association. 50-59.
- American Speech-Language-Hearing Association. (2016). Childhood apraxia of speech. Retrieved from <http://www.asha.org/public/speech/disorders/ChildhoodApraxia/>
- Anderson, L., Keaton, J., Saarinen, T., & Wells, W., Jr. (1984). *The Utah landslides, debris flows and floods of May and June 1983*. Washington DC: National Academy Press.
- Aylott, J. (2009). Autism spectrum conditions. In: M. Jukes. (Ed.) *Learning disability nursing practice*. MA Healthcare Ltd., London, Quay Books Division, 379-398.

- Baker, E.J. (1979). Predicting response to hurricane warnings: A reanalysis of data from four studies. *Mass Emergencies*, 4(1), 9-24.
- Baron-Cohen, S., Leslie, A., & Frith, U. (1985). Does the autistic child have a “theory of mind”? *Cognition*, 21, 37–46.
- Baron-Cohen, S. (1995). *Mindblindness: An essay on autism and theory of mind*. Boston: MIT Press/Bradford Books.
- Baron-Cohen, S., Bolton, P., Wheelwright, S., Short, L., Mead, G., Smith, A., & Scahill, V. (1998). Does autism more often in families of engineers, physicists, and mathematicians? *Autism*, 2(3), 296-301.
- Baron-Cohen, S., Wheelwright, S., Stone, V., & Rutherford, M. (1999). A mathematician, a physicist, and a computer scientist with Asperger Syndrome: Performance on folk psychology and folk physics tests. *Neurocase*, 5, 475-483.
- Baron-Cohen, S. (2000). Is Asperger’s Syndrome/high-functioning autism necessarily a disability? Retrieved from <http://www.larry-arnold.net/Neurodiversity/Mission/disability.htm>
- Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The Autism-spectrum Quotient (AQ): evidence from Asperger Syndrome/high-functioning autism, males and females, scientists and mathematicians. *Journal of Autism and Developmental Disorders*, 31, 5-17.
- Baron-Cohen, S. (2007). I cannot tell a lie – what people with autism can tell us about honesty. Retrieved from <http://incharacter.org/archives/honesty/i-cannot-tell-a-lie-what-people-with-autism-can-tell-us-about-honesty/>
- Baron-Cohen, S., Wheelwright, S., Burtenshaw, A., & Hobson, E. (2007), Mathematical talent is linked to autism. *Human Nature*, 18, 125-131. doi:10.1007/s12110-007-9014-0

- Baron-Cohen, S. (2008). Autism, hypersystemizing, and truth. *The Quarterly Journal of Experimental Psychology*, 61(1), 64-75.
- Baron-Cohen, S., Golan, O., Chakrabarti, B., & Belmonte, M. (2008). Social cognition and autism spectrum conditions. In C. Sharp, P. Fonagy, & I. Goodyer, (Eds.). *Social Cognition and Developmental Psychopathology*. Oxford University Press.
- Baron-Cohen, S. (2009). Autism: The empathizing-systemizing (E-S) theory. *Annals of the New York Academy of Sciences*, 1156(1), 68–80. doi:10.1111/j.1749-6632.2009.04467.x
- Baron-Cohen, S., Ashwin, E., Ashwin, C., Tavassoli, T., & Chakrabarti, B. (2009). Talent in autism: Hyper-systemizing, hyper-attention to detail and sensory hypersensitivity. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1522), 1377–1383.
doi:10.1098/rstb.2008.0337
- Baron-Cohen, S. (2012a). Simon Baron-Cohen discusses ASD vs. ASC. Retrieved from <https://www.youtube.com/watch?v=BDEHjLMOhHI>
- Baron-Cohen, S. (2012b). When zero degrees is positive. In Baron-Cohen, S. (Ed.), *The Science of Evil: On Empathy and the Origins of Cruelty* (pp. 37, 108). New York, NY: Basic Books.
- Baron-Cohen, S. (2015). Autism, maths, and sex: The special triangle. *The Lancet Psychiatry*, 2, 790-791.
- Bateman, J. M., & Edwards, B. (2002). Gender and evacuation: A closer look at why women are more likely to evacuate for hurricanes. *Natural Hazards Review*, 3, 107-117.
- Beardon, L. (2007). Is autism a disorder? Retrieved from <http://autisticuk.org/wp-content/uploads/2016/05/AUTISTIC-UK-NEED-TO-KNOW-1-IS-AUTISM-A-DISORDER.pdf>

Blakemore, S.-J., Tavassoli, T., Calò, S., Thomas, R. M., Catmur, C., Frith, U., ... Haggard, P. (2006).

Tactile sensitivity in Asperger Syndrome. *Brain and Cognition*, 61, 5-13.

Bölte, S., & Hallmayer, J. (Eds.). (2011). *Autism spectrum conditions*. Cambridge, MA: Hogrefe Publishing.

Bolton, M. J., & Blumberg, W. G. (2015, October). *Learning disorders in the meteorological community: Implications for communication and education*. Oral presentation at the 40th Annual Meeting of the National Weather Association, Oklahoma City, OK. Abstract retrieved from <http://nwas.org/meetings/nwas15/abstracts-html/2481.html>

Bolton, M. J., Wise, G., & Blumberg, W. G. (2016a, June). *Color blindness in the weather enterprise: Discussion and a look at solutions*. Oral presentation at the 44th Conference on Broadcast Meteorology of the American Meteorological Society, Austin, TX. Abstract retrieved from <https://ams.confex.com/ams/44Broadcast/webprogram/Paper295309.html>

Bolton, M. J., Wise, G., & Blumberg, W. G. (2016b, September). *Color blindness in the weather enterprise: Discussion and a look at solutions*. Poster presented at the 41st Annual Meeting of the National Weather Association, Norfolk, VA. Abstract retrieved from http://nwas.org/meetings/nwas16/abstracts_html/Multifarious/2016_2806_oral_Bolton_abstract.html

Bolton, M. J., & Ault, L. K. (2017, March). *The Relationship Between Familiarity With ASD and Disclosure of Diagnosis*. Oral presentation at the 63rd Annual Meeting of the Southeastern Psychological Association, Atlanta, GA.

- Bryant, B., Holiner, M., Kroot, R., Sherman-Morris, K., Smylie, W. B., Stryjewski, L., Thomas, M., & Williams, C. I. (2014). Usage of color scales on radar maps. *Journal of Operational Meteorology*, 2(14), 169–179. doi:10.15191/nwajom.2014.021
- Cancer, A., Manzoli, S., & Antonietti, A. (2016). The alleged link between creativity and dyslexia: Identifying the specific process in which dyslexic students excel. *Cogent Psychology*, 3(1). doi:10.1080/23311908.2016.1190309
- CBC News. (2013, February 23). Cape Breton amateur weather man is a viral video star. Retrieved from <http://www.cbc.ca/news/canada/nova-scotia/cape-breton-amateur-weather-man-is-a-viral-video-star-1.1342904>
- Charman, T. (2003). Why is joint attention a pivotal skill in autism? *Philosophical Transactions of the Royal Society B: Biological Sciences*, 358(1430), 315–324. doi:10.1098/rstb.2002.1199
- Christensen, L., & Ruch, C. E. (1980). The effect of social influence on response to hurricane warnings. *Disasters*, 4(2), 205-210.
- Clare, I., & Woodbury-Smith, M. (2009). Autism spectrum conditions. In S. Young, M. Kopelman, & G. Gudjonsson. (Eds.). *Forensic neuropsychology in practice: A guide to assessment and legal processes*. Oxford University Press.
- Coleman, J. S. M., Newby, K. D., Multon, K. D., & Taylor, C. L. (2014). Weathering the storm: Revisiting severe-weather phobia. *Bulletin of the American Meteorological Society*, 95(8), 1179–1183. doi:10.1175/bams-d-13-00137.1
- Corrigan, P.W., Edwards, A.B., Green, A., Diwan, S.L., & Penn, D.L. (2001). Prejudice, social distance, and familiarity with mental illness. *Schizophrenia Bulletin*, 27, 219–225.
- Dennett, D. (1978). Beliefs about beliefs. *Behavior and Brain Science*, 4, 568-570.

- Egan, P. J., & Mullin, M. (2012). Turning personal experience into political attitudes: The effect of local weather on Americans' perceptions about global warming. *The Journal of Politics*, 74(3), 796–809. doi:10.1017/s0022381612000448
- Farina, A., Felner, R. D., & Boudreau, L. A. (1973). Reactions of workers to male and female mental patient job applicants. *Journal of Consulting and Clinical Psychology*, 41(3), 363–372. doi:10.1037/h0035329
- Festinger, L. (1957). *A theory of cognitive dissonance*. Stanford, CA: Stanford University Press.
- Flavell, J., Botkin, P., Fry, C., Wright, J., & Jarvis, P. (1968). *The development of role-taking and communication in children*. New York, NY: John Wiley & Sons, Inc.
- Frey, H.-P., Molholm, S., Lalor, E. C., Russo, N. N., & Foxe, J. J. (2013). Atypical cortical representation of peripheral visual space in children with an autism spectrum disorder. *European Journal of Neuroscience*, 38(1), 2125–2138. doi:10.1111/ejn.12243
- Frith, U. (2003). *Autism: Explaining the enigma, second edition*. Oxford: Basil Blackwell.
- Frith, U., & Happé, F. (1994). Autism: Beyond “theory of mind.” *Cognition*, 50(1-3), 115–132. doi:10.1016/0010-0277(94)90024-8
- Giovagnoli, A. R., Franceschetti, S., Reati, F., Parente, A., Maccagnano, C., Villani, F., & Spreafico, R. (2011). Theory of mind in frontal and temporal lobe epilepsy: Cognitive and neural aspects. *Epilepsia*, 52(11), 1995–2002. doi:10.1111/j.1528-1167.2011.03215.x
- Good Morning America. (2016, September, 23). New Jersey dad's heartbreaking school photo highlights son's loneliness. Retrieved from <https://gma.yahoo.com/jersey-dads-heartbreaking-school-photo-highlights-sons-loneliness-223414182-abc-news-parenting.html>

- Goffman, E. (1963). *Stigma: Notes on the management of spoiled identity*. New York, NY: Prentice Hall.
- Gordon, P. A., Tantillo, J. C., Feldman, D., & Perrone, K. M. (2004). Attitudes regarding interpersonal relationships with persons with mental illness and mental retardation. *Journal of Rehabilitation, 70*, 50-56.
- Grandin, T. (2013). Knowing your own strengths. In T. Grandin, & R. Panek. (Eds.) *The autistic brain* (pp. 120-124). New York, NY: Houghton Mifflin Harcourt.
- Grant, L. E. (2015, October). *The color conundrum: The many variations of one watch or warning*. Poster presented at the 40th Annual Meeting of the National Weather Association, Oklahoma City, OK. Abstract retrieved from <http://nwas.org/meetings/nwas15/abstracts-html/2443.html>
- Hamilton, L. C., & Stampone, M. D. (2013). Blowin' in the wind: Short-term weather and belief in anthropogenic climate change. *Weather, Climate, and Society, 5*(2), 112–119. doi:10.1175/wcas-d-12-00048.1
- Handmer, J., & Proudley, B. (2007). Communicating uncertainty via probabilities: The case of weather forecasts. *Environmental Hazards, 7*(2) 79–87. doi: 10.1016/j.envhaz.2007.05.002
- Happé, F. (1994). An advanced test of theory of mind: Understanding of story characters' thoughts and feelings by able autistic, mentally handicapped, and normal children and adults. *Journal of Autism and Developmental Disorders, 24*, 129-154.
- Happe, F. (1999). Autism: Cognitive deficit or cognitive style? *Trends in Cognitive Sciences, 3*, 216-222.

- Happé, F., & Frith, U. (2006). The weak coherence account: Detail-focused cognitive style in autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 36(1), 5–25.
doi:10.1007/s10803-005-0039-0
- Heavey, L., Pring, L. & Hermelin, B. (1999). A date to remember: The nature of memory in savant calendrical calculators. *Psychological Medicine*, 29, 145–160. doi:10.1017/s0033291798007776
- Heavey, L., Hermelin, B., Crane, L., & Pring, L. (2012). The structure of savant calendrical knowledge. *Developmental Medicine and Child Neurology*, 54(6), 507–513. doi:10.1111/j.1469-8749.2012.04250.x
- Hill, E. L. (2004). Executive dysfunction in autism. *Trends in Cognitive Science*, 8(1), 26-32.
- Hoekstra, S., Klockow, K., Riley, R., Brotzge, J., Brooks, H., & Erickson, S. (2011). A preliminary look at the social perspective of warn-on-forecast: Preferred tornado warning lead time and the general public's perceptions of weather risks. *Weather, Climate, and Society*, 3(2), 128–140.
doi:10.1175/2011wcas1076.1
- Jaarsma, P., & Welin, S. (2012). Autism as a natural human variation: Reflections on the claims of the neurodiversity movement. *Health Care Analysis*, 20(1), 20–30. doi:10.1007/s10728-011-0169-9
- Jolliffe, T., & Baron-Cohen, S. (2001). A test of central coherence theory: Can adults with high-functioning autism or Asperger syndrome integrate fragments of an object? *Cognitive Neuropsychiatry*, 6(3), 193–216. doi:10.1080/13546800042000124
- Joslyn, S., & Savelli, S. (2010). Communicating forecast uncertainty: Public perception of weather forecast uncertainty. *Meteorological Applications*, 17(2), 180–195. doi:10.1002/met.190

- Karnilowicz, W., Sparrow, & W. A., Shinkfield, A. (1994). High school students' attitudes toward performing social behaviors with mentally retarded and physically disabled peers. *Journal of Social Behavior and Personality*, 9(5), 65-80.
- Klin, A., Jones, W., Schultz, R., Volkmar, F., & Cohen, D. (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry*, 59(9), 809. doi:10.1001/archpsyc.59.9.809
- Korkmaz, B. (2011). Theory of mind and neurodevelopmental disorders of childhood. *Pediatric Research*, 69(5), 101R–108R. doi: 10.1203/pdr.0b013e318212c177
- Kuusikko, S., Pollock-Wurman, R., Jussila, K., Carter, A. S., Mattila, M.-L., Ebeling, H., ... Moilanen, I. (2008). Social anxiety in high-functioning children and adolescents with autism and Asperger Syndrome. *Journal of Autism and Developmental Disorders*, 38(9), 1697–1709. doi:10.1007/s10803-008-0555-9
- Kyaga, S., Landén, M., Boman, M., Hultman, C. M., Långström, N., & Lichtenstein, P. (2013). Mental illness, suicide and creativity: 40-Year prospective total population study. *Journal of Psychiatric Research*, 47(1), 83–90. doi:10.1016/j.jpsychires.2012.09.010
- Lai, M.-C., Lombardo, M. V., Chakrabarti, B., & Baron-Cohen., S. Subgrouping the autism “spectrum”: Reflections on DSM-5. *PLOS Biology*. doi:10.1371/journal.pbio.1001544
- Lecciso, F., Levante, A., Baruffaldi, F., & Petrocchi, S. (2016). Theory of mind in deaf adults. *Cogent Psychology*, 3(1). doi:10.1080/23311908.2016.1264127
- Lefley, H. P. (1989). Family burden and family stigma in major mental illness. *American Psychologist*, 44, 556–560.

- Leekam, S., & Prior, M. (1994). Can autistic children distinguish jokes and lies? A second look at second-order belief attribution. *Journal of Child Psychology and Psychiatry*, 35, 901-915.
- Leslie, A. M. (1987). Pretense and representation: The origins of 'theory of mind'. *Psychological Review*, 94, 412-426. doi:10.1037//0033-295x.94.4.412
- Leslie, A. M., & Frith, U. (1987). Metarepresentation and autism: How not to lose one's marbles. *Cognition*, 27, 291-294. doi:10.1016/s0010-0277(87)80014-8
- Leslie, A. M., & Frith, U. (1988). Autistic children's understanding of seeing, knowing and believing. *British Journal of Developmental Psychology*, 6, 315-324. doi:10.1111/j.2044-835x.1988.tb01104.x
- Lincoln Journal Star. (2016, March 24). Stepmother faces felony child abuse charge after toddler's drowning. Retrieved from http://journalstar.com/news/local/911/stepmother-faces-felony-child-abuse-charge-after-toddler-s-drowning/article_3d9403b5-ecd1-52ae-9d81-b39cf04ebabd.html
- Major, B., & O'Brien, L. T. (2005). The social psychology of stigma. *Annual Review of Psychology*, 56, 393-421. doi:10.1146/annurev.psych.56.091103.070137
- Mazza, M., Pino, C. M., Mariano, M., Tempesta, D., Ferrara, M., Berardis, D., Masedu, F., ... Valenti, F. (2014). Affective and cognitive empathy in adolescents with autism spectrum disorder. *Frontiers in Human Neuroscience*, 8. doi:10.3389/fnhum.2014.00791
- Mazefsky, C. A., Herrington, J., Siegel, M., Scarpa, A., Maddox, B. B., Scahill, L., & White, S. W. (2013). The role of emotion regulation in autism spectrum disorder. *Journal of the American Academy of Child & Adolescent Psychiatry*, 52(7), 679-688. doi:10.1016/j.jaac.2013.05.006
- Mileti, D. S., & Sorensen, J. H. (1990). Communication of emergency public warnings: A social science perspective and state-of-the-art assessment. doi:10.2172/6137387

- Mody, M. (2014). Nonverbal individuals with autism spectrum disorder: Why don't they speak? *North American Journal of Medical Science*, 7(3), 130-134. doi:10.7156/najms.2014.0703130
- Montgomery, C. B., Allison, C., Lai, M.-C., Cassidy, S., Langdon, P. E., & Baron-Cohen, S. (2016). Do adults with high functioning autism or Asperger Syndrome differ in empathy and emotion recognition? *Journal of Autism and Developmental Disorders*, 46(6), 1931-1940. doi:10.1007/s10803-016-2698-4.
- Morss, R. E., Demuth, J. L., & Lazo, J. K. (2008). Communicating uncertainty in weather forecasts: A survey of the U.S. public. *Weather and Forecasting*, 23(5), 974-991. doi: 10.1175/2008waf2007088.1
- Mottron, L., Burack, J. A., Iarocci, G., Belleville, S., & Enns, J. T. (2003). Locally oriented perception with intact global processing among adolescents with high-functioning autism: Evidence from multiple paradigms. *Journal of Child Psychology and Psychiatry*, 44(6), 904-913. doi:10.1111/1469-7610.00174
- National Weather Service. (2016a). Deaf-and-hard-of-hearing lightning safety PSA. Retrieved from <https://www.youtube.com/watch?v=uU1lO1S15e4&feature=youtu.be>
- National Weather Service. (2016b). About the Weather-ready Nation Program. Retrieved from <http://www.nws.noaa.gov/com/weatherreadynation/about.html>
- National Weather Service. (2016c). Lightning safety homepage. Retrieved from <http://www.lightningsafety.noaa.gov/>
- National Weather Service. (2016d). Weather-ready Nation roadmap. Retrieved from http://www.nws.noaa.gov/com/weatherreadynation/files/nws_wrn_roadmap_final_april17.pdf

- Neil, L., Olsson, N. C., Pellicanono, E. (2016). The relationship between intolerance of uncertainty, sensory sensitivities, and anxiety in autistic and typically developing children. *Journal of Autism and Developmental Disorders*, 46(6), 1962-1973. doi:10.1007/s10803-016-2721-9
- Nevill, R. E. A., & White, S. W. (2011). College students' openness toward autism spectrum disorders: Improving peer acceptance. *Journal of Autism and Developmental Disorders*, 41(12), 1619–1628.
- New York Times. (2014, October 17). How Apple's Siri became one autistic boy's BFF. Retrieved from <http://www.nytimes.com/2014/10/19/fashion/how-apples-siri-became-one-autistic-boys-bff.html>
- Nowicki, E. A. (2006). A cross-sectional multivariate analysis of children's attitudes towards disabilities. *Journal of Intellectual Disability Research*, 50(5), 335–348. doi:10.1111/j.1365-2788.2005.00781.x
- O'Neil, M., & Jones, R. S. (1997). Sensory-perceptual abnormalities in autism: A case for more research? *Journal of Autism & Developmental Disorders*, 27(3), 283-293.
- O'Riordan, M. A., Plaisted, K. C., Driver, J., & Baron-Cohen, S. (2001). Superior visual search in autism. *Journal of Experimental Psychology: Human Perception and Performance*, 27(3), 719–730. doi:10.1037/0096-1523.27.3.719
- Popova, M. (2014). The relationship between creativity and mental illness. Retrieved from <https://www.brainpickings.org/2014/07/21/creativity-and-mental-illness/>
- Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a theory of mind? *Behavioral and Brain Sciences*, 1(4), 515. doi:10.1017/s0140525x00076512
- Proust, J. (2007). Metacognition and metarepresentation: Is a self-directed theory of mind a precondition for metacognition? *Synthese*, 159(2), 271-295. doi: 10.1007/s11229-007-9208-3

- Pylyshyn, Z. W. (1978). When is attribution of beliefs justified? *Behavior and Brain Science*, 4, 492-593.
- Reed, P., & McCarthy, J. (2012). Cross-modal attention-switching is impaired in autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 42(6), 947-953. doi:10.1007/s10803-011-1324-8
- Riad, J. K., Norris, F. H., & Ruback, R. B. (1999). Predicting evacuation in two major disasters: Risk perception, social influence, and access to resources. *Journal of Applied Social Psychology*, 29(5), 918-934. doi:10.1111/j.1559-1816.1999.tb00132.x
- Rice, K, Moriuchi, J. M., Jones, W., & Klin, A. (2012). Parsing heterogeneity in autism spectrum disorders: Visual scanning of dynamic social scenes in school-aged children. *Journal of the American Academy of Child & Adolescent Psychiatry*, 51(3), 238–248. doi:10.1016/j.jaac.2011.12.017
- Roelfsema, M. T., Hoekstra, R. A., Allison, C., Wheelwright, S., Brayne, C., Matthews, F. E., ... Baron-Cohen, S. (2011). Are autism spectrum conditions more prevalent in an information-technology region? A school-based study of three regions in the Netherlands. *Journal of Autism and Developmental Disorders*, 42(5), 734–739. doi:10.1007/s10803-011-1302-1
- Rogers, K., Dziobek, I., Hassenstab, J., Wolf, O. T., & Convit, A. (2007). Who cares? Revisiting empathy in Asperger Syndrome. *Journal of Autism and Developmental Disorders*, 37, 709-715.
- Shah, A., & Frith, U. (1983). An islet of ability in autistic children: A research note. *Journal of Child Psychology and Psychiatry*, 24(4), 613–620. doi:10.1111/j.1469-7610.1983.tb00137.x

- Shah, A. & Frith, U. (1993). Why do autistic individuals show superior performance on the block design task? *Journal of Child Psychology and Psychiatry*, 34(8), 1351-1364. doi:10.1111/j.1469-7610.1993.tb02095.x
- Shriberg, L.D., Paul, R., Black, L.M., & van Santen, J.P. (2010). The hypothesis of apraxia of speech in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, 41(4):405-426. doi:10.1007/s10803-010-1117-5
- Smith, V., Mirenda, P., & Zaidman-Zait, A. (2007). Predictors of expressive vocabulary growth in children with autism. *Journal of Speech, Language, and Hearing Research*, 50(1), 149. doi:10.1044/1092-4388(2007/013)
- Sodian, B. (1991). The development of deception in children. *British Journal of Developmental Psychology*, 9(1), 173-188.
- Soke, G. N., Rosenberg, S. A., Hamman, R. F., Fingerlin, T., Robinson, C., Carpenter, L., ... DiGuseppi, C. (2016a). Brief report: Prevalence of self-injurious behaviors among children with autism spectrum disorder—a population-based study. *Journal of Autism and Developmental Disorders*, 46(11), 3607–3614. doi:10.1007/s10803-016-2879-1
- Soke, G. N., Rosenberg, S. A., Hamman, R. F., Fingerlin, T., Rosenberg, C. R., Carpenter, L., ... DiGuseppi, C. (2016b). Factors associated with self-injurious behaviors in children with autism spectrum disorder: Findings from two large national samples. *Journal of Autism and Developmental Disorders*. doi:10.1007/s10803-016-2951-x
- Stewart, A. E. (2009). Minding the weather. *Bulletin of the American Meteorological Society*, 90(12), 1833–1841. doi:10.1175/2009bams2794.1

- Stewart, A. E., Lazo, J. K., Morss, R. E., & Demuth, J. L. (2012). The relationship of weather salience with the perceptions and uses of weather information in a nationwide sample of the United States. *Weather, Climate, and Society*, 4(3), 172–189. doi:10.1175/wcas-d-11-00033.1
- Strutt, P. A., Campbell, L. E., & Burke, D. (2014). *High anxiety levels are associated with divergent empathising and systemising tendencies. Cogent Psychology*, 1(1). doi:10.1080/23311908.2014.981973
- Sussman, A. (2007). Mental illness and creativity: A neurological view of the “tortured artist”. *Stanford Journal of Neuroscience*, 1(1), 21-24.
- Swettenham, J., Baron-Cohen, S., Charman, T., Cox, A., Baird, G., Drew, A., ... Wheelwright, S. (1998). The frequency and distribution of spontaneous attention shifts between social and nonsocial stimuli in autistic, typically developing, and nonautistic developmentally delayed infants. *Journal of Child Psychology and Psychiatry*, 39(5), 747–753. doi:10.1111/1469-7610.00373
- Tager-Flusberg, H., Paul, R., & Lord, C.E. (2005). Language and communication in autism. In F. Volkmar, R. Paul, & A. Klin. (Eds.) *Handbook of autism and pervasive developmental disorder* (3rd ed. Vol 1, pp 335-364). New York: Wiley.
- Tampa Bay Times. (2014, November 7). Boy with Asperger Syndrome finds calling as a weatherman calming. Retrieved from <http://www.tampabay.com/news/education/k12/boy-with-asperger-syndrome-finds-calling-as-weatherman-calming/2205610>
- Tavassoli, T., Miller, L. J., Schoen, S. A., Nielsen, D. M., & Baron-Cohen, S. (2014). Sensory over-responsivity in adults with autism spectrum conditions. *Autism*, 18(4), 428–432. doi:10.1177/1362361313477246

- Tavassoli, T., Hoekstra, R. A., & Baron-Cohen, S. (2014). The Sensory Perception Quotient (SPQ): Development and validation of a new sensory questionnaire for adults with and without autism. *Molecular Autism*, 5(29).
- Taylor, A., de Bruin, W. B., & Dessai, S. (2014). Climate change beliefs and perceptions of weather-related changes in the United Kingdom. *Risk Analysis*, 34(11). doi:10.1111/risa.12234
- The Guardian. (2015, May 18). The abuse of disabled people is a hidden crime we must face up to. Retrieved from <https://www.theguardian.com/commentisfree/2015/may/18/abuse-disabled-people-sexually-abused-england-cuts-services>
- Thomas, A. (2000). Stability of Tringo's hierarchy of preference toward disability groups: 30 years later. *Psychological Reports*, 86(3), 1155-6. doi:10.2466/pr0.86.3.1155-1156
- Treffert, D. (2009). The savant syndrome: An extraordinary condition. A synopsis: Past, present, future. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1522), 1351–1357. doi:10.1098/rstb.2008.0326
- Tringo, J. L. (1970). The hierarchy of preference toward disability groups. *The Journal of Special Education*, 4(3), 295–306. doi:10.1177/002246697000400306
- Uekermann, J., & Daum, I. (2008). Social cognition in alcoholism: A link to prefrontal cortex dysfunction? *Addiction*, 103(5), 726–735. doi:10.1111/j.1360-0443.2008.02157.x
- U.S. Centers for Disease Control. (2014). Prevalence of autism spectrum disorder among children aged 8 years. Retrieved from <http://www.cdc.gov/mmwr/pdf/ss/ss6302.pdf>
- WABC-TV. (2016, March 21). Parents allege aide abused 5-year-old son at Staten Island school, then school covered it up. Retrieved from <http://abc7ny.com/education/parents-allege-aide-abused-5-year-old-son-at-staten-island-school-then-school-covered-it-up/1256718/>

- Wallace, G., Happé, F., & Giedd, J. (2009). A case study of a multiply-talented savant with an autism spectrum disorder: Neuropsychological functioning and brain morphometry. *Philosophical Transactions of the Royal Society B: Biological Sciences*. 364(1522), 1425–1432.
doi:10.1098/rstb.2008.0330
- Westfield, J. (1996). Severe weather phobia: An exploratory study. *Journal of Clinical Psychology*, 52(5), 509-515.
- Wheelwright, S., & Baron-Cohen, S. (2001). The link between autism and skills such as engineering, maths, physics, and computing: A reply to Jarrold and Routh, *Autism*, 1998, 2(3), 281-9. *Autism*, 5(2), 223-227.
- Wing, L. (1988). The autistic continuum. In L. Wing (Ed.), *Aspects of autism: Biological research*. London: Gaskell/Royal College of Psychiatrists.
- Wing, L. (1997). The autistic spectrum. *The Lancet*, 350(9093), 1761–1766. doi:10.1016/s0140-6736(97)09218-0
- WRIC-TV. (2015, February 3). Richmond boy with autism meets idol Bill Nye the Science Guy.
Retrieved from <http://wric.com/2015/02/03/richmond-boy-with-autism-meets-idol-bill-nye-the-science-guy/>
- WSB-TV. (2016, March 24). Mother accused of severely abusing daughter with cerebral palsy.
Retrieved from <http://www.wsbtv.com/news/local/mother-accused-of-abusing-disabled-daughter/163231958>