Underlying thinking pattern profiles predict parent-reported distress responses in autism spectrum disorder

Abstract

Appreciating autistic neurodiversity is important when supporting autistic people who experience distress. Specifically, use of a profiling model can reveal less visible autistic differences, including strengths and abilities. Binary logistic regressions showed that the likelihood of extreme distress responses could be interpreted based on parent-reported autistic thinking pattern profiles for 140 young people. Perspective-taking (specifically empathy), extreme demand avoidance, and over-sensory sensitivity each contributed to the combined regression models. From the clinical perspective of autism as a multi-dimensional and inter-connected construct, there may be implications for planning support and building positive self-understanding. Individually tailored adjustments and support strategies may be identified more easily after delineating variables found across four core aspects: sensory coherence, flexible thinking, perspective-taking, and regulation.

Key words: autism; thinking patterns; strengths; profile; distress

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Acknowledgements

The authors would like to acknowledge the families who attended the diagnostic assessment service, and to thank Dr Oliver Clark, Dissertation Supervisor, Manchester Metropolitan University; Prof Taj Nathan (Director of Research and Effectiveness), Prof Sujeet Jaydeokar and Dr Matthew Howard (Clinical Directors), Dr Ian Davidson (Consultant Psychiatrist and Royal College of Psychiatrists Autism Champion) and Dr Phil Elliott (Senior Research Facilitator), all at Cheshire and Wirral Partnership NHS Foundation Trust. The authors would also like to thank West Cheshire Clinical Commissioning Group for the £1,000 bursary which was awarded. The authors would like to thank Heather Pearce (Advanced Specialist Speech and Language Therapist) for help with data collation and coding reliability, as well as invaluable feedback on the clinical utility of the model. We also thank the anonymous reviewer for their careful reading of our manuscript and their insightful and extremely constructive comments. Finally, thank you to Mr David Tollerfield for permission to use the Thinking Patterns in Autism (TPA) Profiling Model digital innovations.

Underlying thinking pattern profiles predict parent-reported distress responses in autism spectrum disorder

Distress experienced by autistic children can often be the reason parents seek specialist assessment and support. Autism is a pervasive neuro-developmental condition affecting social communication, and flexibility of behaviour and interests. It has an impact on participation in relationships and academic activities (American Psychiatric Association (APA), 2013). Interactions with social and non-social features of the world can be challenging and often emotionally dysregulating for individuals with autism (Mazurek et al. 2013). In line with Valla and Belmonte (2013), autism can be viewed as comprising discrete core sets of autism pattern profiles that each contain a subset of dimensions on partially independent sliding scales. It is suggested that these separate continuous dimensions constitute the spokes of a multi-dimensional autism spectrum. Researchers have yet to agree on whether or how to split the construct of autism, but the debate continues and remains important. An accurate profile has potential benefits for mental health and well-being because it enhances understanding and enables individually tailored support to be designed.

Profiling skills and thinking patterns

In autism diagnostic assessment clinics, service-users often ask two questions: 'How do you know it is autism?' and 'If I am autistic, why am I not like others with autism?'. Viewing autism as a multi-dimensional spectrum enables an understanding of the common diagnostic aspects (i.e. difference in all core profiles) as well as the diversity (i.e. individual profile dimensions affected to different degrees). Indeed, the need to develop a profile of strengths, skills and impairments is recommended in National Institute for Health and Care Excellence (NICE) guidelines (2017). In 2020, Tollerfield and Pearce described use of the Thinking Patterns in Autism (TPA) Profiling Model within a diagnostic assessment service for autism. When used as part of diagnostic assessments, seventeen variables are included, across four core aspects: sensory coherence, flexible thinking, perspective-taking and regulation (Figure 1). As discussed in more detail below, profiling can enlighten and inform beyond the binary diagnostic outcome.

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Fig. 1
Thinking Patterns in Autism (TPA) Profiling Model

Positive autism narratives

As a diagnoseable set of neuro-developmental differences, autism is identified in DSM-V (APA, 2013) based on observable symptoms. These 'symptoms' can be used effectively to offer diagnostic opinions on the presence or absence of autism. However, the importance of finding positive ways of talking about autism and sharing

diagnoses is recognised (Prentice, 2020). The work of Wing and Gould (1979) was ground-breaking and led to the 'Triad of Impairments': language and communication; interaction; and restricted or repetitive behaviours. For decades the Triad of Impairments provided a valuable autism framework, but with the benefit of experience and contemporary research, several issues can be identified. Our view of autism now needs to be broadened to encompass the following: Firstly, to acknowledge the invisibility of some autistic perceptions and perspectives. Exacerbating the negative internal impact, these differences can be missed until later in life and hidden due to camouflaging (Bargiela et al. 2016; Hull et al. 2017; Rynkiewicz et al. 2016). Secondly, to specifically include sensory differences which are now acknowledged in DSM-V (APA, 2013). Thirdly, to capture the profiles of demand-avoidant individuals (Gillberg et al. 2015). Fourthly, to acknowledge the primary role of emotion in the foundations of autism, and not just as a secondary outcome or impact (Beversdorf et al. 1998). Finally, to focus on personal strengths and developmental skills in addition to life-long impairments (Wright et al. 2020). To clarify the latter, every person has strengths, and it is beneficial to identify and appreciate those strengths. However, inherent strengths can be missed without systematic inquiry as they may not be visibly obvious. For example, an enhanced ability to notice sensory details; to process logic-based patterns in music and mathematics; to assimilate expert knowledge on topics of interest; to respond with absolute honesty; or to remember certain detailed information. Shifting the focus from impairments to skills the person is currently able to demonstrate, is also beneficial as a pre-requisite for identifying and scaffolding the next developmental learning steps. Importantly, the life-long impairment in autism sometimes becomes less visible over time but can be nonetheless present. For example, when skills are learnt rather than being intuitively acquired, they may continue to require additional conscious effort and continue to consume significant cognitive and emotional resource (Hull et al. 2017). Emerging evidence indicates a need for Triad of Impairment based autism narratives to be updated. Above all, early positive autism narratives are warranted to support social identity, self-esteem, and mental health (Cooper et al. 2017).

Further, van der Cruijsen and Boyer (2021) found an association between externalising responses (e.g. 'physically attacks people') and low implicit self-esteem. Speculatively, this relationship is likely to be bidirectional and also influenced independently by the person's autistic features and related perceptions. Early positive autism narratives might then benefit people via several mechanisms. Firstly, facilitating development of self-esteem and self-affirmation directly (Prentice, 2020). Secondly, enabling communication partners to make individually tailored adjustments based on an understanding and appreciation of strengths as well as needs in the person's profile, may reduce the incidence of distress. Thirdly, self-esteem may be positively influenced due to

better interactions and lower levels of stress experienced. Distinguishing unique autistic thinking pattern profiles (within-person factors) may therefore play a crucial role in mechanisms for identifying necessary adjustments (external factors), reducing distress, and building self-esteem.

Mapping profile variables onto existing constructs and diagnostic criteria

Whilst the Thinking Patterns in Autism (TPA) Profiling Model (Tollerfield and Pearce, 2020) is reported to have clinical utility for communicating autism diagnostic information, construct validity is yet to be established. When TPA variables are mapped against existing DSM-V (APA, 2013) constructs (Figure 2), there is no re-invention of sub-components. Rather the TPA Profiling Model re-frames existing constructs associated with autism in a way that Tollerfield and Pearce (2020) suggest is therapeutically advantageous. As shown in Figure 2, some broad or composite constructs may straddle more than one core TPA aspect. Alexithymia, for example, which is defined as an inability to register and describe one's own affect (Sifneos, 1973), belongs in at least two locations because it comprises at least two components. Firstly, as indicated by Shah et al. (2016), it is fundamentally a difference related to interoceptive registration of the internal sensation of emotion and therefore this aspect of alexithymia is a constituent of the sensory coherence profile. Secondly, as highlighted by Connolly and Deney (2007), it is an inability to express the emotion experienced and therefore this aspect of alexithymia is suitably placed as a constituent of the regulation skills profile. It could further be argued that alexithymia is also a component of the perspective-taking profile because a person who is unable to interpret their own internal sensations is unlikely to be able to adequately resonate the emotion of others (Mul et al. 2018). These distinctions are valuable therapeutically because they allow better tailored approaches to be used, based on which aspects of alexithymia are affected. For example, a different approach may be needed for a person who is unaware of the internal sensations, compared to a person who can describe the somatic sensation, but is unable to verbalise the emotion.

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Fig. 2
Mapping dependent and independent variables onto constructs and diagnostic criteria

Underlying explanations

One of the strengths of the Thinking Patterns in Autism (TPA) Profiling Model is that communication, language and interaction are viewed as the medium or 'lens' through which underlying differences are identified (Figure 1). When talking about individual profiles, the emphasis is placed on underlying cognitive and affective differences rather than the observable impact on social functioning. For example, the observable feature 'failure to initiate social interactions' is listed as a 'symptom' in DSM-V (APA, 2013). To understand, and offer

appropriate support, there is a need to ask 'why?' and 'under what circumstances?'. Firstly, some verbally fluent people might avoid initiating conversation as an attempt to regulate their emotion (i.e. to avoid something that causes awkward, uncomfortable or anxious feelings). At times, people might be so distracted or overwhelmed by sensory information that they miss the opportunity. Thirdly, people might misinterpret the expectations of others or misunderstand the social conventions. Fourthly, people might recognise the cues but lack the imagination to know what to say. Finally, people might choose to say nothing because in their logic-driven view, there is no communicative purpose considered to be sufficiently important at that time. One major drawback of the Thinking Patterns in Autism (TPA) Profiling Model is that it has not yet been trialled with a pre-school or non-verbal population. However, pre-linguistic communication, interaction and play might provide a similar medium or 'lens' through which underlying differences can be identified in these populations. A 'lack of joint attention' (DSM-V, APA, 2013; Mundy and Crowson, 1997) for example, might also be more meaningfully explained and treated with reference to underlying cognitive and affective differences in regulation (e.g. an extreme distress response such as screaming, hitting or turning away), sensory coherence (e.g. covering ears due to sensory overload and difficulties understanding a meaningful context for sensory information), perspective-taking (e.g. missing the intention or the focus of others) or flexible thinking (e.g. using or fixing on repetitive movements or vocalisations). Of course, the importance of challenging assumptions and the power of curious inquiry for exploring complexities beneath the surface is not a novel or unfamiliar notion (Van Seggelen-Damen et al. 2017).

In terms of deep core psychological determinants of autistic responses, many researchers support a multiple theory account (Brunsdon and Happe, 2014). Influential theories such as Frith's (1989) central coherence theory, which suggests increased ability to focus on details, and decreased ability to perceive and make sense of the whole (Happé and Frith 2006) may offer an incomplete explanation (Mayer, 2017). To expand the explanatory power, additional cognitive and affective influences may be needed. For example, Pennington and Ozonoff's (1996) theory on executive dysfunction contributes insight on a person's ability to focus, switch attention, prioritise, plan, organise, stay motivated, apply effort, and use self-control as required, to complete both social and learning-related tasks. However, as Kanner suggested in 1943, an affective component may be needed (Hobson, 1989; Kanner, 1943) to account for differences in perception, interpretation, expression and regulation of emotional information relating to self and others. Indeed, Beversdorf et al. (1998) provided direct evidence supporting the role of emotion beyond central coherence in their study, with findings suggesting that emotion was not simply an effect of weak central coherence.

Extreme distress responses (EDR) and links to profile variables

EDR can occur in situations when a person experiences negative emotion to an extent that causes distress, and they are unable to employ healthy regulation strategies. Understanding the within-person neuro-developmental patterns that lie beneath EDR is highlighted as a vital topic for research considering links with quality of life at school (Ashburner et al. 2010) and at home (Nuske et al. 2018). Even more compelling, is evidence of the impact on mental health and well-being due to repeated experiences of stress or distress (Kerns et al. 2015). Higher levels of EDR are found in autistic individuals compared to individuals without autism, and irrespective of cognitive abilities (McStay et al. 2014; Pisula et al. 2017; and Nicholls et al. 2019), co-existing ADHD (Montes and Halterman 2007; Ros et al. 2018), co-existing anxiety (Granic 2014); co-existing sleep difficulties (Lindor et al. 2019) and parental adjustment (Benson 2014; McStay et al. 2014). Based on principles of learning and development outlined by Vansteenkiste and Ryan (2013), all individuals in an interaction have potential for psychological growth (e.g. emotional regulation skills) and vulnerability (e.g. emotional dysregulation) within complex dynamic interactions with social and physical environmental features. In other words, it is possible that the probability of EDR might be dependent on the within-person aspects of both interaction partners. Taken together, there is evidence for a composite model; with core aspects of autism viewed in the context of one another, and then viewed in the context of other internal and external aspects.

To an extent, each core aspect of autism is likely to influence the incidence of EDR. Viewed as one of the core aspects of autism, the term ‘sensory coherence’ is adopted here because it emphasises the importance of understanding sensory information meaningfully in the context of the whole situation. Indeed, Pellicano (2013) identified that integration and interpretation of sensory information are considered to be the principal sought after skills. Further, the term highlights the underlying influence of Frith’s (1989) central coherence theory. Negative emotion might result when sensory details are perceived more acutely or when they are perceived as out of context and unexpected or unfamiliar (Scheydt et al. 2017). Logically, higher levels of negative emotion might then be expected for people experiencing over-sensory sensitivity, identified by Dunn et al. (2002) as sensory-avoiding or refined sensory sensitivity, compared to those experiencing under-sensory sensitivities, identified by Dunn et al. (2002) as those with weak registration or sensory-seeking. Risks of distress might be further exacerbated in the context of a flexible thinking skills profile that includes difficulties in flexibly predicting and interpreting what is happening in the situation (Neil et al. 2016; Ozsivadjian et al. 2020). Also, when a person struggles to recognise and understand or respond as empathically as expected, to the emotions of others (Euler et al. 2017). This supports the notion of interlinking aspects and the need for a combined model

because the aspects (e.g. differences in sensory coherence, flexible thinking and perspective-taking) do not appear to function as independent causes with independent effects. Rather, they seem likely to function in combination.

Research findings also reveal more specific EDR associations. For example, Trundle et al. (2017) identified a link between EDR and extreme demand avoidance (EDA) in their case study. EDA involves extreme resistance to everyday demands and requests, with attempts to control social situations to avoid anything unpredictable, or unexpected (O'Nions et al. 2014). In the Thinking Patterns in Autism (TPA) Profiling Model, EDA is viewed as a form of social inflexibility. It is suggested that every autistic individual will experience flexible thinking pattern differences of some sort. However, flexible thinking subtypes will be affected to varying degrees and some subtypes may be unaffected in certain individuals. Supporting this view, studies found varying subtype prevalence, with inconsistent occurrence of restricted and repetitive behaviours, extreme demand avoidance, and systemising (Chowdhury et al. 2010; Gillberg et al. 2015; and Vanegas and Davidson et al. 2015 respectively). In research studies related to EDR, subtypes of flexible thinking are not always delineated but an association with the broad construct is reported (Lawson et al. 2015; Ozsivadjian et al. 2020), and Sullivan et al. (2019) identified a link with sameness. The strongest evidence for a systemising-EDR link comes from parents who report children experiencing significant distress in response to things being moved or removed. In clinical settings, a comprehensive measure of flexibility (e.g. The Flexibility Scale described by Strang et al. 2017) can serve two purposes. Firstly, demarcating which subtypes of inflexibility are affected and to what extent, so that this information can inform future management plans. Secondly, demonstrating the omnipresence of flexible thinking differences in autism and therefore perhaps reducing the level of missed diagnoses in females (and males), where the camouflaging itself might represent restricted imagination (i.e. imitating others) and application of learnt social rules (Hull et al. 2020). Additionally, those with demand-avoidant profiles might have major social inflexibilities in the absence of obvious non-social inflexibilities. Certainly, in the Trundle et al. (2017) study purposeful exploration was required to identify autistic social inflexibilities in a male offender previously labelled with anti-social personality disorder.

The present study

The current study builds on existing literature identifying links between thinking pattern profiles and extreme distress responses (EDR) in autistic young people. Specifically, the study aims to examine whether outcome (i.e. extreme distress response) can be predicted by a combined set of five predictor variables (or combined variables) selected from the Thinking Patterns in Autism (TPA) Profiling Model (Tollerfield and Pearce, 2020). See Figure

2. Selections were based on the literature, clinical observations, and conversations with experts by experience (i.e. individuals with autism and their parents) about situations involving distress: sensory coherence (over-sensory sensitivity and under-sensory sensitivity), flexible thinking (systemising and extreme demand avoidance), and perspective-taking (a combined score for empathy). See Figure 3A. This study is worthwhile because people are perplexed by autistic heterogeneity. Further elucidation of within-person profiles might facilitate positive autism narratives that serve to improve trajectories for autistic people prone to experiencing distress. This study expected that EDR would be predicted by low levels of empathy, low levels of flexible thinking, and high levels of over-sensory sensitivity (Figure 3B). It was further expected that high levels of empathy, flexible thinking, and under-sensory sensitivity would predict little or no EDR (Figure 3C). After the initial data analysis, it was suspected that co-existing ADHD might help to explain some unexpected findings. It was speculated that co-existing ADHD might influence the outcome both independently and in combination with aspects of the autistic thinking pattern profiles.

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Fig. 3
Graphic representation of research hypotheses

Methods

To determine whether profile-EDR links were statistically significant, a cross sectional, quantitative study design was selected. Binary logistic regressions were required to determine whether the binary outcome (i.e. EDR or little/no EDR) could be predicted by the combined set of variables (i.e. scores relating to perspective-taking, flexible thinking, and sensory coherence). With regression as the mode of analysis, it was possible to determine whether a binary outcome could be predicted by a combined set of variables.

Participants

This study used anonymised patient data collected during a 12-month period May 2017-April 2018 from an NHS autism diagnostic assessment service in the United Kingdom. Data were from 140 individuals aged 4-19 years, where parents completed all pre-assessment questionnaires and attended all appointments through to positive autism diagnosis. No cases were excluded. Based on guidelines provided by Field (2013), this sample size is sufficient to obtain a reliable regression model, where a medium or large effect size is expected. Using sensitivity power analysis, given the available sample, the minimum log odds ratio that can be observed 95% of the time is 2.57 (Faul et al. 2009). This means that if the log odds ratio is lower than 2.57 then there is a risk of errors impacting on findings and a larger sample size would be needed for replication studies.

Procedure

In addition to questionnaire scores, data were included on gender, age, anxiety, and co-existing diagnosis of ADHD. Parental responses to the following specific diagnostic interview questions were coded: 'How frequently does your child lash out physically towards others?', and 'How would you describe the risk to the safety of others: significant, moderate, mild or no risk at all?'. For clinical profiling purposes, a broader range of emotional regulation related information is gathered from parents during the assessment. Questions from the Emotion Dysregulation Inventory (Mazefsky et al. 2018) and questions based on the emotional regulation sections from the Social Communication, Emotional Regulation and Transactional Support (SCERTS) manual (Prizant et al. 2006) are used. However, for the purposes of this study, this simple set of questions was used to capture whether or not parents identified this aspect of EDR as having a significant impact in terms of frequency and/or risk of harm to others. When checked in a 10% sample, coding reliability was 96% across all variables, and 100% for the outcome variable. When first and second coding was different, there was a brief discussion between coders, revealing human error rather than disagreement, and consensus was reached without involving a third team member.

Measures

From three questionnaires, five predictor variable scores were obtained. Figure 2 shows how each predictor variable maps onto existing and proposed constructs.

The Empathy Quotient-Systemizing Quotient (EQ-SQ) Child questionnaire is a 55-item parent-report questionnaire, with 28 items measuring systemizing and 27 items measuring empathy (Auyeung et al. 2009). Item responses were made on three-point Likert scales that were sometimes reversed (0=strongly agree, 0=slightly agree, 1=slightly disagree 2=strongly disagree) to discriminate 'lacking', 'mildly', and 'strongly' empathic or systemising behaviour. Empathy items (e.g. 'My child is often rude or impolite without realising it') produce EQ scores out of 54, with higher scores indicating a greater level of empathy. Systemising items (e.g. 'My child gets annoyed when things aren't done on time') produce SQ scores out of 56, with higher scores indicating a greater level of systemising. These scales are publicly available and have been shown to exhibit good validity and reliability (Lawrence et al. 2004; Vanegas and Davidson 2015). Vanegas and Davidson (2015) identified that internal reliability and test-retest reliability of SQ are α=.78 and r=.84 respectively. For EQ, moderate associations were suggestive of concurrent validity, and test-retest reliability r=.84 (Lawrence et al. 2004).

The Extreme-Demand-Avoidance questionnaire is a 26-item parent-report questionnaire measuring demand avoidance (O'Nions et al. 2014). Item responses were made on four-point Likert scales that were sometimes reversed (0=not true, 1=somewhat true 2=mostly true, 3=very true) to discriminate levels of demand avoidance. Items (e.g. 'Driven by the need to be in charge') produce a score out of 78, with scores above 45 indicating a possible risk of clinically significant demand avoidance.

The sensory questionnaire is a clinically developed tool, based on 8 sensory domains (auditory, visual, tactile, olfactory, gustatory, proprioceptive, vestibular, and interoceptive). It includes sensory differences identified from published first-hand accounts (see Robledo et al.2012 and Burns et. al.2017 for a review); an online clinical tool (Pro-ACT 2013); and from parents of children previously diagnosed with autism. This parent-report questionnaire quantified over-sensory sensitivities: sensory-avoiding (e.g. resists touch), and refined sensitivity (e.g. excellent visual memory) out of 63, relative to under-sensory sensitivities: weak registering (e.g. unaware of pain), and sensory-seeking (e.g. licks hands or body) out of 69. There is a lack of validated sensory measures (Burns et al, 2017), so this rudimentary measure, despite having no published psychometric testing for reliability and validity, was considered sufficient for the purpose of proposing a model of predictor variables in the current study.

Data Analysis

Binary logistic regressions were used to investigate the two combined model hypotheses: 1. EDR would be predicted by low levels of empathy, low levels of flexibility, and high levels of over-sensory sensitivity; 2. Little/no EDR would be predicted by high levels of empathy, flexibility, and under-sensory sensitivity (Figure 3). The independent (or predictor) variables were numerical scores on empathy, systemising, extreme demand avoidance, over-sensory sensitivity, and under-sensory sensitivity; the dependent variable was the outcome 'EDR': parent-reported frequency ≥1 times a week, and/or moderate-significant risk to the safety of others (coded '1') or 'little/no EDR' (coded '0'). Predicted probability of EDR was determined by Exp(*B*) to show the odds ratio. Analyses showed the change in odds resulting from adding predictor variables. The primary outcome analysis was a statistical measure of probability that the outcome (i.e. EDR or little/no EDR) can be predicted by the combined predictor variables (i.e. scores relating to perspective-taking, flexible thinking, and sensory coherence).

T-tests were used as post-hoc analyses to compare under-sensory sensitivity and systemising scores between ADHD-positive and ADHD-negative groups as these results were unexpected. For example, based on literature

and clinical experience, it was predicted that higher levels of systemising would be related to EDR, but this was not supported by the study data. Co-existing ADHD was considered a possible explanatory factor. It was suspected that systemising scores of autistic individuals with co-existing ADHD might be counter-balanced, with features of disorganisation (e.g. 'My child doesn't mind if things in the house are not in their proper place' and 'My child's bedroom is usually messy rather than organised') alongside features of systemised organisation (e.g. 'My child likes to collect things' and 'My child quickly grasps patterns in numbers in maths'). No post-hoc analysis of co-existing anxiety was completed due to small sample sizes (i.e. the low percentage of young people with medicated anxiety and low percentage of young people without parent-reported anxiety).

Results

Complete data from 140 cases were provided. The young people were aged 4-19 years (27.1% females, 60.0% co-existing ADHD, 81.4% parent-reported anxiety). All were verbal communicators. See Table 1 for further case characteristics.

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EDR was found in 40% of cases (31.6% of females, 43.1% of males, 50% of those with ADHD, 25% of those without ADHD). The log odds ratio was 1.5. Descriptive statistics for scaled variables are presented in Table 2.

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The mean scores for individuals showing EDR were compared to the mean scores for individuals showing little/no EDR. There was a statistically significant difference in mean scores for empathy ($t=5.52$, $p=.000$), extreme demand avoidance ($t=-7.54$, $p=.000$) and over-sensory sensitivity ($t=-4.56$, $p=.000$). Effect sizes were large (Cohen 1992). This means that, as expected, there was an association between EDR and lower empathy scores, higher extreme demand avoidance scores (i.e. lower flexibility), and higher over-sensory sensitivity scores. No significant difference was found between group means related to age ($t=0.22$, $p=.827$), systemising ($t=-0.74$, $p=.462$), and under-sensory sensitivity ($t=-0.43$, $p=.671$). This means that, contrary to expectations, EDR was not associated with higher systemising scores (i.e. lower flexibility), and little/no EDR was not associated with higher under-sensory sensitivity scores. Table 3 shows tolerance and variance inflation factors (VIF) for each variable.

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No multicollinearity problems were found (Menard, 2002) which means that the variables were independent and not significantly correlated to one another.

The results of hierarchical logistical regression analyses, performed to examine the project hypotheses are presented in Tables 4 and 5.

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For both models, it can be seen that chi-square value is statistically significant ($p \leq 0.05$), and this indicates that there is predictive capability in the models. Both models were able to accurately classify 80.7% cases correctly, compared to 60.0% in the null model (i.e. with no predictor variables added). This suggests that the models were sensitive (Pallant 2007). The Hosmer and Lemeshow (2000) test indicated a good model fit, with good sensitivity and predictive capability for both models. Empathy, extreme demand avoidance and over-sensory sensitivity are statistically significant predictors in regression equation Model 1 (Table 4), estimated by a Wald statistic with 1 degree of freedom. Controlling for individual differences in the other variables, a one unit increase in empathy is associated with a 10% decrease in probability of individuals showing EDR, and a one unit increase on extreme demand avoidance and over-sensory sensitivity is associated with a 7% and 5% increase (respectively) in probability of individuals showing EDR. As shown in Table 5, empathy, and extreme demand avoidance are significant predictors in regression equation Model 2. This indicates that empathy, extreme demand avoidance and over-sensory sensitivity each make a unique contribution in the context of the overall combined model effect. Controlling for individual differences in the other variables, a one unit increase on empathy and extreme demand avoidance scales is associated with 11% increase and 8% decrease (respectively) in probability of individuals showing little/no EDR.

The exploratory post-hoc t-test analyses showed a statistical difference in mean systemising scores when the coexisting ADHD-positive group (M=23.25, SD=7.95) was compared to the co-existing ADHD-negative group (M=27.25, SD=9.91): F=3.52, p=.063, t=2.64, p=.009. Cohen's d=.45 indicated a medium effect size (Cohen 1992). There was also a statistically significant difference in mean under-sensory sensitivity scores when the coexisting ADHD-positive group (M=20.81, SD=10.99) was compared to the ADHD-negative group (M=16.63, SD=12.79): F=.981, p=.324, t=-2.07, p=.041. Cohen's d=-.35 indicated a small-medium effect size. These findings indicate that, co-existing ADHD may influence both systemising and under-sensory sensitivity scores.

Discussion

The aim of this study was to determine if the probability of extreme distress responses (EDR) could be predicted by variables related to perspective-taking, flexible thinking and sensory coherence. Consistent with predictions, there were statistically significant improvements in the capability of the combined models to predict EDR compared to the null model with no predictor variables added. When variables of interest were included, both models correctly classified 113 cases (80.7%); a clear 20% increase in predictive capability. In the context of these combined models, a one unit change in scores related to empathy (a component of perspective-taking), extreme demand avoidance (a component of flexible thinking), or over-sensory sensitivity (a component of sensory coherence) was found to significantly change the probability of EDR, providing supportive evidence that these variables are strong predictors of EDR. Whilst these findings are interesting and strengthen some previously reported links, further research is needed to explore predictive capabilities compared to other models. The present findings are consistent with other studies reporting links between regulation and empathy (Euler et al 2017), flexible thinking (Samson et al. 2014; Visser et al. 2014), and sensory coherence (Mazurek et al. 2013). Mirroring previous studies (Archer 2004; Pisula et al. 2017; Farmer and Aman 2009), the study findings show that prevalence of EDR is not significantly affected by sex or age. Also, consistent with other studies (Billstedt et al. 2017; Granic, 2014; and Montes and Halterman, 2007), the data showed that there are statistically significant differences in prevalence of EDR when ADHD is co-existing. Further, post-hoc exploration provided evidence of co-existing ADHD influencing systemising and under-sensory sensitivity scores. In the context of previous literature, the data presented in this paper provide support for a thinking patterns view of autism.

Limitations

Several study limitations should be considered when interpreting these results. Firstly, since the study was powered at 2.57, and the log odds ratio was 1.5, the effect size was not sufficient to reliably observe a significant effect 95% of the time. As such these findings must be interpreted with some caution. A larger sample size would be needed to reduce risks of type-1 and type-2 errors. Secondly, as a cross-sectional study, the directionality of reported relationships cannot be determined. Thirdly, further research attention is needed to explore the modifying effects of co-existing ADHD. Fourthly, there were some measure-related issues which will be covered later in this discussion. Not least of these, no intelligence quotient (IQ) proxy aspect was included. Finally, the possibility of population bias must be taken into consideration further, as the study sample did not include individuals diagnosed by non-NHS services nor those diagnosed before four years. It therefore excluded most young people with early, visible forms of autism. Indeed, non-verbal individuals were not referred to this service during the 12-month study period, so the study does not take account of the profiles of

those at pre-verbal or pre-intentional stages of development. That is, there were no pre-verbal learners, using vocalisations, movements and actions as a form of communication in the absence of spoken words. There were no pre-intentional learners, yet unaware that their vocalisations, movements and actions could be used deliberately for the purpose of communication with another person. Feasibly, the Thinking Patterns in Autism (TPA) Profiling Model might be helpful for both populations for when communication partners endeavour to teach early communication skills by conscientiously observing, interpreting and responding to what they see and hear. For pre-intentional learners, the vocalisations, movements and actions may be an automatic response or reflex to internal states and external stimuli, but every sound and every movement provides an opportunity for the communication partner to build and strengthen links for adaptive regulation (regulation skills profile) and intentional two-way communication (perspective-taking skills profile). For example, a communication partner might say 'it's cold' after a startle reflex in response to an unexpected sensory input (sensory coherence skills profile) and might use a repetitive rocking or stroking motion to restore calm (flexible thinking skills profile). However, until the Thinking Patterns in Autism (TPA) Profiling Model has been trialled with these populations, it cannot be assumed to be a good fit for them.

Perspective-Taking and Empathy

The results of this study support previous research findings and an expected link between low levels of empathy and EDR. However, the measure used provided a composite empathy score, an empathy quotient (Auyeung et al. 2009), that represents only part of the broader construct, perspective-taking. Whilst this did not detract from the present research findings about overall pattern modelling and links with EDR, it falls short of what is required clinically when planning skill-building interventions. Dadds et al. (2008) refers to three subtypes of empathy: cognitive, affective and behavioural empathy which correspond respectively to understanding, sharing, and responding to, the emotions of others. Some researchers view perspective-taking as a component of empathy (Lockwood et al. 2013). In contrast, the term perspective-taking could be considered the broader construct, with cognitive, affective and behavioural perspective-taking corresponding respectively to understanding, sharing and responding to, the thoughts and perspectives as well as the feelings of others. Eisenberg and Miller (1987) suggest that both empathy and perspective-taking are needed for pro-social behaviour. Many researchers such as Decety and Meyer (2008) highlight the importance of understanding the cognitive, affective and neural underpinnings in order to inform practice. For example, Hwang et al. (2018) explains that when a person has low levels of cognitive perspective-taking they are unlikely to cause intentional harm to others; an act of deliberate harm would require a level of victim-perspective insight and understanding regarding the likely impact on the

victim. Indeed, studies found that autism was associated with lower levels of cognitive empathy (Lockwood et al. 2013) and reactive EDR rather than proactive EDR (Euler et al. 2017). Lockwood et al. (2013) further found that alexithymia was associated with lower affective empathy. Demarcation of the individual variables within each person's perspective-taking profile therefore seems crucial for refined intervention planning. Related conversations might also help to explain the underlying processes involved when a naturally loving and caring person displays EDR towards others. Equally, when a person's cognitive perspective-taking differences are camouflaged due to skilled application of learnt social rules.

Sensory Coherence

Whilst the results of the present study support an established link between sensory differences and EDR (Ben-Sasson et al., 2017; Mazurek et al., 2013; van den Boogert et al. 2021), there were also some unexpected aspects in the findings. In contrast to the current study, Mazurek et al. (2013) used a composite measure for sensory differences, and van den Boogert et al. (2021) examined links with each sensory subtype separately. Consistent with others (Ben-Avi et al. 2012; Levitt, 2019), this study found that over-sensory sensitivities contributed to the combined model for EDR. However, contradicting the study hypothesis, under-sensory sensitivities were not found to be a predictor for little/no EDR. This was despite the hypothesis being in line with researchers who found sensory-seeking to be the only subtype associated with positive affect (Ben-Avi et al. 2012; Engel-Yeger and Dunn, 2011). Since the data were inconsistent with the hypothesis, further consideration is warranted. Although Ben-Avi et al. (2012) suggested that sensory-seeking might also be linked to extroversion, Greven et al. (2019) provided evidence to conclude that sensory differences and other personality constructs can be distinguished as separate. Conceivable explanations for disparities in this study include the use of an unpublished measure with unestablished validity (Burns et al., 2017), and co-existing ADHD in the sample, with symptoms that include inattentiveness, impulsivity, and hyperactivity that might influence the sensory profile; perhaps disrupting autistic tendencies towards analytical perception of sensory information (Hadad and Ziv, 2015). Although the present study found that 50% of the ADHD-positive group experienced EDR, the same group had a significantly higher average score for under-sensory sensitivities, compared to the ADHD-negative group. A possible explanation for the findings in the present study is presented in Figure 4. It is suggested that introversion / extroversion could be plotted against Gray's (1982) inhibition / approach axis. In this way, EDR towards others might result for individuals with high levels of sensory-seeking approach (or impulsivity), provided they have a propensity towards extroversion and externalising when under stress. Similarly, risk of externalised EDR might also be higher for sensory-avoiding (or inhibition-driven) extroverts when under stress.

This is understandable due to the dissonance that an extrovert may experience when driven by anxiety and inhibition in the context of real or perceived stressors. This mechanism might be involved when people with demand-avoidant profiles (i.e. with high extreme demand avoidance scores) display EDR.

---------- (INSERT FIGURE 4) ----------

Fig. 4
Sensory coherence and extreme distress responses (EDR)

Social Flexibility (e.g. extreme demand avoidance (EDA) scores)

Ozsivadjian et al. (2020), found cognitive inflexibility was the strongest predictor of EDR in their study. In the present study the strongest predictor was extreme demand avoidance specifically. However, it was a limitation of this present study that flexibility measures related only to social responses and systemising, rather than a more comprehensive measure (e.g. Strang et al, 2017). In clinical practice, the list of aspects related to flexible thinking includes differences related to social responses, routines and change, systems and ordering, creativity and imagination, focused interests, speech, language and sensory-motor actions (Figure 1). It seems prudent to view each subcomponent as a possible neuro-developmental contender that cannot be ruled out until it has been considered. There is an acknowledgement that differences may be partially hidden. NICE guidelines (2011; 2017) identified these less visible forms of autism in 2011, and since 2013 when the diagnostic criteria for autism changed (APA, 2013), there has been increased recognition of the true breadth of the autism spectrum. There is clear evidence from previous research to show that when less observable neuro-developmental differences are not discovered, the personal cost and detriment to mental health can be very grave (Cassidy et al. 2014; Cassidy et al. 2019). Additionally, as mentioned previously, it is also important for mental health and well-being to ensure that strengths are not missed (e.g. skills that are refined as a consequence of the need to maintain predictability as well as inherent qualities).

Non-Social Flexibility (e.g. Systemising scores)

Unsurprisingly, research studies have indicated links between flexibility and emotion. With preferences for rules, predictability and familiarity, autistic individuals might sense pleasure and comfort when rituals, routines, patterns, events, and interactions are repeated, and this might reduce anxiety (Lidstone et al. 2014). Equally, problems might result when the same are unexpectedly disturbed, threatened or prevented (DeLeon et al. 2013; Samson et al. 2014). Indeed, Visser et al. (2014) found links between inflexibilities and EDR and other researchers identified that an intolerance of uncertainty might be involved (Cai et al. 2018), particularly in the context of sensory differences (Neil et al. 2016). Nevertheless, in the present study, systemising scores were not

found to be a predictor for EDR. Perhaps resolving the apparent contradiction, Overskeid (2016) found that both positive and negative emotions can be associated with systemising. A highly systemised person might experience distress when environmental items are not as expected. However, the same person, might experience satisfaction and positive emotion when creating orderliness. Adding to this explanation, exploratory post-hoc analyses indicated that co-existing ADHD influenced systemising scores. This provides possible support for the notion that the systemising scores of individuals with co-existing ADHD might mask a mix of extremes. They may be chaotic and disorganised on one hand due to differences associated with ADHD (APA 2013; Liu et al. 2017; Willcutt et al. 2005). However, they may have highly systemised thinking patterns on the other hand, due to differences associated with autism (Auyeung et al. 2009). Garcia-Winner (2019) provides a useful distinction between static organisation (of objects, events and interests) and dynamic organisation (of tasks and time). It seems that overly rigid static organisation might lead to highly systemised thinking patterns and raised systemising scores, at the same time as difficulties with dynamic organisation cause systemising scores to be lowered (e.g. individuals described as in the top left corner in Figure 5).

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Fig. 5
Systemising and intolerance of uncertainty

Regulation

Overall, the present study findings are based on aggregated data that demonstrated that a certain autism profile pattern (i.e. scores relating to perspective-taking, flexible thinking and sensory coherence) can be linked to a certain regulation profile outcome (i.e. EDR). However, the inclusion of regulation as a core dimension of autism requires some explanation. A case is made for considering regulation differences as a fundamental marker of functional impact, which is required for autism diagnosis (APA, 2013). The focus in the context of autism will be on emotional regulation, but in the context of broader neuro-developmental conditions, regulation profiles could be extended to include regulation of impulses and regulation of attention (Bailey and Jones 2019). Incontrovertibly, emotional regulation difficulties, like sensory abnormalities, are not exclusive to autism. However, they are commonly associated with autism (Mazefsky et al. 2013; Mazefsky 2015; Samson et al. 2015). Whilst universality as a core diagnostic feature has not yet been empirically established, it seems likely that regulation pattern profiles could help to elucidate the nature of the functional impact and enhance the mapping out of bespoke support systems. Regulation pattern profiles (Figure 1) include information on adaptive self-regulation strategies and adaptive mutual-regulation strategies alongside pre-requisite skills (e.g. ability to

describe internal signals, states and arousal levels including those relating to emotion) as identified by Prizant et al. (2006). It seems credible that regulation differences might be found universally in autism, albeit with diverse causes and manifestations for individuals. Study findings reveal 40% prevalence of EDR and 81% prevalence of parent-reported anxiety. The study dataset did not include prevalence of regulation differences related to alexithymia, depression, self-harm, suicidal ideation, or school refusal. Essentially, the universality of regulation differences is perhaps self-evident since a person with fully intact regulation skills will not meet the criteria for a formal diagnosis of autism which states that symptoms must be present to the extent that they cause clinically significant impairment in everyday functioning (DSM-V, APA, 2013). Importantly, the prevalence of alexithymia, an inability to register / describe own affect, has been reported at 63% (Samson et al. 2012). Albeit in a small research sample, this finding highlights the importance of pro-actively searching to identify and support those with alexithymia whose needs might otherwise be missed. Equally important, levels of self-regulation must be considered to understand links between internalising (or bottling) and externalising (or lashing out). Finally, it will be important to consider the concept of double empathy (Milton, 2012) or bi-directional empathy, as mutual regulation involves explicit two-way communication relating to emotional signals experienced by interaction partners with differing profiles. The value of including regulation pattern profiles as part of autism diagnostic assessments is indicated.

Practical Applications

These data illustrate the potential for identifying the subcomponents of a profile contributing to an outcome such as extreme distress responses (EDR). As previously mentioned, autistic individuals often want to understand how two people with the same diagnosis can be so dissimilar. It is suggested that a valuable level of understanding can be achieved when visual profiles are used to explain interlinking features and plan for individualised skill-building and support. Evidence from this study supports the view that a combined model is needed. Indeed, the combined effect of the variables in the study resulted in a model that was 20% more accurate at predicting the EDR outcome, compared to a model with no predictor variables added.

The Thinking Patterns in Autism (TPA) Profiling Wheel (Tollerfield and Pearce, 2020) has been used in Figure 6 to show clinical examples of how a simplified version of the TPA Profiling Model can visually display the relative strengths and needs of individuals. Viewed in combination with other internal and external factors, these profiles can be used to design support strategies for learning, social interaction and minimising distress. The more colour in each segment, the more conventionally a skill or thinking pattern has developed. No additional support strategies or accommodations are needed if the colour fills all four inner rings. When an individual has

advanced skills (e.g. relative to other skills in their profile, they may have an advanced ability to feel the emotion of others, extraordinary topic knowledge, or super-sensitivities that result in a strength or talent) a star is displayed in the outer ring. Each profile shows skills and thinking patterns relative to each other so specific aspects cannot meaningfully be compared across individuals in isolation from the rest of the profile. For example, the social flexibility segments (blue) depicted in the profiling wheels for Jason and Kim look comparable (Figure 6). However, the TPA Profiling Model is an interlinking model, so this information is only meaningful in the context of other segments contained in the same profile. Kim's social flexibility differences are considered in the context of severe difficulties expressing and regulating anxiety, an intolerance of noise, a strong logical mind, and a tendency to over-analyse. In contrast, Jason experiences social flexibility differences in the context of an intense dislike of change, and a tendency to monopolise and talk at length on topics of interest or get too close and make loud noises; he is unaware of many social rules and conventions. Despite the contrasts, Kim and Jason both have a diagnosis of autism, with features of autism found across all four core aspects: sensory coherence, flexible thinking, social perspective-taking and regulation. These cases illustrate the value of the TPA Profiling Model for understanding extreme distress responses (EDR) and appreciating the complex interlinking variables that exist beneath each unique lived experience.

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Fig. 6
Clinical examples of Thinking Patterns in Autism (TPA) profiles and matched support (Thinking Patterns in Autism (TPA) Profiling Model digital innovations © D.A.Tollerfield, used with permission to create visual profiles).

Summary

In summary, the current study findings suggest that certain autistic thinking pattern profiles can be linked to extreme distress responses (EDR) directed towards others. When interpreted in the context of exiting literature, the need for a composite model is indicated. Understanding autistic heterogeneity and distinguishing unique autistic thinking pattern profiles in the context of co-existing features (within-person factors), could enable individuals to be understood such that environmental demands (external factors) could be suitably modified to reduce distress. This paper has implications for future research and practice. Such applications could help to bridge the void between diagnostic criteria and therapeutic support for autistic people experiencing distress; a systematic way of translating complexity into positive and practical insight.

Future Directions

Clinically, the Thinking Patterns in Autism (TPA) Profiling Model (Figure 1), has been trialled as part of a diagnostic assessment profiling pathway (Tollerfield and Pearce 2020). In this context, it provided a means of understanding and explaining both core and unique aspects of autism for each young person assessed. Further, it seemed to contribute to quality and efficiency improvements within the diagnostic assessment pathway; providing a system that enabled streamlining. As mentioned above, there is a need to explore the clinical utility of this model with pre-school and non-verbal populations to explore its value relative to existing models that have so far been serving the needs of these groups. For example, research is needed to evaluate whether the TPA model provides any value for a person who is functioning at a pre-intentional developmental stage. Skill-building work for this person may be focused on a developmental skill such as 'object permanence' (i.e. learning that a person does not cease to exist when they shift out of your line of vision) or 'cause and effect' (i.e. learning that your actions can cause a reaction). These skills might be viewed as early development perspective-taking skills. However, the importance of a combined model approach might be just as valuable for a pre-intentional stage learner as for a cognitively able verbal learner because it encourages partners (e.g. family and professionals from education health and social care) to take consideration of sensory differences, emotional differences and flexibility (e.g. sameness may bring comfort and calm). Undoubtedly, a focus on strengths and developmental skills in addition to lifelong impairments is important for all populations. Specifically, encouraging partners to recognise strengths and qualities, and to identify the next small developmental learning steps. The benefits of adopting a profiling structure such as the Thinking Pattens in Autism (TPA) Profiling Model for this combined model approach, warrants further research involving both verbal and non-verbal populations.

Identifying the profiles of difference for each core aspect of autism can enrich our understanding of each person and the interplay between factors. Profiling can be an asset when seeking to identify both advantageous and disadvantageous features and factors influencing situational responses. In analysing both the context and the individual profile, the specificity of future management plans can be enhanced, with environment modifications and support strategies matched to the features in the holistic profile. Snapshot feedback from parents accessing the service for 4-19 year olds (Tollerfield and Pearce, 2020) was positive, however, longitudinal studies would be needed to explore empirically whether sharing individual profiles has an impact on autism-specific understanding, needs being met, and levels of distress experienced.

Other future directions might include exploration of other situational responses in autism. The Thinking Patterns in Autism (TPA) Profiling Model might also be used to understand and explain the prevalence of responses such as school refusal, risk-taking, deliberate self-harm, and elopement. If supported by future studies, and robust

under critical review, this contextual depiction of autism might contribute a means of appreciating and delineating the population diversity. The TPA Profiling Model allows clinician to develop more individualised strategies for skill-building support and environmental modifications. The consequential links with self-esteem and mental health and well-being also need to be further explored. A final future direction might be to explore whether unique profiles can be used in efficacy studies to understand and explain why certain interventions work for some people but not for others.

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Figure Captions

Figure 1. Thinking Patterns in Autism (TPA) Profiling Model

Figure 2. Mapping study variables onto constructs and diagnostic criteria

Figure 3. Graphic representation of research hypotheses

Figure 4. Sensory differences and extreme distress responses (EDR)

Figure 5. Systemising and intolerance of uncertainty

Figure 6. Clinical examples of Thinking Patterns in Autism (TPA) profiles and matched support (Thinking Patterns in Autism (TPA) Profiling Model digital innovations © D.A.Tollerfield, used with permission to create visual profiles).

Figure 1 top

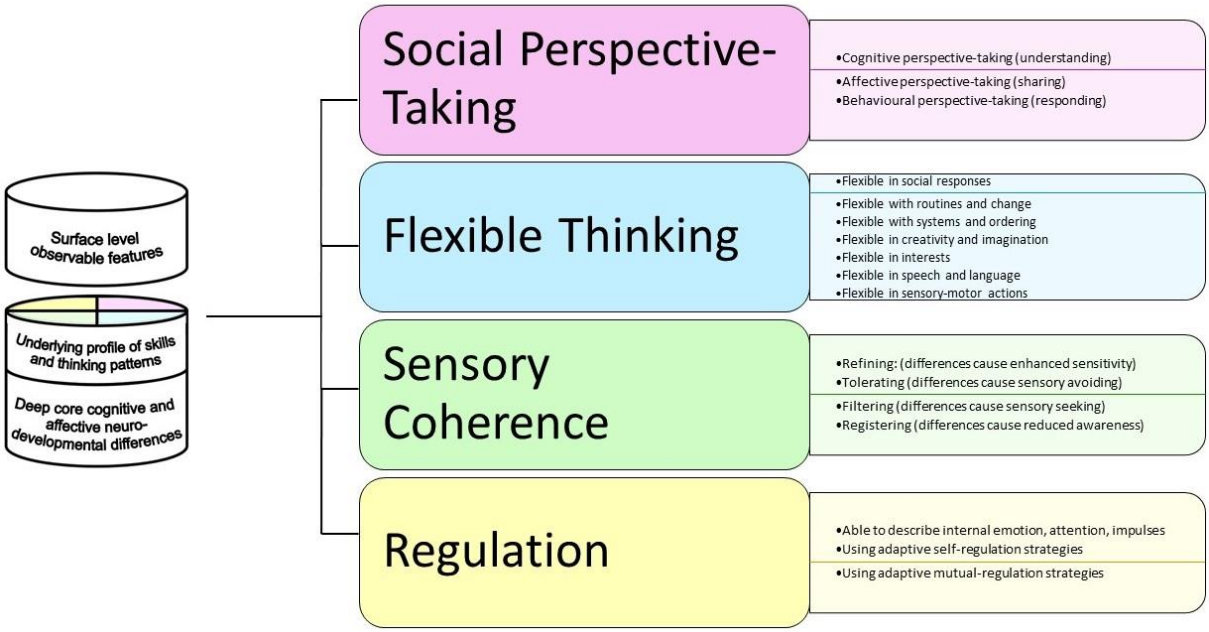

Fig. 1
Thinking Patterns in Autism (TPA) Profiling Model

Figure 2 top

Underlying theories	TPA core components	TPA sub-components	TPA skills (variables)	Existing constructs (INDEPENDENT VARIABLES shaded below)	DSM-V diagnostic criteria (APA, 2013)	Triad of Impairments (Wing and Gould, 1979)
Weak Central Coherence (Happé & Frith, 1996)	Perspective-Taking: Understanding and sharing the thoughts, emotions and perspectives of others	Cognitive Perspective-Taking	Cognitive perspective-taking	Theory of mind (Baron-Cohen, Leslie and Frith, 1985)	Deficits in social-emotional reciprocity Deficits in relationships Impaired nonverbal communication	Impaired language and communication Impaired social interaction
		Affective Perspective-Taking	Affective perspective-taking	**EMPATHY QUOTIENT** (Auyeung et al. 2009) Cognitive empathy (Dadds et al. 2008) Affective empathy (Dadds et al. 2008)		
				Resonance (Decety and Meyer, 2008)		
			Behavioural perspective-taking	Behavioural empathy (Dadds et al. 2008)		
				Pro-social behaviour (Eisenberg and Miller 1987)		
Executive Dysfunction (Pennington and Ozonoff, 1996)	Flexible Thinking: Thinking flexibly in relation to people, belongings, interests, and actions	Social Flexibility	Flexible in social responses	**EXTREME DEMAND AVOIDANCE** (O'Nions et al. 2014)	Insistence on sameness	Restricted and Repetitive Behaviour and Interests
		Non-Social Flexibility	Flexible in routines and changes and transitions	Insistence on sameness in social interchanges Insistence on sameness in routines Intolerance of uncertainty (Dugas et al. 1997)		
				Insistence on sameness in environment		
			Flexible with systems and ordering	**SYSTEMISING QUOTIENT** (Baron-Cohen, 2006)		
				Static organisation (Garcia-Winner, 2019)		
			Flexible in creativity and imagination	Restricted imagination	Highly restricted, fixed interests	
			Flexible in interests	Circumscribed interests		
			Flexible in speech and language	Literal use and interpretation of language	Stereotyped or repetitive movements, use of objects or speech	Impaired communication
				Stereotyped language or echolalia (Wing and Gould, 1979)		Restricted and Repetitive Behaviour and Interests
			Flexible in sensory-motor actions	Restricted and repetitive movements (Wing and Gould, 1979)		
Disturbances of affective contact (Kanner, 1943), and affective and social relations (Hobson, 1989)	Sensory coherence: Registering, filtering, tolerating and refining perception of sensory details within context	Over-sensory sensitivities	Refining	**OVER-SENSORY SENSITIVITIES**: Sensory sensitivity (Dunn et al. 2002)	Hyper- or hypo-reactivity to sensory input or unusual interest in sensory aspects of the environment	Not included
			Tolerating	Sensory-avoiding (Dunn et al. 2002)		
		Under-sensory sensitivities	Filtering	**UNDER-SENSORY SENSITIVITIES**: Sensory-seeking (Dunn et al. 2002)		
			Registering	Weak registration (Dunn et al. 2002)		
				Alexithymia – registration of emotion specifically (Sifneos, 1973)		
	Regulation: Perceiving, interpreting, expressing and regulating own emotions and responses	Self-regulation	Describing internal signals	Alexithymia (describing emotion) (Connolly and Deney, 2007)	Symptoms cause clinically significant impairment in social, occupational, or other important areas of current functioning (e.g. **Extreme distress responses = DEPENDENT VARIABLE**)	Not included
			Using adaptive self-regulation strategies	Self-control / other executive functioning skills (Pennington and Ozonoff, 1996), including dynamic organisation (Garcia-Winner, 2019)		
				Self-regulation (Prizant et al. 2006)		
		Mutual regulation	Using adaptive mutual regulation strategies	Double empathy (Milton, 2012)		
				Mutual regulation (Prizant et al. 2006)		

Fig. 2
Mapping dependent and independent variables onto constructs and diagnostic criteria

Figure 3 top

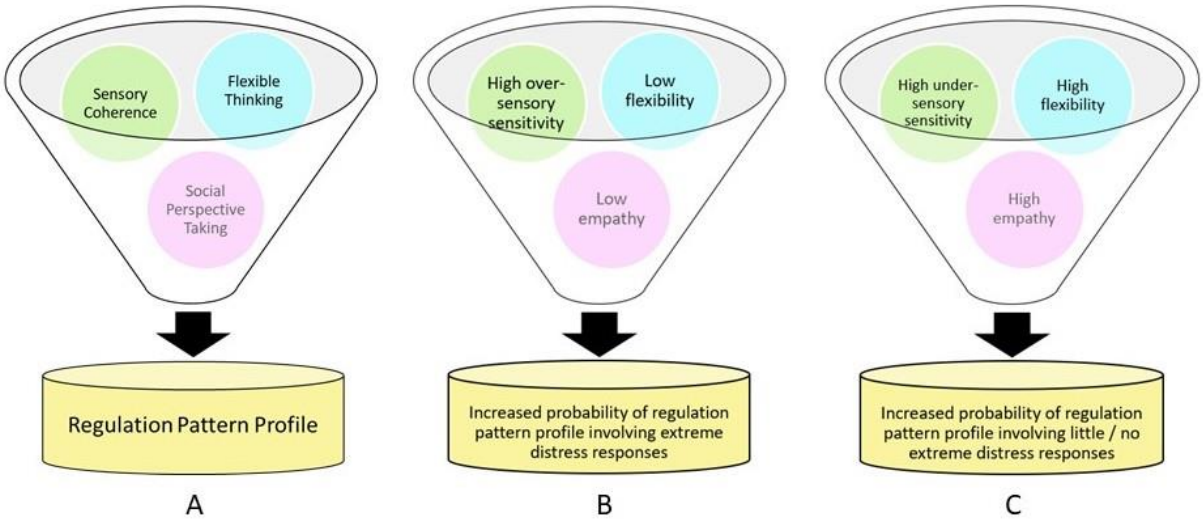

Fig. 3
Graphic representation of research hypotheses

Figure 4 top

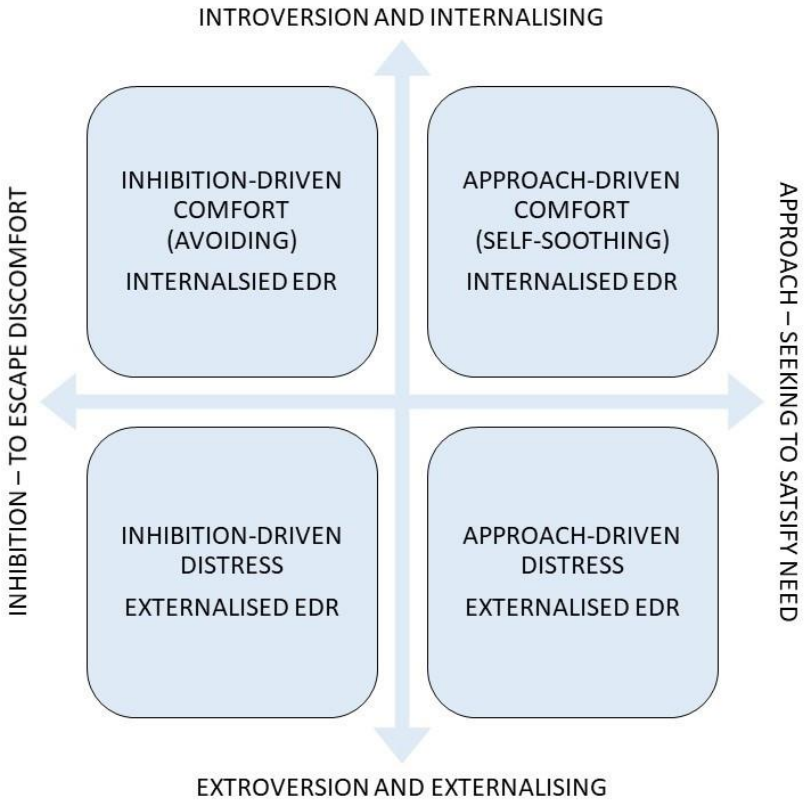

Fig. 4
Sensory coherence and extreme distress responses (EDR)

Figure 5 top

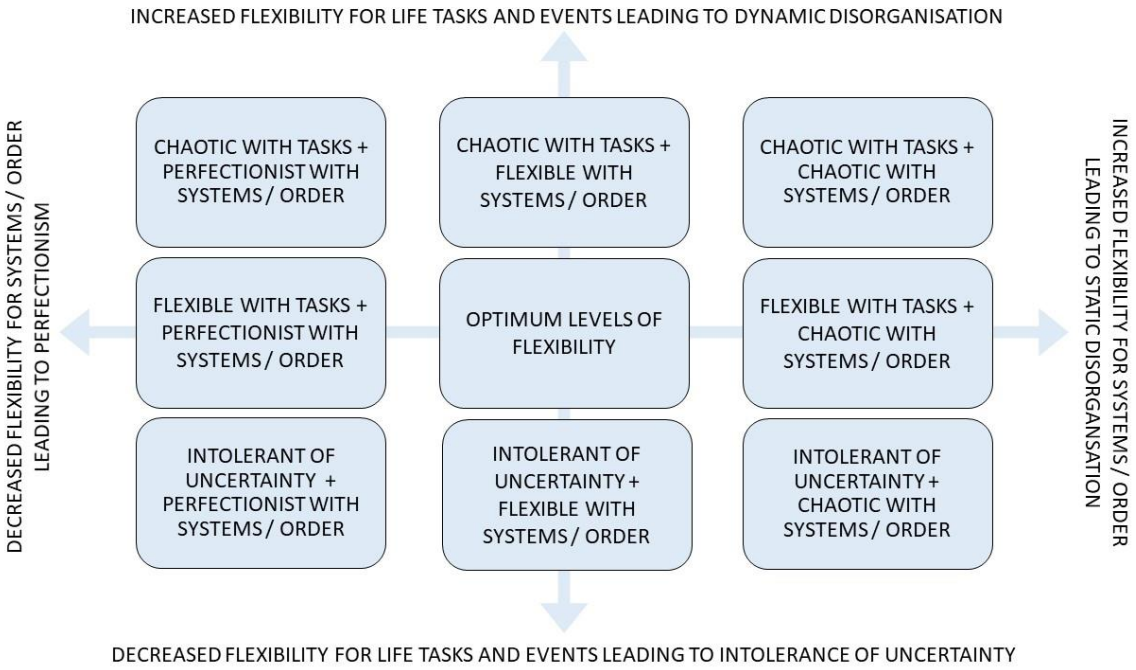

Fig. 5
Systemising and intolerance of uncertainty

Figure 6 top

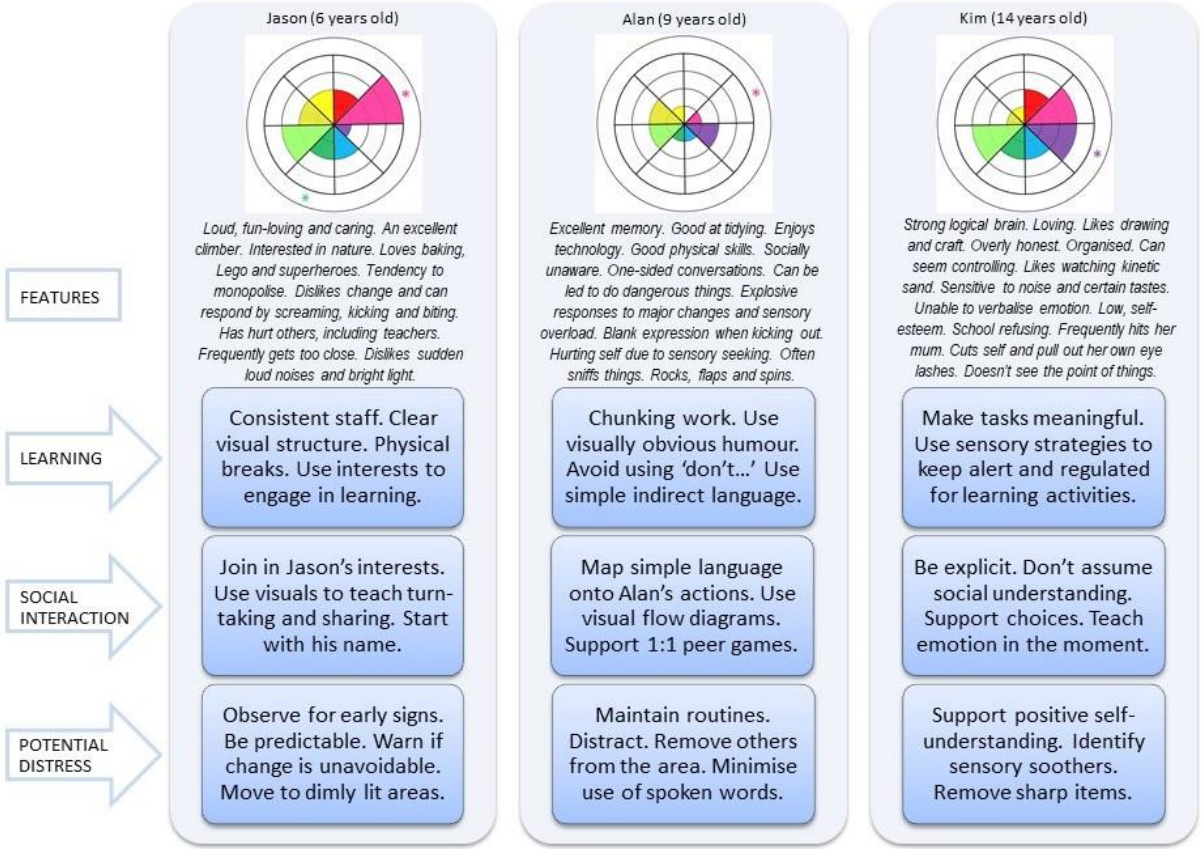

Fig 6.
Clinical examples of Thinking Patterns in Autism (TPA) profiles and matched support (Thinking Patterns in Autism (TPA) Profiling Model digital innovations © D.A.Tollerfield, used with permission to create visual profiles).

Tables

Table 1
Case characteristics as percentage of EDR group and total sample

Characteristic	n (% of EDR group, % of total sample)			Prevalence of EDR (%)
	Significant EDR group	Little / No EDR group	Total Sample	
EDR	56 (100.0, 40.0)	-	56 (40.0)	-
Little / no EDR	-	84 (100.0, 60.0)	84 (60.0)	-
Male	44 (78.6, 31.4)	58 (69.0, 41.4)	102 (72.9)	43.1
Female	12 (21.4, 8.6)	26 (30.1, 18.6)	38 (27.1)	31.6
Co-existing ADHD positive	42 (75.0, 30.0)	42 (50.0, 30.0)	84 (60.0)	50.0
Co-existing ADHD negative	14 (25.0, 10.0)	42 (50.0, 30.0)	56 (40.0)	25.0
4-6 years	6 (10.7, 4.3)	9 (10.7, 6.4)	15 (10.7)	40.0
7-10 years	26 (46.4, 18.6)	37 (44.0, 26.4)	63 (45.0)	41.3
11-13 years	12 (21.4, 8.6)	20 (23.8, 14.3)	32 (22.9)	37.5
14-18 years	12 (21.4, 8.6)	18 (21.4, 12.9)	30 (21.4)	40.0
Parent reported anxiety positive	52 (92.9, 37.1)	62 (73.8 ,44.3)	114 (81.4)	45.6
Parent reported anxiety negative	4 (7.1, 2.9)	22 (26.2, 15.7)	26 (18.6)	18.2
Medicated anxiety positive	9 (16.1, 6.4)	13 (15.5, 9.3)	22 (15.7)	40.9
Medicated anxiety negative	47 (83.9, 33.6)	71 (84.5, 50.7)	118 (84.3)	39.8

Total sample N=140; EDR group n=56; little/no EDR group n=84.
Age range 4-18 years as there were no 19-year-olds in the study period.

Table 2
Descriptive statistics and comparisons between EDR groups for scaled variables

Measure (possible range)	Group (M, SD)			Comparing group means		
	Combined	EDR	Little / No EDR	T	P	Cohen's d
Age in years (4-19)	10.41, 3.35	10.34, 3.19	10.46, 3.47	0.22	.827	0.04
Empathy Quotient (0-54)	19.30, 8.05	15.13, 7.42	22.08, 7.24	5.52	.000	0.95
Systemising Quotient (0-56)	24.85, 8.97	25.54, 8.69	24.39, 9.18	-0.74	.462	-0.13
Extreme demand avoidance (0-78)	38.51, 15.64	48.82, 12.52	31.64, 13.66	-7.54	.000	-1.31
Over-sensory Sensitivities (0-63)	23.74, 10.70	28.46, 11.19	20.58, 9.15	-4.56	.000	-0.78
Under-sensory Sensitivities (0-69)	19.14, 11.87	19.66, 10.93	18.79, 12.51	-0.43	.671	-0.07

Empathy Quotient – higher scores reflect higher empathy skill; Systemising Quotient – higher scores reflect lower flexibility skill; Extreme demand avoidance – higher scores reflect lower flexibility skill; Over-sensory Sensitivities – higher scores reflect lower sensory coherence skill; Under-sensory Sensitivities – higher scores reflect lower sensory coherence skill. Lavene's test for equality of variances showed that SDs were not statistically different from each other for any of the variables in Table 2. Cohen's d is reported for all effect sizes, with negative values indicating higher scores in the EDR group.

Table 3
Testing for multicollinearity

Predictor Variables	Collinearity Statistics		
	Tolerance	Variance Inflation Factor (VIF)	Variance proportions (%)
Empathy Quotient	.742	1.347	58
Systemising Quotient	.826	1.211	4
Extreme Demand Avoidance	.655	1.526	49
Over-sensory Sensitivities	.703	1.422	0
Under-sensory Sensitivities	.862	1.160	3

Dependent variable: EDR. Variance proportions shown for the smallest eigenvalue

Table 4
Logistic regression model predicting probability of EDR (n=140).

Model and predictor variables	*B*	SE	Wald	Df	*P*	Exp(B)	95% CI for Exp(B)	
							Lower	Upper
Null model								
Control model, no variables added	-.405	.173	5.524	1	.019	.667		
Model 1								
Empathy Quotient	-.101	.035	8.231	1	.004	.904	.843	.968
Systemising Quotient	-.005	.027	.031	1	.861	.995	.943	1.050
Extreme demand avoidance	.063	.018	12.874	1	.000	1.066	1.029	1.103
Over-sensory sensitivity	.051	.024	4.569	1	.033	1.052	1.004	1.102

Chi-square value for model 1=60.05, degrees of freedom: df=4, statistical significance: p=.000; Nagelkerke R^2=.471; Hosmer-Lemeshow test chi-square =8.37, degrees of freedom: df=8, significance: p=.399; classification accuracy of model 1 =80.7%; classification accuracy of null model =60.0%.

Table 5
Logistic regression model predicting probability of little or no EDR (n=140).

Model and predictor variables	*B*	SE	Wald	Df	*P*	Exp(B)	95% CI for Exp(B)	
							Lower	Upper
Null model								
Control model, no variables added	-.405	.173	5.524	1	.019	1.500		
Model 2								
Empathy Quotient	.102	.035	8.493	1	.004	1.107	1.034	1.186
Systemising Quotient	-.018	.026	.467	1	.495	.982	.934	1.034
Extreme demand avoidance	-.084	.018	20.629	1	.000	.920	.887	.953
Under-sensory sensitivity	.036	.019	3.588	1	.058	1.037	.999	1.076

Chi-square value for model 2 =58.88, degrees of freedom: df=4, statistical significance: p=.000; Nagelkerke R^2=.464; Hosmer-Lemeshow test chi-square =2.71, degrees of freedom: df=8, significance: p=.951; classification accuracy of model 2 =80.7%, classification accuracy of null model =60.

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The authors would like to acknowledge the families who attended the diagnostic assessment service, and to thank Dr Oliver Clark, Dissertation Supervisor, Manchester Metropolitan University; Prof Taj Nathan (Director of Research and Effectiveness), Prof Sujeet Jaydeokar and Dr Matthew Howard (Clinical Directors), Dr Ian Davidson (Consultant Psychiatrist and Royal College of Psychiatrists Autism Champion) and Dr Phil Elliott (Senior Research Facilitator), all at Cheshire and Wirral Partnership NHS Foundation Trust. The authors would also like to thank West Cheshire Clinical Commissioning Group for the £1,000 bursary which was awarded. The authors would like to thank Heather Pearce (Advanced Specialist Speech and Language Therapist) for help with data collation and coding reliability, as well as invaluable feedback on the clinical utility of the model. We also thank the anonymous reviewer for their careful reading of our manuscript and their insightful and extremely constructive comments. Finally, thank you to Mr David Tollerfield for permission to use the Thinking Patterns in Autism (TPA) Profiling Model digital innovations.

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