Chapter 6

Beyond the Black-and-White of Autism: How Cognitive Performance Varies with Context

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1. Introduction

A child's cognitive performance can vary considerably from one task context to the next, even when only small details of the task are changed. Such context dependence has given rise to a new way of looking at the underlying processes of children's thinking (e.g. Smith, Thelen, Titzer, & McLin, 1999; Spencer, Thomas, & McClelland, 2009). Rather than attributing performance to a particular competence (or a lack thereof), performance is attributed to a synergy between the actor and environment, highly sensitive to even seemingly irrelevant details of the task context. Though not complete, this view makes it possible to map out how changes in the context could be harnessed to bring about changes in a child's behavior. The current chapter looks at whether the same view can be applied to autism spectrum disorder (ASD). A first step in this direction is to explore the extent to which cognitive performance in ASD is affected by apparently irrelevant variations of the task context.

Autism spectrum disorder comprises of a cluster of disorders that include Autistic Disorder (also known as "classic" autism), Asperger's Syndrome, and Pervasive Developmental Disorder-Not Otherwise Specified (DSM-IV-TR; American Psychiatric Association, 2000). Though there are important differences between these sub-groups, they share a common set of general symptoms that arise early in a child's life: ASD is characterized by pronounced social difficulties and communication impairment, along with restricted, repetitive behaviors or interests (APA, 2000). In particular, children often demonstrate atypical eye contact, a lack of verbal speech or atypical language use, odd mannerisms such as arm flapping, and narrow, obsessive interests (e.g.: an encyclopedic knowledge of former U.S. Secretaries of the Interior; Klinger, Dawson, & Renner, 2003).

Importantly, despite extensive research into ASD, no causal factors have been isolated so far. For example, even though the patters of neurological activity show numerous

differences between typical development and ASD, no single difference appears to capture the disorder (for a review see Fein, 2011). And even though ASD appears to have a strong genetic component, genome variations appear diffuse (e.g., Devlin & Scherer, 2012). This raises the possibility that the disorder is not reducible to a static causal factor that can differentiate between typical development and ASD. Instead, the disorder might be the result of complex interdependence among multiple factors that change each other's effect as they interact over time. Take for example, the language impairments documented in ASD. Rather than being attributed to a stable factor (language-specific, neurological, genetic, or otherwise), these behaviors might have their origin in virtually undetectably minimal discrepancies in how the perceptual system combines information into higher-order patterns. The discrepancy from typical development might be minimal at first, but then get amplified by a variety of child-internal, environmental, and social factors (e.g., a difficulty detecting higher-order patterns, a low tolerance for over-stimulation, the hierarchical order inherent in a language, a disrupted communication synchrony between child and caregiver, etc). The coming-together of environmental factors further intensify the initially minimal difference in perceptual processes – which then in turn amplify environmental and social factors. In other words, what may start out as a barely noticeable difference in how information is integrated might enter a cycle of forces that amplify each other's effect over time, an interdependence that heralds a major departure from typical development.

The view that ASD behavior is the result of interdependent factors that amplify each other's effects over time is a stark departure from the view that overt behavior is reducible to a stable factor that marks autism. And while there is no conclusive evidence to support the former view, there is nevertheless strong support in the developmental literature of ASD. First, it is difficult to predict the developmental trajectories of individual children (for a review, see Seltzer, Shattuck, Abbeduto & Greenberg, 2004). For example, while overall language abilities can improve over time (Sigman & McGovern, 2005), various atypicalities sometimes remain, including echolalia or fixations on various topics of interest (Lord, Rici, & Pickles, 2004). Some children may even exhibit an increase in general symptom severity over time (e.g., Nordin & Gillberg, 1998).

Second, developmental patterns tracked over time sometimes show a non-linear trajectory. For example, differences in social behavior (e.g. eye contact, visual tracking, visual disengagement, imitation, social interest, and sensory-motor behaviors), apparent at 12 months of age, are missing in younger children (Zwaigenbaum et al., 2005; Bryson , Brian, Roberts, Szatmari, Rombough, & McDermott 2007). And while 6-month-old infants with a high risk of autism show less frontal Gamma power than low-risk children, this difference is negligible when infants are 24 months old (Keehn, Luyster, Vogel-Farley, Tager-Flusberg & Nelson, 2012). Explaining such non-linear trajectories under the reductionist viewpoint would require an additional assumption, namely that the isolated causal factor comes online at a certain point in time. These trajectories imply instead that the disorder has to be attributed to complex interactions among factors that change in nature over time.

The interdependence view on ASD has strong implications for how to go about studying the source of this disorder and its treatment. Rather than looking for black-and-white

differences between ASD and typical development, and interdependence view advocates the study of trajectories, the stability of trajectories, and how stable cycles can be perturbed. Furthermore, an interdependence view implies that even small changes in the context can potentially have a large effect on behavioral outcomes. In the remainder of the chapter, we review performance variability of already published research to describe such context dependence in cognitive tasks. As such, this review differs from already existing reviews (e.g., Klinger, Dawson, & Renner, 2003; Rajendran & Mitchell, 2007) in one crucial way. Rather than emphasizing consistencies in findings to promote the idea of a stable difference in ASD (and discussing conflicting findings to undermine one over another reductionist ASD theory), our goal is to highlight context effects detected in ASD research.

The chapter is organized as follows: we will first highlight some findings in pattern perception, a large research field centered on the idea of the so-called weak central coherence (cf., Frith, 1989). We will then turn to findings related to learning, focusing specifically on learning of higher-order patterns and statistical information in sequences. Next, we will discuss ASD research on executive functioning, the child's ability to control their actions to achieve a certain outcome. Finally, we will turn to research on social reasoning, discussing findings in joint attention and theory of mind.

2. Perception

Perceiving meaningful configurations in the array of ever-changing information (visual or otherwise) requires the mind to combine separate bursts of sensation into an organized unit of perception. The mind has to detect or impose coherence (cf., Thagard, 1989) For example, in order to perceive a painting, the mind has to ignore the individual pixels of color and detect the higher-order organization of objects and scenes. The possible patterns of organization are nested hierarchically, ranging from a very local organization (e.g., an individual object in the painting) to a more global organization (e.g., the theme of the painting). The ability to detect patterns of organization at various levels of abstraction is commonly studied under the framework of local versus global perception, with the central question pertaining to the degree to which local and global perception interfere with one another (cf. e.g., Baylis & Driver, 1993; Herrmann & Bosch, 2001; Humphreys, Olson, Romani, & Riddoch, 1996; Kahneman & Henik, 1981; Kahneman & Treisman, 1984; Kimchi, 1992; Kramer & Jacobson, 1991; Maurer, Le Grand, & Mondloch, 2002; Moore & Egeth, 1997; Pellicano & Rhodes, 2003).

An essential difference between ASD and typical development is the degree to which the perception of global order interferes with the perception of local order. Rather than exhibiting a bias towards coherence, perception of individuals with ASD is typically characterized by what is known as weak central coherence. Best example of this difference was established with the classical Navon task, a task in which stimuli consist of many small letters configured in the arrangement of a large letter (cf., Navon, 1977). In typical development, results show a distinct interference of large letters on the perception of small letters, both in children (Ozonoff Strayer, McMahon & Filloux 1994; Plaisted, Swettenham,

and Rees, 1999) and in adults (Fagot & Deruelle, 1997; Navon, 1977). In particular, when participants are asked to focus on small letters, reaction time is longer for trials in which large and small letters differ than on trials in which large and small letters match. This global interference is non-detectable in participants with ASD: They perform equally fast in both letter-mismatch trials and letter-match trials – and that with high accuracy (e.g. Mottron, Burack, Stauder, & Robaey, 1999; Plaisted et al., 1999).

Another example of weak central coherences in ASD comes from face-perception tasks. The identity of a face is defined not only by its individual parts (e.g., nose, eyes, mouth), but also by the holistic configuration of these parts, something that appears to be disrupted when faces are presented upside down. For typically developing children, recognition accuracy decreases when faces are presented upside down, compared to trials in which faces are presented upright (Mondloch, Le Grand, & Maurer, 2002). In contrast, children with ASD do not perform differently as a function of face orientation (Langdell, 1978; Tantam, Monaghan, Nicholson, & Stirling, 1989). Along the same lines, participants with ASD could classify faces better when local rather than global features were exaggerated (through the use of a high-pass vs. low-pass filter; Deruelle, Rondan, Salle-Collemiche, Bastard-Rosset, & Da Fonséca, 2008). The inverse pattern of results was obtained for typically developing children.

A final example of preferential local focus comes from research involving auditory perception (Foxton Stewart, Barnard, Rodgers, Young, O'Brien, & Griffiths 2003). Stimuli were 5-tone sequences that varied in specific tones, pattern of switch in pitch direction (e.g., a down sequence was followed by up sequence), and timing of the switch. In the crucial task (a global-interference condition), participants had to focus on only one of these features, ignoring changes in the other features. In particular, they had to decide on whether two sequences match in the patterns of switch, ignoring differences in specific tones or differences in timing. Result show superior performance for participants with ASD than matched controls. Vice versa, when sequences differed only in specific tones (the patterns and timing of the sequences being identical), ASD performance matched that of control participants (see also Mottron, Peretz & Menard, 2000). Further evidence for enhanced local processing of auditory information comes from the finding that individuals with ASD can label isolated tones better than TD controls and are more likely to have perfect pitch, meaning that they can replicate or identify individual musical tones without assistance (Bonnel, Mottron, Peretz, Trudel, Gallun, & Bonnel 2003; Heaton, Hermelin, & Pring, 1998).

In broad strokes, while typical development is characterized by a bias towards perceiving higher-order Gestalts over perceiving an isolated detail, this bias is thought to be missing or at least less prevalent in ASD (for reviews, see Happé, 2000; Happé & Booth, 2008; Happé & Frith, 2006). However, even though research generally supports the idea of a weak bias towards higher-order Gestalt in ASD, there are some interesting exceptions. For example, when individuals with ASD are told to look at relevant information in face processing tasks, they perform in a similar way to typically developing children (Lopez, Donnelly, Hadwin, & Leekam, 2004). The task was to determine which of two test items matched with a target face. In configuration trials, the test items were faces, one of which always matched the

target, while the other one differed in a single feature. And on feature trials, the test items were individual features (e.g., eyes), one of which match the respective feature of the target. Critically, participants were sometimes provided with a cue indicating on which feature to focus. For example, they were told "look at the eyes." In cued configuration trials, the cue focused attention to the mismatched feature. On feature trials, it focused attention to the matching feature. The typically developing group demonstrated superior performance on configuration trials, compared to feature trials, regardless of cueing. The ASD group, in contrast, demonstrated a configural advantage only on cued trials, but not in un-cued trials.

A similar effect of instruction was found when the task was to read sentences that contained homographs (words that have the same spelling are a pronounced differently, depending on the context of a sentence). As one would predict from a weak-central-coherence assumption, individuals with ASD are less likely than typically developing individuals to use the context of a sentence to disambiguate homographs (Frith & Snowling, 1983; Happé, 1997; Jolliffe & Baron-Cohen, 1999; Lopez & Leekam, 2003). For example, when asked to read aloud a sentence containing the homograph "tear", participants with ASD are less likely to take the sentence context into account when deciding on how to pronounce the word. However, this pattern of performance changes dramatically when attention is explicitly directed to the homographs (Snowling & Frith, 1986). That is, when explicitly told to look for homographs, their use of proper pronunciation approaches that of typically developing individuals.

Variations in instruction also affect ASD performance on tasks involving optical illusions, another area that attests to Gestalt interference in typical development. Typically, the task is to focus on a local piece of information and ignore the embedding context. For example, in the Muller-Lyer illusion, the task is to compare the length of the two lines, ignoring the arrows on each end of the lines. Findings show that typically developing participants are strongly affected by the embedded context, succumbing to the illusion to the expense of focusing on the local elements (for a review, see Changizi, Hsieh, Nijhawan, Kanai, & Shimojo, 2008). While individuals with ASD are far less affected by such visual configurations (e.g., Brosnan Scott, Fox, & Pye, 2004), important context effects are apparent. For example, participants with ASD were found to be more susceptible to Muller-Lyer illusions when asked, "which line *looks* longer," versus "which line *is* longer" (Scott, Brosnan, & Wheelwright, in preparation, as cited in Happé & Frith, 2006). It appears that individuals with ASD can see both that the lines are equally long, and that the lines look like they differ in length.

In sum, while individuals with ASD differ from typical development in the degree to which they focus on the higher-Gestalt of a pattern (vs. the local elements), this difference is susceptible to variations in task context. Findings reviewed here pertain to the domains of shifting attention from local elements to global patterns (and vice versa), face perception (which depends on detecting relations between facial parts), reading homographs (which require the entire sentence to be taken into account), and optical illusions (which depends on children failing to ignore the embedding aspects of the target). Such context effects on perception have led to some revisions in the ASD theory of weak central coherence (e.g. Happé & Booth, 2008). Rather than positing an all-or-none competence of Gestalt

processing, weak central coherence is now seen as a tendency, a preference of some sort that could be changed under ideal task contexts.

3. Learning of patterns

As mentioned above, ASD is characterized by delays in language learning, including the learning of new words, their use, the pragmatics of language, or the fluidity of use (see e.g., Lord, Risi, & Pickles, 2004, for a review). These delays, as well as other symptoms of autism, have been attributed to differences in how patterns of information are learned (e.g., L. G. Klinger, Klinger, & Pohlig, 2007). More specifically, individuals with autism might have difficulty learning underlying patterns of events when hypothesis-testing strategies cannot be applied. This kind of learning is commonly studied under the umbrella of implicit learning (see Perruchet, 2008; Shanks, 2005, for reviews), artificial-grammars learning (e.g., Reber, 1967), or pattern detection in category formation (e.g., Ashby & Maddox, 2005; Keri, 2003). Here, we use the term "implicit learning", consistent with the term used in ASD research.

Studies of pattern learning have led to interesting findings in ASD. On the one hand, there are several findings that suggest impaired implicit learning in ASD (e.g., Romero-Munguía, 2008). Consider, for example, findings obtained with the so-called serial reaction time (SRT) task: Participants are asked to press a key to indicate a particular stimulus in a sequence. Learning is reflected in a decrease in reaction time for sequences that contain subtle repeated patterns, compared to random sequences (cf., Nissen & Bullemer, 1987). While typically developing children demonstrated such learning, participants with ASD did not (Mostofsky, Goldberg, Landa, & Denckla, 2000). Further support for compromised implicit learning comes from findings on prototype learning (Klinger & Dawson, 2001). The task was to categorize fictitious animals that differed in features like ear length, leg length, and neck length (cf., Younger, 1993). Children with ASD performed more poorly than control participants match in verbal age (see also Klinger et al., 2007). In fact, performance on implicit learning tasks was highly correlated with ASD symptomatology, including communication skills, social skills, and the occurrence of repetitive behaviors.

However, the difference in implicit-learning abilities between ASD and control participants is not stable across task context, even when tested in the same lab (cf., Klinger & Dawson 2001; Klinger et al., 2001). Consider the SRT task again: when the inter-stimulus interval was reduced to 120ms (Barnes, Howard, Howard, Gilotty, Kenworthy, Gaillard 2008) or omitted altogether (Travers, Klinger, Mussey, & Klinger 2010), there was no difference between ASD and control participants. Both groups of children could learn to anticipate the rule-based sequence, compared to a random sequence (see also Muller, Cauich, Rubio, Mizuno, & Couchesne, 2004). Similarly, there was evidence for sequence learning when the rule was greatly simplified and the training extended to multiple sessions (Gordon & Stark, 2007). Furthermore, children with ASD demonstrate repetition priming effects comparable to those of controls (i.e., they could identify studies items better than non-studied items; Renner, Klinger, & Renner, 2000). And they were found to have intact semantic priming for simple common words (Toichi & Kamio, 2002) – further evidence for implicit-learning abilities in

ASD. Overall, these findings have undermined a claim that ASD is characterized by a general difficulty with implicit learning, in turn undermining an effort to explain social deficits, motor abnormalities, and language deficits associated with the disorder.

There are many ways in which context effects on implicit learning could be explained. For example, one could address the differences in findings by looking for differences in the groups of participants, whether in age, symtomatology, or co-morbidity. It is possible that the findings fail to univocally address the question of implicit-learning competence in ASD because participants differ across different tasks. Or one could look for differences in other internal processes that could explain the pattern of performance. Tasks might differ in the degree to which they tap a participant's working memory. Or they differ in the extent to which they require the integration of gross-motor movements. Or they differ in whether they afford or undermine the use of explicit (i.e., hypothesis-testing) strategies. Indeed, ASD performance is comparable to that of typically developing children when the prototype learning task required a rule-based approach (Klinger & Dawson, 2001). And an exceedingly short inter-stimulus interval might have forced the minds of participants with ASD to abandon their bias to use a hypothesis-testing strategy and therefore make room for an implicit-learning process. There are multiple problems with this kind of reasoning, a major one being that it fails to address the entire list of context effects – beyond a comparison of a few studies.

4. Executive functioning

Executive functioning (EF) is an umbrella term to describe various cognitive abilities assumed to be involved in conscious problem-solving. They pertain, for example, to inhibiting incorrect but dominant actions, planning a future action, and flexibly switching attention when instructed to do so (e.g., Zelazo & Müeller, 2002). EF plays an important role in cognitive development, as it leads to an improved ability to override automatic responses (Garon, Bryson, & Smith, 2008). A classical EF task – but by far not the only one – is the Stroop task, a task in which participants are asked to name the color of the ink used for a printed word, the word spelling a particular color (Stroop, 1935). The central finding is a slowing in reaction time when the ink color differs from the spelled-out color (compared to trials in which the ink color matches the spelled-out color), demonstrating the difficulty of inhibiting the automatic tendency to read the word.

EF is thought to be associated with typical ASD attributes, including the need for sameness, difficulty with switching attention, a tendency to perseverate, and a lack of impulse control. Indeed, there are tasks in which participants with ASD show difficulty with inhibition (for a review see Rajendran & Mitchell, 2007). Consider, for example, an inhibition task in which participants have to point to an empty window in order to receive the reward shown in a non-empty window (Hala, & Russel 2001). Unlike control participants, a majority of participants with ASD have difficulty inhibiting their natural response of pointing to the reward they desire, compared to controls matched on mental age. Other examples of EF difficulties consist of difficulties with planning (e.g., (Ozonoff & Jensen, 1999, Ozonoff, Pennington, & Rogers, 1991), mental flexibility (e.g., Hughes, Russell, & Robbins, 1994;

Ozonoff, 1997), the generation of novel ideas (Turner, 1999), and self-monitoring (e.g., Hughes, 1996; Phillips, Baron-Cohen, & Rutter 1998; Russell & Jarrold, 1998, 1999).

However, there are findings that undermine a straightforward ASD theory surrounding EF differences. For example, participants with ASD do not have more difficulty with the Stroop task than control participants (e.g., Ozonoff & Jensen, 1999; Eskes, Bryson, & McCormick, 1990): participants with ASD were found to show a typical slowing in reaction time when naming the ink of a word that spells a different color. Similarly, context effects were found with planning task that involves keeping in mind a certain set of rules to produce an outcome (e.g., Tower of Hanoi task, Stockings of Cambridge task). ASD performance was equivalent to typically developing performance on trials with only a small number of required steps for completion. Performance only differentiated between groups on longer, more complex trials. Further, performance appeared modulated by each individual child's nonverbal IQ, rather than symptomology (Hughes, Russell, & Robbins, 1994).

It appears that a claim about EF differences between typical development and ASD is not supported in all instances (for further review, see Hill, 2004). Performance seems instead dependent on specifics of the tasks and individual differences among children. Of course, it is always possible to interpret discrepant results consistent with a reductionist viewpoint. For example, one could argue that EF differences between typical and atypical development are most pronounced in so-called "hot" EF task, those that involve an emotional component (cf., Hongwanishkul, Happaney, Lee, & Zelazo, 2005). The differences might disappear in "cool" EF tasks, those that lack immediate rewards. These claims, though plausibly incorporating currently existing data, might not be able to capture context effects likely to accumulate as more data is being collected.

5. Social reasoning

Adaptive functioning includes social reasoning, or a child's ability to engage in social interactions. ASD is characterized by major difficulties in this domain, ranging from attending to irrelevant features of social situations (e.g., Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998; Klin, Jones, Schultz, Volkmar & Cohen 2002), giving atypical responses to social cues (e.g., Kjelgaard & Tager-Flusberg, 2001; Mottron, 2004; Mundy, Sigman & Kasari, 1990; Parish-Morris et al., 2007; Sigman & Ruskin, 1999; Stone, Ousley, Yoder, Hogan, & Hepburn 1997), having difficulty understanding the intentions of others (e.g., Baron-Cohen, 1995; Preissler & Carey, 2005; Warreyn, Roeyers, Oelbrandt, & De Groote 2005), and poor imitation skills (e.g., Hobson & Lee, 1999; Loveland, Tunali-Kotoski, Pearson, Brelsford, Ortegon, & Chen 1994). Here we describe findings for two of these areas, namely joint attention (i.e., the act of sharing another's attentional focus) and of theory of mind (i.e., the understanding of others' intentions).

5.1. Joint attention

The ability to share somebody else's focus of attention, known as joint attention, is critical for successful social interactions, setting up a context in which a child can learn from others.

For example, a child needs to know what a person is looking at to understand what a new label might refer to. Indeed, joint attention has been studied extensively in relation to children's word learning (e.g., Baldwin, 1995; Mundy & Newell, 2007; Carpenter, Nagell, & Tomasello, 1998; Tomasello, 1995; see also Flom, Lee, & Muir, 2007). A common task involves presenting children with a set of objects, and an adult visibly looking at the one that is being named. Both the amount of time the participant follows the eye-gaze of the adult and the degree of labelling are thought to reflect the amount of joint attention that occurs between them.

Children with ASD have demonstrated difficulty following the gaze of an adult in joint attention tasks (for a review, see Meindl & Cannella-Malone, 2011). And this deficit is observed alongside difficulties with learning new object names (Baron-Cohen, Baldwin, & Crowson, 1997; McDuffie, Yoder, & Stone, 2006; Parish-Morris, Hennon, Hirsh-Pasek, Golinkoff, & Tager-Flusberg, 2007; Preissler & Carey, 2005). For example, there is a pronounced learning difference between children with ASD and typically developing children when the labeled object was held by the experimenter, versus by the child (Preissler & Carey, 2005). This difference cannot be attributed to general word-learning deficits because word learning did not differ between diagnostic groups when the labeled object was in the child's hand. Similarly, learning did not differ between diagnostic groups when the labeled object was the only novel object.

Yet, despite strong evidence in favor of ASD impairments in joint attention, findings from other research complicate the picture: participants with ASD appear perfectly capable of joint attention in some contexts, if not even more skilled than their typically developing counterparts (Chawarska, Klin, Volkmar 2003; Kylliainen & Hietanen, 2004; Vlamings, Strauder, van Son, Mottron 2005). Consider, for example, a task in which participants have to press a corresponding button as soon as they see a target appear either at the top left or the bottom right of a monitor. A face was also shown in the center of the monitor. The gaze of the face was straight ahead, averted to the top left, or averted to the bottom right, 200ms before the target appeared. Findings show faster reaction time on trials in which the target appeared on the same side of the screen as the face's gaze, with no difference between diagnostic groups (Kylliainen & Hietanen, 2004).

An argument could be made that different joint-attention tasks are not equally suited to capture the construct of joint attention. Maybe the reaction time task is a better reflection of joint-attention processes than a word-learning task. Such argument about what task might best reflect a stable factor is a common argument in the larger literature of cognition and cognitive development. However, it gets quickly overwhelmed as more context effects accumulate.

5.2. Theory of mind

Another aspect of social reasoning is the ability to understand someone else's mental state, including their desires, motivation or beliefs. This kind of understanding is coined as theory of mind, with numerous studies investigating it and its development (Perner, 1991; Wellman, 1990). In a traditional theory of mind task, children are presented with two hiding

locations, a basket and a box and two dolls, Sally and Anne. The story involves Sally placing a marble in a basket, which is then moved into the box by Anne – without Sally being present. The critical task is to determine the location where Sally would search for her marble upon her return. If children understand Sally's mental state, they should pick the basket, because that is the marble's location known to Sally. If, on the other hand, children go by their own beliefs, they should pick the box, because they know that Anne has moved the marble into the box.

Many studies have sought to identify general deficits in theory of mind reasoning in individuals with ASD, as a means of better understanding their social deficits (for reviews see Rajendran & Mitchell, 2007). For example, Baron-Cohen et al. (1985) found that 80% of children with ASD failed the Sally-and-Anne test, compared to only 20% of matched controls. This difference cannot be attributed to general difficulties understanding the task instructions, given that children with ASD were able to answer control questions about the various locations of the marbles. Taken alone, these data appear to highlight a pathology specific impairment to theory of mind reasoning in individuals with ASD.

However, highly variable performance between similar theory of mind tasks has been observed (Grant, Grayson and Boucher, 2001; Baron-Cohen, Leslie, & Frith 1985; Yirmiya, Solomonica-Levi, Shulman & Pilowsky, 1996; Zelazo, Burack, Benedetto, & Frye 1996). Consider, for example, findings with the so-called deceptive-box task, a task in which the content of a box does not match with the label on the box (Grant, Grayson & Boucher, 2001). After being shown the content of the box, participants are asked about what another participant would predict about the contents of the box (without having seen inside the box). To answer accurately, the participant must understand that their knowledge of the contents of the box is not accessible to the other participant. Comparison of performance on the deceptive-box and Sally-and-Anne tasks revealed important differences in ASD: Performance was better on the deceptive-box task than the Sally-and-Anne task, despite the conceptual similarity.

In defense of a reductionist framework for ASD, one could go about dissecting the tasks in order to find the stable factor that could explain ASD. For example, one could argue that the two tasks differ in whether they involve real people (the deceptive box task) or puppets (the Salley-and-Anne task). Variable performance between these tasks may therefore reflect a difference in the perception of behavior associated with living versus inanimate actors. However, this explanation falls apart when the larger body of theory of mind research is considered: The inconsistent findings in theory of mind tasks (for a review, see Rajendran & Mitchell, 2007) to do separate on the fault line of inanimate vs. animate stimuli.

6. Summary and conclusions

ASD is diagnosed in about 1 in every 88 children (CDC, 2012), many of whom will have poor outcomes as adults, requiring some level of assistance throughout their lives (Seltzer,

Shattuck, & Greenberg, 2004). In addition to this high prevalence of the disorder, there is a high heterogeneity, high co-morbidity, and the possibility of several subgroups of ASD. Together, these factors make it imperative to better understand the disorder and develop effective interventions. However, as more research accumulates, so do inconsistent findings and unexpected differences in patterns of performance on tasks that were designed to measure the same cognitive process or factor.

In the current chapter, we have reviewed some context effects taken from the domains of perception, learning, executive functioning, and social reasoning. On the one hand, while there are robust differences in performance in all of these domains, these differences can disappear under certain task contexts – rendering them less robust than initially thought. Specifically, while ASD is characterized by a focus on local details (vs. on an overall Gestalt), by difficulty with implicit learning, executive functioning, and social reasoning, these differences disappear as the variability in tasks increases. It is plausible that more context effects accumulate as ASD research expands in cognitive development, further exasperated by a focus on individual children.

Context effects are nothing new in the literature of cognitive development (e.g., Kloos & Van Orden, 2009). A plausible reaction is to dismiss them as isolated instances, leaving an existing hypothesis intact, or refining it to incorporate the context effects. The problem, however, is that both these solutions can only address context effects locally. Yet, context effects are not a local phenomenon. And they are not likely to disappear with more participants, more precise methods, or simply more data. In fact, if research with typically developing participants is any guide for predicting the patterns of findings, context effects are a necessary feature of the enterprise. And with more research we are likely to find more context effects (e.g., see Shanks, Rowland & Ranger, 2005, for a discussion on implicit learning in neuro-typical adults). An expanding of a reductionist theory of ASD to incorporate them all is unlikely to retain its usefulness. Instead, context effects undermine a reductionist theory altogether.

Rather than focusing on a binary interpretation of patterns of performance, context effects hint at the possibility of a complex interplay between factors that make a black-and-white approach to understanding performance insufficient. By shifting attention away from searching for a "smoking gun" of ASD, it may be possible to better understand the emergence of how the components are coordinated. It is possible that the coordination among components is compromised in individuals with ASD, reverberating through all areas of functioning, and amplifying itself with development. It gives rise to atypical perception patterns, implicit learning, planning, and social interactions – at least when the immediate task context does not support an adaptive coordination of interdependent components. This approach, while failing to reduce ASD to a single deficit, has important implications for training and teaching strategies. In particular, this approach makes it possible to map out how changes in support of coordination exist in the environment to bring about improved task performance.

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