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A mixed-methods investigation into the role of sensory, social and emotional factors in the overlap between autism and anorexia nervosa

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Thesis submitted for degree of Doctor of Philosophy (PhD)

2023

Thesis declaration

I, Emily Nimbley, confirm that the following thesis is my own work, and that the thesis has not been submitted for any other degree of professional qualification. I confirm that any included publications are my own work and co-authorship is declared and specified where relevant.

Signature:

Date: 06/10/2023

Acknowledgements

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Abstract

Background: It is estimated that around a third of individuals with anorexia nervosa (AN) are Autistic. Despite this elevated prevalence, underlying mechanisms of this overlap remain poorly understood, with early work implicating a range of factors including sensory, social and emotional factors. Autistic individuals with AN have been reported to have poorer eating disorder (ED) treatment outcomes and experiences compared to their non-Autistic peers, such as longer and more frequent inpatient stays, more severe ED symptomology and a greater detriment to psychosocial functioning. Therefore, to provide more effective support, it is imperative to identify underlying factors. The current thesis aims are to explore the possible role of sensory, social and emotional factors in autism and AN, seeking to identify both shared and autism-specific differences that may help untangle the overlap between the two.

Methods: Adopting a mixed-methods approach, the current thesis draws on several methodologies to address overarching thesis aims. Firstly, a systematic review was conducted to explore the relationship between sensory processing and eating behaviours in autism across the lifespan. Secondly, a qualitative study was conducted to explore experiences of sensory and social factors with Autistic and non-Autistic adults and their parents. Finally, an observational study was conducted to explore group differences in non-verbal social communication behaviours, as well as to explore the relationship between non-verbal behaviours and sensory and emotional factors.

Results: Thesis findings suggest that investigated factors play an important yet inter-twined role in the overlap between autism and AN. Sensory processing was found to be play an important role in Autistic experiences of AN, with tentative evidence to suggest that sensory differences may be integral in discriminating between Autistic and non-Autistic individuals. Key differences in social interactions and communication were also identified in the qualitative study, however this was not supported by quantitative findings. Finally, emotional difficulties, particularly alexithymia (being able to identify and describe your own emotions) were found to play an important role in experiences of AN and were tentatively linked with sensory and social factors.

Discussion: Results from the current thesis tentatively highlight targets for future ED interventions, as well the need to acknowledge and adapt for the heterogenous Autistic experience. Not only could this involve modifying current ED interventions, but it also could involve the development of novel, neurodiverse-affirming approaches. Future research should continue to adopt a mixed-method approach and extend research focus to a broader range of ED diagnoses. Such research studies should include participatory approaches, from the designing of studies to the active role of those with lived/living experience in conducting the research, thereby ensuring that future research reflects the priorities and realities of Autistic individuals with EDs.

Lay summary

Around a third of people with AN may be Autistic. Autistic individuals with AN have been found to face poorer treatment outcomes and experiences, using a broader range of more intensive services more frequently than their non-Autistic peers. It has also been suggested that Autistic individuals with AN report higher eating disorder (ED) severity and rates of mental health difficulties such as depression, anxiety and OCD. It is therefore clear that current ED interventions fail to meet the unique needs and experience of Autistic individuals, and it is essential that we develop more effective ED interventions for Autistic individuals. To do this, we must further understand possible shared and autism-specific factors, such as behaviours, thinking styles or internal processes such as sensory differences. Recent models highlight a broad range of factors implicated in the overlap between autism and AN, with general consensus that sensory, social and emotional factors are of key concern.

Accordingly, the overall aim of this thesis is to explore the possible role of sensory, social and emotional factors in autism and AN, seeking to identify both shared and autism-specific differences that may help to untangle the overlap between the two conditions. Initially, a systematic review was conducted to establish the relationship between sensory processing and eating behaviours in autism. This was then followed by an in-depth interview study further exploring sensory, social and emotional factors, and a study that observed behaviours during a social interaction in order to investigate differences in non-verbal social communication and their possible relationship with sensory and emotional factors.

Thesis findings suggest that all factors play an important yet inter-twined role in the overlap between autism and AN. Sensory processing was found to be play an important role in Autistic experiences of AN, with tentative evidence to suggest that sensory differences may be integral is discriminating between Autistic and non-Autistic individuals with AN. Key differences in social interactions and communication were also identified in qualitative analyses, however this was not supported by behavioural coding findings. Finally, emotional difficulties, particularly being able to identify and describe your own emotions, were found to be play an important role, and were linked with sensory and social factors.

Results highlight several possible targets for ED interventions in both Autistic and non-Autistic individuals. Future treatments could modify current interventions to account for sensory, social and emotional factors, but they could also involve the development of new treatments in collaboration with Autistic individuals themselves. Future research should continue to collect both measurable and lived experience data and consider other ED diagnoses. Such research should also draw on participatory approaches, including Autistic individuals with EDs as active members of in the research team and not just as participants.

List of common abbreviations

ADHD	Attention Deficit Hyperactivity Disorder
ADOS	Autism Diagnostic Observation Schedule
AN	Anorexia Nervosa
AN-P	Anorexia Nervosa – Purging type
AN-R	Anorexia Nervosa – Restrictive type
APA	American Psychological Association
ARFID	Avoidance and Restrictive Feeding Intake Disorder
ASD	Autism Spectrum Disorder
BED	Binge Eating Disorder
BMI	Body Mass Index
BN	Bulimia Nervosa
CAMHS	Child and Adolescent Mental Health Services
CBT-E	Enhanced Cognitive Behavioural Therapy
DD	Developmental Delay
DSM-5	Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition
ED	Eating Disorder(s)
EDE-Q (6.0)	Eating Disorder Examination Questionnaire, Sixth Edition
EDI	Eating Disorder Inventory
FBT	Family-Based Treatment
GI	Gastrointestinal
HADS	Hospital Anxiety and Depression Scale
ID	Intellectual Disabilities
IPA	Interpretative Phenomenological Analysis
ISQ	Interoceptive Questionnaire
ISQ-8	Interoceptive Questionnaire – 8-item version
MANTRA	Maudsley Model of Anorexia Nervosa
NHS	National Health Service
NICE	National Institute for Clinical Excellence
NIH	The National Institutes of Health
NIHR	National Institute for Health and Care Research
NT/HC	Neurotypical/Healthy Controls
OCD	Obsessive Compulsive Disorder

OSFED	Other Specified Feeding or Eating Disorder
PRISMA	Preferring Reporting Items for Systematic Reviews and Meta-Analyses
RED	Restrictive Eating Disorder
SCDC	Social and Communication Disorders Checklist
SIGN	Scottish Intercollegiate Guidelines Network
SIT	Sensory Integration Theory
SRS-2	Social Responsiveness Scale, Second Edition
SWEAA	Swedish Eating Assessment for Autism spectrum disorders
TAS-20	Toronto Alexithymia Scale
TS	Tourette's syndrome
WASI-II	Weschler Abbreviated Scale of Intelligence, Second Edition

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Dissemination of research

Publications included in thesis:

Nimbley, E., Golds, L, Sharpe, H., Gillespie-Smith, K., & Duffy, F. (2022). Sensory processing and eating behaviours in autism: A systematic review. *European Eating Disorders Review, 30*(5), 538-559.

Nimbley, E., Gillespie-Smith, K., Duffy, F., Maloney, E., Ballantyne, C., & Sharpe, H. (2023). "It's not about wanting to be thin or look small, it's about the way it feels": an IPA analysis of social and sensory differences in Autistic and non-Autistic individuals with anorexia and their parents. *Journal of Eating Disorders, 11*(8), https://doi.org/10.1186/s40337-023-00813-z

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Gillies-Walker, L., Ramzan, N., Rankin, J., Nimbley, E., & Gillespie-Smith, K. (2022). "You Feel Like You Kind of Walk Between the Two Worlds": A participatory study exploring how technology can support emotion regulation for Autistic People. *Journal of Autism and Developmental Disorder.* Available at: https://doi.org/10.1007/s10803-021-05392-z

Golds, L., Nimbley E., MacBeth, A., & Gillespie-Smith, K. (2022). What factors influence dyadic synchrony? A systematic review of the literature on predictors of infant-mother dyadic processes of shared behaviour and effect. *Infant Mental health, in print.*

Manuscripts currently under review:

Arcari Mari, A, P., Nimbley, E., McConachie, D., Goodall, K., & Gillespie-Smith, K. (2023). Understanding the neurodiversity of grief: a systematic literature review of experiences of grief and loss in the context neurodevelopmental disorders. Manuscript submitted for publication.

Conference presentations associated with the thesis:

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Nimbley, E. (June 2022). *Social and sensory differences in Autistic and non-Autistic adults with anorexia and their parents.* [Paper presentation]. Neurodevelopmental Annual Seminar Series, Edinburgh, UK.

Nimbley, E. (July 2022). *Social and sensory differences in Autistic and non-Autistic adults with anorexia and their parents.* [Paper presentation] AND *Sensory processing and eating behaviours in autism: A systematic review.* Autistica, online.

Nimbley, E. (June 2023). *"It's not about wanting to be thin, it's about the way it feels": An IPA analysis of social and sensory differences in Autistic and non-Autistic adults with anorexia and their parents.* [Poster presentation]. International Conference of Eating Disorders, Washington D.C., USA.

Non-academic dissemination:

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Murphy, B., O'Connor, J., & Nimbley, E. (Hosts). (2022, August 9). Sensory processing, eating behaviours and autism (Episode 6) [Audio podcast episode] in *The BodyWhys podcast*. BodyWhys – The Eating Disorder Association of Ireland.

Statement of work

Chapter 1: Thesis framework

This chapter is the candidate's own work. The candidate received feedback from Dr Fiona Duffy and Dr Karri Gillespie-Smith.

Chapter 2: Introduction

This chapter is the candidate's own work. The candidate received feedback from Dr Helen Sharpe and Dr Fiona Duffy.

Chapter 3: Sensory processing and eating behaviours in autism: A systematic review

The candidate was the lead researcher in the systematic review. The second author, Lisa Golds, was a second reviewer during the screening and quality assessment stages. All other authors – Dr Karri Gillespie-Smith, Dr Helen Sharpe and Dr Fiona Duffy, provided feedback on the manuscript prior to feedback, as well as during the peer review process.

Chapter 4: "It's not about wanting to be thin or look small, it's about the way it feels": an IPA analysis of social and sensory differences in Autistic and non-Autistic individuals with anorexia and their parents

The candidate collected and analysed the data. The second author, Ellen Maloney, was involved with the development of the interview schedule, recruitment and in the data analysis. Dr Carrie Ballentyne, Dr Karri Gillespie-Smith, Dr Helen Sharpe and Dr Fiona Duffy, provided feedback on the manuscript prior to feedback, as well as during the peer review process.

Chapter 5: Observational Study Methods

This chapter is the candidates own work. This chapter was reviewed, and feedback was provided by Dr Karri Gillespie-Smith and Dr Helen Sharpe.

Chapter 6: Non-verbal social communication behaviours in Autistic and non-Autistic young adults with AN

The candidate was the lead researcher on the study outlined in Chapter 6. The candidate collected and analysed the data and wrote up the manuscript that is included in this chapter. Karri Gillespie-Smith gave guidance during the IRAS ethics process, as well as being present at the REC review. Feedback on Chapter 6 was provided by Dr Karri Gillespie-Smith and Dr Helen Sharpe.

Chapter 7: The relationship between non-verbal social communication behaviours and sensory, social and emotional factors in Autistic and non-Autistic young adults with AN

The candidate was the lead researcher on the study outlined in Chapter 7. The candidate collected the data, as per Chapter 6, conducted data analysis and wrote up the manuscript that is included in this chapter. Feedback on Chapter 7 was provided by Dr Karri Gillespie-Smith and Dr Fiona Duffy.

Chapter 8: Discussion

This chapter is the candidates own work. Feedback was provided by Dr Karri Gillespie-Smith and Dr Fiona Duffy.

Structure of the thesis

Chapter 1 provides an overview of the thesis framework, advocating for three key principles; firstly, that all research into the overlap between autism and EDs should operate under a neurodiverse-affirming approach; secondly, that research should be conducted by and with those with lived/living experience (participatory approaches); and thirdly, that language should be carefully considered and influenced by those with such experience.

Chapter 2 introduces the reader to the key concepts of the thesis. This chapter provides an overview to anorexia nervosa (AN) and autism and the overlap between the two conditions, before reviewing proposed sensory, social and emotional mechanisms.

Chapter 3 is a systematic review exploring the evidence base for the relationship between sensory processing and eating behaviours in Autistic individuals across the lifespan. This chapter reports the manuscript as accepted for publication:

Nimbley, E., Golds, L., Sharpe, H., Gillespie-Smith, K., & Duffy, F. (2022). Sensory processing and eating behaviours in autism: A systematic review. *European Eating Disorders Review, 30*(5), 538-559.

Chapter 4 is a qualitative study exploring the role of social and sensory factors in experiences of AN in Autistic and non-Autistic adults and their parents. This chapter reports the manuscript as accepted for publication:

Nimbley, E., Gillespie-Smith, K., Duffy, F., Maloney, E., Ballantyne, C., & Sharpe, H. (2023). "It's not about wanting to be thin or look small, it's about the way it feels": an IPA analysis of social and sensory differences in Autistic and non-Autistic individuals with anorexia and their parents. *Journal of Eating Disorders, 11*(8), https://doi.org/10.1186/s40337-023-00813-z

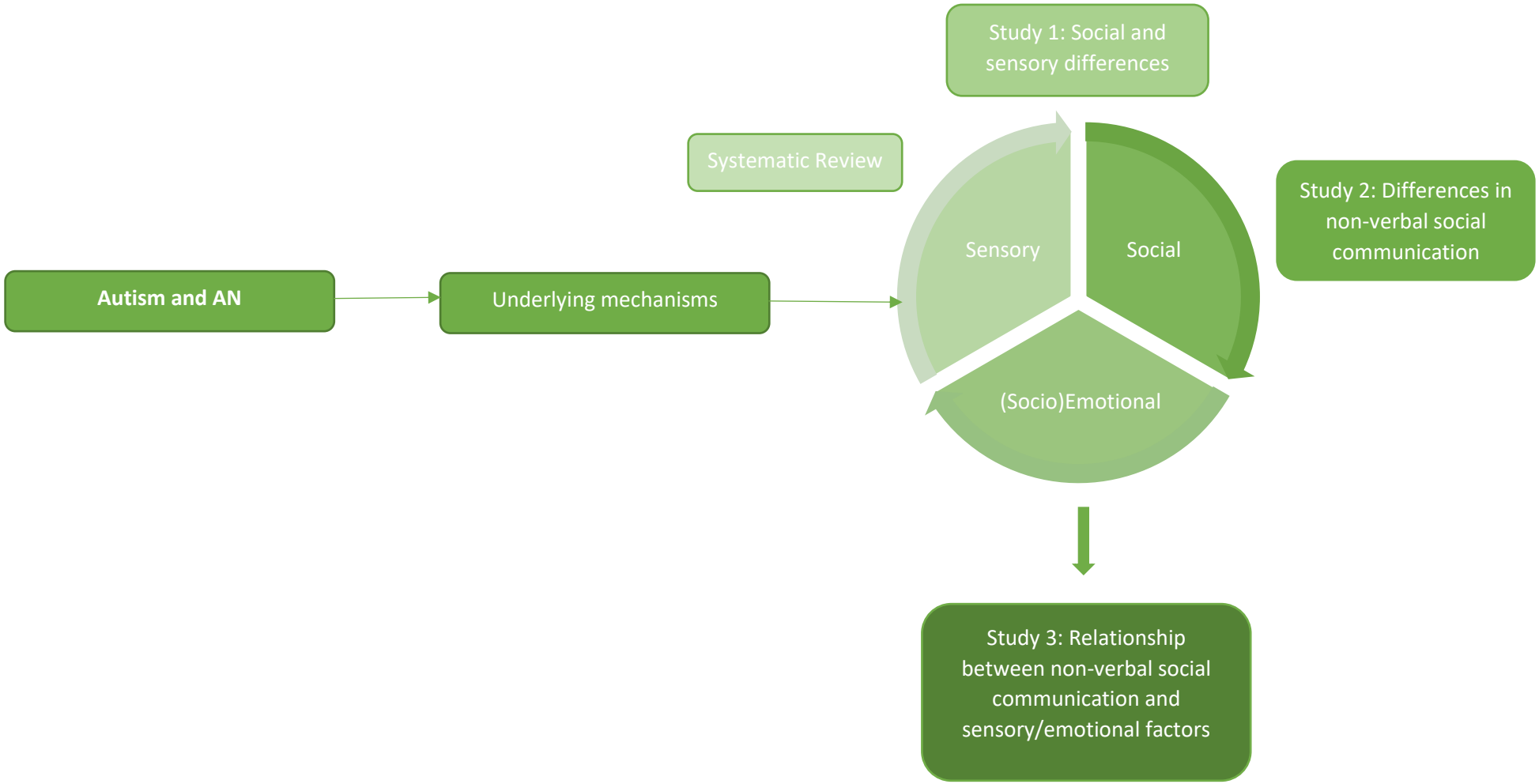
Chapter 5 outlines the methodology used in the studies reported in the Chapter 6 and 7.

Chapter 6 presents empirical data exploring possible differences in non-verbal social communication behaviours in autism and AN, as well as the possible role of emotion through a series of experimental conditions.

Chapter 7 presents empirical data exploring associations between non-verbal social communication behaviours and sensory (interoception) and emotional (alexithymia) factors, as well as depression and anxiety in autism and AN.

Chapter 8 provides a general discussion of key thesis findings and how these can be synthesised with existing literature. Clinical implications of thesis findings are discussed and directions for future research are suggested.

Figure 1. Thesis map



Chapter 1 – Thesis framework

The following section will outline the over-arching thesis framework. It is important to highlight this from the outset, as it has been fundamental in the conceptualisation, development and implementation of all stages of the thesis. The current thesis advocates for three key principles: firstly, that research should operate under a neurodiversity approach; secondly, that research should be conducted by and with those with lived/living experience; and thirdly, that language should be carefully considered and influenced by those with lived/living experience.

Neurodiversity

The last few decades have seen significant social and cultural shifts in discourse surrounding autism research, theory and practice. In the 1990's, a growing number of Autistic self-advocacy and Autistic rights groups asserted that autism is an identity and a culture (Leadbitter et al, 2021). From this environment emerged the Neurodiversity movement, a social view that opposes traditional medical approaches that conceptualised autism as a disease or disorder (Singer, 1998). The Neurodiversity movement advocates that neurological development and function varies across all humans and is a fundamental concept of diversity (Singer, 2017), thus conceptualising autism as reflecting differences and diversity as opposed to reflecting deficits or abnormalities.

Neurodiversity refers to a broad range of conditions and perspectives, such as ADHD and autism, that are posited to be caused by brain structural and functional variations leading to certain behaviours and cognitions (Baron-Cohen, 2017). Importantly, it is emphasised that such differences can confer both advantages and disadvantages, depending on the circumstances (Sonuga-Barker & Thapar, 2021). Falling under the umbrella of the movement are several different terms, including using terms such as 'neurodivergent' for individuals, and 'neurodiverse' populations of both neurodivergent and neurotypical individuals (Shaw, McCowan, Doherty, Grosjean & Kinnear, 2021).

Drawing on a neurodiversity framework has widespread implications for autism research. Within the context of the current thesis, there are three key areas that this has influenced: (1) the importance of Autistic voices and perspectives, both as participants and as active collaborators and co-producers in the research process (see Section 2.3); (2) the importance

of language and involving the Autistic community is this discourse (see Section 2.4); and (3) the importance of approaching research topics, such as social communication, in neurodiverse-affirming ways, highlighting diversity and difference in communication as opposed to deficits (see Study 2 and 3).

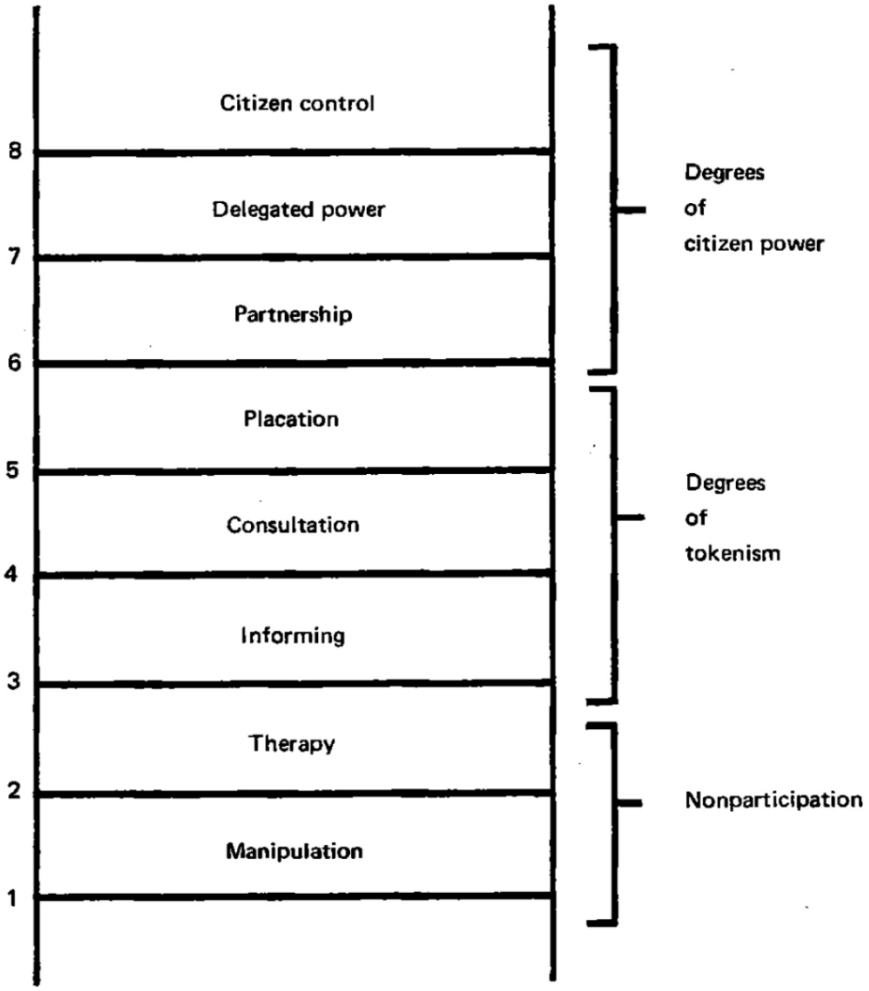
Participatory research

Including the voices of those with lived/living experience in research has been increasingly emphasised in recent years. While conducting qualitative research that explores lived/living perspectives of participants is vital in providing person-centred experiences (see Chapter 4), the focus of this section will be discussing the importance of including those lived/living experience as active collaborators in policy, practice and predominantly research processes. Participatory research can take many forms, often taking place during the preparation stage of the research process by including lived/living experience perspectives in steering committees or in a consultation role during the development of research projects. Recently, a more integrated approach has been encouraged, promoting research that is informed, consulted, collaborated, and controlled by those with lived/living experience, throughout the entire research process. Thus, the current thesis aligns with participatory research defined as the inclusion of lived/living experience views in what research gets done, how it is done and how it is shared (Cornwall and Jewkes, 1995; Levine and Piran, 2001).

Early conceptualisations of these approaches can be seen in Arnstein's (1969) ladder of citizenship empowerment, which describes how power is denied to citizens and how levels of agency, control and power can be promoted (see Figure 1). The bottom 'rungs' show non-participation, such as manipulation (such as involving citizens in advisory roles that give them the illusion of participation). Moving up the ladder, several 'rungs' show what is termed the degrees of tokenism, including simply informing participants of their rights, with no channel for feedback or negotiation, as well as consultation without assurance of incorporating voiced concerns or perspectives. At the top of the ladder, Arnstein proposes three clear areas of giving citizen's power: partnership, delegated power and citizen control (Arnstein, 1969).

Figure 2.

Arnstein's (1969) ladder of citizen participation. From Arnstein, S. (1969.) A ladder of citizen participation. Journal of the American Planning Association, 35(4), 216–224.



There are several limitations to the model that should be highlighted, warranting caution of its direct application of participatory research designs. Firstly, the model is conceptualised as being linear and hierarchal, and such models fail to account for the complex and fluctuating dynamics that are inherent to citizen engagement. Secondly, the ladder analogy has connotations that lower 'rungs' in the ladder are negative and higher 'rungs' are more positive. While this could be the case in terms if you are only incorporating lower 'rungs' into your practice, this does not mean that instances of consultation, for example, do not

have their place in the overarching engagement process. Finally, this is a simple and widely applicable tool that can (and should) be modified, and thus it should not be blindly applied to the current context of participatory research designs with those with lived/living experience. Regardless however, Arnstein's (1969) ladder offers a simple conceptual tool in participatory designs and offers an intuitive foundation for such approaches.

Perhaps more applicable to the current thesis are approaches that focus on improving participatory research more specifically. The INVOLVE Advisory Group (2018), associated with the National Institute for Health and Care Research (NIHR), outline five key principles; (1) sharing power, specifying that the research is jointly owned and people work together to achieve a shared understanding; (2) including a diverse range of perspectives and skills, particularly those from underrepresented groups to ensure that all those who can are able to contribute; (3) respecting and valuing all contributors, emphasising that everyone is of equal importance; (4) reciprocity and ensuring that everyone involved benefits from working together; and (5) building and maintaining relationships (NIHR, 2021). Another relevant example of this is Simmons & Robertson's (2014) paper outlining how to strengthen participatory research to involve children and young people with disabilities in advocacy. They conceptualise participation as involving children and young people in the decision-making process which affect their lives and the lives of their community. Authors say that this can occur at: an individual level, such as influencing their daily living; a structural level, such as within education and community services; and a systemic level, such as influencing policy. At the core of participatory approaches is an acknowledgement that individuals have a contribution to make, that their capability should be recognised and developed, and that there is a culture of valued participation in receipt of these contributions. Collectively, such approaches will lead to empowerment, citizenship and improved relationships (Simmons & Robertson, 2014).

Therefore, for the purposes of the current thesis, meaningful participatory research is conceptualised as *a shared culture of power and citizenship, embedded across multiple contexts and promoting the active involvement of underrepresented communities in all stages of the decision-making process.*

Participatory approaches in eating disorders

Within the eating disorder (ED) field, the importance of collaborating with lived/living experience perspectives has been advocated for across policy, practice and research contexts. A number of mental health policy initiatives within the UK have advocated for participatory approaches, often referred to as co-production (e.g., NHS England, 2019), with a recent Scottish Eating Disorder Services Review strongly recommending the utility of and access to co-produced initiatives (Scottish Government, 2021). For example, involving lived/living experience in ED interventions across different stages has been reported to confer significant treatment benefits, from improved motivation and engagement with treatment to the co-design of ED treatments and initiatives (Fogarty et al, 2016). A recent systematic review highlighted that the role of lived/living experience in ED interventions exists on a spectrum, ranging from passive and isolated roles, such as blog posts or videos, to more continuous and active roles, such as peer mentoring programmes (Lewis & Foye, 2022). An important benefit of these roles is that they can offer support that caters outside more targeted clinical practice, such as dealing with emotions and overall quality of life (Ranzenhofer et al, 2020), as well as sharing in and validating their experience (Lewis & Foye, 2022).

While the whole spectrum of involvement is vital to generating outcomes that are centred in lived/living experiences, it is the more active roles that are gaining increasing attention in ED research contexts. While several different terms are used throughout the literature, the current thesis has used and will continue to use the over-arching principle of *participatory research*. Within these designs are a number of different ways that lived/living experiences can be utilised in research. For example, this can refer to the *co-production* of research, including elements of study design and study delivery, as well *co-interpretation* of research data and *co-dissemination* of findings (Music et al, 2021). It has been noted that failing to include lived/living experience in research can limit our understandings across eating disorder trajectories, including treatment efficacy (Pellizzer & Wade, 2023; Heafala, Mitchell & Ball, 2022) and definitions of recovery (Hower et al, 2022; Kenny et al, 2022).

Despite the clear importance for participatory approaches in ED research, it is worth noting the challenges or concerns that can arise. These can include tension, significant delays to

the research process, and a lack of clear consensus on how to define participatory research, leading to different and perhaps conflicting expectations (Oliver, Kathari & Mays, 2019). Furthermore, there may be discrepancies in what to research, what the research shows or what to do with the research, leading to difficulties in ensuring all stakeholders' priorities are being met. However, clear definitions and communication from the outset of the process are likely to produce benefits that outweigh the negatives. For example, conducting participatory research involving lived/living experience as active collaborators can confer significant bi-directional benefits between the researcher and the individual with lived/living experience, leading to an increased sense of agency, validation and empowerment (Music et al, 2021). Simultaneously, participatory research approaches generate research that more accurately reflects the reality of ED experiences and fosters a sense of trust between researchers and the ED community (Music et al, 2021).

Participatory approaches in autism

Participatory approaches have also been increasingly encouraged in the autism field. With regards to policy and practice, the Scottish Strategy for Autism (2011) included a participatory approach through involving Autistic people, their families and their carers in decision-making and service planning. Ten years later, an evaluation of the strategy outlined some of approaches adopted within the strategy, reflecting a predominantly consultatory role across practice, legislative and policy issues (Scottish Government, 2021). Furthermore, the inclusion of Autistic individuals in various advisory or steering groups has been implemented in leading charities and organisations across the UK, such as Scottish Autism (https://www.scottishautism.org/), Ambitious about Autism (https://www.ambitiousaboutautism.org.uk/) and Inspiring Scotland (https://www.inspiringscotland.org.uk/). Participatory approaches have also been utilised in service provision; for example, a recent paper reflected on using co-production methods to adapt psychological therapies to support mental health needs within Autistic populations (Stark et al, 2021).

An important consideration of the above examples is that Autistic people were recruited within a consultatory capacity. While this is an important part of participatory research approaches, it is also important to involve Autistic people within a collaborative capacity.

This nuance has been at the forefront of debates across autism research. Leading advocates for participatory approaches have argued that despite the 'boom' in autism research that has emerged in the past decade, findings remain poorly implemented into public and professional services (Pellicano et al, 2013). Thus, it appears there is a lack of empirical evidence to support the translation of this notable increase in research into improved care and support for Autistic people. One explanation that has been proposed for this is a general lack of Autistic voices in autism research (e.g., Gowen et al, 2019). Participatory research has been proposed as a means through which autism research can make meaningful contributions to the lives of Autistic people, shifting from research being conducted *on* Autistic people to being conducted *with* or *by* Autistic people (Milton & MacLean, 2013). This also helps to address a fundamental component of participatory research approaches, through its acknowledgement of the power imbalance between researcher and participant and by seeking to achieve devolved power (Arnstein, 1969; Pickard et al, 2021). Effective participatory approaches involve not only consultation with the community, but also engagement with Autistic people and leadership by Autistic researchers (Fletcher-Watson et al, 2019; Nicoalidis et al, 2019; Pellicano et al, 2017). They also involve including Autistic people across all stages of the research process, from identifying research questions, study design, data collection and analysis, and disseminating study findings (Keating, 2021).

Active involvement of Autistic people in autism research ensures that research yields relevant and translatable benefits by placing Autistic people at the forefront of autism research (Long et al, 2017). However, despite such clear benefits, participatory approaches within autism research are not commonly adopted. It has been suggested that this is perhaps due to concerns from autism researchers about factors such as methodological rigour, practical considerations (such as funding and limited timelines) or a lack of clear guidelines on facilitating effective communication (Pickard et al, 2021). Moving forward, it is vital for autism researchers to adopt participatory approaches across the research process, all the while producing clear, instructive guidelines of their process along the way.

Participatory approaches in autism and EDs

There is tentative but encouraging evidence that participatory approaches are being conducted in clinical and research practice exploring the overlap between autism and EDs. For example, the development and implementation of the PEACE Pathway, a clinical care pathway developed specifically for Autistic people with anorexia nervosa (AN), involved lived/living experience perspectives at several stages, including priority setting, environmental modifications to the wards, and the development of specialised menus and autism-friendly psychoeducation materials (Tchanturia, Smith, Glennon & Burhouse, 2020). Examples are also emerging from research too; for example, Nimbley et al (2023a) conducted an interpretative phenomenological analysis (IPA; Smith, Flowers & Larkin, 2004) using a data triangulation approach with an Autistic researcher with lived/living experience of anorexia nervosa, providing guidelines for approach at each step of the IPA process (see Chapter 4).

A recent paper outlined the need for autism-led research within the ED field, focusing on the importance of including Autistic lived/living experience in defining and conceptualising recovery from an ED (Nimbley, Maloney & Duffy, 2023). This commentary makes several suggestions on how including autism-led, participatory approaches can led to improvements in recovery research, as well as clearly highlighting the multi-faceted benefits that such approaches can bring, such as establishing clearer, autism-centred treatment goals, and fostering trust and communication between researchers, clinicians and the lived/living experience community (Nimbley et al, 2023a). It is hoped that future research will continue to apply and develop participatory research approaches, including Autistic voices with lived/living experience of EDs in studies across ED trajectories.

Participatory research in the current thesis

The current thesis therefore sought to adopt participatory research approaches throughout the project, here defined as: *a shared culture of power and citizenship, embedded across multiple contexts and promoting the active involvement of communities in all stages of the decision-making process.* Participatory research approaches were applied through involving lived/living experience perspectives not only as participants but also in the co-production, co-interpretation and co-dissemination of research, although it should be noted that there

were certain limitations associated with the nature, resources and timeframe of the thesis that led to key missing elements. A full discussion and personal reflection on this process can be found in Chapter 8, Section 8.6.

An Autistic researcher with lived/living experience of AN (EM) was involved across the project. Initially, EM reviewed early protocols and provided guidance at the start of the project on language and terminology. For study 1, presented in Chapter 4, EM was involved in the development of early research proposals and active recruitment. EM was also involved in the data analysis, providing a data triangulation perspective during theme development (see Chapter 4 for further details). For study 2 and 3, presented in Chapters 6 and 7 respectively, EM was involved the co-design stage, including the development of research proposals, providing valuable insights into appropriate methodologies (e.g., measures used) and environmental considerations (e.g., conditions of the observation room). EM was also an active member in recruitment and will also be involved in the dissemination of study findings to the Autistic community (the co-dissemination stage). Of note, EM was not able to be involved in co-production stage of the research due to being involved in the development of the research protocol (see Chapter 8, Section 8.6 for reflections on this).

Language

Language is a fundamental and powerful tool of communication and expression. It has the power to both harm and heal, and to shape people, societies and cultures. It is therefore of the utmost importance that we carefully consider our use of language to ensure that the terms used are sensitive and respectful to the populations that we are working with. The following section will discuss the importance of language in EDs and in autism, seeking to provide a clear rationale for the terms used in the current thesis.

Language in EDs

The language and terms used in ED discourse warrants careful consideration. To facilitate communication across clinical, research and community contexts, editors from the International Journal of Eating Disorders published an article outlining a series of terms to

avoid, clarify and reconsider (Weissman et al, 2016). This paper suggested avoiding terms such as 'anorexic' or 'bulimic' due to implications that the person is defined by their ED, as well as reconsidering emotive terms such as 'sufferer' or 'struggling with an eating disorder'. Authors also suggested that clinical terms, such as 'anorexia nervosa', should be used when referring to the presence of an ED, while 'anorexia' only should be used when referring to the specific symptom of loss of appetite. Accordingly, the current thesis will use anorexia nervosa, or AN once this has been suitably abbreviated. Attempts will be made throughout to avoid any further terms that conflates the identity of the individual with the ED or places any onus of blame on the individual. An example of this is avoiding the use of terms such as 'treatment resistant' and instead providing specific examples of their challenges engaging with treatment. Emotive terms such as 'sufferer' and 'survivor' will be avoided, unless such terms come from participants themselves. There has also recently been notable backlash against the term 'terminal anorexia nervosa' as well as 'severe and enduring anorexia', with strong opposition to both the terms themselves and to their clinical application (Guarda, Hanson, Mehler & Westmoreland, 2022; Elywn, 2023; Hay & Touyz, 2018).

An important caveat to making suggestions for language use is the fact that different people may prefer different terms. The above terms were decided based on suggestions by Weissman et al (2016), following consultation with the lived/living experience researcher involved in the project and through discussions with participants. To our knowledge, no study to date has conducted research with the ED community to explore their preferences, and future studies should consider drawing on this to provide further guidance to ED clinicians, researchers and policy makers.

Language in autism

Use of language has been a source of debate amongst autism literature over the past decade or so. Historically, the term autism has been conceptualised through a medical model, with clinicians and researchers seeking to understand 'abnormalities' with a view to 'fix' or 'cure' them. This medicalised approach has increasingly been challenged as an ableist perspective, leading to the discrimination, objectification and stigmatization of Autistic people (Botha & Cage, 2022). A current example of this is the use of 'profound autism'. Some argue that such terns are limited and dehumanizing to Autistic people (Natri et al,

2023), while other suggest that there remains a need for certain medicalised terms in order to advance clinical and research practice (Singer et al, 2022). Neurodiversity and Autistic rights movements lead the opposition of such terms, positioning autism as a heterogenous condition that reflect an interplay between difference and identity (Kapp et al, 2013; Leadbitter et al 2021). These diverging approaches have given rise to a debate concerning language use, with medicalised approaches often using person-first (e.g., child with autism) and deficit-based (e.g., impairment) language, while neurodiversity and Autistic rights approaches advocating for identity-first (e.g., Autistic) and difference-based (e.g., communication differences) language.

An important consequence of this deficit versus difference debate is the increasing acknowledgement that the preferences of the Autistic community should be at the heart of language use in autism research and practice. Subsequent research has sought to elicit these perspectives. In the UK, Kenny et al (2016) sought to explore Autistic people, parents and autism professionals' preferences about terms used to describe autism. Results showed that there remained a wide range of terms used, with terms such as 'autism' or 'on the autism spectrum' highly endorsed across all groups. In line with the above debate however, there were notable differences between the autism community (who preferred 'Autistic') and autism professionals (who used 'person with autism'). In Australia, Autistic adults ranked autism terms, rating 'Autistic' and 'Person on the Autism Spectrum' as the most preferred and least offensive, as autism is core to or part of one's identity and spectrum terms reflect diversity and reject stigmatisation (Bury, Jellett, Spoor & Hedley, 2020). Several commentaries have since been published with clear suggestions for language use; for example, Bottema-Beutal et al (2021) outlined a list of potentially ableist terms and suggested alternatives for autism researchers, while Monk, Whitehouse & Haddington (2022) provides a summary of potentially offensive terms and Autistic preferred terms, with rationales for each term from the Autistic community and clear examples how to use preferred language in research.

As with the ED literature, an important caveat to such suggestions is that there is unlikely to be universal agreement of preferred terms across individuals. Indeed, the militant advocation for a one-size-fits-all approach may lead to negative implications, such as

intimidation, the fear of not getting in right and reticence engaging in further discussion. Lei, Jones & Brosnan (2021) explored an e-learning online community's response to terms used in autism discourse. They found that specific terms or semantic choices matter less than ensuring Autistic individuals are those responsible for guiding language use. This is in line with recent commentaries that emphasise that decisions surrounding language use should consider the preferences of participants or those with lived/living experience, reflected as a key component of participatory research as opposed to just simple discourse around language (Vivanti, 2020; Robinson, 2019).

Finally, the current thesis will use capitalisation for Autistic, and lower case for autism. This decision draws from discussions with the lived/living experience researcher involved in the project (EM) and from the same theory as that of the Deaf community, where this is a general preference for a capital D when referring to terms associated with culture, community and identity, and a lower case when referring to the condition (National Centre of Disability and Journalism, 2021). In line with a neurodiversity perspective, this decision advocates that being Autistic is an identity and I therefore will affirm this with use of capitals in Autistic terms.

Thesis statement

The above section has outlined a clear rationale for adopting neurodiverse-affirming, participatory research approaches when conducting research into autism and EDs. The following thesis will present a series of studies developed within and guided by these principles. Acknowledging the heterogeneity of differences in autism and the multi-dimensional nature of EDs, a mixed-method approach was adopted, and a broad range of sensory, social and emotional experiences and outcomes were considered. It is hoped that, by anchoring the following research with this framework, research findings will make important and meaningful contributions to the lives of Autistic and non-Autistic individuals with AN.

Chapter 2 – Introduction

Feeding and eating disorders

Feeding and eating disorders (EDs) are mental health conditions characterised by severe and persistent disturbances in behaviours and cognitions surrounding food and eating (APA, 2013). EDs are highly prevalent worldwide, with an estimated lifetime ED prevalence of around 8.4% for women and 2.2% for men (Galmiche, Dechelotte, Lambert & Tavolacci, 2019). Furthermore, there is evidence to suggest that this has been increasing over the past ten years (Galmiche et al, 2019) with a notable increase over the COVID-19 pandemic (Matthews et al, 2021; Solmi et al, 2021a). The impact of EDs is far-reaching, impairing psychological and economic wellbeing, as well as that of families and other social support systems (Erskine, Whiteford & Pike, 2016). Mortality rates are also very high, particularly in anorexia nervosa and bulimia nervosa (van Hoken & Hoek, 2020), with suggestions that this can be as much as five to seven times higher than mortality risk in the general population (Iwajomo et al, 2020).

Following its revision in 2013, the DSM-5 provides diagnostic criteria for six feeding and eating disorders; anorexia nervosa (AN), bulimia nervosa (BN), binge eating disorder (BED), avoidant and restrictive food intake disorder (ARFID), pica and rumination disorder (DSM-5; APA, 2013). Additionally, there is a seventh category known as other specified feeding or eating disorder (OSFED) for those who have eating disorder presentations that significantly impair their daily functioning and quality of life but do not meet the full diagnostic criteria for other ED diagnoses. Under this OSFED category fall diagnoses such as atypical anorexia (all diagnostic criteria of AN met with the exception of significant weight loss and/or that weight is within or above the normal range), purging disorder (in the absence of binge eating behaviours) and night eating syndrome (recurrent episodes of night eating).

Anorexia Nervosa

Across EDs, AN poses one of the most dangerous threats to life. AN has been found to have the highest mortality rate of any mental health disorders (Meczekalski, Podfigurina-Stopa & Katulski, 2010), estimated at around fives time higher than the general population (van Hoeken & Hoek, 2020). AN is a restrictive ED, characterised by persistent behaviour to restrict

energy intake, an intense fear of gaining weight, and disturbances in body weight or shape (APA, 2013). There are two recognised subtypes of AN: restricting type (AN-R) and binge-eating/purging (AN-BP). Those with AN-R present with significant weight loss due to fasting, dieting and/or excessive exercise and have no recurrent episodes of binge eating or purging behaviours, while those with AN-BP present with recurrent episodes of binge eating or purging behaviours. However, some question the validity or utility of separating between subtypes, with both types exhibiting similar ED and psychiatric outcomes, and individuals often fluctuating between the two presentations (Peat et al, 2009; Serra et al, 2021).

Another related ED diagnosis that has met with controversy is atypical AN, where patients meet all the criteria for AN except for significant weight loss and/or that weight remains within or above the normal range. Importantly, atypical AN is classified under OSFED, as opposed to being considered a sub-type of AN. A review of prevalence estimates found evidence to suggest that atypical AN is as common or more common than AN, however authors pointed out that rates of atypical AN varied significantly based on the population studied and how it was defined (Harrop et al, 2021). This latter point is emphasised by those who highlight inconsistencies in the DSM-5 criteria, such as contradictory criteria of whether or not a low body weight is required (Walsh, Hagan & Lockwood, 2022), and significant overlaps with both disordered purging behaviours (Davenport, Rushford, Soon & McDermott, 2015; Ekeroth, Clinton, Norring & Birdegard, 2013) and with BN (Lowe et al, 2018; Forney et al, 2022). Furthermore, Walsh et al (2023) reported similar characteristics between atypical AN and AN, as well as being equally or more severe than AN. Thus, there is significant uncertainty surrounding differentiating between atypical AN and AN, underpinned by a lack of clarity surrounding the definitions and requirement of weight loss, as well as notable similarities in possible subtypes.

Epidemiology

A recent systematic review exploring prevalence rates of ED diagnoses reported that lifetime prevalence rates of AN ranged between 1.7% to 4% in females and 0.3% to 1.2% in males (Dahlgren et al, 2017; van Eeden, van Hoeken & Hoek, 2021), with an overall lifetime

prevalence estimate of 2.2% to 3.6% (Mistelin et al, 2016). While AN appears to be more common in females, there is increasing evidence to suggest that AN in males is mis- or under-diagnosed (Hudson et al, 2007; Raevuori et al, 2014; Strother et al, 2012). AN typically emerges during adolescence or early adulthood, with peak incidence occurring between 15-19 years old (Herpertz-Dahlmann et al, 2018; Abbate-Daga et al, 2007; Hoek, 2016). A recent meta-analysis exploring the global age of onset in mental health conditions reported an 89% proportion onset by 25 years old and a peak age of onset of 15.5 years (Solmi et al, 2022). Of concern, it appears that the age of onset may be shifting backwards in development, with a younger age of onset reported during childhood and adolescence (Petkova et al, 2019; Swanson et al, 2011; Pinhas et al, 2011; Morris, Elliot & Madden, 2022; Grilo & Udo, 2021).

AN is a chronic and pervasive mental health condition. Long illness durations and low recovery rates of around 62% have been reported (Dobrescu et al, 2020), with relapse rates estimated around 52% (Khalsa et al, 2017). Furthermore, AN is consistently associated with high rates of co-occurring mental health difficulties, like depression, anxiety and obsessive-compulsive disorder (OCD; Calvo-Rivera et al, 2022; Solmi et al, 2018; Udo & Grilo, 2019; Llyod, Haase, Foster & Verplanken, 2019; Levinson et al, 2020). The mortality risk of AN is very high, both from ED complications, such as cardiac arrests, and from suicide (Arcelus et al, 2011; Jaurgeui-Garrido & Jauregui-Lobera, 2012; Udo, Bitley & Grilo, 2019; Papadopoulous, Ekbom, Brandt & Ekseluis, 2009), with a recent systematic review reporting that AN carries a five or more times increase risk of mortality that the general population (van Eeden et al, 2021).

Treatment and models of AN

Currently, the National Institute for Clinical Excellence (NICE) guidelines recommend The Maudsley Model of Anorexia Nervosa (MANTRA; Schmidt, Treasure & Startup, 2018) and Enhanced Cognitive Behavioural Therapy (CBT-E; Dalle Grave et al, 2018) in adults with AN, and Family-Based Treatment (FBT; Lock & Le Grange, 2013) for children and adolescence (NICE, 2017). Guidelines also emphasise the need for a multi-disciplinary team, accounting for a broad range of factors in AN treatment approaches (NICE, 2017). Similarly in Scotland, Scottish Intercollegiate Guidelines Network (SIGN) guidelines recommend CBT-E as a first-line

therapy, followed by interpersonal therapy, Specialised Supportive Clinical Management (SSCM), MANTRA or focal psychodynamic therapy, while FBT should be the first-line intervention for children and adolescents (SIGN, 2022). While there is general consensus that family-based treatments are effective in children and adolescent's (Watson & Bulik, 2013), a recent network meta-analysis concluded there does not appear to be reliable or consistent evidence to support the superiority of one intervention over the other in adult patients (Solmi et al, 2021b). It has also been suggested that research fails to account for the complexity inherent to practice settings, such as multi-disciplinary treatment approaches or level of care, and thus does not reflect the clinical reality of ED treatments (Watson & Bulik, 2012).

Mixed treatment efficacy may be in part explained by a limited understanding of the underlying processes and mechanisms of AN (Strober & Johnson, 2012). Indeed, Murray (2020) argued that novel theories and models are needed to advance research, clarifying AN mechanisms and incorporating these into treatments. It is this lack of understanding of how change can be facilitated through targeting possible maintenance factors that is acting as a barrier to the development of stronger, evidence-based successful interventions (Pennesi & Wade, 2016). Several theories have been put forward to explain the persistence and maintenance of AN, accounting from a broad range of biological, psychological and social factors (Schmidt & Treasure, 2006; Treasure & Schmidt, 2013; Fairburn, 2008; Fairburn, Cooper & Shafran, 2003; Oldershaw, Startup & Lavender, 2019). A comprehensive overview of AN theories is outside the scope of this thesis, and the following section focuses on three key theories that align sensory, social and emotional factors.

Cognitive-interpersonal maintenance model of AN

The cognitive-interpersonal model (Schmidt & Treasure, 2003; Treasure & Schmidt, 2013) is a socio-emotional model of AN that posits cognitive and interpersonal factors increase vulnerability and contribute to the maintenance of AN through influencing key thoughts and behaviours. The leading traits of this model are obsessive compulsive features (cognitive) and anxious avoidance of close social (interpersonal) relationships. The model proposes that obsessive and compulsive traits, such as fixations and rigidity, are pre-disposing factors that,

when triggered by an external stressor such as a stressful life event, lead to dieting behaviours. Underpinning these obsessive-compulsive traits are cognitive processing styles, such as central coherence and set shifting, that are posited to take dieting behaviours into disordered eating behaviours through their rigidity and hyper-focus.

In line with the cognitive aspect of this model is evidence to support weak central coherence and poor set shifting abilities in those with AN (Lang et al, 2016; Wu et al, 2014; Keegan, Tchanturia & Wade, 2020). With regards to interpersonal factors, a broad range of socio-emotional difficulties, such emotion sensitivity, social and emotional avoidance, and negative self-evaluations (Treasure & Schmidt, 2013), are proposed as the second defining feature in the model and are considered to be both a lead pre-disposing and maintenance factor in AN. Support for these socio-emotional factors comes from evidence to suggest difficulties in emotion recognition (Harrison, Sullivan, Tchanturia & Treasure, 2009; Nalbant et al, 2019; Gramaglia et al, 2016), difficulties expressing emotions (Davies et al, 2012; Harrison, 2021) and interpreting social signals and cues (Renwick et al, 2013; Hamatani et al, 2016, Dalmaso et al, 2016; Harrison et al, 2018). Further support comes from the efficacy of interventions at improving AN outcomes developed in line with the model, such as MANTRA (Schmidt, Startup & Treasure, 2018; Byrne et al, 2017; Startup et al, 2021).

Transdiagnostic model of AN

Originally developed as a theory for bulimia nervosa (BN), the transdiagnostic cognitive-behavioural model (Fairburn, 2008; Fairburn, Cooper & Shafran, 2003) has been applied to AN to account for the persistence of AN. Under this theory, it is proposed that the various EDs and behaviours share a common underlying mechanism or disturbance that transcends ED subtype. The core cognitive factor here is body shape and weight disturbances, where ED cognitions (e.g., body dissatisfaction) are used to explain both restrictive and binge eating behaviours (Karazsia et al, 2016). This dysfunctional self-evaluation system manifests as AN cognitions and behaviours through restrictive dieting, seeking to exert control over the body and weight and leading to an over-evaluation of body and shape.

Key to the model is a further four tenets. Firstly, core low self-esteem is proposed to play an important role in motivating individuals to adopt restrictive eating behaviours and to associate a particular weight and shape with increased self-worth. Secondly, perfectionistic traits are applied to eating and weight-ideals, manifesting as a fear of failure and evaluation of the self in line with perfectionist weight and shape standards. Thirdly, interpersonal problems can be a consequence of AN behaviours, as well as working to maintain the ED. Finally, mood intolerance may lead to some individuals adopting certain ED behaviours as a way of regulating negative emotions (Fairburn, 2008). The key take home message from the transdiagnostic model is that while mechanisms may differ across ED presentations, all four factors are relevant to all ED diagnoses through the complex interplay of self, social and emotional factors. However, while this is intuitive in theory, empirical evidence suggests that this does not successfully map onto clinical presentations, and certain factors may be more commonly associated with one ED diagnoses over another, particularly self-esteem and mood intolerance (Puttevils, Vanderhasselt & Vervaet, 2019; Lampard, Tasca, Balfour & Bissada, 2012; Jones, Egan, Howell, Hoiles & Mazzucchelli, 2020). Nonetheless, the model has found to successfully translated into effective ED interventions, such as Cognitive Behavioural Therapy for Eating Disorders (CBT-E; Linardon, Wade, Garcia & Brannan, 2017).

Developmental Lost Emotional Self theory

Focusing on emotional difficulties, Oldershaw, Startup & Lavender (2019) proposed the 'lost emotional self' theory. Proponents acknowledge the complex interplay between genetic, biological, psychological and socio-environmental factors that contribute to the development and maintenance of AN, before positing that difficulties in emotion processing leads to a lost sense of 'emotional self'. This is defined by authors as the struggle to navigate the self, the world and others due to difficulties expressing and regulating their own emotions, leading to an over-reliance on feedback from others. This loss of emotional self is then argued to be the core underlying mechanism that unifies the broad range of observed risk and maintenance factors in AN. Difficulties in emotion processing, such as emotion awareness and regulation, have been consistently found to play a significant role in AN (Oldershaw et al, 2011, 2015;

Lavender et al, 2015; Castro et al, 2021). These emotional difficulties are then proposed to impact the development of the self, leading individuals to integrate AN within their concept of the self, whilst simultaneously feeling disconnected or 'lost' from an emotionally grounded sense of self (Oldershaw et al, 2019).

While the theory emphasises the underpinning quality of emotion processing, the theory also draws on a developmental approach to account for the development and maintenance of emotional difficulties and thus AN. In infancy and childhood, emotion difficulties are argued to be rooted in childhood attachment, the socialisation of gender, and potentially distressing food and mealtime environments. During adolescence, identity development and management occurs within the context of parents and of peers, and the effect that negative evaluations within these contexts can have on the development of poor body image. At this stage, emotional difficulties become increasingly integrated with the social environment, suggestive of a complex yet important interplay between social and emotional factors. During AN, difficulties with sensory processing, specifically body perception, (known as proprioception), identifying internal body sensations (known as interoception) and the neurological impact of starvation can reduce emotional awareness and processing, further confusing the integration of emotional experience with perceptions of the self and thus serving to reinforce AN. Fundamentally, AN is here conceptualised as a means of emotion regulation and management, whilst simultaneously providing a false sense of self (Oldershaw et al, 2019). Therefore, unlike previous models and associated treatments such as MANTRA and CBT-E where weight and shape difficulties form core treatment targets, authors suggest the pursual of emotion-focused therapies, targeting emotion processing and it's overlap with social and sensory factors.

Autism Spectrum Disorders

Autism Spectrum Disorder (ASD), hereon referred to as autism, is a neurodevelopmental condition that influences the way individuals interact with the world and with those around them. Specifically, it is characterised by differences in social interaction and communication, as well as differences in restrictive and repetitive behaviours and sensory processing (APA,

2013). Symptoms must be present early in development; however, it is noted that they may not fully manifest until later in development (APA, 2013). Autism is considered to exist along a spectrum, reflecting a heterogenous population of varying degrees of strengths and difficulties across social, sensory, emotional and motor domains (Lai et al, 2013; Lombardo et al, 2019).

Epidemiology

The prevalence of autism in the UK is estimated to be around 1% of the population (Taylor et al, 2013; Russell et al, 2022), which is similar to global prevalence estimates (Elsabbagh et al, 2012; Zeidan et al, 2022). Autism has traditionally been more frequently diagnosed in males than females, with the DSM-5 stating a ratio of 4:1 (APA, 2013). However, recent evidence has begun to challenge this, suggesting that autism may be more prevalent in females than previously assumed (Lai et al, 2015). This is reflected in updated gender ratios of 3:1 (Loomes et al, 2018), and increased incidence rates of an autism diagnosis in females (Russell et al, 2022).

This leads to questions surrounding why there has been delayed (Kirkovski et al, 2013) or missed (Lai & Baron-Cohen, 2015) diagnoses of autism in females. One of the leading reasons is likely that the key Autistic characteristics described above were informed by male presentations of autism (see Tillman et al, 2018) and fail to account for potential gender differences in presentation. For example, females have been reported to have different behavioural presentations to their male counterparts, such as exhibiting less pronounced social communication and interaction differences (Lai et al, 2015; Sedgewick et al, 2016; 2019a; Libster et al, 2023; Lundin et al, 2022) and a greater number of masking or camouflaging behaviours during social situations (Hull et al, 2020). Furthermore, it has also been reported that both the presentation and content of restricted and repetitive behaviours and interests differ between males and females (Werling & Geschwind, 2013; Ratto et al, 2019; Harrop et al, 2018). Current measures and diagnostic tools are biased through their lack of understanding of these nuances in behavioural presentations (Navarro-Pardo, Lopez-

Ramon, Alonso-Esteban & Alcantud-Marin, 2022), and may continue to under- or mis-diagnose autistic females unless modified.

A broad range of diverse clinical and behavioural features have been reported to characterise autism. Reflecting the DSM-5 criteria, the leading features associated with autism are differences in sensory processing, social interactions and communications, and social cognition. For example, multi-dimensional differences in sensory processing are one of the most prevalent differences in autism (Leekam et al, 2007; Marco et al, 2011; Suarez et al, 2012a). Autistic people also report a broad range of social and emotional differences, with differences in social relationships and interactions (Davis & Crompton, 2020), how they think and respond to social situations (Leekam, 2016), how they communicate with those around them (Tajik-Parvinchi et al, 2021) and how they identify, express and regulate emotions (Nuske, Vivanti, & Dissanayake, 2013). Furthermore, a complex interplay between all these factors has been suggested. In a comprehensive systematic review, Glod et al. (2015) found associations between sensory processing and social communication, as well as with emotional functioning. Subsequent evidence supports a complex link between social, sensory and emotional differences (Thye et al, 2017; Samson et al, 2014), keenly highlighting the heterogenous and dimensional nature that is inherent to autism.

Theories of autism

Despite this wealth of evidence supporting differences in a broad range of clinical and behavioural features, the causes of autism remain elusive. The aetiology of autism has broadly been described as a genetic predisposition influenced by an environmental impact (Newschaffer et al, 2007; Masi, DeMayo, Glozier & Guastella, 2017), however, beyond this, there is a notable lack of coherent theory that unifies the experience of autism. Perhaps this is unsurprising, given that the clinical and behavioural features of autism are fundamentally heterogenous (Mottron & Bzdok, 2020), and subsequent theories have tended to account for single domains. There are those who would go as far to say that attempts to provide a singular account of autism should be abandoned (Happe et al, 2006). Despite this however, several leading theories can provide significant insight if applied to understandings of the aetiology

and influence of their domains (Sarovic, 2021). The following section will provide an overview of a sample of theories that have been used to account for key social, sensory and associated features outlined above.

Social cognitive and communication theories

Social cognition refers to the ability to predict, process and explain the behaviours of others (Birtwell, Willoughby & Nowinksi, 2015), and is a domain that has been consistently implicated in the aetiology of autism (e.g., Baron-Cohen et al, 2008; Leekam et al, 2016; Fernandes et al, 2018). However, attempts to generate specific socio-cognitive theories, such as Theory of Mind (Baron-Cohen et al, 1985) and the Empathising-Systematising Theory (Baron-Cohen et al, 2009), have been increasingly challenged in recent years. This has been in light of an encouraging societal shift away from medicalised, ableist frameworks that conceptualise autism as a deficit or disorder and that have led to stigmatization and the discrimination of Autistic people (Botha & Cage, 2022). An exciting avenue for future researchers will be generating testable theories or models that seek to explain differences in social cognition, paying close attention to an increasing body of evidence that suggests a complex interplay with emotion (Oschner, 2008; Gaigg, 2012) and sensory processing (e.g., Thye et al, 2018).

A more contemporary theory is the Double Empathy Theory (Milton, 2012). Double Empathy Theory seeks to provide a contemporary and neurodiverse-affirming explanation for differences in social communication for Autistic people. Social communication has traditionally been assumed to reflect a core “deficit” in autism (Lee et al, 2023). However, this assumption is increasingly being challenged by those who argue that these autism-specific differences in social communication reflect a bidirectional misunderstanding and miscommunication between Autistic and neurotypical individuals (Davis & Crompton, 2021; Milton, 2012; Bolis et al, 2017). The Double Empathy Theory is therefore a social model that posits that there are mutual difficulties in reciprocity and communication between Autistic and non-Autistic individuals, leading to two-way difficulties in perspective taking, communication and understanding (Milton, 2012; Milton, 2020).

Empirical evidence is beginning to emerge in line with the Double Empathy Theory. For example, non-Autistic individuals are less accurate at identifying Autistic facial expressions than non-Autistic individuals (Brewer et al, 2016) and struggle to accurately identify Autistic individuals' mental states (Sheppard et al, 2016; Edey et al, 2016). Conversely, matching Autistic neurotypes appears to have a beneficial advantage on social communication (Crompton et al, 2020a), feelings of comfort in social situations (Crompton et al, 2020b) and in the interpretation other's mental states and intentions (Heasman & Gillespie, 2018). Research exploring the Double Empathy Theory is important, both in providing a stronger evidence base for the broader theory and for being rooted in neurodiverse approaches, celebrating difference and the Autistic identity.

Sensory patterns and integration

There are several theoretical models and approaches to sensory processing differences in autism, two of which will be discussed here. The first theoretical model discusses patterns of sensory processing, or specifically sensitivities, positing that there are two leading patterns: hypersensitivity and hyposensitivity (DSM-5; APA, 2013). These broad patterns are inherently characterised by the behavioural reaction or response to sensory input (Boyd et al, 2006). This model of sensory processing unites several different approaches under one diagnostic account; for example, these patterns are mirrored in Miller et al (2007)'s over responsivity, under responsivity and sensory seeking subtypes in sensory modulation, and Dunn's (1997) dimensional model of sensory processing, dividing hyper- and hyposensitivity's into passive (avoiding) and active (seeking) strategies. These patterns have been found to successfully discriminate autism from other neurodevelopmental conditions (Leekam et al, 2007; Baranek et al, 2006), while also being simultaneously associated within the same Autistic individual (Ben-Sasson et al, 2009; He et al, 2023).

A second relevant theory is Sensory Integration Theory (SIT; Ayres, 1979). This goes beyond providing accounts for sensory sensitivities at an individual modality level, towards

understanding sensory processing differences at a higher order, integrative level. The original theoretical model sought to explain the behavioural, motor and emotional responses to sensory stimuli through differences in registration, modulation and motivation of sensory input (Ayres, 1979). Interestingly, in her initial book, the two leading patterns observed were hyper- and hypo responses to sensory stimuli in Autistic children; thus, SIT and sensory patterns models could be conceptualised as complementary sensory theories, with the latter focusing on observable behaviours and the former focusing on the underlying process. Modern empirical support has caused this theory to receive renewed attention through the development of contemporary neuroscientific research methods (Marco et al, 2011; Kilroy, Aziz-Zadeh & Cermak, 2019). Structural and functional differences have been reported in the registration (Nair et al, 2015; Maximo et al, 2019; Keown et al, 2017), modulation (Kilroy et al, 2019; Ben-Sasson et al, 2009; Green et al, 2016; Acevedo et al, 2018) and motivation (Salimpoor et al, 2013; Gordon et al, 2016) of sensory input. Importantly, SIT has notable implications for sensory interventions in autism, leading to the development of sensory integration therapy (Ayres, 1979). SIT involves sensory and motor exercises with a view to develop more effective regulation of sensory input (Kilroy et al, 2019) and has multi-dimensional benefits on development, social environments, learning and emotion regulation (Schaaf et al, 2007; Guardado & Sergent, 2023). Thus, SIT suggests sensory processing differences are at the core of autism and responsible for influencing other associated domains, in line with recent evidence to suggest sensory processing is associated with a broad range of clinical and behavioural features in autism (Glod et al, 2015). Currently, the evidence-base for SIT interventions is small but promising, with a recent review concluding that, it is an effective intervention for Autistic children (Schoen et al, 2019). It should be noted however that methodological flaws and lack of consistency in the application of SIT principles are commonly observed across studies in studies (see Lang et al, 2012), and future SIT interventions require more robust guidelines and application.

Monotropism

Monotropism is a theory of autism that draws on attention and intense interests as central to the Autistic experience (Murray, Lesser & Dawson, 2005; Murray 2018a). Monotropism

advocates that Autistic individuals have a single-attention system, whereby the allocation of attention is highly focused, leading to so called 'attention tunnels' (Woods & Waltz, 2018), and not broadly distributed as in in neurotypical populations. Thus, Monotropism can be viewed as a neurodiverse-affirming theory, stating that variations in attention occur on a continuum, with monotropism at one end and polytropism (dividing and distributing attention) on the other. What is also significant about Monotropism is that it can be used to unify several different features of autism, such as difficulties with disengaging attention, attention shifting and intense interests (Murray et al, 2005), as well as thinking styles and social interactions (Fletcher-Watson & Bird, 2019; Murray et al, 2005), thus suggesting it may be a promising explanatory theory of autism (Murray, 2018).

Despite being aligned to the aforementioned features of autism, very little research has been conducted into validating Monotropism specifically (Milton, 2017). Thus, there remains a pressing need to conduct research into the theory, ensuring that there is a strong empirical evidence base to align with the Autistic community's support for Monotropism as a unifying theory of the Autistic experience. An encouraging example of this is the development of a self-report measure that has been reported to have high consistency reliability and convergent validity (Garau et al, 2023), although it is clear that more research is urgently needed.

Autism and EDs

Atypical eating behaviours are reported to be notably more frequent in autism, with prevalence estimates as high as 90% (Sharp et al, 2013; Ledford & Gast, 2006; Mayes & Zickgraf, 2019). Indeed, they are so prevalent that it was previously considered a criterion for early diagnosis of autism, and while this is no longer the case, atypical eating behaviours are one of the most commonly associated behavioural characteristics of autism and remain strongly considered during clinical formulation (Martins et al, 2008). Clinicians and caregivers frequently report that Autistic children display a broad range of atypical eating behaviours, such as food selectivity, limited food intake, disruptive mealtime behaviours and food neophobia (Margari et al, 2020; Edmond et al, 2010; Cermak et al, 2010; Wallace et al, 2018).

Furthermore, unlike neurotypical peers, these atypical eating behaviours have been reported to persist beyond childhood into adolescence (Bandini et al, 2017; Baraskewich et al, 2021). There is also an increasing body of evidence to suggest a notable overlap between autism and EDs. This overlap was first reported by Gillberg (1983), when he observed similar cognitive and social difficulties in Autistic individuals and service users with AN. He also observed that a disproportionate number of those with AN has Autistic family members (Gillberg, 1983). In the past decade or so, empirical research has sought to further understand and disentangle this relationship.

An important clarification in the emerging stages of this research exploring the overlap between autism and AN was establishing a true aetiological relationship between the two conditions. Early concerns were raised regarding how traits associated with the cognitive impact of starvation, such as cognitive inflexibility and reduced social motivation, mimic Autistic traits, thus suggesting elevated reports of Autistic traits were due to starvation and not the presence of true autism (Treasure, 2013; Hiller & Pellicano, 2013). However, subsequent studies provide convincing evidence for an overlap between the two conditions. Firstly, several studies have found that BMI is not associated with Autistic traits in individuals with AN (Bentz et al, 2017a; Tchanturia et al, 2019; Nazar et al, 2018; Sedgwick et al, 2019; Susanin et al, 2022; Pruccolli et al, 2021), suggesting that elevated traits may not be solely the result of starvation. Secondly, autism and Autistic traits have been reported to remain high amongst those who have recovered from AN (Nazar et al, 2018; Bentz et al, 2017a; Sedgewick et al, 2019b). Finally, the presence of Autistic traits has been reported to be present from childhood, years prior to the onset of an eating disorder (Westwood, Mandy, Simic & Tchanturia, 2018; Vagni, Moscone, Travaglioine & Cotungo, et al, 2016), with a recent longitudinal study suggesting that greater Autistic traits in childhood are associated with disordered eating during adolescence (Solmi et al, 2021b; Leno et al, 2022). Collectively, these studies provide convincing evidence for an overlap between autism and EDs.

Prevalence

Across ED diagnoses, the overlap between autism and AN has received the most research attention. Following the initial observations by Gillberg (1983), his collaborators provided further evidence to suggest that in certain individuals with AN, social and cognitive difficulties may reflect underlying autism (Rastam, 1992; Wentz, Gillberg, Gillberg & Rastam, 2001). In the UK, Mandy & Tchanturia (2015) sought to establish early estimates of co-occurrence by administering the ADOS and clinical observation on ten women receiving ED treatment. Out of these ten, seven women were thought to be Autistic (Mandy & Tchanturia, 2015). Subsequent studies have gone beyond this case series and sought to provide prevalence estimates. Autistic traits have been reported to range between 8-40% (Anckarsater et al, 2012; Huke et al, 2013; Westwood et al, 2016; Inoue et al, 2021; Westwood & Tchanturia, 2017), with slightly elevated rates in adults when compared to younger samples (Bolti & Sapuppo, 2021).

Less research has been conducted exploring EDs in Autistic samples, with studies reporting that Autistic individuals are twice as likely to experience an ED compared to neurotypical peers (Sedgewick et al, 2021), and that this effect may be particularly pronounced in females (Spek et al, 2019; Schroder, Danner, Spek & van Elburg, 2022). Recent Bayesian prevalence estimates suggest that 8.3% of Autistic women have AN specifically, with a median prevalence of 6% in females (McCrossin, 2023), compared to prevalence rates of between 2.2% to 3.6% in neurotypical populations (Mustelin et al, 2016). Finally, while the main body of literature has focused on AN, recent studies have begun to explore autism estimates in other ED subtypes, finding evidence to suggest elevated Autistic traits in BN (Huke et al, 2013; Gesi et al, 2020), BED (Gesi et al, 2020; Karjalainen et al, 2016; Numata et al, 2021) and ARFID (Koomar et al, 2021; Inoue et al, 2021).

Outcomes and experiences

There is increasing evidence to suggest that Autistic individuals with EDs do not benefit from standard ED interventions and exhibit a broad range of detrimental outcomes. Specifically, it has been reported that Autistic individuals with EDs utilise a broader range of range of ED

services (Zhang et al, 2022; Babb et al, 2022; Nazar et al, 2018), utilise ED services more frequently (Zhang et al, 2022; Bentz et al, 2022) and reported longer treatment duration (Babb et al, 2022; Stewart et al, 2017; Tchanturia et al, 2016). Interestingly, there does not seem to be a significant difference between groups on treatment completion or drop-out rates (Huke et al, 2013; Nazar et al, 2018; Susanin et al, 2022; Bentz et al, 2022), although there is evidence that treatments can be more effective if delivered individually compared to group formats (Adamson et al, 2018; Dandil et al, 2020).

With regards to clinical outcomes, Autistic individuals report a broad range of more severe ED and psychosocial outcomes than their neurotypical peers. Several studies report that Autistic individuals or those with elevated Autistic traits have longer illness durations (Saure et al, 2020), and more severe ED behaviours and cognitions (Stewart et al, 2017; Li et al, 2022a) although not all studies support this (Huke et al, 2013; Pruccolli et al, 2021; Susanin et al, 2022). Future studies are needed to establish consensus here, perhaps by seeking to move beyond using Autistic traits as an indicator of autism and recruiting those with an autism diagnosis or those with a self-diagnosis of autism, allowing for a developmental distinction between trait and state presentations of AN. Alternatively, studies could work towards developing and implementing more autism-specific measurements for ED symptomology. Autistic individuals with an ED have also been found to have more severe mental health outcomes such as mood disorders (Li et al, 2020; Nazar et al, 2018; Pruccolli et al, 2021) and OCD (Nazar et al, 2018; Prucoli et al, 2021; Stewart et al, 2017), compared to their non-Autistic peers. Furthermore, it also appears that broader psychosocial functioning is more impacted in Autistic individuals with EDs than their non-Autistic peers (Li et al, 2020; Nazar et al, 2018; Nielsen et al, 2015; Ankarsater et al, 2012; Nielsen et al, 2022).

Several qualitative studies have explored the lived/living experience of Autistic individuals with EDs. Both Autistic individuals and their caregivers report frustration and difficulties engaging with ED services (Kinnaird et al, 2019; Adamson et al, 2020), particularly with regards to first-line interventions such as CBT (Babb et al, 2021). Studies also report a notable disparity between what current ED services offer and the unique individual needs of Autistic

people, such as differences in social communication and sensory sensitivities, and that such differences impact their ability to engage with and access treatment (Babb et al, 2021; 2022). Here, qualitative findings can help contextualise the quantitative ED outcomes outlined above; for example, this misunderstanding of autism-specific needs has been linked with outcomes such as a broader range and frequency of ED services utilised (Babb et al, 2021; Kinnaird et al, 2019). Similarly, ED clinicians mirror this by reporting a lack of experience, awareness and confidence in delivering treatments to Autistic individuals (Kinnaird et al, 2017). A recent paper exploring case notes and discussions from ED clinicians working with Autistic adults with AN identified a range of reported challenges, including communication, sensory and emotional difficulties, as well as atypical presentations of eating difficulties and the logistics of autism screening (Li, Hutchings-Hay, Byford & Tchanturia, 2022). Thus, it is apparent that ED outcomes and treatment experiences in Autistic individuals are detrimental and multi-faceted. Indeed, a recent scoping review that sought to identify how ED treatments can be modified to improve treatment outcomes and experiences outlined that identifying factors that distinguish between autism and AN in co-occurring populations should be key focus for future research and practice (Beygui & Cascio, 2022).

Proposed models of autism and EDs

The wide range of ED outcomes and service experiences that are reported by Autistic individuals suggests that this group could benefit from modified or alternative treatment (Dudova, Kocourkova & Koutek, 2015). In order to provide more effective treatments for this population, a more comprehensive understanding of possible common and autism-specific factors must be obtained (Beygui & Cascio, 2022). Furthermore, a recent paper called for the integration of Autistic perspectives into ED models, suggesting that an inclusive understanding of the overlap between autism and EDs requires either the adaptation of existing models or novel, parallel explanatory frameworks (Longhurst & Clark, 2022). This has involved generating theoretical, testable models or frameworks for the development, maintenance and recovery from EDs in Autistic individuals, which are then subject to subsequent empirical investigation.

Two key models or frameworks have been proposed to account for the overlap between autism and EDs. Drawing on interviews with Autistic women, parents of Autistic women and ED healthcare professionals, Brede et al (2020) proposed a multi-dimensional model of factors associated with restrictive eating disorders (REDs) in Autistic women. Within this model, differences in sensory sensitivities, social interactions and relationships, self and identity, emotions, thinking styles, and control and predictability emerged as key factors in the development and maintenance of REDs in Autistic females (Brede et al, 2020). Key strengths of this model were the inclusion of multiple perspectives; however, it should be noted that the majority of the sample was AN and did not include males in the study. A second recent clinical framework was proposed by Kinnaird & Tchanturia (2021). Authors drew on a broad range of shared features between autism and AN, focusing on neuropsychological, social communication and sensory differences. Authors also outlined key differences in the presentation of these shared features in autism and in AN individually, offering the framework as a reference for clinicians working in the field seeking to distinguish between Autistic and non-Autistic AN patients (Kinnaird & Tchanturia, 2021).

While these models took different approaches – Brede et al (2020) generated the model from qualitative data and Kinnaird & Tchanturia (2021) drew from published studies in the broader literature – they both sought to generate testable models for the overlap between autism and EDs, particularly with regards to AN. Furthermore, while Kinnaird & Tchanturia (2021) drew on empirical studies exploring these shared factors, the overwhelming majority of these studies were conducted on autism and AN samples individually. Thus, there remains pressing scope for the empirical investigation of factors highlighted in these frameworks in Autistic individuals with EDs. The remainder of the introduction will provide a more in-depth look at several of these implicated factors and provide a rationale for focusing on sensory, social and emotional factors.

Sensory factors

One of the most consistently implicated mechanisms in autism and AN is sensory processing (e.g., Brede et al, 2020; Kinnaird et al, 2021). The two areas of sensory processing that have

received considerable research attention are those of specific sensory sensitivities, such as taste, smell and touch (here referred to as exteroception), and the awareness and identification of internal body sensations (known as interoception). The following section will discuss both of these in turn, reviewing the evidence in both autism and AN individually before discussing how these factors may play a role in AN for Autistic individuals.

Exteroception

Eating is an inherently multi-sensory experience, involving sensory input from taste, smell and tactile systems (Pucci & Forney, 2022). Sensory sensitivities are either patterns of hyper- or hyposensitivity to exteroceptive (external) stimuli (Booth, 2013), and have previously been explored within the context of AN. Self-report studies have found that individuals with AN and those that are recovered both report higher perceived sensitivities than healthy controls (Zucker et al, 2013; Merwin et al, 2013). Sensory sensitivities have been correlated with lowest BMI but not current BMI (Zucker et al, 2013; Saure et al, 2022), suggesting that sensitivities may be associated with AN pathology specifically as opposed to weight. Neither of these studies explored specific modalities, however. Two senses that have received most attention within the AN literature are taste and olfaction, due to their integral role in eating behaviour (Boesvedlt & de Graaf, 2017; Islam et al, 2015). A recent systematic review of taste processing in AN by Kinnaird et al (2018) reported tentative support for reduced taste recognition and detection in AN. However there were no differences between those with AN and healthy controls on self-report ratings of taste intensity (e.g., sweetness, fattiness), and authors acknowledged that the literature is limited by methodological heterogeneity (Kinnaird et al, 2018). Interestingly, studies that adopted longitudinal designs found that taste processing improved during recovery (Aschenbrenner et al, 2008; Nakai et al, 1987; Casper et al, 1980), suggesting that taste sensitivities may be more pronounced during the acute state of AN.

Olfactory (smell) processing has also been explored in AN. Studies that look at olfactory discrimination – being able to detect differences in smells – have yielded mixed results, with some studies reporting significant differences between those with AN and healthy controls

(Schreder et al, 2008; Aschenbrenner et al, 2009; Dazzi et al, 2013), while others report no significant differences (Rapps et al, 2010; Lombien-Poutheir et al, 2006; Schecklmann et al, 2012; Fernandez-Aranda et al, 2015). Olfactory identification findings are similarly inconsistent (Kopala et al, 1995; Lombion-Poutheir et al, 2006; Dazzi et al, 2013; Fernandez-Aranda et al, 2015; Goldzak-Kunik et al, 2012; Schecklmann et al, 2012). There does however appear to be evidence to support heightened olfactory processing in those with AN (Fernandez-Aranda et al, 2016), with another study suggesting that this is more pronounced in individuals with current AN than recovered AN (Bentz et al, 2017b). This study also found that those with current AN performed better than those who were recovered on odour discrimination tasks, suggesting olfactory processing, much like taste processing (Kinnaird et al, 2020) is more pronounced during the acute stages of AN.

Sensory processing has received considerably more research attention in autism. Sensory processing differences are considered a key feature of autism (APA, 2013) and have been reported in up to 97% of Autistic children and adults (Leekam et al, 2007; Billstedt et al, 2007; McCormick, Hepburn, Young & Rogers, 2016; Dellapiazza et al, 2018). In line with established sensory processing patterns (Ben-Sasson et al, 2009; APA, 2013), sensory profiles can vary widely across Autistic individuals, with hyper- and hyposensitivity's reported across multiple, if not all, exteroceptive sensory modalities (Baranek et al, 2006; Kern et al, 2007; Rogers et al, 2005; McCormick et al, 2015; Robertson & Baron-Cohen, 2017). Furthermore, different patterns of sensory processing can occur within the same individual across different contexts and exteroceptive modalities (Brown & Dunn, 2010). Therefore, unlike sensory processing in AN, it is a well-established and more constant feature in autism. Not only is it well-established however, but differences in sensory processing are increasingly recognised as a core factor, influencing a broad range of clinical and behavioural features of autism (Glod et al, 2015; Hazen et al, 2014), including differences in social cognition (Thye et al, 2018) and communication (Watson et al, 2011; Roconi et al, 2016), emotion regulation (Samson et al, 2013) and eating difficulties (Nimbley et al, 2022). Thus, differences in sensory processing are not only a leading feature of autism but also a core and influential feature.

Of particular relevance to the current thesis are studies that have explored the relationship between sensory processing and eating behaviours in Autistic groups. A recent systematic review looking at the relationship between sensory processing and eating behaviours in autism found evidence of a consistent link across studies, with tentative evidence for the role of taste and smell sensitivities, as well as hypersensitivity patterns (Nimbley et al, 2022). While no study was found to have explored this relationship in ED samples, the majority of studies looked at restrictive eating behaviours, such as selective eating or limited food intake (Nimbley et al, 2022), and may have important implications on the elevated incidence of restrictive eating disorders such as AN in autism (Westwood & Tchanturia, 2017). This is in line with a recent study that found that participants with elevated Autistic traits exhibited more selective eating behaviours, and that this relationship was in turn influenced by both taste perceptions and preferences (Chen et al, 2022). Furthermore, qualitative studies exploring the experience of AN in Autistic individuals have found that sensory sensitivities are perceived to play a significant role in the developmental and maintenance of their ED (Kinnaird et al, 2019a; 2019b; Brede et al, 2020).

Interoception

Another sensory factor that has been implicated in the overlap between autism and AN is interoception. Interoception broadly refers to the perception and integration of body sensations that represent the physiological condition of the body, such as pain, temperature, hunger and thirst (Craig, 2002; 2003). Following confusion regarding terminology and different concepts falling under the umbrella term of interoception, Garfinkel and authors (2016) conceptualised three key constructs; interoceptive accuracy (the objective ability to detect internal stimuli), interoceptive sensibility (self-reported ability to detect internal stimuli) and metacognitive insight into their interoceptive abilities. Thus, this thesis defines interoception as the interpretation, identification and awareness of internal body sensations (Critchley & Garfinkel, 2017).

Difficulties with interoception have been implicated in the development and treatment of eating disorders, especially patients with AN (Jacquemot & Park, 2020; Preyde et al, 2016; Friederich et al, 2010). Early clinical observations observed that failing to identity body

sensations and states was a key characteristic in AN and is included in the Eating Disorder Inventory (EDI; Garner et al, 1983). It has been proposed that interoception has a neurological basis in AN, with the aberrant structure and function of the insula, a key area involved in the integration of sensory perception, emotion and cognition that is inherent to interoception, in AN (Kurth et al, 2010; Kerr et al, 2016). For example, Kerr et al (2016) conducted a study exploring functional and structural brain imaging where participants were asked to attend to sensations of a particular organ, including stomach, heart and bladder, as well as an anxious rumination condition where participants were asked to think about situations associated with peers, family or careers that worried them. The study found evidence for decreased activity in the dorsal insula during the stomach condition, mirrored by increased activity in this area during anxious rumination. Furthermore, activity in the dorsal insula during the stomach interoception condition was found to be negatively correlated with anxiety and eating disorder symptomology, a finding not replicated in other interoceptive modalities (Kerr et al, 2016).

Building on neurological foundations, studies have begun exploring interoception through behavioural or experimental approaches. Returning to Critchley & Garfinkel (2017)'s definition, studies suggest that individuals with AN report a general lack of interoceptive sensibility (Jenkinson et al, 2018; Fischer et al, 2016), while there have been more mixed findings on more objective measures of interoceptive accuracy (Pollatos et al, 2008; Kinnaird, Stewart & Tchanturia, 2020c; 2020d). There could be several reasons for such mixed findings. Firstly, this could be due to variability in methodologies, with an over-reliance on tasks such as the heartbeat tracking task, which has been reported to be influenced by other variables such as BMI (Kinnaird et al, 2020c) and prior beliefs about heart rate (Murphy et al, 2018a). Encouragingly, researchers are beginning to explore other objective approaches to interoception, with a recent narrative review suggesting the role of gastrointestinal interoception in giving rise to difficulties with hunger and thirst in EDs, however the methodological and modelling approaches required to explore this remain in their infancy (Khalsa, Berner & Anderson, 2022).

There is also evidence to suggest that interoception is closely linked to difficulties with the processing of emotion (Critchley & Garfinkel, 2017b; Jacquemot & Park, 2020; Oldershaw et

al, 2011; 2019) and the ability to detect, describe and communicate about emotions, otherwise known as alexithymia (Longardo et al, 2015; Brewer, Cook & Bird, 2016; Murphy et al, 2018b), something that may be particularly exacerbated by low weight (Oldershaw et al, 2019). Finally, interoceptive abilities may be influenced by other co-occurring conditions such as depression, anxiety and autism (Pollatos et al, 2008; Ambrosecchia et all, 2017; Eggart et al, 2019; Khoury, Lutz & Schuman-Olivier, 2018; Adams, Murphy, Catmur & Bird, 2022).Thus, there remains a pressing need for studies seeking to untangle the role of interoception in AN, accounting for the possible presence of autism, emotion difficulties and co-occurring mental health conditions.

Difficulties in interoception have also been explored in autism (DuBois et al, 2016). Studies to date have yielded mixed and often contradictory results (Suzman et al, 2021); for example, some studies have reported impaired interoceptive accuracy compared to neurotypical controls (Garfinkel et al, 2016; Nicholson et al, 2018; Palser et al, 2018; Mul et al, 2018), while others have reported no difference between groups (Schauder et al, 2015; Nicholson et al, 2019; Failla et al, 2020; Pickard et al, 2020). Studies also report similarly inconsistent results on self-reported interoceptive sensibility (Fiene & Brownlow, 2015; Garfinkel et al, 2016; Mul et al, 2018; Palser et al, 2018; Pickard et al, 2020). Williams et al (2023) conducted a recent systematic review and meta-analysis of interoception in autism and found that Autistic individuals generally reported higher confidence in task performance (interoceptive sensitivity), with small and varying differences on objective task performance (interoceptive accuracy). Authors suggested that despite these differences when compared to neurotypical controls, it is unlikely that interoception is a core feature of autism, and instead might be more importance in its contribution to the development of mood disorders (Hollocks et al, 2019), alexithymia (Kinnaird et al, 2019c) and eating disorders (Adams et al, 2022).

Recent research has begun to explore interoception in AN patients with elevated autistic traits, attempting to further elucidate the relationship between interoception and both autism and AN. Using the heartbeat detection task, Kinnaird et al (2020d) found no evidence for lowered interoceptive accuracy but found significant evidence for heightened interoceptive sensibility. Interestingly, interoception accuracy was not associated with either alexithymia or Autistic traits (Kinnaird et al, 2020c). There are several possible interpretations

of these results. Firstly, it could be that these findings do indeed reflect an absence of association between interoception, alexithymia and autism. Secondly, and perhaps more likely, certain design limitations may need to be addressed in future research to clarify these findings. For example, research should be conducted in individuals who have received a diagnosis of autism or are self-diagnosed, providing insights into state presentations of the relationship in autism as opposed to trait presentations, there are also notable methodological limitations associated with the heartbeat task, such as the influence of prior knowledge about heart rates improving task performance (Ring et al, 2015; Murphy et al, 2018a) and the use of non-interoceptive strategies, such as estimating heart beats (Desmedt et al, 2018). These limitations have led to concerns regarding the validity of current measures that are notably holding researchers back from understanding the role of interoception in the overlap between autism and EDs (Adams et al, 2022).

Promising developments in measures of interoceptive sensibility, or self-report measures of interoception, have come from the development of the Interoception Sensory Questionnaire (ISQ; Fiene et al, 2018), a theory-driven measurement of interoception developed for Autistic adults. This was then followed by a shortened version (ISQ-8; Suzman et al, 2021), which suggested the removal of previously repetitive or redundant items showed an improved fit, while maintaining a high internal reliability. Thus, the ISQ-8 offers a promising measure of interoception, discriminating between Autistic and non-Autistic participants and addressing previous measurement limitations by developing a comprehensive, psychometrically evaluated measure. There remains scope to apply this measure to test its clinical validity in Autistic individuals with clinical conditions similarly associated with interoception, such as AN, and further explore the role of interoception in the overlap between autism and AN.

Social factors

Key differences across several social factors have been implicated in the overlap between autism and AN (Brede et al, 2020). The following section will further explore several of the factors identified in models of autism and AN (Brede et al, 2020; Kinnaird & Tchanturia, 2012). The following section will discuss social cognition, focusing on socio-emotional processing (how individuals identify, respond and communicate their emotions with others), social

communication (verbal and non-verbal communication in social situations) and social interactions and relationships.

Social cognition

Difficulties with several domains of social cognition have been reported in AN. Socio-emotional processing is a socio-cognitive processing stream that acknowledges the entwined nature of social and emotional cognitions and behaviours (Ochsner, 2008). Socio-emotional factors have been consistently implicated in the development, maintenance, and treatment of AN (Treasure & Schmidt, 2013; Cardi et al, 2018), not only influencing the behavioural expressions of AN, such as need for control and fixation of food, eating, weight and shape to regulate negative emotions (Oldershaw et al, 2019), but also influencing other social domains, such as interpersonal functioning (e.g., Treasure & Schmidt, 2013). Emotion judgement, referring to an ability to infer emotional mental states in others, is an example of socio-emotional processing that has been reported to be impaired in acute AN (Oldershaw et al, 2011), with tentative evidence to suggest abilities may return to typical levels once the individual has recovered (Oldershaw et al, 2010). Emotion recognition studies have also demonstrated mixed results (Caglar-Nazali et al, 2014; Harrison et al, 2010; Kucharsrska et al, 2016; Oldershaw et al, 2011; Dinkler et al, 2019; Kerr-Gaffney et al,2020a). Heterogeneity in findings may be due to a number of factors, including reliance on self-report measures (e.g., Oldershaw et al, 2011) or the use of static stimuli lacking ecological validity (e.g., Dinkler et al, 2019). A recent study adopting more dynamic, ecologically valid stimuli found that patients with AN did show reduced emotion recognition compared to healthy controls, and that this effect is more pronounced in those with longer illness duration and those with a lower weight (Blomberg et al, 2021). Finally, AN is associated with a number of variables which may themselves alter socio-emotional processing, such as BMI (Treasure, 2013), alexithymia (Brewer et al, 2016; Westwood et al, 2017), interoceptive abilities (Jacquemot & Park, 2020; Stanghellini et al, 2015) and the presence of autism (Westwood & Tchanturia, 2017; Huke et al, 2013), and warrant inclusion in future attempts to understand the nature of socio-emotional processing in AN.

Differences in socio-emotional processing have also been consistently implicated in autism. Indeed, autism was initially conceptualised as an "affective contact disorder" (Kanner, 1943), based on observed difficulties in the processing and interpreting of socio-emotional information (Li et al, 2022). Differences in socio-emotional processing have been found to exert an impact on broader social functioning in Autistic individuals; for example, reduced emotion recognition performance has been reported to be associated with differences in social interaction and communication outcomes (Hoyland et al, 2017; Russ et al, 2018; Martinez-Gonalez et al, 2021; Krishnan et al, 2021). Differences in emotion recognition have been implicated across all stages of development and across cultures (Uljarevic & Hamilton, 2013; Rump et al, 2009), with several meta-analyses have concluded that difficulties identifying all basic emotions are found in autism (Ulkarevic & Hamilton, 2013; Lozier et al, 2014; Yeung, 2022). Historically, it has been widely believed that Autistic individuals were not able to successfully judge emotional states in others (Fletcher-Watson et al, 2014), however recent attempts to delineate between cognitive and affective dimensions have found that emotional judgement in autism may be similar to that of neurotypical controls (Dziobek et al, 2008; Lockwood et al, 2013; Rueda et al, 2015), with possible differences only evident in the interpretation of negative emotions (Mazza et al, 2014; Li et al, 2022). Much like in AN, the possible role of other variables, such as alexithymia (Kinnaird et al, 2019c; Trevisan et al, 2016; Cook et al, 2013) and interoception (Quattrocki & Friston, 2014), in socio-emotional processing have been highlighted and warrant inclusion in future research.

Given the prominence of socio-emotional processing evident in current understandings of both AN and autism, these constructs offer an intuitive target for possible underlying mechanisms (Zucker et al, 2007; Kinnaird & Tchanturia, 2021). Several studies have begun to directly compare Autistic and non-Autistic individuals with AN. A comparative study looking socio-emotional skills in autism and AN found similarities in some emotional dimension, such as feelings of distress and lack of emotional introspection, yet marked differences in socio-emotional skills, such as emotional judgement (Courty et al, 2013). Other studies have explored emotion recognition studies, with early evidence to suggest that reduced emotion recognition performance is associated with Autistic traits in both acute (Kerr-Gaffney et al, 2020a) and recovered (Dinkler et al, 2019) AN, as opposed to being specific to AN. Collectively, these studies highlight the importance of considering socio-emotional processing in future

attempts to untangle the overlap between autism and AN, as well possibly it's influence on broader social functioning.

Social interactions and relationships

Another domain that has been implicated in the overlap between autism and AN is social interactions and relationships. Difficulties in social or interpersonal relationships have been implicated as a core component in development, maintenance and treatment models of AN (Arcelus et al, 2011; Schmidt & Treasure, 2006; Treasure & Schmidt, 2013; Jones et al, 2015; Vall et al, 2015; Ung et al, 2017). For example, studies have found that individuals with AN report engaging with more solitary activities in childhood and few childhood friends, social behaviours that continue into adulthood (Fairburn, 1999; Krug et al, 2012; Tiller et al, 1997). Loneliness and a lack of social connectedness have also been implicated in the aetiology of AN, with higher levels of perceived loneliness associated with more severe ED cognitions and behaviours (Pritchard & Yalch, 2009), and stronger social connections and support identified as a notable factor in recovery (Rowlands et al, 2021; Weltzer et al, 2020). Several studies have focused on the nature of social relationships, highlighting challenges in connecting with others as preceding factors (Cardi et al, 2018; Westwood et al, 2016), as well as a key maintenance factors during acute illness states (Datta et al, 2021; Tiller et al, 1997; Doris et al, 2014).

Social interactions and relationships have also been implicated in autism, with differences in social interaction posited as a key feature of the condition (APA, 2013). Historically, studies have reported reduced social interaction during childhood, including less play behaviours and less reciprocal friendships (Kasari et al, 2011; Bauminger et al, 2003; Macintosh & Dissanayake, 2006; Scheeren, Koot & Begeer, 2012; Frye, 2018). However, the impact of these differences have been under-researched, largely due to assumptions that Autistic individuals are inherently socially withdrawn and lack social motivation (Chevallier et al, 2012). Challenging these assumptions is recent research exploring the perspectives and experiences of social relationships in Autistic individuals, where the importance of social connections and companionship are reported to be important to their wellbeing and mental health (Cresswell

et al, 2019; Calder et al, 2013; Daniel & Billingsley, 2010; Sedgewick et al, 2016, 2019a; O'Connor et al, 2021). Conversely, higher incidences of loneliness have been associated with poor quality social relationships and a lack of understanding during social interactions with non-Autistic individuals (Sumiya et al, 2018; Whitehouse et al, 2009; Umagami, Remington, Llyod-Evans, Davies & Crane, 2022). Extending beyond interpersonal relationships, a recent qualitative study reported social participation across broad range of contexts in Autistic adults, including neighbourhoods, shared interest groups and online networks (Chan, Doran & Galobardi, 2023).

As differences in social relationships and interactions have been implicated in both AN and autism individually, emerging theories and models have emphasised the possible role of these factors in the overlap between the two conditions (Brede et al, 2020; Kinnaird & Tchanturia, 2021). Only a handful of studies to date have sought to empirically investigate this. Doris et al (2016) conducted a qualitative study with seven patients with AN who displayed high Autistic traits, proposing a shared social phenotype of reduced social networks and connections between autism and AN. Kinnaird et al (2019a) also interviewed with Autistic women with AN and found that confusion surrounding social interactions was reported to be one of the leading factors that influenced their AN. Recently, a quantitative comparative study found that differences in social reciprocity (engaging in social interactions, including back-and-forth communication) were the single feature that discriminated between Autistic and non-Autistic participants with AN, suggesting that this reciprocal social communicative behaviour may be at the heart of untangling autism and AN (Kerr-Gaffney et al, 2021a).

Social communication

Social communication is a multi-faceted concept, generally referring to both verbal and non-verbal behaviours used to communicate with others. Social difficulties have been key factors implicated in the development, maintenance and treatment of AN (Fairburn & Cooper, 2003; Fairburn, 2008; Treasure & Schmidt, 2013), and social communicative difficulties have been reported as a notable example of this. For example, expressing emotions has been found to be challenging for those with AN (Davies et al, 2016; Harrison, 2021) and this may in part

explain broader social difficulties (Harrison et al, 2014). Non-verbal communication, such as body language and eye gaze, have also been explored in AN, with recent studies reporting less use of hand gestures, reduced eye contact, and differences in body orientation when compared to healthy controls (Harrison, 2021; Monteleone et al, 2022). These differences in social communication have been associated with clinical and behavioural outcomes, leading to poor treatment outcomes and delayed recovery (Deter et al, 2005; Patel et al, 2016). Qualitative studies have also found that individuals with AN feel that social communicative difficulties negatively influence their friendships and other social interactions (Westwood et al, 2016), thus further supporting the idea that these difficulties may play an important underlying role in broader social functioning. However, the aetiology of these differences has been questioned amongst the literature. It has been suggested that social communicative difficulties do not constitute a global risk factor in the development of AN, but instead serve as a perpetuating factor, while there may be a sub-group demonstrating autism-specific social communicative difficulties, particularly non-verbal communication, during childhood that led to the development of disordered eating in adolescence (Anackster et al, 2012).

In addition to differences in social interactions, differences in social communication are also a hallmark feature of autism (APA, 2013), and thus a notable body of studies have explored verbal and non-verbal communication behaviours in autism. The inherently heterogenous nature of autism is keenly highlighted in verbal communication; for example, some Autistic individuals reported difficulties with the physical act of speech, while others report difficulties in the function of speech, including prosody (rhythm, stress and intonations), semantics (valence and meaning of words) and pragmatics (the influence of context to meaning; Tager-Flasburg et al, 2005; Levy et al, 2010; Riches et al, 2010; Georgiou & Spandoudis, 2021; Costescu et al, 2022). A significant number of studies have also explored the use of non-verbal behaviours. Studies have reported differences in eye gaze behaviours, notably mutual eye contact (Madipakklam et al, 2017; see Stuart et al, 2022) and atypical gaze patterns to facial features during experimental tasks (Papagiannoipoulou, Chitty, Hermes, Hickie & Lagopoulous, 2013; Ma, Gu & Zhao, 2021). Furthermore, a recent review found evidence to suggest that the broad range of social difficulties reported in autism may be notably related to differences in social communication earlier in development (Tajik-Parvinchi et al, 2021),

suggesting that social communication should be a key consideration in future explorations of social factors in autism. However, recent social models of autism are challenging interpretations of these findings, offering a new lens through which to view these social differences. These theories advocate that these autism-specific differences in social communication and their impact are reflective of a bidirectional misunderstanding and miscommunication between Autistic and neurotypical individuals (Davis & Crompton, 2021; Milton, 2012; Bolis et al, 2017). Recent evidence supports this, suggesting that this mismatch in communication and interpersonal styles between Autistic and non-Autistic individuals may contribute to perceived social communication difficulties (Crompton et al, 2020a), and that communication between Autistic individuals is in fact highly effective (Crompton et al, 2020b). In light of this, there is a pressing need to develop approaches to investigating social communication in autism that are rooted in such thinking, instead of relying on limited quantitative measures that were developed in neurotypical populations (Morrison et al, 2019) and which currently fail to predict actual social communication in Autistic individuals (Sasson et al, 2020).

Thus far there is sparse evidence base exploring social communication as a target mechanism in understanding the overlap between autism and AN, despite initial conceptualisations of the overlap highlighting the possible influence of Autistic traits on social communication behaviours in AN (Gillberg, 1985). A recent longitudinal study reported that Autistic social traits in childhood, as measured by the Social and Communication Disorders Checklist (SCDC; Skuse, Mandy & Scourfield, 2005), predicted disordered eating in adolescence (Solmi et al, 2021b). These findings would suggest that Autistic socio-communicative traits specifically are a risk factor for the development of disordered eating, and social communicative differences may be at the core of subsequent ED pathology. Future research is therefore urgently needed expanding on this evidence base for AN samples specifically, using ecological and neurodiverse-affirming methods of exploring social communication as a possible discriminative factor in autism and AN.

Aims and hypotheses

The overall aim of the current thesis is to investigate the role of sensory, social and emotional factors in anorexia nervosa (AN) in Autistic and non-Autistic individuals. The overarching hypotheses were that there will be both similarities and differences in sensory, social and emotional factors between Autistic and non-Autistic individuals with AN, and differences in these factors will be crucial in discriminating between Autistic and non-Autistic individuals. The thesis adopted a mixed method approach, conducting a systematic review to identify possible mechanisms, followed by a qualitative exploration of implicated mechanisms, before empirically investigating these mechanisms using observational methods.

Systematic Review – Sensory processing and eating behaviours in autism

The first paper of the thesis is a systematic review of studies exploring the link between sensory processing and a range of eating behaviours in autism. Despite a significant number of studies exploring this link, this review was the first paper to date that sought to systematically collate the evidence base, comparing the relationship across different eating behaviours. This review provided a solid foundation for the remainder of the thesis, beginning to shed important insights not only on sensory processing differences and their possible links with disordered eating but also how these differences can interact with social and emotional domains.

Aims: The review aimed to identify, evaluate and synthesise up-to-date literature exploring the relationship between sensory processing and eating behaviours across the lifespan in autism.

Study 1 – Qualitative – "It's not about wanting to be thin or look small, it's about the way it feels": An IPA analysis of social and sensory differences in Autistic and non-Autistic individuals with anorexia and their parents

The first empirical study of the thesis sought to further elucidate sensory and social mechanisms implicated in Autistic and non-Autistic adults with AN. Building on previous multi-perspective studies (Brede et al, 2020; Babb et al, 2021), this study adopted a novel dyadic approach, drawing on the shared experiences of social and sensory factors in Autistic and non-Autistic adults and their parents.

Aims: This study sought to explore the lived experience of Autistic and non-Autistic adults and their parents, and to provide novel insights into the role of social and sensory factors in the developmental, maintenance and recovery from AN. The study also sought to compare these experiences between groups, seeking to untangle possible shared or condition-specific differences in social and sensory experiences.

Research questions: (1) What social, sensory and other factors do Autistic and non-Autistic dyads perceive to play a role in their AN? (2) What are the similarities and differences in the factors identified by Autistic and non-Autistic dyads?

Study 2 – Observational – Non-verbal social communication behaviours in Autistic and non-Autistic young adults with AN

The second empirical study of the thesis adopted an observational design. The study involved a short, structured social communication task between the participant and the researcher through a positive, negative and neutral condition. The task was filmed and coded using a modified non-verbal behavioural coding scheme (Harrison, 2021). The study sought to explore similarities and differences across four groups: (1) Autism and AN; (2) Autism only; (3) AN only; and (4) neurotypical/healthy controls (NT/HC).

Aims: The current study sought to investigate non-verbal social communication behaviours in in Autistic young adults with AN, Autistic young adults, young adults with AN and neurotypical/healthy controls (NT/HC) in order to identify both common and condition-specific non-verbal behaviours that may help to untangle the overlap between autism and AN.

Hypotheses: Firstly, to explore between-group differences, it was hypothesised that there will be overall differences in non-verbal behaviours across groups however, due to the novel nature of the research questions, these hypotheses were non-directional. Exploratory analyses regarding between-group differences in the positive, negative and neutral condition were also conducted due to the novel nature of the research questions.

Secondly, to explore within-group differences, it was broadly hypothesised that in Autism and AN, Autism only and AN only, there would be a significant effect of condition (positive, negative and neutral) on non-verbal social communication behaviours, while there will be no effect on condition in the NT/HC groups. Similarly, these hypotheses were non-directional. Furthermore, no hypotheses were generated regarding the remaining codes across all groups, and exploratory analyses were conducted.

Study 3 – Observational – The relationship between non-verbal social communication behaviours and sensory, social and emotional factors in Autistic and non-Autistic young adults with AN

The final empirical study of the current thesis adopted an observational design. As per Study 2, the study involved a short, structured social communication task across three conditions (positive, negative, neutral). The task was recorded, and non-verbal behaviours were coded using a modified version of a behavioural coding scheme (Harrison, 2021). Research interest lay in the relationship between non-verbal behaviours and sensory and emotional factors, as

well as comorbid psychopathology The study sought to explore these relationships in four participant groups: (1) Autism and AN; (2) Autism only; (3) AN only; and (4) neurotypical/healthy controls. Due to the novel approach and design of the study, interest also lay in the feasibility of recruiting for and adopting current methods.

Aims: The aim of study 3 is to investigate the relationship between social communication, as measured by non-verbal behaviours, and several factors implicated in the overlap between autism and AN, including interoception, alexithymia and depression and anxiety.

Hypotheses: It was hypothesised that (i) higher self-reported eating disorder symptomology will be correlated with gaze aversion, body positioning and reduced use of hand gestures in Autism and AN and the AN only group but not in the Autism only or neurotypical/healthy control (NT/HC) group; and (ii) higher self-reported Autistic traits will be correlated with gaze aversion and increased use of hand gestures in the Autism and AN and the Autism only group, but not in the AN only or NT/HC group.

With regards to interoception, alexithymia and depression and anxiety, the novel nature of the study mean that analyses were predominantly exploratory however it was anticipated that: (i) higher self-reported interoception will be correlated with non-verbal social communication behaviours such as gaze avoidance and leaning or facing away from the conversational partner in Autism and AN, Autism only and AN only; (ii) higher rates of self-reported alexithymia will be correlated with non-verbal social communication behaviours such as gaze avoidance and leaning or facing away from the conversational partner in Autism and AN, Autism only and AN only; and (iii) depression and anxiety will similarly be correlated with non-verbal social communication behaviours such as gaze avoidance and leaning or facing away from the conversational partner in Autism and AN, Autism only and AN only.

Chapter 3 – Sensory processing and eating behaviours in autism: A systematic review

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Abstract

Objectives: The aim of this review was to assess the relationship between sensory processing and a range of eating behaviours in autism across the lifespan.

Methods: Five electronic databases of published and unpublished quantitative studies were systematically searched, evaluated for risk of bias and synthesized according to identified eating outcomes.

Results: Across 25 studies, there was consistent evidence of a relationship between sensory processing and a range of eating behaviours. There was early evidence for the particular role of taste/smell sensitivities, as well as hypersensitivities, although future research is needed looking at different sensory patterns and modalities. There was a lack of research looking at this relationship in adolescence and adulthood, as well as a lack of exploring the relationship within the context of disordered eating or feeding outcomes.

Discussion: Study findings are discussed in relation to implications for sensory-based eating and feeding interventions and the development of eating or feeding disorders. Methodological and conceptual limitations are discussed and suggestions for future research are made to address these limitations. A broader investigation of multi-sensory issues and clearly defined eating behaviours, including disordered eating in clinically diagnosed samples, will allow for a more comprehensive and robust understanding of the relationship between sensory processing and eating behaviours in autism.

Introduction

Autism Spectrum Disorder (ASD), here on referred to as autism, is clinically characterised by differences in social interaction and communication, the presence of restrictive and repetitive behaviours and differences in sensory processing (APA, 2013). Sensory differences reflect a heterogenous presentation of global and multi-modal differences and have been reported in up to 90% of individuals (Baranek et al, 2006; De Both & Reynolds, 2015). The DSM-V (APA, 2013) adopts one of the most common theoretical approaches to sensory processing that highlights patterns of hyper- and hypo-sensitivities (Boyd et al, 2009; Marco et al, 2011) as well as sensory seeking behaviours (Ben-Sasson et al, 2009). These subtypes can refer to sensitivities at an individual sensory modality but are also hypothesised to apply across multiple sensory modalities (Tomchek et al, 2007; Crasta et al, 2020). This latter conceptualisation of sensory processing is in line with emerging evidence for differences in integrating sensory information across modalities in autism (Iarocci & Donald, 2006; Stevenson et al, 2015). It is now generally accepted that sensory differences are integral in our understanding of autism, not just as core symptoms but also in their influence on different behavioural and clinical features (Robertson & Baron-Cohen, 2017; Glod et al, 2015).

While atypical eating behaviours are reported to be common in neurotypical childhood (Dubois et al, 2008; Dovey et al, 2008; Micali et al, 2011), such behaviours appear to be a more frequent and persistent issue in autism (Twachtman-Reilly et al, 2008; Bandini et al, 2017; Baraskewich et al, 2021; Sharp et al, 2013). Clinicians and caregivers frequently report a broad range of such behaviours in Autistic individuals, such as food selectivity, disruptive mealtime behaviours and food neophobia, here defined as a fear of trying new foods (Margari et al, 2020; Edmond et al, 2010; Wallace et al, 2018). Aversions have also been cited based on sensory characteristics or features of foods, such as texture, colour or specific brands (Ahearn et al, 2001; Schrek et al, 2004; Schrek & Williams, 2006). Subsequent empirical studies have implicated these food-specific sensory characteristics in Autistic individuals who demonstrate atypical eating behaviours (Kuschner et al, 2015; Hubbard et al, 2014; Postorino et al, 2015), leading to the proposal that differences in sensory processing may account for these aversions and may in turn be an underlying

mechanism of atypical eating behaviours in autism (Mari-Bauset al, 2014; Cermak et al, 2010).

The clinical implications of this relationship are significant. Not only are there associated health risks, such as weight concerns and gastrointestinal (GI) issues (Brown et al, 2016), but there is also increasing evidence suggesting a heightened risk of developing eating and feeding disorders in autism (Westwood & Tchanturia, 2017; Tchanturia et al, 2019; Gesi et al, 2021; Bourne et al 2021). The trajectory and underlying mechanisms of this relationship remain largely unknown. Recent longitudinal studies report that greater Autistic traits in childhood predict disordered eating in adolescence (Solmi et al, 2021), with fussy eating habits in childhood identified as a possible mediator (Leno et al, 2022). This would suggest that autism could be a risk factor in the development of disordered eating, and that atypical eating behaviours in childhood particularly act as a precursor to the development of eating or feeding issues. Alternatively, there could be common underlying vulnerability mechanisms, such as sensory processing (Kinnaird et al, 2018; Brede et al, 2020).

Two previous reviews have addressed the relationship between sensory processing and eating behaviours in autism. In a systematic review looking at a range of psychological correlates of sensory processing, Glod et al (2015) identified one study exploring eating behaviours that did not find evidence to support a relationship. More recently, Page et al (2021) reviewed correlates of childhood eating and feeding difficulties in autism and found that atypical eating behaviours, particularly food selectivity, are consistently correlated with differences in sensory processing. The current review seeks to extend these reviews by adopting a lifespan approach to the relationship between sensory processing and eating behaviours. This review also seeks to account for a wide range of clearly defined and conceptualised eating behaviours following calls to address significant heterogeneity in definitions of eating behaviours and criticism of previous measures in their neglect of important autism-specific behaviours associated with the mealtime environment (Bandini et al, 2017; Page et al, 2021; DeMand et al, 2015). Therefore, this review will aim to identify, evaluate and synthesize up-to-date literature to provide an evidence-based answer to the

following research question: is there a relationship between sensory processing and eating behaviours in autism across the lifespan?

Methods

This review was conducted in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (PRISMA; Page et al, 2020).

Inclusion criteria

Studies were eligible for inclusion if they looked at the relationship between sensory processing and eating behaviours in individuals with a diagnosis of autism, in both clinical and community populations. Full text was required to be available in English. Both published and unpublished studies were included, with no exclusion based on publication date. Studies were also required to report a measure of effect of the relationship between sensory processing (considered here as the exposure) and eating behaviours (considered here as the outcome).

For the purposes of this review, *sensory processing* was defined as sensory sensitivities, such as modality-specific as well as interoceptive, proprioceptive and vestibular hyper- and hypo-sensitivities, as well as sensory seeking and multi-sensory integration (Ben-Sassoon et al, 2009; Mari-Bauset et al, 2014). Studies were included if they used a measure of sensory processing in line with this definition. These measures could be observational, behavioural or physiological, and could involve self-, parent- and/or clinician-report. Studies that looked at sensory characteristics of food (e.g., consistencies, brand, foods touching other foods, etc.) or cognitive or affective processing of food or food-related stimuli (e.g., emotional/hedonic ratings or responses to food) *only*, without linking these processes to general sensory modalities or patterns were not included. *Eating behaviours* was here defined as any eating or feeding behaviours, including mealtime behaviours, food selectivity, food neophobia or disordered eating (Martins et al, 2008; Margari et al, 2020). Studies were included if they used a measure of eating behaviours in line with this

definition. These measures could be observational or behavioural, and could involve self-, parent- and/or clinician-report. Studies were excluded if they reported on dietary-related conditions *only*. No exclusions were made with regard to age, gender or comorbidity.

Information sources and search strategy

Following a scoping search, five databases were searched in March 2021: psychINFO (OVID), Scopus, PubMed and Web of Science were used to search for published studies, while ProQuest Dissertation and Theses for unpublished studies. Search terms were identified from early scoping searches and in collaboration with information specialists at the University of Edinburgh and included autism AND sensory processing OR hypersensitivities OR hyposensitivity's AND eating OR feeding OR food OR mealtime.

Selection and data collection process

Two reviewers (EN, LG) independently screened title and abstracts, with the LG screening two thirds (66%). Full texts of potentially eligible studies were retrieved where possible and screened against inclusion criteria. Any full texts that did not meet inclusion criteria were excluded. The following data was extracted from each paper by EN: study characteristics (e.g., population, setting, power and/or sample calculations, missing data computations, adjustment for confounders), participant characteristics (e.g., means and standard deviations of age, percentage of gender, percentage ethnicity) and measures of interest (e.g., measures of relationship between sensory processing and eating behaviours). Where more than one paper was published from the same study, data was extracted in chronological order, starting with primary publication and updating relevant data where appropriate.

Study risk of bias assessment

Quality assessment based on the NIH Quality Assessment Tool for Observational, Cross-Sectional and Cohort Studies was conducted by EN and LG on included studies. Inter-rater

agreement was 87%, and agreement was reached on the remainder through mutual agreement.

Results

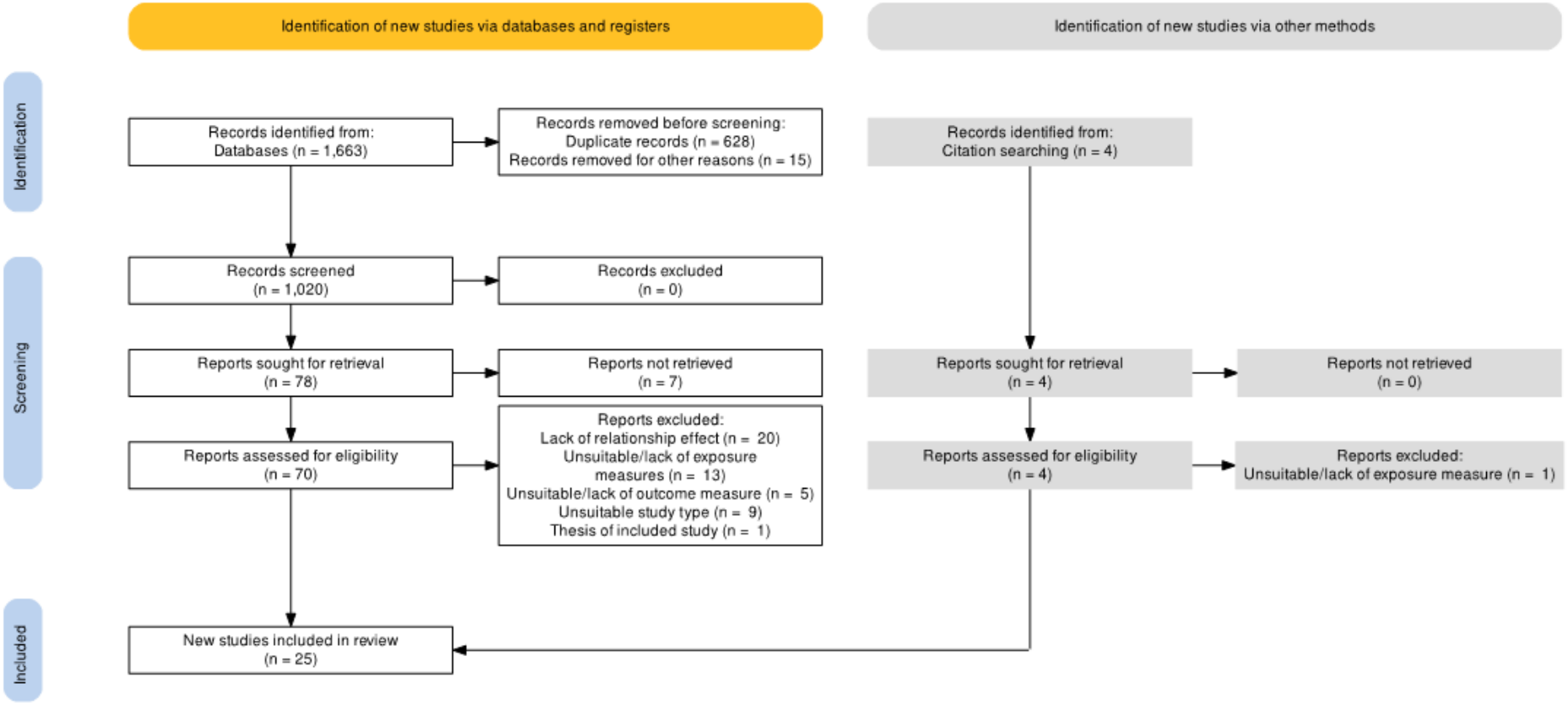
Online database searches generated 1,663 studies that were screened for eligibility. Following screening of titles and abstracts, 71 studies were screened at full text. The selection and screening process resulted in 26 papers reporting 25 independent studies to be included in the current review. Four studies were identified by the process of backward citation chaining. See the PRISMA flow diagram depicting the screening and selection process for included studies (Figure 1).

Study characteristics

Of the 25 studies included in this review, 24 had a cross-sectional design and one study had a longitudinal design (see Table 1). Two of the studies conducted a secondary data analysis, and the remaining 24 studies utilised primary data. All studies were published between 2008 and 2021, with most studies conducted in the US (n=11). Across studies, there was a total of 4,338 participants included, with sample sizes ranging from 25 to 1112 (median n = 98). Participants ages ranged from 1 to 28 years, with the majority looking at the relationship between sensory processing and eating behaviours during childhood (n = 18). Stage of childhood varied considerably across studies, and there was a notable lack of definition or justification of chosen age range. 24 studies look at mixed-gender samples, and one study looked at a female only sample.

Figure 1.

PRISMA flow diagram depicting the screening and selection process of the current review.



Risk of bias

Out of the 25 studies included, six were deemed Good Quality, four were deemed Poor Quality and the remaining 15 were deemed Fair Quality (see Table 2). Eight of the included studies reported that participation rates of eligible persons were at least 50% and nine studies failed to report full inclusion and exclusion criteria, suggesting risk of selection and response bias. Due to only one study being a longitudinal design, there was a consistent lack of sufficient timeframe to reasonably expect to see an association between variables. Furthermore, three studies did not use a validated measures of sensory processing and six studies did not use a validated measure of eating behaviours, suggestive of a measurement bias, particularly regarding eating outcome measures. Additionally, all unpublished studies reported significant results, suggesting there was no evidence of publication bias.

Table 1.

Study characteristics.

Author	Country	Design	Control group	N=	Developmental stage (range)	M(SD) in years	%Female
Bitsika & Sharpley (2018)	Australia	Cross-sectional	None	37	Childhood (6-11yrs)	8.5(1.5)	100%
Chistol et al (2018)	US	Cross-sectional	Age-matched NT	53 AUT 56 NT	Childhood (3-11yrs)	6.6(2.1) AUT 6.7(2.4) NT	17% AUT 22% NT
Crasta et al (2014)	India	Cross-sectional	ID	41 AUT 56 ID	Childhood (3-10yrs)	6.42(1.92) AUT 7.15(1.76) NT	26%*
Johnson et al (2014)	US	Cross-sectional	None	256	Childhood (2-11yrs)	5.4(2.4)	16%
Koshy (2015)	UK	Cross-sectional	None	144 ASD 391 Autism 123 Asperger	Childhood and adolescence (2-18yrs)	5.2 ASD 4.2 Autism, 7.4 Asperger	18.2% ASD 18.8% Autism 12.2% Asperger
Kral et al (2015)	US	Cross-sectional	NT	25 AUT 30 TD	Childhood (4-6yrs)	5.0(0.9) AUT 5.2(0.7) NT	28% AUT 53% NT
Lane et al (2014)	Australia	Cross-sectional	None	36	Childhood (3-10yrs)	6.7	20%
Leader et al (2020)	Ireland	Cross-sectional	None	136	Childhood & adolescence (ns)	8.46(4.13)	28%
Leader et al (2021)	Ireland	Cross-sectional	None	120	Childhood & adolescence (ns)	8.0(3.79)	22.5%

Martins et al (2008)	Australia	Cross-sectional	NT, SIB	41 AUT 14 SIB 41 NT	Childhood (2-12yrs)	-	17% AUT 50% SIB 44% NT
Nadon et al (2011)	Canada	Cross-sectional	None	95	Childhood (3-10yrs)	7.3(2.4)	8.4%
Padmanabhan & Schroff (2020)	India	Cross-sectional	None	146	Childhood (3-11yrs)	7.09(2.55)	19%
Panerai et al (2020)	Italy	Cross-sectional	None	111	Childhood (2-12yrs)	*Median, split into:* 5.0 AUT 5.3 NT	*Split into:* 18.9% AUT-W 24.3% AUT-WO
Pomoni (2016)	UK	Cross-sectional	NT	103 AUT 151 NT	Childhood (2-14yrs)	7.32(2.58) AUT only	22.3% AUT 51.0% NT
Riccio et al (2018)	Italy	Cross-sectional	Age-matched NT	43 AUT 41 NT	Childhood (2-11yrs)	6.28(2.3) AUT 7.2 NT	30% AUT
Schnizler (2014)	US	Cross-sectional	Age- and IQ-matched NT	28 AUT 31 NT	Childhood & adolescence (2-18yrs)	12.75(1.90) AUT 13.07(2.92) NT	21.4% AUT 45.2% NT
Shamaya et al (2017)	Israel	Cross-sectional	Age- and gender-matched NT, SIB	50 AUT 12 SIB 29 NT	Childhood (3-6yrs)	*In months:* 5.41(11.1) AUT 77(32) SIB 51.6(11.6) NT	19.6% AUT 28.6% SIB 24.1% NT
Smith et al (2020)	UK	Cross-sectional	NT, TS, ADHD	27 AUT 27 NT 27 TD 17 ADHD	Childhood & adolescence (6-17yrs)	-	40.7% AUT 18.5% NT 18.5% TS 41.2% ADHD

Suarez et al (1. 2012; 2. 2014)	US	1. Cross-sectional 2. Longitudinal	None	1. 141 2. 54	Childhood (3-9yrs)	1. *Split into:* 6.23(1.85) Severe 6.24(1.39) Moderate 6.88(1.51) Typical 2. -	1. 5% 2. 12%
Tanner et al (2015)	US	Cross-sectional	None	35	Childhood (4-10yrs)	*Split into:* 6.5(1.9) Selective 6.9(2.0) Nonselective	*Split into:* 11.8% Selective 5.6% Nonselective
Trinh (2014)	US	Cross-sectional	NT	9 AUT 16 NT	Childhood (5-12yrs)	9.11(0.72) AUT 7.19(0.53) NT	-
Wang et al (2019)	China	Cross-sectional	Age-matched NT	81 AUT 153 NT	Childhood (3-7yrs)	5.18(0.92) AUT 5.34(1.14) NT	17.3% AUT 16.8% NT
Zickgraf & Mayes (2018)	US	Cross-sectional	None	1112	Childhood & adolescence (1-17yrs)	6.4(3.3)	10.6%
Zickgraf et al (2020)	US	Cross-sectional**	None	185	Childhood, adolescence & young adulthood (4-17yrs)	8.65(3.03)	28%
Zobel-Lachiusa et al (2015)	US	Cross-sectional	NT	34 AUT 34 NT	Childhood (5-12yrs)	8.61(2.32) AUT 8.76(2.23) NT	3% AUT 20.6% NT

AUT = autism, NT = neurotypical, ID = intellectual disability, DD = developmental delay, ASD = autism spectrum disorder, SIB = neurotypical siblings of an autistic child, AUT-W = autism with feeding problems, AUT-WO = autism without feeding problems, TS = Tourette's syndrome, ADHD = attention deficit hyperactivity disorder, OCD = obsessive compulsive disorder, REP = representative sample, UG = undergraduate sample

Table 2.

Quality assessment and risk of bias.

	Research question or aims/ objectives clearly stated?	Study population clearly and specifically defined?	Participation rate of eligible participants at least 50%?	All subjects recruited from same/ similar populations?	Inclusion and exclusion criteria prespecified and uniformly applied?	Sample size, power or variance and effect estimates?	Exposure measured prior to outcome?	Sufficient timeframe to reasonably expect association?	Exposure clearly defined, valid, reliable and implemented consistently?	Exposure assessed more than once?	Outcome clearly defined, valid, reliable and implemented consistently?	Outcome assessors blind to exposure status?	Loss to follow-up 20% or less?	Key confounding variables measured and controlled for?	***Overall Quality of Study***
Bitsika & Sharpley (2018)	-	+	NR	+	NR	-	-	-	+	-	-	-	NA	+	*Poor*
Chistol et al (2018)	+	+	NR	+	+	+	-	-	+	-	+	-	NA	+	*Good*
Crasta et al (2014)	-	+	+	+	CD	+	-	-	+	-	+	+	NA	+	*Fair*
Johnson et al (2014)	+	+	+	+	CD	-	-	-	+	-	+	-	NA	+	*Fair*
Koshy (2015)	+	+	-	+	+	+	-	-	+	-	+	-	NA	+	*Fair*
Kral et al (2015)	+	+	NR	+	+	-	-	-	+	-	+	-	NA	+	*Fair*
Lane et al (2014)	+	+	NR	+	NR	-	-	-	+	-	+	-	NA	+	*Fair*
Leader et al (2020)	+	+	NR	+	NR	-	-	-	+	-	+	-	NA	+	*Fair*

Leader et al (2021)	+	+	NR	+	NR	-	-	-	+	-	+	-	NA	+	*Fair*
Martins et al (2008)	+	+	+	+	+	-	-	-	-	-	CD	-	NA	-	*Poor*
Nadon et al (2011)	+	+	+	+	+	-	-	-	+	-	+	-	NA	+	*Fair*
Padmanabhan & Schroff (2020)	+	+	NR	+	+	+	-	-	+	-	+	-	NA	-	*Good*
Panerai et al (2020)	+	+	NR	+	+	+	-	-	+	-	+	-	NA	+	*Good*
Pomoni (2016)	+	+	NR	+	+	-	-	-	+	-	+	-	NA	+	*Fair*
Ricco et al (2018)	+	+	NR	+	+	-	-	-	+	-	+	-	NA	-	*Fair*
Schnizler (2017)	+	+	NR	NR	NR	-	-	-	+	-	+	-	NA	+	*Poor*
Shmaya et al (2017)	+	+	+	+	+	+	-	-	+	-	+	-	NA	+	*Good*
Smith et al (2020)	+	+	+	+	+	-	-	-	+	-	+	-	NA	+	*Good*
Suarez et al (2012; 2014)	+	+	-	+	+	-	-	+	-	-	-	-	-	+	*Fair*
Tanner et al (2015)	+	+	+	+	+	+	-	-	+	-	+	-	NA	+	*Good*
Trinh (2014)	+	+	NR	+	+	+	-	-	+	-	+	-	NA	+	*Fair*
Wang et al (2019)	+	+	NR	+	+	+	-	-	+	-	+	-	NA	+	*Fair*

Zickgraf & Mayes (2019)	+	+	+	-	+	+	-	-	-	-	-	-	NA	+	*Poor*
Zickgraf et al (2020)	+	+	NR	NR	NR	-	-	-	-	-	-	-	NA	+	*Poor*
Zobel-Lachiusa et al (2015)	+	+	NR	+	+	+	-	-	+	-	+	-	NA	+	*Fair*

+ Yes
- No
NR Not reported
CD Cannot determine
NA Not applicable

Study results

Key results of included studies are presented in Table 3. The following section will synthesize the results summarized by eating outcome. There was notable heterogeneity within studies as to standardized definitions of eating outcomes. In some cases, food selectivity is used to describe a singular behaviour indicative of picky eating, while in others it was used interchangeably with terms such as food refusal or limited repertoire. Attempts towards a standardized definition acknowledge these latter terms of selective behaviours as two separate and empirically measurable domains (Bandini et al, 2010; 2017) leading to recent calls for defining and measuring each domain individually (Page et al, 2021). Thus, for the purposes of this review, they will be treated as distinct categories in instances whereby these separate behaviours can be isolated; food refusal behaviours will fall under the umbrella category of *Mealtime Behaviours*, while *Food Repertoire* will form a category of its own. In instances whereby these two domains cannot be isolated, food selectivity will be used to describe the singular behaviour of fussy eating and will similarly be included under the umbrella category of *Mealtime Behaviours.* Thus, the following section will qualitatively synthesize results by the following eating outcomes:

- *Mealtime Behaviours*, which here refers to outcomes associated with behaviours typically displayed around mealtimes, such as general mealtime and eating behaviours, food refusal, food selectivity or fussiness, ritualistic eating behaviours and over- or under-eating.
- *Food Repertoire*, which here refers to food or dietary intake; and
- *Food Neophobia*, which here refers to fear of trying new foods. No study that met inclusion criteria explored disordered eating as an outcome.

With regards to sensory processing, it is also important at this stage to clarify possible heterogeneity. “Oral sensory processing” refers to the processing of food or other objects put in the mouth, and oral sensory sensitivities refer to atypical sensory processing associated with this process (Chaware et al, 2021). Oral sensory sensitivities can encompass atypical processing across multiple sensory domains, including taste, smell and tactile

Table 3.

Study results.

Author	N=	Sensory measure*	Sensory measure collection method	Eating measure**	Eating measure collection method	Controlled for	Other measures***	Relationship findings
Bitsika & Sharpley (2018)	37	SP	Parent-report	SWEAA	Parent-report	Medication, comorbidities	WASI-II, ADOS-2, SRS	Two SRS RRB subscales only variable that sig predicted eating disturbances
Chistol et al (2018)	56 AUT 56 NT	SP	Parent-report	FFQ, 3-day food record	Parent-report	Age, sex, race/ethnicity, only child	VABS, DAS	Autistic children with oral sensitivities exhibited more food refusal and less vegetables; oral over-sensitivities associated with food refusal, limited repertoire and limited fruit/vegetable
Crasta et al (2014)	41 AUT 56 ID	SP	Parent-report	BAMBI	Parent-report	Gender, IQ, comorbidity	CARS, BKSI/GDS, VSMS	Food refusal, disruptive mealtime behaviour and limited repertoire sig associated with sensory processing across domains; food selectivity associated with oral only
Johnson et al (2014)	256	SSP	Parent-report	BAMBI, HEI	Parent-report	Medication	ADOS, MSEL/SB:5th, RBSR, CBCL	Predictive relationship of sensory processing on eating behaviours
Koshy (2015)	639	SSP	Parent-report	ASD-CC	Parent-report	Age	ASD-PBC	Sig association between both under- and over-eating and sensory processing across

Kral et al (2015)	25 AUT 30 NT	SP	Parent-report	CFNS, CEBQ	Parent-report	Age, sex, race/ethnicity height, weight, BMI	SCQ, CFQ, PFSQ	AUT: atypical oral sensory sensitivity showed higher food neophobia and fussiness
Lane et al (2014)	30	SP	Parent-report	BAMBI, 3-day food record	Parent-report			Sig, association between taste/smell sensitivities and both food refusal and limited repertoire
Leader et al (2020)	136	SSP	Parent-report	STEP-CHILD	Parent-report	Age, gender, GI symptoms, challenging behaviour, comorbid psychopathology	GI Symptom Inventory, BPI-S, ASD-CC	Sig relationship between sensory processing and rapid eating, food refusal, food selectivity Sig predictive relationship of sensory processing for food selectivity
Leader et al (2021)	120	SSP	Parent-report	STEP-CHILD	Parent-report	Age, gender, GI symptoms, challenging behaviour, comorbid psychopathology, adaptive functioning, quality of life	GI Symptom Inventory, BPI-S, ASD-CC, Pedsql, VABS-II, CAM treatments	Sig relationship between sensory processing and: chewing problems, particularly sensory seeking; rapid eating, particularly auditory; food selectivity. Sig predictive relationship of sensory processing for food refusal
Martins et al (2008)	41 AUT 14 SIB 31 NT	CARS	Parent-report	Eating Behaviours Questionnaire, BPFAS, FNS	Parent-report		BPFAS(PEB), VABS	AUT: sig relationship between sensory processing and ritualistic feeding behaviour
Nadon et al (2011)	95	SSP	Parent-report	Eating Profile	Parent-report			Sig, predictive relationship between sensory processing and eating problems, particularly taste/smell and visual/auditory; tactile sig correlated but not predictive

Padmanabhan & Schroff (2020)	146	SSP	Parent-report	BAMBI, 24hr dietary recall	Parent-report		BMI	Sig relationship between sensory processing and eating behaviours; taste/smell sig associated with mealtime behaviours and food refusal
Panerai et al (2020)	111	SSP, SEQ	Parent-report	CEBQ, BAMBI	Parent-report	Age, gender, autism severity	ADI-R/CARS	Group differences = AUT with feeding problems more likely to have multi-sensory issues (taste/smell, tactile, sensory seeking, auditory, low energy). Sig correlations between sensory processing and general eating behaviours
Pomoni (2016)	103 AUT 151 NT	SSP	Parent-report	FBS	Parent-report	Behavioural/emotional problems, social and communication skills	SCQ, SDQ	Sig relationship between sensory processing and eating behaviours in both groups, across modalities; stronger in AUT group
Riccio et al (2018)	43 AUT 41 NT	TASR38 genotype	Biological	FPI	Parent-report		ADOS-2, GMDS-ER, Leiter-R, ADI-R, CARS, VABS	AUT: sig relationship between food selectivity and bitter taste sensitivity genotype in AUT
Schnizler (2014)	28 AUT 31 NT	EHS	Parent-report	EHS	Parent-report	Age, IQ, gender, behavioural flexibility	ADI, ADOS, WISC-III, Flexibility Scale (Routines/Rituals subscale)	Oral sensitivities emerged as sole predictor; olfactory sensitivities and behavioural flexibility ns predictors
Shamaya et al (2017)	50 AUT 12 SIB 29 NT	SP	Parent-report	BAMBI, 3-day food record	Parent-report		BMI	AUT: Sig association between multi-modal sensory processing (factors, quadrants, sections) and mealtime behaviours, food refusal and limited variety; oral sensitivities implicated

Smith et al (2020)	27 AUT 27 TS 17 ADHD 27 NT	SSP	Parent-report	FPQ, CEBQ (Food Fussiness subscale)	Parent-report	Age, gender, diagnosis	BMI	Taste/smell sensitivities only sig predictor of eating behaviours across all neurodevelopmental disorders; fully mediated food fussiness differences compared to TD
Suarez et al (1. 2012; 2. 2014)	1. 141 2. 54	SOR (Composite score from SSP and Red Flags of Sensory Over-Responsivity	Parent-report	Singe item from online survey	Parent-report	1. Age, physiological factors 2. Age, RRBs	1. Online survey 2. Online survey, RBS-R	1. Sig relationship between sensory over-responsivity only and food selectivity, particularly tactile sensitivities 2. Sig relationship consistent over time, only predictive variable (not RRBs)
Tanner et al (2015)	35	SSP	Parent-report	FFQ, BAMBI	Parent-report	Age, gender, parent sex, race/ethnicity, food security status, BMI, social communication	SCQ, CBCL, RBS-R	Group differences = ns on sensory processing (taste/smell) in selective vs. non-selective. Sig relationship between taste/smell sensitivities and food refusal and food repertoire (limited variety, total foods eaten)
Trinh (2014)	9 AUT 16 NT	Composite scores: SSP and Four-Item Texture Problems	Parent-report	BAMBI, food preferences inventory	Parent-report	Age, diagnosis, coping skills, expressive language skills, parent feeding practices, parent feeding practices	ERC, VABS, Parent Mealtime Action Scale	Sensory processing found to sig predict mealtime behaviours in total sample (both AUT and NT)
Wang et al (2014)	81 AUT 153 NT	SSP	Parent-report	MBQ	Parent-report	Age, gender, autism severity, receptive vocabulary, sleep,	SCQ, CARS, CHSQ, SDQ, PPVT-C	Sig association between sensory processing and mealtime behaviours in both groups; taste

						emotional and behavioural problems		sensitivity particularly implicated in AUT group
Zickgraf & Mayes (2018)	1112	CASD	Clinician-report	CASD	Clinician-report	Age, gender, IQ, medication, comorbid psychopathology	PBS	Tactile processing differences more common in those with atypical eating behaviours, but was ns in predicting atypical eating behaviours
Zickgraf et al (2020)	185 AUT 179 OCD 263 REP 813 UG	EHS (AUT only)	Parent-report	CEBQ (Food Fussiness scale) (AUT only)	Parent-report	Age, gender, rigidity	Flexibility Scale-Revised	Oral sensitivities sig predictor of selective eating (smell ns)
Zobel-Lachuisa et al (2015)	34 AUT 34 NT	SSP, SEC; TIE	Parent-report; Child-report	BAMBI	Parent-report	Age		Sig relationship between all sensory measures and mealtime behaviours; sig relationship between all sensory subscales and mealtime behaviours

**SP = Sensory Profile, SSP = Short Sensory Profile, CARS = Childhood Autism Rating Scale, SEQ = Sensory Experiences Questionnaire. EHS = Eating Habits Survey, SOR = Sensory Over-Responsivity Scale, CASD = Checklist for Autism Spectrum Disorders, TIE = Touch Inventory for Elementary-School-Aged-Children.*

***SWEAA = Swedish Eating Assessment for Autism spectrum disorders, FFQ = Food Frequency Questionnaire, BAMBI = Brief Autism Mealtime Behaviour Inventory, HEI = Healthy Eating Index, ASD-CC = Autism Spectrum Disorder-Comorbidity for Children, CFNS = Child Food Neophobia Scale, CEBQ = Child Eating Behaviour Questionnaire, , STEP-CHILD = Screening Tool of Feeding Problems, for Children, BPFAS = Behavioural Pediatric Feeding Assessment Scale, FBS = Feeding Behaviour Checklist, FPQ = Food Preferences Questionnaire, MBQ = Mealtime Behaviour Questionnaire, FPI = Food Preferences Inventory*

****WASI-II = Weschler Abbreviated Scale of Intelligence 2nd Edition, ADOS-2 = Autism Diagnostic Observation Schedule Second Edition, SRS = Social Responsiveness Scale, VABS = Vineland Adaptive Behaviour Scales, DAS = Differential Abilities Scales, BKIS = Binet Kamat Scale of Intelligence, VSMS = Vineland Social Maturity Scale, ADOS = Autism Diagnostic Observation Schedule, ADI-R = Autism Diagnosis Interview-Revised, MSEL = Mullen Scales of Eating Learning, SB:5th = Stanford-Binet 5th Edition, RBSR = Repetitive Behaviour Checklist, CBCL = Child Behaviour Checklist, ASD-PBC = Autism Spectrum Disorder-Problem Behaviour for Children, SCQ = Social Communication Questionnaire, CFQ = Child Feeding Questionnaire, PFSQ = Parental Feeding Style Questionnaire, ABAS-II = Adaptive Behaviour Assessment System-II, BPI-S = Behaviour Problems Inventory-Short Form, PedsQL = Pediatric Quality of Life Inventory-Fourth Version, VABS-II = Vineland Adaptive Behaviour Scale-Second Edition, CAM = Complementary/Alternative Medicine, BPFAS(PEB) = Parent*

Section of Behavioural Pediatric Feeding Assessment Scale, SDQ = Strengths and Difficulties Questionnaire, GMDS-R = Griffiths Mental Development Scales, Leiter-R = Lieter International Performance Test-Revised, RBS-R = Repetitive Behaviors Scale-Revised, ERC = Emotion Regulation Checklist, CHSQ = Chinese Sleep Habits Questionnaire, PPVT-C = Peabody Picture Vocabulary Test-Chinese Edition, PBS = Pediatric Behaviour Scale.

processing, and thus have been synthesized as a distinct sensory domain than taste/smell sensitivities alone.

Mealtime behaviours

General mealtime and eating behaviours. 11 studies looked at general mealtime behaviours. Three studies looked at the relationship between general sensory processing and mealtime behaviours. Johnson et al (2014) and Zobel-Lachuisa et al (2015) reported significant correlations between sensory processing and mealtime behaviours in Autistic children, with the latter study also providing evidence to suggest that this association is stronger in autism compared to neurotypical peers (r = .378-.747 versus r = .153-.622). Sensory processing difficulties were found to significantly predict mealtime behaviours in Johnston et al (2014) and Trinh (2014) studies, however there was no comparison or control group included. Furthermore, Trinh (2014) used a mixed autism-neurotypical sample, and therefore no autism-specific conclusions can be drawn. These studies offer preliminary support of a relationship between general sensory processing issues and mealtime behaviours in Autistic children.

Six other studies included different sensory domains in their analyses. Crasta et al (2014) and Shamaya et al (2017) reported multi-modal associations between sensory processing and mealtime behaviours in Autistic children, both similarly highlighting the significant role of oral sensory sensitivities. Furthermore, these two studies also found significant associations between emotional responses to sensory processing and mealtime behaviours, tentatively implicating the role of emotion. Nadon et al (2011) supported a multi-sensory association with eating behaviours, however an initially significant association with tactile sensitivities disappeared after adjusting for confounders of age, diagnostic category and comorbidities. This could mean that tactile sensitivities may be of less significance, while other sensory sensitivities, such as taste/smell sensitivities, may be of greater significance in driving observed oral sensory sensitivities.

The remaining studies looking at mealtime behaviours highlighted the importance of taste/smell sensitivities. Padmanabhan & Schroff (2020) and Wang et al (2014) reported multi-modal correlations between sensory processing and mealtime behaviours, with the strongest associations observed for taste/smell sensitivities. Stronger evidence still was reported in Wang et al (2014)'s study, where stronger correlations were reported in their autism sample compared to neurotypical peers. Finally, Panerai et al (2020) found that Autistic children with feeding problems exhibited higher multi-modal sensory differences compared to those without, with the largest effect size (0.52) being for taste/smell sensitivities. Furthermore, this was the only study that differentiated between hyper- and hyposensitivity patterns. Authors reported significant differences between Autistic children with feeding problems and those without, with those with feeding problems demonstrating greater impairments in hypersensitivities (Panerai et al, 2020). Both Padmanabhan & Schroff (2020) and Panerai et al (2020) were deemed to be of high quality during the risk of bias assessment, suggesting that these studies provide strong evidence for the role of taste/smell sensitivities.

Two studies did not find significant evidence to support a relationship between sensory processing and mealtime behaviours. Zickgraf & Myles (2018) implicated more physiological factors, such as appetite and constipation, while Bitsika & Sharpley (2018) found that restrictive and repetitive behaviours were the sole significant predictor of eating behaviours. However, both studies were assessed to have moderate to high risk of bias of measurement bias. Zickgraf and Mayes' (2018) study used a single measure for both sensory processing and eating behaviours, while Bitsika & Sharpley (2018) used an eating measure that had not been validated in their sample. Despite this, it should be noted the latter study conducted a robust analysis to remove overlap items between sensory and eating measures, allowing them to clearly investigate the link between the two.

Food selectivity or fussiness. Seven studies looked at food selectivity or fussiness as an eating outcome. Leader et al (2020) reported that food selectivity, and not food refusal, was predicted by higher global sensory differences. Focusing on oral sensory sensitivities,

Kral et al (2015) found that Autistic children with atypical oral sensitivities were significantly more likely to exhibit food selectivity than those with typical oral sensory processing. Zickgraf et al (2020) and Schnizler (2014) similarly found oral sensitivities to emerge as independent, significant predictors of food selectivity, even when controlling for other modality sensitivities. Caution is warranted however, as these studies were deemed of poor quality due to inconsistent implementation of exposure and outcome measures (Zickgraf et al, 2020) and possible sampling bias (Schnizler, 2014).

Looking across different sensory domains, Pomoni (2016) reported multi-modal associations with food selectivity, however this association was strongest with taste/smell sensitivities, being marginally stronger in the autism group (r = -.834) compared to the neurotypical group (r = -8.24). This was supported by Smith et al (2020), who included a neurotypical control group in their relationship analyses and reported that taste/smell sensitivities were not only an independent predictor of food fussiness but also an independent mediator of this relationship in Autistic children and adolescents compared to their neurotypical peers. Conversely, one study did not report a significant relationship between sensory processing and food selectivity, reporting that children deemed to be selective eaters did not demonstrate significant differences in global sensory nor taste/smell processing (Tanner et al, 2015). This was found to be a high-quality study, and therefore convincingly challenges the role of taste/smell sensitivities in food selectivity; however, it should be noted however that Tanner et al (2015) did not include other sensory domains in their analyses and thus the significance of taste/smell sensitivities over other sensory modalities cannot be inferred.

Food refusal. Nine studies looked at the relationship between sensory processing and food refusal. Three studies looked at global sensory processing and food refusal, with two studies (Padmanabhan & Schroff, 2020; Leader et al, 2021) reporting significant associations. Leader et al (2021) also included other eating behaviours in their regression and found that food refusal was the only eating outcome predicted by sensory processing scores. Conversely, Leader et al (2020) did not find sensory scores to significantly predict food refusal, instead implicating food selectivity. Different samples and analyses were

employed, with Leader et al (2021) including a broader range of possible predictors and thus a possibly more robust regression analysis.

Looking at the relationship between food refusal and multi-modal sensory processing, two studies reported significant associations with oral sensory processing (Crasta et al, 2014; Chistol et al, 2018). Chistol et al (2018) also looked at hypersensitivities, reporting that the association between food refusal and oral sensory processing was strongest for Autistic children with oral sensory hypersensitivities. Furthermore, Crasta et al (2014) found significant associations between food refusal and other important sensory subscales, including the modulation of sensory input affecting emotion levels. This finding also supported by Shamaya et al (2017), who found significant associations between food refusal and modulation of visual input affecting emotion levels. Both studies highlight the importance of approaching food refusal as a multi-dimensional sensory experience, related to differences across sensory, motor and emotional domains.

Three studies focused on taste or smell sensitivities in relation to food refusal, reporting significant associations between food refusal and taste/smell sensitivities (Tanner et al, 2015; Lane et al, 2014). The latter study conducted further analysis using sensory subtypes developed in a previous study and reported that Autistic children who exhibited the highest levels of food refusal displayed a complex sensory subtype characterised by taste/smell sensitivities, as well as proprioceptive dysfunction (see Lane et al, 2014). In the only study to use a physiological measure of sensory processing, Riccio et al (2018) reported an association between the TARS238 gene proposed to be responsible for bitter taste perception and food refusal in Autistic children at the limits of statistical significance ($p = .07$). Caution should be warranted here when interpreting these results as no power calculations were reported to justify their significance level, raising concerns of a reporting bias.

Ritualistic eating behaviours. Two studies looked at the relationship between sensory processing and ritualistic eating behaviours, reporting significant associations with behaviours such as ritualistic feeding patterns and rigid/perseverant eating (Martins et al, 2008; Pomoni, 2016). Pomoni (2016) also found that the strongest correlations were with taste/smell domains (r = -7.16). However, Martins et al (2008) was assessed to reflect a high risk of measurement bias. Their measure of sensory processing was a single item response on the CARS, while their ritualistic feeding behaviour measure was developed for the study and was thus unvalidated. Therefore, due to the spare evidence base and possible bias concerns, findings are inconclusive.

Over- or under-eating. Two studies looked at the relationship between sensory processing and over- or under-eating. Koshy (2015) reported significant but weak (r = -.228-.122) correlations with both over- and under-eating in Autistic children and adolescents, while Kral et al (2015) found that young Autistic children with atypical oral sensitivities displayed greater emotional under-eating, specifically due to negative emotions. This would imply that emotion may play a role in regulating the relationship between sensory processing and under-eating. Under-eating was implicated across both studies suggesting that this may be a common eating issue in autism, with tentative evidence to suggest this persist into adolescence.

Food repertoire

Seven studies included looked at food repertoire. Chistol et al (2018) found oral sensitivities to be significantly associated with vegetable variety but not total repertoire or fruit variety. Interestingly, when the analysis focused on oral hyper-sensitivities, a significant relationship was observed across all three variables, thus highlighting the importance of distinguishing between hyper- and hypo- sensitivities. Shamaya et al (2017) reported a significant relationship between motor and visual domains, as well as taste/smell sensitivities and limited food repertoire. Tanner et al (2015) and Lane et al (2014) reported significant associations between taste/smell sensitivities and food repertoire, including a reduced number of total number of foods eaten and a limited variety of foods eaten. Tanner et al

(2015) only looked at taste/smell sensitivities, while Lane et al (2014) included a broad range of sensory domains, thus suggesting that taste/smell sensitivities may play a particularly important role.

Conversely, one study (Suarez et al, 2012b; 2014) reported that tactile hypersensitivity was significantly associated with limited food repertoire (Suarez et al, 2012b), consistent across a follow up of 20 months (Suarez et al, 2014). Both papers were found to reflect a moderate risk of measurement bias, using eating behaviour measures that were developed for the purpose of the study and thus unvalidated. The study also adopted a dichotomous approach to sensory processing, looking at tactile hypersensitivities as one domain and putting all other senses in an "other" categories. Collectively, these studies suggest a limited food repertoire is associated with multi-sensory differences, with more research required before any conclusions can be drawn regarding specific modalities.

Food neophobia

Two studies investigated food neophobia, with both studies finding evidence to support a significant association. Kral et al (2015) found that food neophobia was significantly elevated in Autistic children with atypical oral sensitivities versus those with typical oral sensory processing, while Pomoni (2016) reported significant correlations between food neophobia and both taste/smell and tactile sensitivities, reporting strongest correlations with taste/smell ($r = -.589$ vs. $r = -.312$). Both studies also investigated this relationship in children between 4 and 14 years old, suggesting that this association may persist across childhood and into early adolescence. Collectively, these studies tentatively support a relationship between oral sensory processing and food neophobia, particularly taste/smell sensitivities, although they form a spare evidence base demanding future research, both with regards to the relationship itself and with regards to how this relationship persists across development.

Discussion

The aim of this review was to provide a comprehensive synthesis of studies looking at the relationship between sensory processing and eating behaviours in autism. Included studies generally supported a significant relationship between sensory processing and a broad range of eating behaviours, with preliminary evidence to implicate taste/smell sensitivities and the possible role of hypersensitivities. Key findings are discussed below.

The relationship between sensory processing and eating behaviours was supported across all three broad eating outcomes of mealtime behaviours, food repertoire and food neophobia, suggesting that sensory processing underpins an extensive range of eating behaviours in autism. An interesting finding from the current review was that only two studies investigated food neophobia (Kral et al, 2015; Pomoni, 2016), despite food neophobia being one of the most frequent eating behaviours in autism (Marshall et al, 2014). This could be due to conceptual constraints of previous studies, reflecting heterogeneity of definitions and the conflation of food neophobia with food selectivity (Wallace et al, 2018; Marshall et al, 2014). Future research should heed calls for independent measurement of food neophobia in order to generate a more focused line of research and add to the limited evidence-base regarding the relationship between food neophobia and sensory processing.

There was evidence across all three domains that eating was reflective of a multi-sensory experience, with a broad range of sensory modalities implicated in the relationship with atypical eating behaviours. This is in line with previous research suggesting that over 90% of Autistic individuals present with differences in sensory modulation, organization and integration across multiple sensory domains (Tomchek et al, 2007; Ben-Sasson et al, 2009; Marco et al, 2011). These findings have clear implications regarding the design and implementation of mealtime interventions in autism, as they would suggest that detailed sensory evaluation and tailored sensory-based interventions may be an effective way of managing atypical eating behaviours in Autistic individuals. Such sensory-based approaches to eating patterns and behaviours are starting to be incorporated into behavioural

interventions, reporting promising results (Galpin, Osman & Paramore, 2018, Luisier et al, 2015, 2019; Seiverling et al, 2018).

While oral sensory processing was associated with mealtime behaviours, food repertoire and food neophobia, it should be noted that oral processing encompasses multiple sensory domains, including taste/smell and tactile sensitivities (Chaware et al, 2021). The current review found evidence to suggest that tactile sensitivities may not play as significant a role, with studies either reporting non-significant associations (Zickgraf & Mayes, 2018; Nadon et al, 2011) or having measurement limitations that prevent generalizable or comparable conclusions (e.g., Suarez et al, 2012a; 2014). On the other hand, taste/smell sensitivities were consistently implicated in the relationship between general mealtime and eating behaviours (Padmanabhan & Schroff, 2020; Wang et al, 2014; Panerai et al, 2020), food selectivity (Pomoni, 2016; Smith et al, 2020), food refusal (Tanner et al, 2015; Lane et al, 2014), ritualistic eating behaviours (Pomoni, 2016), food repertoire (Tanner et al, 2015; Lane et al, 2014) and food neophobia (Pomoni, 2016), suggesting that taste/smell sensitivities may be an important underlying mechanism in the manifestation of a broad range of atypical eating behaviours.

A small number of studies implicated the role of hypersensitivities to sensory stimuli (Chistol et al, 2018; Suarez et al, 2012a; 2014) however, at this stage, firm conclusions cannot be drawn. Only three studies investigated hypersensitivities in only two out of seven eating behaviours, reflecting a very small evidence base, and only one study (Panerai et al, 2020) included hypo-sensitivities in their analysis. Intuitively, different sensory profiles may be associated with different eating difficulties; for example, hypersensitivities may be associated with food avoidance or restrictive behaviours while hyposensitivity's may lead to seeking sensations from food, which in turn may manifest as over-eating. This latter hypothesis could help explain recent longitudinal evidence to suggest that fussy eating behaviours partially mediated the relationship between childhood Autistic traits and disordered eating behaviours in adolescence, particularly binge eating behaviours (Leno et al, 2022). Further studies exploring different sensory profiles across a range of eating

behaviours, including restrictive and binge eating, will allow researchers to address such hypotheses.

At the time of the literature search, no study looked at the relationship between sensory processing and disordered eating, despite research evidence to support an over-representation of EDs, such as Anorexia Nervosa (AN; Westwood & Tchanturia, 2017) and Avoidant and Restrictive Food Intake Disorder (ARFID; Bourne et al, 2021). Elucidating underlying mechanisms of this relationship has clear clinical implications. For example, despite food-specific sensory aversions being a diagnostic criterion of ARFID (APA, 2013), the majority of interventions have focused on cognitive and behavioural techniques, and no study to date has looked at such interventions in autism (Bourne et al, 2021). Similarly, there is a limited evidence base for treatment adaptions for Autistic individuals with AN (Li et al, 2022a), with only one clinical pathway identified (Tchanturia et al, 2020) that delivers promising but limited evidence of efficacy. A recent comprehensive framework of differences in common features of autism and AN include experiencing sensory processing difficulties as a prominent shared feature (Kinnaird & Tchanturia, 2021) and studies have begun to attempt to untangle these differences by exploring the role of sensory processing in AN samples with elevated Autistic traits (e.g., Kinnard et al, 2020a), however his has yet to be explored in clinically diagnosed Autistic samples. Encouragingly, a brief, pragmatic sensory screener implemented in the PEACE Pathway has been reported to be beneficial to eating disorder services in adjusting treatment to personal, sensory needs (Kinnaird et al, 2020b), suggesting that sensory processing may play an important role and should be considered and adjusted for in clinical approaches to AN in autism.

Interestingly, the possible role of emotion was implicated across several eating behaviours, including mealtime behaviours and food refusal (Crasta et al, 2014; Shamaya et al, 2017). Specific emotions were investigated in one study only (Kral et al, 2015) which reported participants with oral sensitivities displayed greater emotional under-eating, particularly due to negative emotions. These would tentatively suggest that experiencing emotion, particularly negative emotions, may lead some Autistic individuals to reduce or restrict the

amount of food they eat. While this is evidence base is limited and such hypotheses are exploratory at best, again the possible implications of this finding on the development of restrictive eating disorders, such as AN and ARFID, make it an interesting avenue for future research. Indeed, the underlying mechanisms of both comorbidities remain poorly understood. Similar sensory profiles have been reported in autism and in both ARFID and AN (Dovey et al, 2019; Kinnaird et al, 2021), while differences in emotion processing (Brede et al, 2020; Kerr-Gaffney et al, 2021; Courty et al, 2013) or alexithymia (Vuiller et al, 2020) have been proposed as possible mechanisms linking autism and AN. However, no study to date has explored the possible interplay between sensory processing, emotion and eating behaviours in the development of disordered eating in autism. Understanding the complex relationship between these domains may help researchers and clinicians work towards untangling mechanisms of these co-existing conditions.

There were several methodological limitations observed across studies. There was a notable lack of control or comparison groups, with many studies excluding these groups in their relationship analyses, and almost all studies adopting a cross-sectional design. Furthermore, the majority of studies conducting their research in Western countries and parent demographics typically skewed towards educated mothers, raising generalizability concerns. Almost all studies utilised parent-report measures, reflecting an urgent need for direct, observational assessment of eating measures and physiological measures of sensory processing to eliminate bias and increase objectivity. Finally, while taste/smell sensitivities appear to be implicated, these two modalities are collapsed into one domain on the Sensory Profile and the Short Sensory Profile. It could be that one modality may play a more prominent role than the other, however their conflation into one subscale leads to an inability to differentiate between their possible roles. Overall, only six out of 25 included studies were deemed to be of good quality, suggesting that these limitations may be raising notable bias concerns.

There were also several conceptual limitations. There was a notable lack of attention paid to specific sensory patterns, with only one study looking at hyposensitivity's (Panerai et al,

2020) and no study looking at multi-sensory integration. Furthermore, no single study looked at adult participants, reflective of a wider childhood-bias in autism research (Ratto & Mesibov, 2015), which may also in part explain why no study explored disordered eating as an outcome. Applying a developmental approach will shed important insights on the relationship between sensory processing and eating behaviours across the lifespan and may allow for the identification of early behaviours indicative of future disordered eating. See Table 4 for a summary of directions for future research highlighted by the current review.

Understanding the relationship between sensory processing and eating behaviours in autism has important implications for clinicians and healthcare professionals, suggesting that individual sensory evaluation and tailored sensory interventions may help tackle a broad range of atypical eating behaviours. Careful consideration should be given to the possible importance of taste/smell sensitivities and hypersensitivities, however all possible sensory modalities and patterns should be evaluated and addressed. Elucidating the precise nature of this relationship is of the utmost importance in helping Autistic individuals manage their eating behaviours and could even help in preventing the development of disordered eating. Future research should address the outlined methodological and conceptual limitations, working towards clear, standardized definitions of eating behaviours, and utilising longitudinal designs with more objective, physiological measures of sensory processing and eating behaviours.

Table 4.

Summary of directions for future research.

Conceptual Considerations	Research Design	Measurement and Assessment	Interventions
Research focusing on food neophobia, including treatment of food neophobia as a distinct eating outcome	Research including control and/or comparison groups	Research adopting direct, observational assessments of eating behaviours	Research focusing on developing sensory-based eating and feeding interventions for non-clinical eating outcomes
Research focusing on disordered eating outcomes (restrict, binge, purge) in clinically diagnosed autism samples	Research adopting a longitudinal design, measuring the relationship across and/or development	Research adopting physiological or neurological assessments of sensory processing	Research focusing on developing sensory-based eating and feeding interventions for disordered eating outcomes
Research focusing on taste and smell sensitivities as distinct sensory modalities	Research including more diverse and representative samples		
Research focusing on different sensory patterns, particularly hypersensitivities, hyposensitivity's and sensory seeking	Research including more Autistic adolescents and, in particular, Autistic adults		
Research focusing on the possible role of emotion in the relationship between sensory processing and eating behaviours, particularly with regards to the development of disordered eating			

Chapter 4 – “It’s not about wanting to be thin or look small, it’s about the way it feels”: an IPA analysis of social and sensory differences in Autistic and non-Autistic individuals with anorexia and their parents

Nimbley, E., Gillespie-Smith, K., Duffy, F., Maloney, E., Ballantyne, C., & Sharpe, H. (2023). “It’s not about wanting to be thin or look small, it’s about the way it feels”: an IPA analysis of social and sensory differences in Autistic and non-Autistic individuals with anorexia and their parents. *Journal of Eating Disorders, 11*(8), https://doi.org/10.1186/s40337-023-00813-z

Abstract

Background: Despite increasing evidence to support an overlap between autism and anorexia nervosa (AN), underlying mechanisms remain poorly understood. Social and sensory factors have emerged as promising targets in both autism and AN, however there remains scope to compare these differences across Autistic and non-Autistic experiences of AN. Drawing on dyadic multi-perspectives, this study explored experiences of social and sensory differences in Autistic and non-Autistic adults and their parents and/or carers.

Methods: Using Interpretative Phenomenological Analysis (IPA), dyadic interviews were conducted with 14 dyads, with seven Autistic dyads and seven non-Autistic dyads. Data analysis was subjected to a triangulation of interpretations: (1) the participants themselves; (2) a neurotypical researcher; (3) and an Autistic researcher with lived/living experience of AN.

Results: IPA identified three themes in each group, with similarities and differences between Autistic and non-Autistic dyads. Similar themes were identified regarding the importance of social connectedness and socio-emotional difficulties, as well a common lack of trust in the social and sensory self and body. Autism-specific themes centred on feelings of social 'defectiveness', disparities between sensing and expressing certain cues, and lifelong, multi-sensory processing differences. Non-Autistic themes reflected social comparisons and inadequacy, and sensitivities to the learning of ideals and behaviour through early experiences.

Discussion: While similarities were observed across both groups, there appeared to be notable differences in the perceived role and influence of social and sensory differences. These findings may have important implications on the delivery and modification of eating disorder interventions. Specifically, they suggest that while treatment targets may look similar, subtle differences in underlying mechanisms and approaches may be required for Autistic individuals with AN across sensory, emotion and communication-based interventions.

Introduction

Autism Spectrum Disorders (ASD, here on referred to as autism – see Kenny et al, 2016; Lei, et al. 2021) is a neurodevelopmental condition, characterised by differences in social communication and interaction, sensory processing and rigid behaviours (APA, 2013). Anorexia Nervosa (AN) is a severe eating disorder (ED), characterised by an intense fear of gaining weight, body shape disturbances and persistent attempts to restrict dietary intake (APA, 2013). Increasing research evidence suggests a significant overlap between autism and AN, with prevalence estimates range between 20-40% (Westwood & Tchanturia, 2017; Spek et al 2019; Huke et al, 2013). Furthermore, despite early concerns that the cognitive impact of starvation can mimic certain Autistic traits (e.g., Treasure, 2013), several lines of evidence support a true etiological relationship; for example, Autistic traits have been found in those who have recovered from AN (Nazar et al, 2018; Bentz et al, 2017) and are longitudinally associated with disordered eating in adolescence (Solmi et al, 2020).

Autistic individuals with AN report more severe and enduring ED symptoms (Leppanen et al, 2022), poorer psychosocial outcomes (Neilsen et al, 2022; Tchanturia et al, 2019) and poorer treatment outcomes (Nazar et al, 2018; Li et al 2022a). They also report frustration with ED services (Kinnaird et al, 2019b) and a disparity between ED treatments and their individual needs (Babb et al, 2021; Babb et al, 2022). Despite this, Autistic individuals have been reported to conceptualise recovery in notably similar ways to non-Autistic individuals (Sedgewick, Leppanen, Austin & Tchanturia, 2022). Thus, to be able to further understand the co-occurrence of autism and AN and effectively support Autistic individuals, a more comprehensive understanding of their similarities and differences in underlying mechanisms must be achieved. Several promising targets have been identified, including socio-emotional domains of emotion recognition (Kerr-Gaffney et al, 2018) and theory of mind (Leppanen, 2018; Sedgewick et al, 2019). Broader social difficulties, such as friendship difficulties, have also been implicated in autism (O'Connor et al, 2022) and AN (Westwood et al, 2016), with a recent comparative study suggesting that reciprocal social interaction may help discriminate between Autistic and non-Autistic individuals and AN (Kerr-Gaffney et al, 2021a). A recent qualitative model exploring restrictive EDs in Autistic women highlighted a broad range of

possible autism-specific mechanisms, including differences in emotion perception, sensory processing, social interactions and relationships (Brede et al, 2020).

Both social and sensory factors therefore offer promising targets for untangling common and autism-specific mechanisms in the development of AN. Qualitative research allows for the generation of understanding rooted in the lived/living experience of the individual. These understandings can also be further informed by including multi-perspectives, such as those of parents and/or carers. Carers have expressed frustrations with ED services in similar ways as their children (Adamson et al, 2020) and their perspectives have made an important contribution to our understanding thus far (Brede et al, 2020; Babb et al, 2022). However, this has typically taken the form of collecting perspectives individually, before drawing across interviews and considering shared and distinctive features. Dyadic approaches not only provide multiple perspectives but also allows for a real-time interaction of perspectives, creating novel opportunities to discuss ideas that may not have occurred to each individual separately (Morgan, Eliot, Lowe & Gorman, 2015; Szulc & King, 2022). This study will therefore seek to explore social and sensory differences across Autistic and non-Autistic adults with current or lifetime history AN and their parents and/or carers. The study will seek to address the following research questions:

1. What social, sensory and other factors do Autistic and non-Autistic dyads perceive to play a role in their AN?
2. What are the similarities and differences in the factors identified by Autistic and non-Autistic dyads?

Methods

Participants

Dyads were recruited from the community through relevant ED and autism charities and organisations, and advertisements on social media platforms. Study adverts were also disseminated through internal mailing lists and waiting rooms within the University of Edinburgh. The inclusion criteria for participation were that both members of the dyad were fluent in English and over 18 years old. Autistic and non-Autistic adults with current or lifetime history of AN were required to be UK-based and to have received a clinical diagnosis of AN, including atypical anorexia. Their parents or caregivers were required to be their mother, father or someone that taken on a caregiving role across development. Due to the broad focus of the study in exploring the role of social and sensory factors across AN trajectories, participants were not grouped into current or recovered, however this information was collected (Table 1). In total, 14 dyads were recruited. Seven dyads were recruited across each group (n=28), reflecting an even balance across Autistic and non-Autistic dyads and in line with published recommendations for the chosen method of qualitative analysis (Clarke, 2010).

Procedure

Ethical approval was obtained from the University of Edinburgh (CLPS064). Participants were invited to contact the lead researcher if they were interested in taking part in the study. A participant information sheet was shared and contact details of the other member of the dyad were obtained. Once eligibility was confirmed and both members of the dyads had been given the opportunity to ask any questions, participants were asked to provide consent and complete a demographic survey using a secure online survey platform (Qualtrics). Dyads then participated in a semi-structured interview, lasting between 45 and 60 minutes on a secure online video platform (Zoom). Interview recordings were then transcribed and anonymised, assigning participants pseudonyms and removing all other names, locations, services or other possible identification sources. Please see Appendix A and B for ethical approval and recruitment documents.

Table 1.

Demographics of the Autistic and non-Autistic dyads.

	Autistic Group		***Non-Autistic group***	
	Individual with AN (n=7)	*Parent (n=7)*	*Individual with AN (n=7)*	*Parent (n=7)*
AN status	Current (n=4), Recovered (n=3)		Current (n=4), Recovered (n=3)	
Age in years (mean, SD)	24.14 (3.13)	54.86 (4.14)	24.58 (5.16)	55.83 (5.23)
Gender	Female (n=6), Male (n=1)	Female (n=7)	Female (n=7)	Female (n=5), Male (n=2)
Ethnicity	White (n=7)	White (n=7)	White (n=7)	White (n=7)
Level of education	Primary/secondary education (n=4), Undergraduate degree (n=1), Postgraduate degree (n=2)	Undergraduate degree (n=3), Vocational training (n=1), Doctorate or professional degree (n=3)	Primary/secondary education (n=1), Undergraduate degree (n=5), Non-specified employment (n=1)	Primary/secondary education (n=2), Postgraduate degree (n=2), Vocational training (n=1), Doctorate/professional degree (n=2)
Level of employment	Student (n=2), Unemployed (n=2), Part-time employment (n=1), Full-time employment (n=1)	Full-time employment (n=3), Self-employed (n=1), Full-time carer (n=1), Part-time employment (n=1), Retired (n=1)	Student (n=2), Part-time employment (n=2), Full-time employment (n=3)	Full-time employment (n=3), Self-employed (n=1), Part-time employment (n=1), Retired (n=2)

Interpretative Phenomenological Analysis

Semi-structured interviews were developed by the lead researcher and an Autistic researcher with lived/living experience of AN. Dyads were asked to provide a brief overview of how they received a diagnosis on anorexia and to identify any general factors or behaviours they thought affected their anorexia. Questions then focused specifically on the role of social and sensory factors. Prompts were also included for developmental perspectives from parents or caregivers, and specifically for the Autistic group with AN (please see Appendix C for interview schedule). Interview schedules guided by pre-determined questions, allowing participants flexibility to discuss their experiences, a key component of Interpretative Phenomenological Analysis (IPA; Smith, Flowers & Larkin, 2004). This approach was chosen as it acknowledges the complexity of experiences and allows for an in-depth analysis of the perceptions and experiences of individuals in smaller and purposive samples. IPA approaches are concerned more with how the individual experiences the phenomenon of interest, as opposed to producing an objective record of the phenomenon (McGregor et al, 2014). This approach is rooted within phenomenological and hermeneutic theoretical underpinnings, thereby seeking to understand and interpret the meaning of lived experiences (Tuffour, 2017).

IPA has typically been used in relatively homogenous samples of participants, looking to explore shared perspectives across individual participants regarding the phenomenon of interest. However, recent research has begun to use an idiographic IPA approach to exploring and synthesising multiple perspectives of the same phenomenon (Larkin, Shaw & Flowers, 2019). This allows researchers to move away from the potentially limiting nature of one-dimensional accounts and is useful for research questions that have a strong social and relational dimension (Tuffour, 2017). Dyadic data has previously been analysed through an IPA lens with a focus on the pair as a pair (de Visser & McDonald, 2007; Loaring, Larkin, Shaw & Flowers, 2015) and at a group level (Larkin, Clifton & de Visser, 2009; Rostill-Brookes, Larkin, Toms & Churchman, 2011). Combining these approaches, an idiographic IPA approach was applied to each transcript individually, looking for emerging themes from the shared experiences within each dyad, before each dyad's emerging themes eventually being integrated and analysed to generate superordinate themes across the group. This process

was conducted twice; firstly, with the Autistic adults and their parent's group, and then again with the non-Autistic adults and their parents' group.

The IPA process involves two stages of interpretation: firstly, participants attempt to make sense of their experience; and secondly, the researcher attempts to interpret and make sense of the participant making sense of their experiences. It is recognised that during this process, the researcher's interpretation may be influenced by their own personal experiences and understandings. Drawing on this, the current study adopted a data triangulation approach (Carter et al, 2014), involving an Autistic researcher with lived/living experience of AN in the coding and development of the themes. This approach is rooted in calls for participatory research, both in autism (Fletcher-Watson et al, 2019) and in ED (Nicholls, Fogary, Hay & Ramjan, 2016; Music et al, 2022) research, while also playing an important and novel role in the interpretation of experiences that is inherent to IPA. This data triangulation approach involved an Autistic researcher with lived/living experience of AN reviewing emerging themes with the dyads in each group, as well as emerging group themes. Several rounds of further analysis and discussions with the lead researcher were then conducted, before dyadic themes were finalised and merged into finalised superordinate group themes (please see Appendix D for a more detailed overview of the triangulation process).

Researcher reflexivity

It is important here to include researchers' reflexivity statements, reflecting on how expertise and experience may have affected the interpretation of the data. Two authors (EN, EM) were involved in the IPA process and thus it is important to consider possible influences on their personal interpretation of the data. Primary analysis was conducted by EN, a neurotypical PhD student who developed an interest in autism and disordered eating across her psychology undergraduate and postgraduate degrees. EN has also worked closely with the Autistic and ED community throughout her education and training and is keenly aware of both the complexity and the urgency associated with untangling autism and EDs. She is also mindful of the need for lived/living experiences in generating meaningful research. EM is an Autistic researcher with lived/living experience of AN and was involved in the coding and development of themes. EM has worked closely with families, clinicians, and

Autistic and non-Autistic individuals with lived/living experience of AN across various advocacy and policy projects, and has a special interest in understanding the overlap and differences between autism and AN.

Results

IPA analysis revealed three superordinate themes across Autistic dyads: *The Social Self,* with sub-themes of *Different and 'Defective'* and *Understood and (Un)United; Sensory Foundations;* and *Feeling the Unknown,* with sub-themes of *Emotion Sensitivity vs. Expression* and *Interoceptive Sensitivity vs. Expression.* Similarly, three superordinate themes were identified in non-Autistic dyads: *The Social Self,* with sub-themes of *(In)adequacy and Acceptance* and *Over-empathy, Self-Apathy; Damaging Early Experiences,* with sub-themes of *Reinforcement of Body and Weight Ideals* and *Control-Seeking Behaviours;* and of *Distrust of the Bodily Self,* with sub-themes of *Interpreting Stomach Cues* and *Body Checking.*

The following results section is a narrative synthesis of similarities and differences between Autistic and non-Autistic dyads across social and sensory factors. Pseudonyms are provided after each quote, with an A next to members of the Autistic dyads; for example, Holly(A). See Figure 1 for a comparative summary of themes and sub-themes between Autistic and non-Autistic dyads.

Social factors

A superordinate theme identified across both Autistic and non-Autistic dyads was *The Social Self.* This theme centred on a socially driven sense of self, with reflections on social experiences and connections playing a key role in how they defined themselves and their AN. However, within this shared superordinate theme were sub-themes that highlighted key group differences.

For Autistic dyads, this was defined by feelings of being different and therefore 'defective' (*Different and 'Defective').* This keen sense of difference to other people, mostly to their peers, led to feelings of social isolation and alienation. This was often perceived to be

particularly notable in the immediate lead up to restrictive eating behaviours, suggesting that these particular social difficulties were a leading factor in the development of their AN. Often this was also accompanied by a certain degree of confusion, suggesting that it was not only the feeling of being different but the lack of understanding in what caused these differences that exerted an influence on their AN:

"When I was in school, which was around the kind of the time I was diagnosed or just before, I can only realize now but how much I struggled with social interaction and kind of things like that. I've always felt really really different, and I didn't really know why…just the way that I feel about myself, I think that's a big part in feeling…um…I guess not feeling like I deserve or need to eat" (Holly(A))

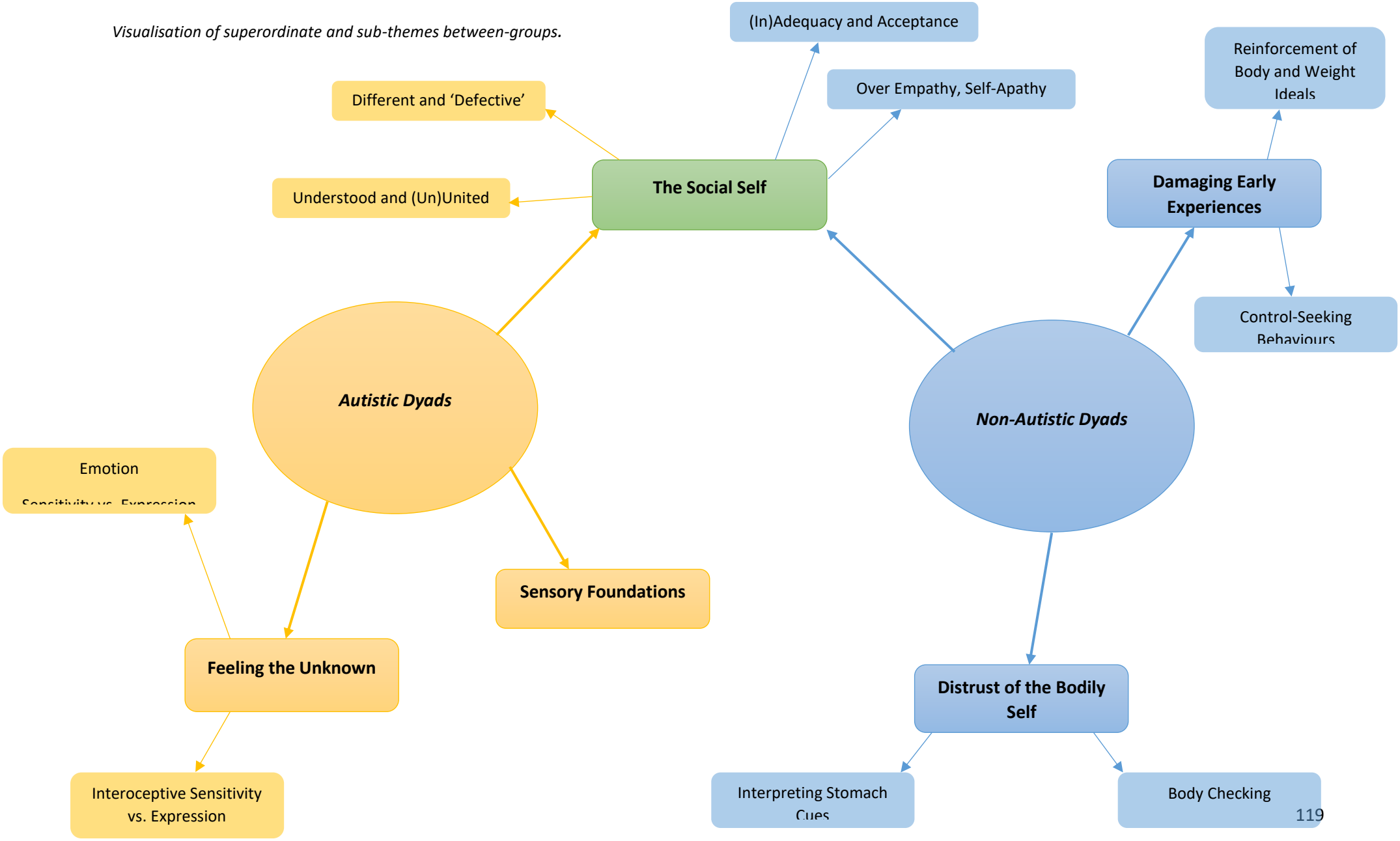
This combination gave rise to an internalized sense of 'defectiveness', of not only being different but of being to blame for this difference. This led in turn to disordered eating behaviours and thoughts. A lack of belonging and unworthiness was thought to play an integral role in the development and maintenance of anorexia by both members of the dyad:

"I think the social aspect as much as anything, like Anita has never felt like she fitted in, she's never felt like she's had friends...I think a lot of it has stemmed from social interaction and not feeling like you're not fitting in and not having what you think a friendship should be. [To Anita] do you agree?" (Anita's mum(A))
[Anita nodding]

The absence of social connections and feeling like they did not belong was perceived to be a lifelong experience; not something that was a consequence of the eating disorder but instead preceded and often influenced it. Furthermore, perceived disparity between individual's expectations and the reality of their social interactions was a common experience across participants, feeding back into feelings of internalized inadequacy and inferiority. Subsequently, feelings of internalized unworthiness distorted their perceptions of other people's emotions or intentions and led to a negative, self-biased interpretation of

Figure 1.

Visualisation of superordinate and sub-themes between-groups.



the world around them. This lens often led the individual to believe that they were cause of other people's negative moods or behaviours:

"If there is something wrong with somebody you'll know right away...but it automatically causes you anxiety, because you're first thought is what have I done wrong" (Aaron's mum(A))

"There's some distortion there like is occurring on my side. It's not my ability to perceive those emotion but it's just that distortion about myself and the way people feel about me that kind of interrupts the processing of that" (Aaron(A))

Several participants reflected on the influence that receiving their autism diagnosis had on shedding light on their perceived social difficulties, although for many this was an ongoing process. Their autism diagnosis offered a lens through which to understand this entrenched sense of self-blame when it came to their feelings of social inadequacy:

"I think when my diagnosis it was kind of a weight off my shoulders. Like okay with the socializing example, like I knew blaming myself…like I was doing something wrong, and I was finding this more difficult than a normal person so clearly there is something wrong with me. And when I got the diagnosis it was like okay, I've not done anything wrong it's just my brain works differently and I can now put things in place, try and like help myself in a way" (Anita(A))

Also unique to Autistic dyads' reflections on their social self was an emphasis on the protective role that feeling understood can have (*Understood and (Un)United).* For several dyads, this was discussed in the context of shared interests and 'wiring', and how meeting likeminded people help them to feel seen, heard and accepted. For some, this took a while for some participants to find, with one participant reflecting that this did not happen until she met others during treatment for her AN:

"Actually, the first time I think since starting school I felt that I could relate to my peers was when there was a particular group of us in inpatient care… who I think were all wired the same way." (Madeline(A))

"By which time you were how old? " (Madeline's mum(A))

"16" (Madeline(A))

"16 before she could relate!"(Madeline's mum(A))

Once this was achieved, participants began to feel less misunderstood and isolated, and thus were able to begin renegotiating their social sense of self. On the flip side of this was the negative impact that an absence of shared wiring or connections can have, notably from a lack of understanding from non-Autistic individuals. This draws attention to a bi-directional pathway of communication between Autistic and non-Autistic individuals, whereby Autistic dyads felt more understood and thus more connected with other Autistic people, while non-Autistic people reinforced a sense of alienation and disconnectedness. A lack of autism understanding or awareness often came from healthcare professionals during ED treatment, where certain behaviours were misattributed to more neurotypical interpretations:

"We have had so many non-Autistic aware nurses and healthcare supporters and psychologists, even in the last period in hospital in the last year, saying you [Emma] are so rude." (Emma's mum(A))

"Yeah, I get that a lot." (Emma(A))

"She did this once in a whole ward round….[so they said] what would you like to happen, and she said go home. Oh, that's fantastic, we can see that Emma has got purpose she wants to get better, they start doing a plan and I'm like no logically Emma just wants to go home. She's just answered the question!." (Emma's mum(A))

This labelling of the participant as "rude" reflects a disparity between ED services' understandings of disordered eating and autism-specific behaviours, ultimately leading to feelings of frustration within ED services. This only in turn served to negatively reinforce the individuals' perceptions of being different, feeding back into this socially driven sense of self and ultimately into the manifestation of their AN.

Conversely, non-Autistic dyads reflected on a sense of social and self-inadequacy as being a key factor underlying the development and maintenance of their AN *((In)adequacy and*

Acceptance). This was predominantly driven by social comparisons, with participants frequently feeling like they were inferior or a failure:

"But the summer before I became unwell…I was with a group of people that I didn't know, and in that situation that's when I started to hear what they've done, what they're doing and that's when I started to feel I'm not good enough." (Mia)

"You had met other people who, you know, you felt were doing so much more than you were which again, I'm sure wasn't true or wasn't factual." (Mia's mum)

Through this comparison, participants began to internalise a sense of inferiority, often distorted from reality. Social interactions and relationships therefore took on a significant role in defining the participants sense of self, and ultimately leading to the expression of their AN. Mirroring this, several other dyads discussed the restorative power that social connection and acceptance can have on the expression of their AN. This could come from feeling able to communicate within the family or with peers, as well as support services. Social acceptance was intertwined with self-worth, and influential in the expression of their AN:

"And think just being liked more generally, feeling like people respond more positively to me as a person I think in some ways…makes me feel better about myself which makes it easier for me to be like the eating and exercise stuff feels less important because I'm like, well I'm a good person, like look, other people like me so this doesn't really matter." (Zoe)

Disordered eating was commonly felt to be a means of social and emotional regulation; restrictive eating behaviours were perceived to have emerged in attempt to mitigate feelings of social inadequacy and to regulate the emotional impact this had on the individual. This emotional salience of social factors took on significance in making sense of their experiences of AN:

"I was not allowed to restrict anymore but I just could not, did not know how to manage that impotence of doing everything I could think of and still feel alone or being abandoned, not appreciated. Most of my eating disorders is related to that" (Rosie)

Another manifestation of a socially driven sense of self unique to non-Autistic dyads was reflections on being overly empathetic to the needs and emotions others, while simultaneously showing a lack of empathy towards the self (*Over-empathy, Self-apathy):*

"And also, in terms of how she is with other people, you know, I think a couple of times your empathy... doesn't get in the way, but you have to find that fine line between being empathetic and it having an impact on you." (Zoe's mum)

"Yeah, I remember finding it quite difficult living with someone else because I would be going like they'll be finding this annoying, or they don't want to hear this about me or I don't want to bring up this thing that they've done because I don't want to make them feel bad. And then I would be like oh great they're making loads of noise at midnight again, but I don't want to say anything because I don't want to make them feel unsafe in our living environment" (Zoe)

Often this was expressed as something that caused distress or interfered with the lives of individuals, suggestive of low self-worth and a lack of prioritising their own needs. There was a general sense that empathy was prevalent but often inaccurate, biased towards this hyper-focus on others and a hypo-focus on the self:

"Hyper-able I would say [to identify emotions]… probably more so for other people. Like I'll know if someone's had enough [of] talking to me, you know [laughing] I'll know to wrap it up like. I'll notice the signals, I'll see the glance at the watch, I'll see the eyes flittering to the left. I'll pick up the anger signals, I'll pick up if someone is upset very easily, yeah." (Louise)

"I'm not sure…. That a part of being aware of other people's emotions is possibly, ehm, going back to the whole notion of what people think of me...I'm not sure if there's- there might be a little of that coming in there." (Louise's dad)

"Oh, there definitely is." (Louise)

A hyper-awareness and attuning to into other people's emotions became integrated with a sense of self and social acceptance, before fundamentally being expressed through their AN:

"And then when I was growing up, I gave up on being myself to be able to be loved, so I was doing whatever other people would do or what other people would expect from me, so as to get their attention and be loved. And it's only now that I'm like trying, trying, not to care too much. To prioritize being myself as opposed to just accommodating what to what other people say." (Rosie).

Additionally unique to the non-Autistic group was a superordinate theme discussing the damaging influence of childhood experiences leading to the learning and expression of disordered eating behaviours (*Damaging Early Experiences).* For many dyads, this involved harmful exposure to weight, food and eating ideals (*Reinforcement of Weight and Eating Ideals).* Many of these discussions centred on the reinforcement of body or food shaming, coming from different social settings including schools, sports or at home:

"There would have weighing scales in the changing room, there was weighing scales at our squad trainings and our weight was recorded. We used phrases like "I am a gymnast we do not eat sweets or chocolate" at every session at the beginning and end of the session." (Louise)

Through early exposure to these ideals, individuals learned to fear specific body shapes or weight gain from a young age. While the messages surround eating and body shape were explicit and thus consciously adopted, it is the implicit or unconscious learning of fear and shame that felt integral to the individuals experience of their subsequent AN. As a parent, this was felt to invoke guilt and a sense of having let down their child:

"It was only years later that we heard "I'm a gymnast don't eat sweets" We have been quite shocked that someone would do that, so it would make me very wary, something that I would say to my daughters who have children, to be very careful." (Louise's dad)

A notable focus of several discussions was the influence of gender stereotypes. Weight and body shape were linked with societal expectations, and female participants felt the expectation to be thin. Many participants discussed this in the context of social factors, such as fitting in, being bullied at school, and learning to associate being accepted with being thin. These experiences were felt to be integral in the development of acceptance, as well as their experiences of AN:

"For me it was like I felt that to be thin was to be loved so I started restricting a lot with food." (Rosie)

Another important dimension was the learning of emotions surrounding disordered eating behaviours. Several dyads discussed these experiences, focusing on the emotional associations with food and eating that they were exposed to early in their development:

"Also, my mum…I think she has some form of an eating disorder. Not anorexia but sort of disordered eating behaviours, in terms of like being quite restrained in what she eats and sort of, ehm, don't really know how to describe…like….a bit…I don't know dad, how would you describe it?" (Nina)

"Anxious. Anxious about what she's eating." (Nina's dad)

"I think just always the sort of sense that she was….one had to be cautious about what you ate, or one had to be careful not to eat too much and to only eat as much as you need, you know, that sort of thing." (Nina)

This extends beyond the learning of specific eating behaviours to subconscious internalisations of functions of an eating disorder, such as food restriction as an emotional coping skill. From an early age, exposure to a complex interplay between emotions and eating, gave rise to either a consciously or unconscious hypervigilance to food.

For other non-Autistic dyads, early social experiences were perceived to be damaging through the subconscious development of non-ED specific behaviours that were ultimately adopted as a means of seeking control within the context of their AN (*Control Seeking Behaviours).* These discussions focused on factors that were not specific to weight or food

but were still perceived to be integral to their AN. This could take the form of bereavement, childhood trauma or mental illness in the family. Such experiences were felt to function as a leading driver behind the development of their AN, and the filter through which other disordered cognitions and behaviours developed from:

"It was a coping mechanism that I knew. So I wasn't grieving anything when I had anorexia but um, I was grieving a life that I didn't have in a way, and the only coping mechanism was around food and it started off as a way of control and then it became wanting to be thin…the focus is always about my [alcoholic] dad and there was never anything about me." (Rebecca)

For another dyad, adverse academic pressures had a significant influence in how they made sense of AN:

"You get pressures from the teachers being like you must revise, work hard, whatever, and I think from that being grilled into every day I kind of took it in a way that not everyone took it, and my brain must have just kind of took a different response…. If you don't get the top grades employers aren't going to want to see you, the better the grade the better your life will be." (Sophie)

"So I haven't heard some of the things Sophie has said tonight and for me, that teacher who said that comment, I'm really disgusted with and it kind of almost started with her school life?" (Sophie's mum)

These experiences often invoked feelings of distress and inadequacy in the individual, giving rise to control-seeking behaviours that then ultimately lead to the development of AN; for example, this participant went on to discuss how she then began to revise tirelessly, losing her sense of self and developing restrictive eating behaviours. There was a sense amongst dyads that the individual with AN was particularly vulnerable to these experiences, playing into perfectionistic and self-driven personalities, and that it was this combination that gave rise to disordered eating. Thus, for several dyads, these early experiences were felt to play an instrumental role in their experiences of AN, giving rise to behaviours that allowed them a sense of control in what was felt to be an uncontrollable situation.

Sensory factors

Notable differences were found in both the relative influence and the longevity of sensory processing differences between groups. Specifically, unique to Autistic dyads was the perception that sensory processing differences were a core factor, through which other factors (social, emotional, self) are influenced *(Sensory Foundations).* All seven dyads discussed lifelong sensitivities to a broad range of senses, including sound and touch, as well as to smell and taste, that were felt to be particularly salient to their disordered eating. It was not the nature of these sensitivities that were the focus of discussions however, but the response and impact that they had on the Autistic individual. Experiences of these sensory processing differences were deemed overwhelming by many, evoking a whole-body response:

"Very uncomfortable. Not just like, I think with a lot of the sensory things it's not just a case of a like or a dislike. I used to explain it as a full body response to it as opposed to oh I like that smell, I don't like that smell." (Emma(A))

"It's like torture" (Emma's mum(A))

There was a keen sense across dyads that sensory sensitivities were highly emotive and inescapable experiences, and such factors were perceived to be the core lens through which all other aspects of their life were filtered. For example, sensory processing difficulties were reported to regulate social interactions:

"It's because social interaction is an extra thing to have like to try and process that I'm already putting a lot of my effort into that that other things will slip through easier. Like the lights will affect me more or people talking in the background will affect me more and that kind of stuff." (Anita(A))

This was thought to influence the expression of AN, in that that certain restrictive or rigid eating behaviours were attempts to regulate sensory stimulation. For example, one participant reflecting that her preferences for certain texture of foods lead to *"less mental noise" (Madeline(A)).* In time, these sensory- and regulatory-based eating preferences

develop into disordered eating behaviours, creating a complex interplay between sensory processing and AN:

"Her coping mechanism is the eating disorder. So, it actually goes the other way. Do you know what I mean? Not just the sensory being highlighted, the more impact there is on the eating disorder – I see it like a seesaw – I mean, more impact there is on the Autistic Emma coping with the world, the eating disorder struggles." (Emma's mum(A))

Conversely, non-Autistic dyads did not discuss multi-sensory processing difficulties; instead, there was a general sense that any sensitivities, such as in taste or smell, were a consequence of the AN. For non-Autistic dyads, experiences of sensory processing differences were understood within the context of their AN and the resulting distrust of their body and of their self (*Distrust of the Bodily Self).* This was a key superordinate theme for non-Autistic groups and was notably discussed within the context of interoceptive cues, specifically that of hunger and fullness (*Interpreting Stomach Cues).* Dyads commonly reflected on the individuals ongoing attempts to make sense of internal bodily signals, particularly those related to hunger and fullness. Experiences of AN led participants to question hunger or fullness cues, evoking distrust not only of the signals themselves but their own ability to interpret them:

"And it almost disrupts my knowing whether I feel hungry or if I've just got an uncomfortable tummy, so I could be hungry or I could not but I just don't know because the overwhelming thing is just it feels uncomfortable." (Zoe)

"That's it. Because even quite recently you've said oh I don't really feel hungry, you know, I don't feel hungry." (Zoe's mum)

This was evident across AN trajectories, with those in recovery noting that these signals remain salient and evocative, leaving them with a lingering sense of distrust:

"Definitely hunger and fullness I find tricky, and I still don't quite trust myself in terms of knowing whether a feeling is hunger or whether it's just feeling a bit tired or sick... I don't trust my feelings of fullness or hunger" (Mia)

Discussions around these body signals reflected ongoing and collaborative sense making within the dyads, and their role in AN seemed less clear to the individual than social factors. However, there was a clear sense that this was a consequence of the AN and was more to do with a lack of trust in the self than with an underlying difficulty identifying the signal:

"Before [AN], I always used to feel you know the hungry, the signs of when you're hungry or full up. During my anorexia I kind of lost those signs. Now I do get hunger signals, however, I can be hungry, like all the time, but I wouldn't recognize that. Well, I recognize that, but I chose to ignore it." (Sophie)

Another expression of this distrust in the sensory perceptions and experiences of the body was body checking behaviours (*Body Checking),* such as fixating on certain body parts, feeling for fat or bone or comparing pictures of the body to others. This was a personal, often internal experience to the individual and was typically expressed by the individual with AN as opposed to their parents. Body checking was often noted to cause maintenance behaviour, serving to reinforce disordered eating:

"Sort of body checking [as maintenance]. So, looking in mirrors, feeling for bones over hips and over stomach, so certainly body checking would be one, a big one." (Mia)

For non-Autistic dyads, body checking was felt to be more of a safety or reassurance behaviour in light of an overarching distrust of the body, reflective of an attempt by the participant to regain trust with their physical body. Another example of this was comparing bodies and eating habits with peers as a means of indirectly seeking reassurance, both with regards to the self and in relation to their peers. The subtle nature of these body checking behaviours meant that they were harder to identify and thus harder to control:

"I was in a friendship group with two other girls that had eating disorders….we almost bounced off each other. We were close, but we would compare each other without even noticing…it wasn't until one girl was so bad that she was hospitalized that we really realized." (Rebecca)

The Autistic lens of social and sensory experiences

Another superordinate theme that was uniquely identified in the Autistic group highlighted an experience of multi-dimensional confusion that spanned both socio-emotional and sensory factors. Specifically, this was an overarching sense of being able to sense or feeling sensations or emotions but feeling unable to identify or communicate them (*Feeling the Unknown).* While this was discussed separately both socio-emotional and sensory context, it is felt that this sense of confusion between cues and communication of cues was universal and integral to the Autistic experience.

Participants reflected on both their awareness of emotions and their sensitivity to emotions in social contexts *(Emotion Sensitivity vs. Expression)*. Many participants reputed having a heightened sensitivity to the emotions of others; in some cases, this was felt to be a *"a superpower" (Holly(A)).* However, while Autistic participants felt they were hyper-able to register emotions, difficulties were reported in identifying or naming what that emotion was. This often left the individual disorientated and distrustful of their interpretation of other people's emotions too:

"What I struggle with, and I struggle with it in my own life as much as anybody else's, is actually knowing what to call this feeling and therefore what the solution to this feeling might be...I know people are down, I have seen down, but there is more than one route to down...And I can't necessarily say this is down, I just know that this is not good... But I'm not very good at knowing how other, verbally, how other people are feeling. I just sort of feel like I absorb it like a sponge. And I sometimes feel in my own life, I often don't know how to describe how I'm feeling, does that make sense?" (Madeline(A))

Absorbing unidentifiable emotions was here felt to give rise to internal conflict, renewing feelings of confusion, distrust and frustration with the self. Similarly, some dyads discussed difficulties with the individual expressing their emotions to others, with subtle differences across participants around the perceived mechanisms underpinning this. Some dyads felt that this difficulty with expressing their emotions originates from this lack of self-identification, and that this became integrated with AN:

"Um, expressing my emotions is very very difficult. Um, and that makes…that usually means that I kind of end up bottling them up. And I guess I know when I'm feeling bad, or I'm struggling or a lot, but kind of really pinpointing what I'm feeling, I just don't really seem to be able to do that very well....trying to express how I feel or my emotions, that is very very hard for me." (Holly(A))

"I think Holly does bottle things up and then things get really bad and she'll have a bit of a meltdown, which is, you know, hard for her. And usually around the time of when she's got to eat something" (Holly's mum(A))

For other dyads, a lack of emotional communication or expression was a form of emotional avoidance:

"If someone asked how are you feeling, I would know exactly how I'm feeling, but I'm not going to tell them how I'm feeling." (Milly(A))

"You have to ask the right questions" (Milly's mum(A))

"I don't want to communicate. I think it was because I knew it would be hard communicating how I was feeling, especially when things felt like a lot, I knew that if I answered truthfully then it would lead to more questions. And sometimes it felt easier to keep everything buried than to start working through how I was feeling" (Milly's mum(A))

Regardless of these subtle differences in underlying routes to emotion expression difficulties, participants universally reflected that they were integral to their experiences of AN, highlighting the enmeshed nature of emotions and disordered eating.

A similar phenomenon was also discussed with regards to sensory processing, particularly in the context of interoceptive cues *(Interoceptive Sensitivity vs. Identification)*. Participants reflected on their ability to register internal cues but expressed difficulty with labelling them. Some participants discussed this in the context of temperature or pain thresholds, while many dyads discussed the role of hunger and fullness cues:

"So, I can tell you that I feel dizzy, that my stomach hurts, that I feel tired, that my mouth feels dry, but will not connect that to I feel hungry, or I feel thirsty. And I used, even

when I was younger didn't I, my eating would be on a routine so I knew that I had lunch so I would eat. It wasn't like, oh I'm hungry" (Emma(A))

"Oh, can I have a biscuit" (Emma's mum(A))

"And if I've eaten something, it was usually for the sensory seeking side of it? So, I've had time when I've wanted something crunchy so I've had something crunchy, it's not like oh I'm hungry I'll have a snack. I've never really done hungry." (Emma(A))

This was not felt to reflect a distrust in the signals themselves but an internalized distrust of their own interpretation of these signals. Thus, much like discussions around emotions, participants felt internal confusion and subsequent mistrust of the body and self:

"I'm not very good at knowing when I'm hungry. It's not necessarily that I don't know when I'm hungry...it's a bit hard sometimes to tell the difference? I know there's a problem but I can't tell you….I can't tell you what the actual sensation is. Sometimes I can't tell whether I'm really full or really hungry." (Madeline(A))

While dyads discussed pronounced and multi-faceted differences in interoception, it was notable that discussions around interpreting these internal bodily signals centred on hunger and fullness signals. The confusion that arose from these signals were both lifelong and salient to their experience of AN, suggesting that dyads felt this misinterpretation directly impacted their eating habits.

Discussion

The current study explored the perceived role of social and sensory factors in AN across Autistic and non-Autistic adults and their parents. IPA analysis revealed three superordinate themes in each group, highlighting key similarities and differences across groups. Notably, while there were some similarities in social and sensory factors, such as socially driven sense of self and distrust in internal bodily sensations, there seems to be significant differences in experiences and manifestations of how social and sensory differences play a role in AN.

Both Autistic and non-Autistic dyads reflected on a socially driven sense of self that was perceived to play a significant role in the development and maintenance of their AN. This is line with existing evidence that suggests social and interpersonal difficulties are common in both autism (O'Connor et al, 2022) and AN (Westwood et al, 2016), and that perceived social difficulties are integrally linked with the self-concept (Nguyen, Ownsworth, Nicol & Zimmerman, 2020; Oldershaw et al, 2019). However, differences emerged in possible underlying mechanisms for these difficulties. For the Autistic group, this was driven by a sense of internalized defectiveness, whereas for non-Autistic participants this was felt to reflect a sense of inadequacy through comparison to others. Previous literature has suggested differences, where social comparisons have been reported to play a significant role in AN pathology (Westwood et al, 2016; Cardi et al, 2018), while difficulties with social interaction and feeling different have been proposed as an autism-specific mechanism in restrictive EDs (Brede et al, 2020). Furthermore, a recent comparative study found evidence to suggest that some aspects of reciprocal social interaction may help discriminate between Autistic and non-Autistic individuals with AN (Kerr-Gaffney et al, 2021a), suggesting that Autistic individuals have possibly unique difficulties in engaging with conversation or responding to social prompts. Current findings support these possible autism-specific differences in social interactions, suggesting that feeling of defectiveness is a significant factor causing these differences.

Both groups also discussed the protective role of belonging and feeling understood by others. This is supported in AN literature, where feeling connected to others and high-quality social relationships are associated with less severe ED pathology (Rowlands et al, 2021). Social connectedness has received considerably less research attention in broader autism research, perhaps due to assumptions that Autistic people are socially withdrawn and lack social motivation (Chevallier et al, 2012). Challenging this approach are Autistic lived perspectives, highlighting how important connections and friendships are to them (Sedgewick et al, 2016; Gillespie-Smith, McConachie & Mair, 2023). For participants in the current study, an important aspect of these connections was the concept of sharing or similar wiring. While not explicitly a social theory, Monotropism (Murray et al, 2005) is a theory accounting for intense interests and connections that could intuitively be applied to understanding social connections, particularly within the context of restrictive eating

behaviours (Brede et al, 2020). Future research should explore this, seeking to further understanding how these shared interests may influence Autistic relationships and how this may play a role AN. Conversely, social interactions and connections were found to be negatively influenced a lack of understanding of Autistic interests or traits, leading to different communication styles. This is consistent with the Double Empathy theory (Milton 2012), which suggest this mismatch in neurotypes (neurotypical vs neurodivergent) causes misunderstandings that result in difficult social interactions (Mitchell, Shappard & Cassidy, 2021). Our findings are also in line with recent qualitative research suggesting that connecting with other Autistic people has a positive impact on their wellbeing (Crompton, et al, 2020b). ED services should promote awareness of these possible differences, applying these understandings into the modification of treatment and ensuring that Autistic individuals feel understood by support services.

Across both groups, emotion difficulties were integrally linked with their perceptions of their social relationships and felt to directly influence AN. Socio-emotional difficulties have consistently been implicated in AN (Oldershaw et al, 2011) and difficulties in identifying, regulating and communicating emotions have been implicated in Autistic women with AN (Brede et al, 2020; Sedgewick et al, 2019). By comparing the experiences of Autistic and non-Autistic individuals, the current study was able contextualise these similarities and work towards identifying different underlying mechanisms. While both groups reflected on difficulties expressing or communicating emotions, they differed in what they perceived to be the cause of these difficulties. Autistic dyads felt these difficulties were caused by an inability to identify the emotion, while non-Autistic participants believed these were caused by heightened consideration for others leading to a lack of consideration for expressing their own emotions. Future research could work towards further understanding how these different underlying perceptions and motivations may give rise to similar surface-level socio-emotional difficulties. Studies could adopt a mixed-methods approach, allowing comprehensive and complementary findings by generating clinically meaningful and measurable outcomes that are contextualised by lived/living experience perspectives (Regnault, Willgos & Barbic, 2018).

Themes were identified across both groups focusing on the interpretation of internal body cues, particularly salient cues of hunger and fullness, in line with recent studies exploring interoception as a possible mechanism in disentangling autism and AN (Adams et al, 2022). The unique qualitative approach of the current study allows us to add novel insights to Autistic and non-Autistic experiences of detecting or identifying hunger and fullness. Both groups reflected on confusion of these signals that ultimately led to a distrust of their body and of themselves. However, subtle differences were revealed in the perceived cause of these difficulties; for Autistic individuals, this was reported to be a lifelong and multi-dimensional difficulty, while for non-Autistic individuals this was felt to be a consequence of their AN. This has important implications for hunger and fullness cues as a target of ED interventions, suggesting both similar and different treatment targets. For example, both groups would benefit from approaches that foster trust and agency in the self, while for non-Autistic participants particularly, ED clinicians should be aware of the personal and emotional significance of addressing these cues.

Domain-specific sensory processing differences, including taste and smell sensitivities, were reported to reflect a similar pattern across Autistic and non-Autistic groups. Non-Autistic dyads reported that these sensitivities emerging with the development of their AN, while Autistic individuals reflected on lifelong and multi-sensory sensitivities. Sensory processing differences were also felt to be an integral and overwhelming influence on how Autistic individuals see the world, impacting social and emotional functioning as well as the expression of their AN. This is consistent with high prevalence estimates of multi-sensory differences in autism (De Both & Reynolds, 2015) and evidence to support its influential role in socio-emotional difficulties (Glod et al, 2015) and restrictive eating behaviours (Brede et al, 2020; Nimbley, Golds, Sharpe, Gillespie-Smith & Duffy, 2022). This highlights the importance of increasing awareness amongst ED clinicians regarding the heterogeneous nature of sensory processing differences in autism, and the need to modify of ED treatment to account for them in Autistic populations, as opposed to seeking to correct them.

There are several notable strengths of the current study. By using a qualitative approach, the study sought to generate understandings of social and sensory factors in AN that is rooted in lived/living experience, adhering to calls for the inclusion of lived/living experience

within the design, implementation, interpretation and dissemination of ED research (Music et al, 2022). The study is also closely aligned with neurodiversity affirming frameworks and calls for more meaningful participatory research (Fletcher-Watson et al, 2019). An Autistic researcher with lived/living experience of AN was involved in the design and development of the study, and the triangulation of neurotypical, neurodivergent and lived/living experiences perspectives in data analysis allowed for a robust interpretation of participant's realities. Finally, while the study built on previous research that draws on multi-perspectives, the collection of these perspective in the current study through dyadic interviews in both groups, allowed for unique interactions in real time and allowed for a direct comparison between Autistic and non-Autistic groups.

Despite these strengths, the study is not without limitations. The dyadic approach could have created a recruitment bias, excluding participants who were either unable or unwilling to participant with a parent or caregiver. With regards to the sample, there was a female bias across both adult and parent participants. This female bias has been widely reported in the AN literature, as well as in research exploring the overlap between autism and AN (Brede et al, 2020). Future studies should attempt to recruit more representative gender samples, including the under-researched non-binary and transgender Autistic participant groups. Due to the comparative nature of the study between Autistic and non-Autistic individuals, the study did not account for important ED-specific factors, such as age of ED diagnosis, or compare across current and recovered groups. Both of these factors likely influence the experiences of the individual and should be included and explored in future studies with larger samples and more generalisable methodologies. Age of autism diagnosis was also not collected, which intuitively may play a similar role in the participants interpretation of their experiences and warrants future consideration.

The current study has several notable implications. The current study could be used as a foundation or guide for future studies including participatory approaches with lived/living experience researchers, particularly with regards to involving lived/living experience in the data analysis process. Furthermore, social and sensory factors identified in the current study should be explored in further research with larger and more heterogenous samples in future efforts to untangle the co-occurrence between autism and AN. Subject to such future

research it is hoped that further elucidating the role of such factors will identify promising targets in ED interventions for both Autistic and non-Autistic individuals. Current findings suggest that feelings of defectiveness and difference should be addressed to alleviate both AN symptoms and broader socio-emotional functioning in Autistic people, and efforts should be made to accommodate for, as opposed to 'fix', sensory-based eating. Additionally, Autistic individuals may demonstrate different communication styles to non-Autistic individuals which need to be accepted and understood. This awareness should be incorporated towards improving the therapeutic alliance and delivery of interventions, ensuring that Autistic individuals feel understood by ED support services. This could also be translated into developing community-based support services, such as peer support, which could match Autistic individuals with Autistic mentors. Across both groups, interventions could target renegotiating a sense of trust with internal bodily signals, while being aware of potentially subtle differences in mechanisms; for example, the complex interplay with emotion should be accounted for in non-Autistic individuals, while Autistic individuals may need to rely on more external cues to correct an underlying difficulty in identifying such cues. More broadly, identifying, regulating and communicating emotions within social contexts may be a promising target for alleviating AN symptoms across both Autistic and non-Autistic groups.

The current study explored and compared the role of social and sensory factors in AN across Autistic and non-Autistic dyads. Both groups were found to have a socially integrated sense of self, as well as reflecting on socio-emotional and sensory difficulties. Differences also emerged between groups, with Autistic dyads reflecting on feelings of social defectiveness, difficulties with identifying or naming emotions, and more enduring, invasive multi-sensory processing differences. This is different from the non-Autistic participants who were more vulnerable to social comparisons and influences, particularly during childhood, and felt a greater degree of social inadequacy. Future mixed-methods research using more representative samples should seek to further explore these factors, using lived/living experiences to contextualise clinically measurable ED outcomes. These studies could in turn help ED services and clinicians modify their practice or develop autism-informed interventions.

Chapter 5 – Observational Study Methods

Findings reported in chapter 4 suggested that social and sensory factors, as well as their possible interplay with emotional factors, may play an important role in understandings of the overlap between autism and AN. While an IPA approach allows for the rich analysis of the dyadic experiences, such approaches do not allow for generalization beyond included participants. In order to achieve this, a more quantitative and controlled approach is required, seeking to generate measurable outcomes and work towards untangling the role of each factor across different participant groups. Furthermore, in line with the overarching thesis framework and with discussions with Autistic dyads in Study 1, it was important that the study was designed using a neurodiverse-affirming approach; challenging traditional social communication deficit assumptions and accounting for ecologically valid, autism-specific mechanisms. The following chapter therefore presents a methodological outline of a feasibility study drawing on observational designs, with target factors (social communication, interoception, alexithymia) highlighted by IPA findings. Chapters 6 and 7 present two empirical studies exploring the data from this study.

Design

The following study was conducted to explore group differences in non-verbal social communication behaviours, as well as the relationship between social communication and sensory (interoception) and emotional (alexithymia) factors. Interest also lay in exploring the feasibility of an observational study looking at non-verbal social communicative behaviours in Autistic and non-Autistic young adults (16-25 years old) with anorexia nervosa (AN). Particular interest lay in the feasibility of recruiting participants for the study, with a focus on the novel participant group of co-occurring autism and AN, and whether the use of a non-verbal behavioural coding scheme is a useful and acceptable method of social communication research in the current population. The study used a cross-sectional design. The study was a single-centre study, taking place at the University of Edinburgh.

Ethical approval

A favourable opinion for the study was obtained from the Southeast Scotland NHS Research Ethics Committee (22/SS/0092/AM01) and from the University of Edinburgh Health in Social

Science Research Ethics Committee (CLPS026). Please see Appendix E for relevant ethical approval documents. Relevant approval was also obtained from NHS Lothian Participant Identification Centre's and an NHS research passport was approved for the lead researcher (EN).

Participants

The current study initially sought to recruit five participant groups: (1) Autism and AN; (2) Autism only; (3) Current AN; (4) Recovered AN and (5) neurotypical/healthy controls (NT/HC). Unfortunately, due to low recruitment numbers these groups were not successfully recruited, leading to the merging of groups (3) and (4) into a single AN group. Thus, participant groups in the following analyses are Autism and AN, Autism only, AN only and NT/HC.

Inclusion and exclusion criteria

Full inclusion and exclusion criteria for participants are presented in Table 1 and Table 2 respectively. All groups were required to be fluent in English. Both formal and self-diagnosis was accepted for Autistic participants. Proof of AN diagnosis was required. Initially, non-Autistic AN participants were asked to indicate if they felt themselves to be recovered, which was here defined as: *"3+ years since your last significant, acute episode".* This definition was co-produced by the lead researcher and an Autistic researcher with lived/living experience of AN (EM) and aimed to account for a broad range of physical, behavioural and psychological relapses. While recovery is a hard concept to define, this definition aligns with increasing challenges to physical and weight-focused recovery criteria, with challengers seeking to draw attention to previously neglected psychological factors and personal experiences of recovery (Kenny et al, 2022; Bardone-Cone et al, 2018). Indeed, several studies have suggested that such factors are often enough for individuals to define themselves as recovered, regardless of any remaining ED cognitions and behaviours or low weight (see Wetzler et al, 2020). Similarly, a systematic review and meta-analyses found that focusing solely on weight restoration as an indicator of recovery without considering accompanying improvements in psychological, cognitive and psychosocial functioning is associated with high relapse rates observed in AN (Berends, Boonstra & van Ellburg, 2018).

This call for a shift away from a weight-focus has also been used to challenge the use of BMI as a diagnostic criterion in AN and indicator of illness severity (Phillipou & Beilhazr, 2019). While restoring weight and nutrition in AN patients in a hugely important part of treatment, particularly in inpatient services, there are valid concerns to using weight as an indicator of illness and recovery, and thus the current study did not include BMI as an inclusion or exclusion criteria.

Sample size

G*Power sample size calculations indicated that 77 participants would give 80% power to detect a medium effect size of .025 (F^2), with alpha set at .05. Sample size was calculated on the original intention to conduct a mixed, factorial ANOVA exploring the main effects of effects of condition (within-group) and group (between-group) and their possible interactions, as this was intended to be the primary analysis.

Recruitment

The current study adopted a dual recruitment stream strategy. Recruitment started in February 2020 and ended in July 2020. Stream 1 involved community recruitment. Within this stream, online advertisements were posted through two main sources. The first source was ED and Autism charities and organisations, including BEAT (https://www.beateatingdisorders.org.uk/), SWAN (https://swanscotland.org/), SupportED (https://supportedscotland.org/) and Scottish Autism (https://www.scottishautism.org/). Online advertisements were also posted on general mental health research site (https://participate.mqmentalhealth.org/) and a UK-based research recruitment website (https://www.callforparticipants.com/). The second source was internally within the University of Edinburgh. Study adverts were sent on mailing lists for staff and students within the School of Health in Social Science, as well as targeted Microsoft Teams channels. Study flyers were also advertised in student research spaces or waiting rooms in University of Edinburgh services, such as the Disability Services.

Table 1.

Inclusion criteria for participants

Autism and AN	Autism	AN	Recovered AN	NT/HC
16-25 years old	16-25 years old	16-25 years old	16-25 years old	16-25 years old
Fluent in English	Fluent in English	Fluent in English	Fluent in English	Fluent in English
Current or past AN diagnosis		Current AN diagnosis	Past AN diagnosis	EDE-Q score < 2.7
Formal or self-diagnosis of autism	Formal or self-diagnosis of autism			SRS-2 T-score < 59

AN, anorexia nervosa; NT/HC, neurotypical/healthy controls; EDE-Q, eating disorders examination questionnaire; SRS-2, social responsiveness scale 2nd edition.

Table 2.

Exclusion criteria for participants

Autism and AN	Autism	AN	Recovered AN	NT/HC
History of brain trauma and/or learning disability	History of brain trauma and/or learning disability	History of brain trauma and/or learning disability	History of brain trauma and/or learning disability	History of brain trauma and/or learning disability
Non-verbal	Non-verbal	Non-verbal	Non-verbal	Non-verbal
				History of autism or ED diagnosis

AN, anorexia nervosa; NT/HC, neurotypical/healthy controls; ED, eating disorder.

Stream 2 focused on NHS recruitment via NHS Lothian ED services. Notices for the study were placed in waiting rooms in both the Child and Adolescent Mental Health Services and in Adult Services. Participant information sheets were also disseminated to ED clinicians across NHS Lothian services and given to potential participants on their caseload. Participant contact details were then provided to the lead researcher, or the lead researcher contact details were provided to the interested participant. In order to familiarise the potential participant with the lead researcher, a recruitment video was made available

(https://www.youtube.com/watch?v=ZxO7RQ8NQSs&feature=youtu.be), as well as the lead researcher making herself readily available to visit services and discuss the study. Please see Appendix F for recruitment documents, including the Participant Information Sheet, Study Advert and Social Media Advert.

Measures

Demographics

All participants were required to provide the following demographic information: gender (male, female, non-binary/third gender, prefer not to say), age, level of education (primary/secondary education, vocational training, undergraduate degree, postgraduate degree, doctorate/professional degree, other), ethnicity (white, mixed or multiple ethnicities, Asian, Black/African, other), employment (full-time employment, part-time employment, self-employed, unemployed, student, still at school) and psychiatric medication use (yes or no). For AN participants in the Autism and AN and AN only group, participants were asked to provide age of AN diagnosis and length of AN in years and/or months.

Body Mass Index (BMI)

Height and weight were recorded in order to calculate the BMI of each participants (kg/m^2). Due to the sensitive nature of this, all participants were offered the option of being weighed facing backwards or blindfold. This was recorded with the view to control for the possible influence of BMI in subsequent analyses and was not recorded to be an indicator of illness severity or recovery.

Weschler Abbreviated Scale of Intelligence – 2nd Edition (WAS-II; Weschler et al, 2011)

The WASI-II is a measure of cognitive ability, and measures verbal and perceptual reasoning across a series of sub-tests. For the purposes of the current study, the Vocabulary and Matrix Reasoning subscales were used, generating the Full-Scale Intelligence Quotient-2 (FSIQ-2) score. This generates a full estimated IQ score in less time than it takes to conduct all four sub-tests and has showed high evidence of convergent validity with the overall test

(Irby & Floyd, 2013). The WASI-II has demonstrated good internal consistency reliability, test-retest reliability and inter-rater reliability (Weschler et al, 2011; Irby & Floyd, 2013). While the WASI-II was not initially standardized in Autistic populations, it has subsequently demonstrated high convergent validity in Autistic samples (Minshew et al, 2005) and is one of the most widely used measures of intellectual ability in autism (Yu, Ozonoff & Miller, 2023). It has also been commonly used in previous studies exploring the overlap between autism and EDs (e.g., Bitsika & Sharpley, 2018; Kerr-Gaffney et al, 2020a; 2020b).

Self-report measures

The Eating Disorder Examination Questionnaire 6th Edition (EDE-Q; Fairburn & Beglin, 2008). The EDE-Q is a 28-item questionnaire that measures the range and severity of ED psychopathology. The EDE-Q has four subscales (restraint, eating concern, shape concern and weight concern) and a global score ranging between 0 and 6. Frequency data of key eating disorder features is also generated, but these are not included the overall global score. Higher global scores are indicative of more disordered eating behaviours and attitudes, with a suggested cut-off of 2.8 recommended for screening for eating disorders (Fairburn & Beglin, 2008). The EDE-Q is a widely used measure across research and clinical settings. There is good evidence to support test-retest and inter-rater reliability, internal consistency and discriminate validity in clinical and subclinical populations (Aardoom et al, 2012; Berg et al, 2011), however recently the four-subscale structure has been questioned in non-clinical samples (Carey et al, 2019). Previous studies that have used the EDE-Q in Autistic samples show promising evidence of construct validity (e.g., Kinnaird, Sedgewick, Stewart & Tchanturia, 2019) although a robust psychometric evaluation of reliability and validity in Autistic populations is warranted.

The Social Responsiveness Scale 2nd Edition (SRS-2; Constantino & Gruber, 2012). The SRS-2 is a 65-item measure of social differences in autism. There are five subscales (social awareness, social cognition, social communication, social motivation, and restrictive and repetitive behaviours). Each item denotes a statement and respondents are required to indicate their agreement with each statement over the past 6 months using a 4-point Likert scale ranging from *not true* = 1, *sometimes true* = 2, *often true* = 3 and *always true* = 4. Raw scores are converted to T-scores, and scores can range across from <76 (Severe), 66 to 75

(Moderate), 60 to 65 (Mild), >59 (Normal). The SRS-2 demonstrate good test-retest and inter-rater reliability (Bruni, 2014; Charman et al, 2007), as well high internal consistency (Bolte et al, 2008; Nguyen, Ocansey, Miller, Le, Schmidt & Prado, 2019). Good criterion, concurrent, convergent discriminative validity (Frazier et al, 2014; Chan et al, 2017) has also been demonstrated in Autistic populations. The SRS2 has also been validated as an effective screening measure for Autistic traits in AN samples (Kerr-Gaffney et al, 2020b).

The Interoception Sensory Questionnaire 8-item (ISQ-8; Suzman et al, 2021). The ISQ-8 is a self-report measure of interoceptive abilities, measuring awareness and interpretation of internal body sensations. Each item involves a statement and participants are asked to indicate how much they agree with the statement across a 5-point Likert Scale, ranging from *not true of me at all* = 1 to *very true of me* = 5. A higher score indicates more difficulties in identifying or interpreting internal sensations. The ISQ-8 is a shortened version of the original 20-item ISQ (Fiene, Ireland & Brownlow, 2018), demonstrating improved fit, preliminary adequate convergent and discriminant, reliability, and high internal consistency in Autistic adolescents and adults (Suzman et al, 2021), however it is yet to be validated in AN samples.

The Toronto Alexithymia Scale (TAS-20; Bagby et al, 1994). The TAS-20 is a 20-item measure of alexithymia (ability to identify and describe emotions), with three subscales (difficulty identifying feelings, difficulty describing feelings, and externally orientated thinking). Items are completed by respondents using a 5-point Likert scale, ranging from *strongly disagree* = 1, *disagree* = 2, *neither agree nor disagree* = 3, *agree* = 4, and *strongly agree* = 5. Total scores range from 0 to 100 and the relevant cut-offs of scores are as follows: <51 = no alexithymia, 52 to 60 = borderline alexithymia, >61 alexithymia. The TAS-20 has good evidence for high internal consistency and retest reliability (Bagby, Parker & Taylor, 2020; Leising, Grande & Faber, 2009), as well as evidence of good convergent and discriminative validity (Bagby et al 2020) in the general population. The TAS-20 has also previously been validated in ED (Westwood, Kerr-Gaffney, Stahl & Tchanturia, 2017) and Autistic (e.g., Samson et al, 2012) samples.

The Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983). The HADS is a 14-item measure of depression and anxiety symptoms. Using a 4-point Likert scale, respondents are asked to indicate how they have been feeling across the past 7 days, with higher scores indicating more severe symptoms. Depressive and anxiety symptoms correspond to two subscales, and an overall score can also be calculated. For each subscale, the total score can be at most 21, with scores of >11 suggestive of a clinically significant disorder, and a score of between 8 and 10 suggestive of a mild disorder. The HADS is widely used across research, with high internal reliability and construct validity being consistently supported (Djukanovic, Carlsson & Arestedt, 2017). Please see Appendix G for all self-report measures.

Observational task

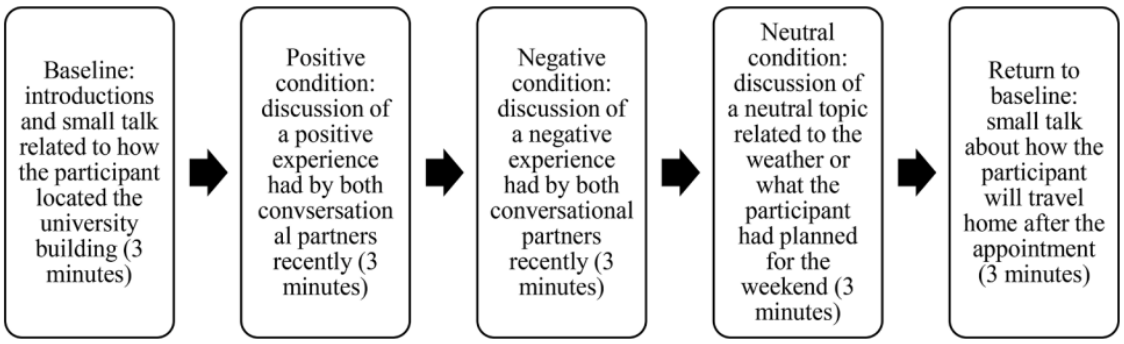
The current study was interested not only possible group differences in non-verbal social communicative behaviours (Chapter 6) and relationships between associated factors (Chapter 7), but also in the feasibility of recruiting for and the utility of using observational study methods within the current sample. Participants completed an observational task exploring social communication, which involved a short video-taped social interaction between pairs. This task is based on a previous study (Harrison, 2021) in ED samples, and involved a guided conversation through a positive, negative and neutral condition, whereby participants were asked to discuss a positive, negative and neutral recent experience respectively. During the task, communication between the participant and the researcher was recorded using a discrete video camera. The interaction was estimated to take approximately 10 minutes, guided by the researcher through a baseline, three experimental conditions (positive, negative, neutral), before returning to baseline (see Figure 1). Please see Appendix H for task script.

The observational task was recorded using the Open Broadcaster Software (OBS, https://obsproject.com/). The OBS is a free, open-source software for video recording and live streaming, recording high performance, real-time videos and audio capturing. OBS was installed on a University of Edinburgh computer in the observational labs and was used to control three cameras placed at complementary positions around the room. The cameras

were positioned in such a way that optimised the recording of all non-verbal behaviours exhibited by the participant throughout the session. The participant sat in the middle of the room, with a table in front of them. The researcher sat opposite the participant on the other side of the table and was not under observation during the video recording.

Figure 1.

Experimental conditions within the social communication task. From Harrison A. (2021). Experimental Investigation of Non-Verbal Communication in Eating Disorders. Psychiatry research, 297, 113732.



Procedure

Interested participants were screened for eligibility and any questions were addressed. Participants were then sent a link to a secure online survey platform (https://www.qualtrics.com/uk/). The participant information sheet was shown again, followed by a consent form on the following screen. Participants provided informed consent by indicating the relevant button to move onto the next screen. Here, basic demographic information across groups, including gender, age, level of education, ethnicity, level of employment and medication use was collected. At the end of this page was a question asking which group the participant was in. If the participant indicated they were in the Autism and AN or AN only group, they were asked to provide age of AN diagnosis and duration of AN on the next screen. All other groups were straight to a page requesting they enter the unique identifier, email address or contact number and GP contact details, which the Autism and AN and AN only group also filled out once they had provided the AN-specific information. The following page informed the participants they were going to complete five

questionnaires about eating disorder symptoms, Autistic traits, depression and anxiety, interoception and alexithymia. They were also encouraged to take breaks when needed and informed that while they could leave and return to the questionnaires, no question could be skipped. The EDE-Q was then administered over three pages, the SRS-2 over six pages and the ISQ-8, HADS and TAS-20 over one page each. Once participants had completed these, the final screen provided a debrief with next steps and support resources. This was required to be done no more than one week before participants attended the task session at the University of Edinburgh central campus.

The observational task took place in the University of Edinburgh Clinical Psychology labs. Careful consideration was paid to make the room as suitable an environment as possible. For example, the observation labs were cleared of unnecessary clutter, windows were shut to avoid noise and lights were controlled. Participants were also asked upon arrival if they were happy with the temperature of the room, and suitable adjustments were made if necessary. In total, the session took around 1 hour and 15 minutes, and the observational task lasted around no more than 10 minutes. Participants were sent a debrief sheet and a £20 Amazon voucher as a thank you for their time.

Coding

Non-verbal behaviours were coded using a coding scheme developed from a previous study in adult women with EDs (Harrison, 2021). Before applying the coding scheme to the data, a piloting of the scheme was conducted on a randomly selected sample. This was due to the fact that the previous study only applied the coding scheme to ED samples, and the inclusion of Autistic participants meant there was a possibility that certain autism-specific non-verbal behaviours would need to be included.

In line with published recommendations for the modification of behavioural coding schemes (Chorney, McMurty, Chambers & Bakeman, 2015), a structured and progressive process was initiated. This started with piloting and refining the coding scheme to account for possible autism-specific behaviours, before implementing the finalised coding scheme.

Piloting the coding scheme

The piloting of the coding scheme was done by the lead researcher (EN) and by an undergraduate student blind to wider study aims (KH). Coding was performed on 25% of the videos and these were randomly selected across the groups. Each video was watched twice through to allow the researcher to familiarise themselves with the data. The recording was coded for non-verbal behaviours, and this was done in conditions intervals (positive, negative, neutral). The coding scheme was an event-based coding scheme, and so no two codes from the same category could be coded at the same time. Specifically, behaviours were coded using a timed-event sequential continuous coding approach (see Chorney et al, 2015), recording the order of behaviours and duration of behaviours. This allowed for the collection of start and stop times of specific behaviours or 'events' within a specific time period. This process was iterative and involved several rounds of watching and checking the video and each identified time period. For transparency and to enhance inter-rater communication, each recorded behaviour was timestamped, and duration of the behaviour was measured in second/milliseconds (00:00.00) using an Excel spreadsheet created by the lead researcher.

During the pilot, both EN and KH developed an initial list of additional codes, along with operational definitions. These included the definition of each code, along with an example when this was deemed necessary and a timestamp to identify this in the data. Following mutual discussion and agreement, the coding scheme was modified to include the following new categories and codes: the *Necklace* code was changed to *Jewellery* in the Hands category to account for a broad range of jewellery being touched in the videos; an additional code of *Sitting* was added to the Hands category to account for instances when hands were being sat on; and a new category of Repetitive Movements was included, with three codes for Hands, Legs and Trunk/Whole Body. Please see Table 3 for the finalised coding, including the operational definitions. Please see Appendix I for the full non-verbal behavioural coding manual.

Implementing the coding scheme

Once the five videos were coded and the piloting of the coding scheme had been completed, the finalised non-verbal behavioural coding scheme was applied to all data, including the five used in the piloting of the coding scheme. All videos were coded by the lead researcher (EN) using the same coding strategy; the video was watched through twice, before each condition was watched, rewatched and finally coded. A second, independent coder who is an undergraduate student (MK) was trained in the coding scheme before coding 25% of the randomly selected videos to calculate inter-rater reliability, in line with recommendations for reliability on behavioural coding schemes (Bakeman & Quera, 2011). Inter-rater reliability yielded an overall percentage agreement of 78%, which indicates substantial agreement (Landis & Koch, 1977; Chorney et al, 2015). Discrepancies were discussed by coders and resolved by mutual agreement, and subsequent analyses were conducted on the lead researchers coded data.

Once all the videos had been coded, the total duration of each non-verbal behaviour was calculated across conditions, as well as in each condition (positive, negative, neutral). Due to variable task and condition duration across participants, these total durations of behaviours were then transformed into proportion data. Therefore, the proportion of time spent showing each behaviour was computed overall, as well as in the positive, negative and neutral condition. These proportions were then used as the dependent variable in subsequent analyses. Study results are presented in Chapters 6 and 7.

Table 3.

Non-verbal social communication codes. Novel codes included in the current analyses are italicized.

Codes	Definition
Body Orientation	Direction of the body in relation to conversational partner
1. Facing	Directly facing conversational partner
2. Up to 44 ◦	Body angled up to 44◦ away from conversational partner
3. 45-90◦	Body angled 45-90◦ away from conversational partner
4. >90◦	Body angled >90◦ away from conversational partner
Legs	Placement of legs

1. Crossed	Legs are crossed over one another at either the knee, calf or ankles
2. Uncrossed	Legs are uncrossed and parallel to one another
Trunk Lean	Trunk/Upper body position
1. Upright	Upright seated position
2. Forwards	Trunk is slanted forwards from the hips
3. Backwards	Trunk is slanted backwards from the hips
4. Other	Trunk is leaning to the right or left
Gaze	Gaze position (anything over 1s)
1. On experimenter	Gaze is positioned directly towards conversational partner
2. Down	Gaze is positioned downwards
3. Away	Gaze is turned away from conversational partner, including ceiling
Hands	Use of hands including position and gestures
1. Beats	Hands move rhythmically along with the speech
2. Deictics	Hands gesture an object, point towards something of interest to direct attention
3. Iconics and metaphors	Hands gesture a real (iconics) or hypothetical/imagined (metaphors) spatial image, action or object
4. Head	Hand(s) touches the forehead or back of the head
5. Chin	Hand(s) touches the chin
6. Neck	Hand(s) touch the neck, including the back of the neck
7. Hair	Hand(s) touch or play with hair
8. Cheeks	Hand(s) touch the cheeks
9. Nails	Hand(s) play with, pick touches nails; person bites nails
10. Eyes	Hand(s) touch the eyes
11. Clothes	Hand(s) play with clothes
12. Nose	Hand(s) touch the nose
13. Ears	Hand(s) touch the ears or play with earrings
14. Jewellery	*Hand(s) touch or play with a necklace, bracelet, earring or other item of jewellery*
15. Mouth	Hand(s) touch the mouth
16. Arms	Hand(s) touch arms or hands clasped or held
17. Legs	Hand(s) rest on or touch any part of the legs
18. Trunk	Hand(s) touch any part of the trunk from the waist up to the base of the neck, including the shoulders
19. *Sitting*	*Hand(s) touching chair or sat on (placed under rear on chair)*
Repetitive Movements	
1. Hands	A similar movement or motion of the limbs, trunk or whole body that is repeated 3+ times OR over 3 times in the allocated timeframe (condition) - if the latter, code as total duration
2. Legs	Hand(s) engage in repetitive movements with each other, such as fidgeting or finger pulling, with other areas of the body, such as the hair, or with clothing, such as sleeves

3. Trunk/Whole Body

Leg(s) and/or feet engage in repetitive movements, such as leg bobbing or foot tapping

Trunk, including the arms, shoulders and torso, engages in repetitive movements, such as swaying or rocking.

Chapter 6 – Non-verbal social communication behaviours in Autistic and non-Autistic young adults with AN

Abstract

Background: There is an accumulating evidence-base to suggest an overlap between autism and anorexia nervosa (AN), with Autistic individuals reporting unique eating disorder (ED) treatment outcomes and experiences. It is therefore imperative that underlying mechanisms are identified and incorporated into more effective treatment. Social difficulties have been reported in both autism and AN but have received little empirical attention in untangling the overlap between the two conditions. To date, no study has explored the role of social communication in the overlap between autism and AN. Therefore, the current study sought to investigate the feasibility of recruiting for and conducting an observational study as an effective method of exploring group differences in non-verbal social communication behaviours in autism and AN, and to explore whether positive, negative or neutral conditions had an influence on non-verbal behaviours.

Methods: Four participant groups were recruited: (1) Autism and AN; (2) Autism only; (3) AN only; and (4) neurotypical/healthy controls (NT/HC). In total, 28 participants took part in the study. An observational design was adopted, involving a recorded short, structured social communication task through a positive, negative and neutral condition. A modified behavioural coding scheme was applied to the data, coding for non-verbal behaviours across the body, trunk, legs, eye gaze, hands and restrictive and repetitive movements (RRMs) codes. To test for between-group differences, a series of Kruskal-Wallis tests were conducted for each non-verbal behaviour. To test for the effect of condition, a series of Friedman's tests were conducted for each non-verbal behaviour.

Results: After adjustments for multiple testing, there were no significant between-group differences on any non-verbal behaviour, both overall and across each of the three conditions (positive, negative, neutral). Similarly, there were no significant within-group differences across conditions.

Discussion: No between-group differences were found on any of the non-verbal behaviours, while there was no effect of condition found within-groups. The low sample size raises concerns about the feasibility of recruiting for observational studies in autism and AN,

however on reflection this was felt to be more to do with recruitment strategies than with the methods. The task, subject to future modifications, was deemed suitable for research purposes. It could be that non-verbal social communication behaviours do not play a leading role in the overlap between autism and AN, and research should focus on other social factors. Alternatively, it could be that limitations of the current study limit drawing conclusive findings. Regardless, future research is warranted, as further understandings of how social communication plays a role in the overlap between autism and AN has important implications on the deliverance of clinical and community ED services.

Introduction

There is increasing evidence to support an overlap between autism and AN (Westwood & Tchanturia, 2017; Solmi et al, 2021), with Autistic individuals reporting unique treatment challenges (Nazar et al, 2018; Tchanturia et al, 2016) and poorer treatment outcomes and experiences compared to their neurotypical peers (Babb et al, 2021; 2022). In order to provide more effective ED treatment and support for Autistic individuals, research attention has turned to investigating possible common and autism-specific mechanisms in the overlap between the two conditions. Two early, multi-dimensional models have been proposed, with both frameworks highlighting the possible role of sensory, social and emotional factors (Brede et al, 2020; Kinnaird & Tchanturia, 2021). Empirical studies have begun to investigate the role of implicated sensory factors, such as taste and smell sensitivities (Kinnaird et al, 2020), or emotion processing (Kerr-Gaffney et al, 2020; Dinkler et al, 2019), however there has been a surprising lack of investigation into social mechanisms.

Social difficulties, such as social communication, have been key factors implicated in the models of AN (e.g., Fairburn, Cooper & Shafran, 2003; Fairburn, 2008; Treasure & Schmidt, 2013). Expressing emotion has been reported to be challenging for those with AN (Davies et al, 2016; Harrison, 2021) and it has been suggested that such difficulties may partially explain broader social difficulties observed in AN (Harrison et al, 2014). These differences have in turn been found to negatively impact clinical and behavioural outcomes, leading to delayed recovery rates and poorer treatment outcomes (Deter et al, 2005; Patel et al, 2016). Qualitative studies further support this broader impact of social communicative difficulties; for example, Westwood et al (2016) reported that individuals with AN often felt that difficulties with social communication negatively influenced their friendships and social functioning. There remains scope, however, to further explore the possible role of social communication in AN, drawing a broader range of measures and methodologies.

An important but often overlooked aspect of social communication are non-verbal behaviours, such as use of eye gaze and hand gestures to facilitate communication. Non-verbal communication is an essential interpersonal skill, allowing individuals to communicate their thoughts and emotions and constitutes a key component of social affiliation and interactions (App, McIntosh, Reed & Hertenstein, 2011; Chartrand & Bargh,

1999; Lakin & Chatrand, 2003). Non-verbal social communication behaviours have only recently begun to be explored in AN. In a recent study, Monteleone et al (2022) explored non-verbal social communication in adults with an ED during a psycho-social stress scenario, reporting reduced use of gesticulation and an increased use of eye gaze on the researcher's face during the stress paradigm when compared to healthy controls. Exploring non-verbal social communication across positive, negative and neutral conditions, Harrison (2021) also found adults with EDs make less use of hand gestures than non-ED, however the study found this to be the case regardless of condition, suggesting that less frequent use of hand gesticulation may be reduced overall in adults with EDs. The study also found evidence to suggest gaze aversion across conditions, and condition-specific effects for body orientation and trunk leaning. Specifically, ED participants were more likely to sit upright when in the positive condition and less likely to lean in towards the conversational partner during the negative condition (Harrison, 2021). Together, these studies suggest that there may be notable differences in social communication in AN compared with healthy controls, such as the use of hand gestures and gaze aversion. Furthermore, the aetiology of these differences in the development and maintenance of AN is poorly understood. Some argue that social communicative difficulties do not constitute a risk factor for the development of AN, but instead constitute a maintenance factor, and that instead there may be a sub-group within AN that reflects underlying autism (Anackster et al, 2012; Harrison, 2021). No study to date has sought to address this, exploring social communication in both autism and AN.

Differences in social communication constitute a hallmark feature of autism (APA, 2013). Consequentially, there is a considerably larger body of empirical investigation in social communicative difficulties than in AN. Perhaps unsurprisingly given the heterogeneity of autism, Autistic individuals have been found to exhibit a broad range of differences in verbal communication, ranging from motor difficulties with the physical act of producing speech to higher order cognitive difficulties with the function of speech, including prosody, semantics and pragmatics (Tager-Flasburg et al, 2005; Levy et al, 2010; Riches et al, 2010; Georgiou & Spandoudis, 2021; Costescu et al, 2022). Non-verbal social communication behaviours have been explored in autism. Studies have reported differences in eye gaze behaviours, such as an aversion to mutual eye contact (Madipakkam et al, 2017; see Stuart et al, 2023) and atypical gaze patterns to facial features (e.g., eyes) during experimental tasks

(Papagiannoipoulou, Chitty, Hermes, Hickie & Lagopoulous, 2013; Ma, Gu & Zhao, 2021). Studies also suggest differences in hand gestures, with evidence to suggest an increased use of hand gestures when compared to neurotypical peers (see de Marchena et al, 2019). Furthermore, a recent review found evidence to suggest that the broad range of social difficulties reported in autism may be notably related to differences in social communication earlier in development (Tajik-Parvinchi et al, 2021), suggesting that social communication should be a key consideration in future explorations of social factors in autism.

When approaching social communication research in autism, it is important that research considers the influence of contemporary social theories of autism that provide alternative explanations for differences in social communication. For example, the Double Empathy theory advocates that difficulties with social communication are not an inherent impairment that accompanies autism, but instead reflects a bi-directional miscommunication between Autistic people and neurotypical people (Milton, 2012; Davis & Crompton, 2021). Thus, future autism research should approach social communication within a neurodiverse-affirming framework, seeking to understand differences as opposed to deficits and including autism-specific behaviours in their approaches. Non-verbal behaviours offer a promising target for such research, seeking to explore more naturalistic and ecological valid indicators of social communication. This is even more important in light of recent evidence that highlights the overuse of quantitative experimental and self-report measures developed using neurotypical norms, and that such measures have been found to fail in predicting real-world social communication in Autistic adults (Sasson et al, 2021).

The current study sought be the first of its kind to investigate non-verbal social communication behaviours in autism and AN. Using a modified version of the non-verbal behavioural coding scheme used in Harrison (2021) to account for possible autism-specific behaviours, the current study sought to explore non-verbal behaviours in Autistic young adults with AN, Autistic young adults, young adults with AN and neurotypical/healthy controls (NT/HC) in order to identify both common and condition-specific non-verbal behaviours that may help to untangle the overlap between autism and AN.Furthermore, previous social communication research has not included an autism and AN group, and it was anticipated that this group may be difficult to recruit to the study. Thus, due to the

novel nature of the study in the target population, interest also lay in the feasibility of recruiting for the study and the suitability of the task for exploring social communication.

Several hypotheses were generated. Firstly, to explore between-group differences, it was hypothesised that participants in the Autism and AN, Autism only, AN only and NT/HC group will show differences in body orientation, leg and trunk positioning, eye gaze, hand movements and repetitive movements. However, due to the novel nature of the research question and a lack of pre-existing literature, these hypotheses were non-directional.

Secondly, to explore within-group differences, it was hypothesised that a significant effect of condition will be found on body orientation, leg trunk positioning, eye gaze, hand movements and repetitive movements in all participant groups (Autism and AN, Autism only, AN only and NT/HC). However, similarly due to a sparse evidence base and the novel nature of the study, these hypotheses were non-directional.

Methods

Design

A cross-sectional, observational design was adopted for the current study. The study was a single-centre study, with the observational task taking place in the University of Edinburgh Clinical Psychology labs. Core methods are described in the Chapter 5.

Data analysis

Data preparation

Behavioural data was coded using Microsoft Excel. Duration of behaviours was recorded in minutes, seconds and milliseconds (00:00.00) and was exported to SPSS.26 where it was converted into proportion data. Demographic information and responses to the self-report measures were downloaded from a secure online survey platform (Qualtrics) onto an Excel spreadsheet. This data was then exported into SPSS.26 and total scores for self-report measures were calculated.

Demographics and preliminary analyses

Means and standard deviations were reported for age, BMI, WASI-II scores in all groups, and for age of AN diagnosis and duration of AN in the Autism and AN and the AN only group. Percentage (%) was reported for gender, level of education, ethnicity, level of employment and medication use. Preliminary analyses were conducted to explore between-group differences on demographic variables. Assumptions of normality were checked using histograms, Q-Q plots and Shapiro-Wilks tests. All variables except age and age of AN diagnosis were found to meet the assumptions of normality. One-way ANOVAs were conducted on BMI, WASI-II scores and duration of AN, and post-hoc Tukey's test were conducted to explore significant effects due to meeting the assumptions of normality and robustness to small sample sizes (Lee & & Lee, 2018). Non-parametric Kruskal-Wallis tests were run on age and age of AN diagnosis as they violated the assumption of normality, with Dunn's post-hoc run to explore any significant results as this is recommended in small and varying sample sizes (Hoffman, 2019). Fisher's Exact test was run on categorical variables (gender, medication use) as this test is recommended when sample sizes are very small

(Kim, 2016). Post-hoc tests were run using adjusted residuals to calculate Bonferroni-corrected p-values when group differences were significant.

With regards to self-report measures, means and standard deviations were reported for scores on the EDE-Q, SRS-2, ISQ-8, TAS-20 and HADS. Assumptions of normality were checked using histograms, Q-Q plots and Shapiro-Wilks tests. All variables met the assumptions of normality. One-way ANOVAs were conducted to explore group differences, and Tukey's post-hoc tests were run to follow up any significant group differences. Internal consistency was calculated on each scale using Cronach's alpha statistic.

The intended and most suitable inferential statistics to test for study hypotheses would have been a mixed within-between ANCOVA, however given the low sample size this was not deemed possible. Therefore, statistical analyses were conducted separately to explore between- and within-group differences. Due to the low power of analyses, relevant effect sizes were calculated and any large effect sizes that may warrant further investigation will be discussed.

Between-group differences

Between-group differences on non-verbal social communication behaviours were analysed firstly across all conditions and secondly in each condition (positive, negative, neutral) individually. Group was considered the independent variable and proportion of time spent exhibiting each non-verbal social communication behaviours were the dependent variables. Assumptions of normality were checked using histograms, Q-Q plots and Shapiro-Wilks test. Assumptions of normality was violated on all included non-verbal social communication behaviours, both overall and in each condition (positive, negative, neutral). Therefore, multiple one-way, non-parametric Kruskal-Wallis tests were run to analyse group differences on non-verbal social communication behaviours, with post-hoc Dunn's test to be run in instances of significant results. In total, 35 Kruskal-Wallis tests were run on each non-verbal social communication behaviour overall, and 35 Kruskal-Wallis tests were run in each condition (positive, negative, neutral). Due to multiple tests and concerns of inflating Type 1 error (heightened risk of reporting false-positives), adjustments for multiple testing were performed. Family-wise-error-rates (FWRE) approaches, such as running Bonferroni

corrections, were decided against, due to general consensus that such adjustments lead to overly conservative results and increasing the risk of Type II, or heightened risk of reporting false-negatives (Chen, Feng & Yi, 2017). Instead, the false-discovery-rate (FDR) was calculated using Benjamini-Hochberg adjustment (Benjamini & Hochberg, 1995). Epsilon-squared was calculated and reported in each analysis as the non-parametric effect sizes, with < .01 indicating a very small effect size, .01 to .05 a small effect size, .06 to .13 a medium effect size and > .14 indicating a large effect size. (Field, 2013; Lopez-Martin & Ardura-Martinez, 2023).

Within-group differences

Within-group differences were analysed in each group individually. Due to the violation of normality across multiple non-verbal social communication behaviours, a series of non-parametric Friedman's repeated measures tests were run. In total, 35 Friedman's tests were run in each group. As with the between-group analyses, there were notable concerns over inflating the risk of Type 1 error after multiple testing, and Benjamini-Hochberg adjustments were run to calculate the false-discovery-rate. Kendall's W, or Kendall's coefficient of concordance, values are reported as non-parametric effect sizes for Friedman's repeated measures tests, with .00 to .20 indicating a slight effect, .20 to .40 indicating a fair effect, .40 to .60 indicating a moderate effect, .60 to .80 indicating a substantial effect and <.80 indicating high effect (Landis & Koch, 1997). Please see Appendix K for example study syntax.

Results

Participants

The final sample consisted of 28 participants: eight in the autism and AN group, seven in the autism only group, three in the AN group and ten in the neurotypical/healthy control (NT/HC) group.

Between group differences on demographic variables were tested for gender, age, BMI, WASI-II scores and medication use across all four groups. As expected, groups significantly

differed on BMI (F(3, 24) = 6.036, p=.003). Autism only and NT/HC did not differ significantly, however AN had a significantly lower BMI than neurotypical/healthy controls (p=.014), as did the Autism and AN group (p=.009). Age was not significantly different between groups. Additionally, group differences on age of AN onset and duration of AN were analysed between the Autism and AN and the AN only groups. Age of AN onset (p=.689) and duration of AN (p=.983) did not significantly differ between the Autism and AN and the AN only group. Using Fisher's exact test, there were no group differences were found in gender, however significant group differences were found on medication use (p=.005), with participants in the Autism and AN group reporting a greater use of medication than the NT/HC group. Demographic characteristics and group differences statistics are presented in Table 1.

Self-report questionnaires

As anticipated, there were significant differences between group differences on all self-report measures. Please see Table 2 for a summary of self-report descriptive and test statistics.

Eating Disorder Examination Questionnaire (6th Edition). Cronach's alpha for all items on the EDE-Q was .964. Scores on the EDE-Q were found to significantly differ between groups (F(3, 24) = 8.189, p = .001). Post-hoc tests revealed that there were significant group differences between the Autism and AN group and the Autism only group (p = .018), with the Autism and AN group reporting a greater EDE-Q scores. Participants in the Autism and AN group were also found to have report significantly greater EDE-Q scores than the NT/HC group (p = .001). EDE-Q scores in the AN only group were not found to be significantly different to the NT/HC group, although it is important to bear in mind the very small sample size (n=3) in the AN only group.

Social Responsiveness Scale (2nd Edition). Cronach's alpha for all 65 items on the SRS-2 was .975. Groups differed significantly on SRS-2 scores (F(3, 24) = 54.81, p = 000). Specifically, participants in the Autism and AN group reported significantly higher Autistic traits than the AN only group (p = .001) and the NT/HC group (p = .000). Participants in the AN group were found to have significantly lower Autistic traits than the Autism group (p =

.038) but higher than the NT/HC (p = .000). There were no significant differences between the Autism and AN group and the Autism only group.

Table 1.

Demographic information and between-group differences.

Demographic Info	**AUT & AN (n=8)**	**AUT (n=7)**	**AN (n=3)**	**NT/HC (n=10)**	**Test statistic**	**p value**
Gender *(%)*	Female = 75% Non-binary / third gender = 25%	Female = 42.86% Non-binary / third gender = 42.86% Prefer not to say = 14.28%	Female = 100%	Female = 100%	*	.051
Age *(M, SD)*	20.36 (3.16)	21.29 (2.14)	21.00 (2.65)	22.30 (1.25)	F(3, 24) = 1.071	.420
Level of education *(%)*	Undergraduate = 37.50% Postgraduate = 12.50% Primary/secondary education = 37.50 Vocational training = 12.50%	Undergraduate = 100%	Undergraduate = 100%	Undergraduate = 30% Postgraduate = 70%	-	-
Ethnicity *(n=)*	White = 100%	White = 71.43% Asian = 28.57%	White = 100%	White = 40% Asian = 30% Multiple / mixed = 30%	-	-
Level of employment *(n=)*	Full-time = 25% Part-time = 12.50% Unemployment = 25% Student = 25% School = 12.50%	Part-time = 42.86% Student = 57.14%	Full-time = 33.33% Student = 66.66%	Part-time = 40% Student = 60%	-	-
BMI *(M, SD)*	19.45 (2.45)	21.33 (3.0)	17.8 (1.73)	25.38 (1.39)	F(3, 24) = 6.036	**.003**

WASI-II (*M, SD)*	99.00 (4.31)	104.29 (3.21)	102.67 (1.76)	104.40 (2.08)	F(3, 24) = .664	.582
Medication *(%)*	75%	14.29%	66.67%	0%	*	**.005**
Age of diagnosis (years) *(M, SD)*	15.75 (2.66)		15.00 (2.65)		F (1, 9) = .174	.686
Duration of AN (years) *(M, SD)*	5.30 (3.27)		5.54 (3.27)		F (1, 9) =. 000	.983

AUT = autism, AN = anorexia nervosa, NT/HC = neurotypical/healthy controls, BMI = body mass index, WASI-II = Weschler Abbreviated Scale of Intelligence – 2nd Edition

* Note that Fishers Exact test was run for Gender and Medication use and has no test statistic to report

Interoceptive Scale Questionnaire. Cronach's alpha for the ISQ-8 was .933. Scores on the ISQ-8 were found to significantly differ between groups ($F(3, 24) = 11.057$, $p = .000$). Post-hoc tests revealed that participants in the Autism and AN group had significantly higher ISQ-8 scores than the NT/HC group ($p = .000$), as did the Autism only group ($p = .003$) and the AN only group ($p = .027$). No group differences were reported between the Autism and AN group, the Autism only group and the AN only group.

Hospital Anxiety and Depression Scale. Cronach's alpha for all 14 items on the HADS was .911. Scores on the HADS were found to significantly differ between groups ($F(3, 24)) = 25.321$, $p = .000$). Post-hoc tests revealed that participants in the Autism and AN group had significantly higher HADS scores than the NT/HC group ($p = .000$), as did the Autism only group ($p = .000$) and the AN only group ($p = .000$). No group differences were reported between the Autism and AN group, the Autism only group and the AN only group.

Toronto Alexithymia Scale. Cronach's alpha for all items on the TAS was .837. Scores on the TAS-20 were found to significantly differ between groups ($F(3, 24) = 17.900$, $p = .000$). Post-hoc tests revealed that the participants in the Autism and AN group reported higher TAS-20 scores than those in the NT/HC group ($p = .000$), as did those in the Autism group ($p = .000$). There were no differences between TAS-20 scores between participants in the Autism and AN group, the Autism only group and the AN only group.

Table 2.

Means and standard deviations of questionnaire scores across groups and between-group differences.

Self-report questionnaires	AUT & AN (n=8)	AUT (n=7)	AN (n=3)	NT/HC (n=10)	Test statistic (F)	Direction of effect
EDE-Q	3.68 (0.80)	1.70 (1.64)	3.06 (1.48)	1.06 (1.0)	12.70	Autism and AN > AN Autism and AN > NT/HC
SRS-2	78.75 (5.01)	74.71 (5.59)	64.00 (10.54)	49.50 (3.54)	F = 54.81	Autism and AN > AN Autism and AN > NT/HC AUT > AN AN > NT/HC
ISQ-8	28.00 (7.90)	24.00 (5.45)	24.33 (11.70)	10.80 (4.90)	15.45	Autism and AN > NT/HC AUT > NT/HC AN > NT/HC
HADS	23.00 (3.93)	22.29 (4.75)	24.00 (3.61)	7.10 (5.15)	18.86	Autism and AN > NT/HC AUT > NT/HC AN > NT/HC
TAS-20	70.00 (8.14)	72.57 (16.00)	63.70 (7.51)	39.70 (8.23)	19.14	Autism and AN > NT/HC AUT > NT/HC

AUT = autism, AN = anorexia nervosa, NT/HC = neurotypical/healthy controls, EDE-Q = Eating Disorder Examination Questionnaire, SRS-2 = Social Responsiveness Scale – 2nd Edition, ISQ-8 = Interoceptive Scale Questionnaire – 8-item, HADS = Hospital Anxiety and Depression Scale, TAS-20 = Toronto Alexithymia Scale

Between-group differences

A series of non-parametric Kruskal-Wallis test were run to explore between-group differences on all non-verbal behaviours overall and across each condition (positive, negative, neutral). These were conducted for proportion of time spent exhibiting each non-verbal social communication across all conditions, and proportion of time exhibiting each behaviour in the positive, negative and neutral conditions. Please see Appendix J for descriptive statistics (medians and interquartile ranges) on the non-verbal behaviour proportion data.

Across all conditions

A series of Kruskal-Wallis tests were conducted to explore group differences on non-verbal behaviours across all conditions. Across the four participant groups, there was no significant group differences detected for any of the included non-verbal behaviours. Non-verbal behaviours with large effect sizes will be reported in each section, however it is important to emphasise that the interpretation of these effect sizes is conjecture and cannot be statistically confirmed.

Despite non-significant results, there were several large effect sizes reported that may warrant further exploration, suggesting that a large proportion of the variance in specific non-verbal social communication behaviours may be attributable to group membership. A large effect size for group was reported for Trunk Backwards ($H(3) = 7.646$, $p = 1.000$, $e2 = .283$). While no conclusions can be drawn about which groups these differences were between, AN participants may have spent more time leaning backwards, with a mean rank of 18.67 compared to a mean rank of 18.30 in NT/HC, 13.71 in Autism only and 8.88 in Autism and AN. Large effect sizes were also reported for Gaze On ($H(3) = 7.050$, $p = 1.000$, $e2 = .261$). Participants in the Autism and AN group appeared to spend the least amount of time looking at the researcher, with a mean rank of 9.50, compared to a mean rank of 12.33 in AN only, 13.86 in Autism only and 19.60 in NT/HC. Conversely Autistic participants with AN seemed to spend the most amount of time looking down ($H(3) = 6.677$, $p = 1.000$, $e2 = .247$), with a mean rank of 18.63 compared to a mean rank of 16.71 in Autism only, 11.90 in NT/HC and 7.00 in AN only.

A large effect size was reported for time spent touching clothes (H(3) = 6.173, p = 1.000, e2 = .229). While again no firm conclusions can be drawn, closer inspection of the data suggests that Autistic participants with AN may have spent more time touching their clothes (Mean Rank = 19.09) compared to AN only (Mean Rank = 15.77), Autism only (Mean Rank = 12.43) and NT/HC (Mean Rank = 11.95). Finally, a similarly large effect size for proportion of time touching nose (H(3) = 6.392, p = 1.000, e2 = .237) could mean that AN only participants may have had a greater tendency to touch their nose (Mean Rank = 21.33) compared to Autism and AN (Mean Rank = 16.00), NT/HC (Mean Rank = 13.73) and Autism only (Mean Rank = 12.00).

Table 3.

Results for Kruskal-Wallis tests (d = 3) exploring between-group differences in non-verbal behaviours across conditions. After adjusting for multiple testing, all p = ns.

	AUTISM AND AN (n=8)	**AUTISM ONLY (n=7)**	**AN ONLY (n=3)**	**NT/HC (n=10)**			
	Mean rank	Mean rank	Mean rank	Mean rank	H	ε2	Adjusted p value
Body Orientation							
Facing	15.50	13.50	15.50	14.10	1.454	.054	1.000
Up to 44 º	13.50	15.50	13.50	14.90	1.454	.054	1.000
45-90º	14.50	14.50	14.50	14.50	.000	.	1.000
>90º	14.50	14.50	14.50	14.50	.000	.	1.000
Legs							
Crossed	15.10	14.14	17.83	13.75	.722	.027	1.000
Uncrossed	14.50	15.86	11.17	15.25	.722	.027	1.000
Trunk Lean							
Upright	17.88	14.00	13.50	12.45	2.354	.087	1.000
Forwards	16.63	13.86	9.00	14.90	2.517	.093	1.000
Backwards	8.88	13.71	18.67	18.30	7.646	.283	1.000
Other	16.50	13.00	13.00	14.40	2.797	.104	1.000
Gaze							
On	9.50	13.86	12.33	19.60	7.050	.261	1.000
Down	18.63	16.71	7.00	11.90	6.677	.247	1.000
Away	15.50	13.43	19.67	12.90	1.799	.067	1.000
Hands							
Beats	12.75	15.14	10.33	16.70	2.099	.078	1.000
Deictics	14.50	14.50	14.50	14.50	.000	.	1.000
Iconics and metaphors	10.63	12.29	19.33	17.70	5.141	.162	1.000

Head	15.31	13.50	18.00	13.50	4.373	.162	1.000
Chin	14.50	14.50	14.50	14.50	.000	.	1.000
Neck	15.75	14.00	14.00	14.00	2.500	.093	1.000
Hair	13.88	13.00	14.67	16.00	.963	.036	1.000
Cheeks	15.31	13.50	13.50	14.85	1.223	.045	1.000
Nails	14.50	14.50	14.50	14.50	.000	.	1.000
Eyes	15.31	13.50	13.50	14.85	1.223	.045	1.000
Clothes	19.09	12.43	15.67	11.95	6.173	.229	1.000
Nose	16.00	11.00	21.33	13.73	6.392	.237	1.000
Ears	14.88	13.00	17.33	14.40	2.104	.078	1.000
Jewellery	17.06	13.57	11.50	14.00	2.526	.094	1.000
Mouth	14.75	13.00	18.00	14.30	2.736	.101	1.000
Arms	13.13	13.57	12.67	16.80	1.381	.051	1.000
Legs	15.25	16.29	12.33	13.30	.908	.034	1.000
Trunk	13.50	14.50	19.83	32.70	2.317	.086	1.000
Sitting	16.50	13.00	13.00	14.40	2.797	.104	1.000
Repetitive Movements							
Hands	15.63	16.71	19.17	10.65	4.355	.161	1.000
Legs	16.00	14.57	12.50	13.85	1.366	.051	1.000
Whole Body	13.31	15.50	15.67	14.40	.644	.024	1.000

Positive condition

A number of Kruskal-Wallis tests were conducted to explore group differences on non-verbal behaviours in the positive condition. Across the four participant groups, there was no significant group differences detected for any of the included non-verbal behaviours.

There were large effect sizes reported for both Trunk and Gaze codes. Specifically, large effect sizes were reported for Trunk Forwards ($H(3) = 3.164$, $p = 1.000$, $e2 = 2.53$). It appears that participants in the Autism and AN group had a greater tendency to spend more time leaning forwards, with a mean rank of 17.38, compared to the mean rank of 14.93 in the Autism only, 13.10 in the NT/C and 10.50 in the AN only. While not achieving statistical significance, there was also a large effect size reported for Trunk Backwards ($H(3) = 6.825$, $p = 1.00$, $e2 = .253$). It could be than AN only participants spent a higher proportion of time leaning backwards than NT/HC (Mean Rank = 17.70), Autism only (Mean Rank = 14.14) and Autism and AN (Mean Rank = 9.25).

Furthermore, a large effect was reported for Gaze On (H(3) = 9.959, p = 1.000, e2 = .369). The Autism and AN group had the lowest mean rank (7.13), suggesting participants in the Autism and AN group may have spent the least amount of time looking at the researcher, compared to a mean rank of 15.14 in the Autism only group, a mean rank of 17.33 in the AN only group and a mean rank of 19.10 in the NT/HC group. Finally a large effect size was also reported for Gaze Down (H(3) = 7.325, p = 1.000, e2 = .271), with the data suggesting that the Autism only group may have shown a greater tendency to spend the most amount of time looking down (Mean Rank = 18.00) compared to the Autism and AN group (Mean Rank = 17.50), the NT/HC group (Mean Rank = 11.00) and the AN only group (Mean Rank = 10.00).

Table 4.

Results for Kruskal-Wallis tests (d = 3) exploring between-group differences in non-verbal behaviours in the positive condition.

	AUTISM AND AN (n=8)	**AUTISM ONLY (n=7)**	**AN ONLY (n=3)**	**NT/HC (n=10)**			
	Mean rank	Mean rank	Mean rank	Mean rank	H	ε2	Adjusted p value
Body Orientation							
Facing	15.50	13.50	15.50	14.10	1.454	.054	1.000
Up to 44 ◦	13.50	15.50	13.50	14.90	1.454	.054	1.000
45-90◦	14.50	14.50	14.50	14.50	.000	.	1.000
>90◦	14.50	14.50	14.50	14.50	.000	.	1.000
Legs							
Crossed	14.44	14.21	17.67	13.80	.684	.024	1.000
Uncrossed	14.56	14.79	11.33	15.20	.684	.025	1.000
Trunk Lean							
Upright	17.88	13.43	13.00	13.00	2.252	.117	1.000
Forwards	17.38	14.93	10.50	13.10	3.164	.253	1.000
Backwards	9.25	14.14	18.67	17.70	6.825	.253	1.000
Other	14.50	14.50	14.50	14.50	.000	.	1.000
Gaze							
On	7.13	15.14	17.33	19.10	9.959	.369	1.000
Down	17.50	18.00	10.00	11.00	7.325	.271	1.000
Away	18.50	11.29	16.00	13.10	3.368	.125	1.000
Hands							
Beats	12.63	14.86	15.00	15.50	1.069	.040	1.000
Deictics	14.40	14.50	14.50	14.50	.000	.	1.000

Iconics and metaphors	13.13	14.29	15.33	15.50	.581	.022	1.000
Head	14.50	14.50	14.50	14.50	.000	.	1.000
Chin	14.50	14.50	14.50	14.50	.000	.	1.000
Neck	15.75	14.00	14.00	14.00	2.500	.093	1.000
Hair	15.75	14.00	14.00	14.00	2.500	.093	1.000
Cheeks	14.50	14.50	14.50	14.50	.000	.	1.000
Nails	14.50	14.50	14.50	14.50	.000	.	1.000
Eyes	15.75	14.00	14.00	14.00	2.500	.093	1.000
Clothes	17.13	14.00	17.00	12.00	4.576	.169	1.000
Nose	15.19	13.50	18.33	13.50	4.805	.178	1.000
Ears	15.31	13.50	18.00	13.50	4.373	.162	1.000
Jewellery	16.63	13.00	13.00	14.30	3.024	.112	1.000
Mouth	14.50	14.50	14.50	14.50	.000	.	1.000
Arms	14.38	15.00	13.00	14.70	.164	.006	1.000
Legs	14.50	14.86	12.67	14.80	.209	.008	1.000
Trunk	13.50	14.14	16.33	15.00	.711	.026	1.000
Sitting	17.00	13.50	13.50	13.50	5.185	.192	1.000
Repetitive Movements							
Hands	17.75	15.86	14.33	11.00	4.725	.175	1.000
Legs	14.88	14.86	13.00	14.40	.454	.017	1.000
Whole Body	15.75	14.00	14.00	14.00	2.500	.093	1.000

Negative condition

A series of Kruskal-Wallis tests were conducted to explore group differences between non-verbal behaviours in the negative condition. Across the four participant groups, there was no significant group differences detected for any of the included non-verbal behaviours. Large effect sizes were reported for Trunk Backwards (H(3) = 7.487, p = 1.000, e2 = .277), with AN only participants appearing to show a greater tendency to spend the most time leaning backwards (Mean Rank = 19.17) compared to NT/HC (Mean Rank = 18.05), Autism only (Mean Rank = 13.07) and Autism and AN (Mean Rank = 9.56).

Interestingly, a large effect size was reported for the Repetitive Movements Hands code (H(3) = 6.415, p = 1.000, e2 = .238). With a mean rank of 20.33, individuals with AN only may spend a higher proportion of time engaging in repetitive hand movements when compared to a mean rank of 18.79 in the Autism only group, 13.69 in the Autism and AN group and

11.10 in the NT/HC group. See Table 5 for differences between groups on non-verbal behaviours in the negative condition.

Table 5.

Results for Kruskal-Wallis tests (d = 3) exploring between-group differences in non-verbal behaviours in the negative condition. After adjusting for multiple testing, all p = ns.

	AUTISM AND AN (n=8)	**AUTISM ONLY (n=7)**	**AN ONLY (n=3)**	**NT/HC (n=10)**			
	Mean rank	Mean rank	Mean rank	Mean rank	H	ε2	Adjusted p value
Body Orientation							
Facing	15.50	13.50	15.50	14.10	1.454	.054	1.000
Up to 44 ◦	13.50	15.50	13.50	14.90	1.454	.054	1.000
45-90◦	14.50	14.50	14.50	14.50	.000	.	1.000
>90◦	14.50	14.50	14.50	14.50	.000	.	1.000
Legs							
Crossed	14.50	13.50	16.83	14.50	.459	.017	1.000
Uncrossed	14.50	15.50	12.17	14.50	.459	.017	1.000
Trunk Lean							
Upright	17.94	15.07	13.50	11.65	3.248	.120	1.000
Forwards	16.38	13.86	9.00	15.10	2.402	.089	1.000
Backwards	9.56	13.07	19.17	18.05	7.487	.277	1.000
Other	16.50	13.00	13.00	14.40	2.797	.104	1.000
Gaze							
On	11.75	13.00	15.00	17.60	2.558	.095	1.000
Down	18.38	15.85	9.00	12.10	5.354	.198	1.000
Away	12.75	14.71	16.67	15.10	.628	.023	1.000
Hands							
Beats	14.56	13.79	9.50	16.45	2.346	.087	1.000
Deictics	14.50	14.50	14.50	14.50	.000	.	1.000
Iconics and metaphors	11.25	10.93	19.50	18.10	6.387	.237	1.000
Head	15.75	14.00	14.00	14.00	2.500	.093	1.000
Chin	14.50	14.50	14.50	14.50	.000	.	1.000
Neck	14.50	14.50	14.50	14.50	.000	.	1.000
Hair	14.00	14.14	12.00	15.90	1.366	.051	1.000
Cheeks	15.75	14.00	14.00	14.00	2.500	.093	1.000
Nails	14.50	14.50	14.50	14.50	.000	.	1.000
Eyes	15.19	13.50	13.50	14.95	1.717	.043	1.000
Clothes	17.81	14.43	12.50	12.50	5.576	.207	1.000
Nose	15.19	13.50	13.50	14.95	1.171	.043	1.000
Ears	14.00	14.00	14.00	15.40	1.800	.067	1.000
Jewellery	17.06	13.57	11.50	14.00	2.526	.094	1.000

Mouth	13.50	13.50	18.33	14.85	4.467	.165	1.000
Arms	13.63	13.50	13.00	16.40	.935	.035	1.000
Legs	13.63	16.86	13.00	14.00	.953	.035	1.000
Trunk	12.00	15.86	17.00	14.80	2.741	.102	1.000
Sitting	15.31	13.50	13.50	14.85	1.223	.045	1.000
Repetitive Movements							
Hands	13.69	18.79	20.33	11.10	6.415	.238	1.000
Legs	16.13	14.57	12.50	13.75	1.547	.057	1.000
Whole Body	15.75	14.00	14.00	14.00	2.500	.093	1.000

Neutral condition

A number of Kruskal-Wallis tests were conducted to explore group differences between non-verbal behaviours in the neutral condition. Across the four participant groups, there was no significant group differences detected for any of the included non-verbal behaviours.

Large effect sizes were reported in several of the Gaze codes. Specifically, a large effect size was reported for Gaze On (H(3) = 7.863, p = 1.000, e2 = .291). The AN only group had a mean rank of 7.00 compared the mean rank of 11.38 in the Autism and AN group, 13.71 in the Autism only group and 19.80 in the NT/HC group. This would suggest that participants in the AN group appeared to spend the lowest proportion of time looking at the researcher. Similarly, a large effect size was reported for Gaze Away (H(3) = 6.303, p = 1.000, e2 = .291). It appears that those in the AN only group spent the highest proportion of time looking away from the researcher (Mean Rank = 25.33) compared to Autism only (Mean Rank = 15.00), Autism and AN (Mean Rank = 12.63) and NT/HC (Mean Rank = 12.40).

A large effect size for Hands Nose (H(3) = 8.385, p = 1.000, e2 = .311) could mean that participants in the AN only group had a greater tendency to spend most amount of time touching their nose (Mean Rank = 22.17) compared to the Autism and AN group (Mean Rank = 14.31), NT/HC group (Mean Rank = 13.75) and the Autism only group (Mean Rank = 12.50). This was also observed for Hands Head (H(3) = 8.333, p = 1.000, .309), with those in the AN only group having a mean rank of 18.67 compared to a mean rank of 14.00 across all three remaining participant groups.

Finally, a large effect size was also reported for Hands Clothes (H(3) = 8.385, p = 1.000, e2 = .311), with a mean rank of 15.19 in the Autism and AN group, a mean rank of 14.95 in the NT/HC group and a mean rank of 13.50 in both the Autism only and the AN only group. This could mean that Autistic participants with AN appeared to spend the greatest proportion of time touching their clothes. See Table 6 for differences between groups on non-verbal behaviours in the neutral condition.

Table 6.

Results for Kruskal-Wallis tests (d = 3) exploring between-group differences in non-verbal behaviours in the neutral condition. After adjusting for multiple testing, all p = ns.

	AUTISM AND AN (n=8)	**AUTISM ONLY (n=7)**	**AN ONLY (n=3)**	**NT/HC (n=10)**			
	Mean rank	Mean rank	Mean rank	Mean rank	H	ε2	Adjusted p value
Body Orientation							
Facing	15.50	13.50	15.50	14.10	1.454	.054	1.000
Up to 44 ◦	13.50	15.50	13.50	14.90	1.454	.054	1.000
45-90◦	14.50	14.50	14.50	14.50	.000	.	1.000
>90◦	14.50	14.50	14.50	14.50	.000	.	1.000
Legs							
Crossed	15.00	14.00	17.33	13.60	.711	.026	1.000
Uncrossed	14.00	15.00	11.67	15.40	.711	.026	1.000
Trunk Lean							
Upright	18.13	13.43	14.17	12.45	3.049	.113	1.000
Forwards	15.81	14.43	10.00	14.85	1.651	.061	1.000
Backwards	8.44	14.57	18.50	18.10	8.272	.306	1.000
Other	14.50	14.50	14.50	14.50	.000	.	1.000
Gaze							
On	11.38	13.71	7.00	19.80	7.863	.291	1.000
Down	18.75	14.71	10.00	12.30	5.455	.202	1.000
Away	12.63	15.00	25.33	12.40	6.303	.233	1.000
Hands							
Beats	12.06	14.79	10.50	17.45	4.255	.158	1.000
Deictics	14.50	14.50	14.50	14.50	.000	.	1.000
Iconics and metaphors	12.38	13.00	20.00	15.60	3.952	.146	1.000
Head	14.00	14.00	18.67	14.00	8.333	.309	1.000
Chin	14.50	14.50	14.50	14.50	.000	.	1.000
Neck	14.50	14.50	14.50	14.50	.000	.	1.000
Hair	14.31	14.71	16.67	13.85	.754	.026	1.000
Cheeks	14.00	14.00	14.00	14.50	1.800	.067	1.000

Nails	14.50	14.50	14.50	14.50	.000	.	1.000
Eyes	14.50	14.50	14.50	14.50	1.171	.043	1.000
Clothes	15.19	13.50	13.50	14.95	8.385	.311	1.000
Nose	14.31	12.50	22.17	13.75	8.385	.311	1.000
Ears	14.50	14.50	14.50	14.50	.000	.	1.000
Jewellery	16.50	15.00	13.00	13.00	3.228	.120	1.000
Mouth	15.75	14.00	14.00	14.00	2.500	.093	1.000
Arms	14.48	12.14	11.33	17.20	2.338	.087	1.000
Legs	16.19	17.93	13.33	11.10	4.292	.159	1.000
Trunk	12.94	13.86	20.83	14.40	4.105	.152	1.000
Sitting	14.00	14.00	14.00	15.40	1.800	.067	1.000
Repetitive Movements							
Hands	14.19	14.71	16.67	13.95	.726	.027	1.000
Legs	13.50	15.43	13.50	14.95	1.412	.052	1.000
Whole Body	14.50	14.50	14.50	14.50	.000	.	1.000

Within-group differences

A series of Friedman's tests were conducted to explore within-group differences in non-verbal behaviours across the positive, negative and neutral conditions. Due to the fact that no significant differences were identified, and almost all effect sizes were slight, tables reporting results per group and per non-verbal behaviour category can be found in Appendix L.

Autism and AN

A series of Friedman's test were conducted in the Autism and AN group. No significant within-group differences in non-verbal behaviours were detected in the Autism and AN group across positive, negative and neutral conditions.

Autism only

A series of Friedman's test were conducted in the Autism only group. No significant within-group differences in non-verbal behaviours were detected in the Autism only group across positive, negative and neutral conditions.

AN only

A series of Friedman's test were conducted in the AN only group. No significant within-group differences in non-verbal behaviours were detected. A large effect size was reported for Gaze On (W = 1.000), suggesting that AN participants had a tendency to spend a greater proportion of time looking at the researcher during the positive condition (Mean Rank = 3.00) than the negative (Mean Rank = 2.00) and neutral (Mean Rank = 1.00) condition. The opposite was observed for Gaze Away (W = 1.000), with a mean rank of 3.00 in the neutral condition, a mean rank of 2.00 in the negative condition and a mean rank of 1.00 in the positive condition. However, it is important to bear in mind that there were only three participants in the AN group, and this should be considered when considering the effect sizes here.

NT/HC

A series of Friedman's test were conducted in the NT/HC group. No significant within-group differences in non-verbal behaviours were detected in the NT/HC group across positive, negative and neutral conditions.

Discussion

The current study aimed to explore possible differences in non-verbal social communication behaviours in autism and AN. Interest also lay in the feasibility of recruiting participants for the observational task, and for whether the observational task itself was a useful and appropriate method to exploring non-verbal social communication in Autistic and non-Autistic participants with AN. The hypotheses regarding group differences on non-verbal behaviours were not supported. Furthermore, no evidence was found to support the hypothesis that there would be an effect of condition (positive, negative, neutral) on non-verbal behaviours. Low sample sizes were predominantly reflective of broader recruitment difficulties as opposed to recruiting for the study design and methods, and the task, subject to future modifications, was is likely suitable for research purposes. Overall, the current study sought to contribute to a sparse and neglected area of research, and future studies

should seek to continue to explore the potential role of non-verbal social communication in the overlap between autism and AN.

The first hypothesis posited that there would be significant differences between groups on non-verbal behaviours, exploring these differences overall and within each condition. This hypothesis was not supported, as current findings did not find evidence for any differences between groups on non-verbal behaviours. For example, trunk positioning was not found to be significantly different between groups, despite previous research that found that people with EDs lent in less frequently towards their conversational partner during the same social communication task adopted in the current study (Harrison, 2021). It could be that disparities in sample size may influence these conflicting results, with a total of 25 participants in each group reported in Harrison (2021) compared to the small sizes in the current study. Despite group differences not being statistically significant, a large effect size was reported for leaning backwards across all conditions, suggesting that participants with AN only may spend more time leaning away from their conversational partner compared with other groups, although this interpretative and not statistically confirmed. This could mean that trunk positioning during social interactions might play an important role in our understandings of non-verbal behaviours in EDs subsequent to further investigation. This may have important implications on communication with ED services, such as within the therapeutic relationship, as understanding subtle nuances in non-verbal behaviours may improve communication and interpersonal functioning. It is important that future studies continue to explore this and build on the current sparse and inconsistent evidence base.

It was also surprising that there were no significant differences between group on eye gaze behaviours. Harrison (2021) reported higher levels of generalized gaze aversion in adults with EDs, and the wider ED literature suggests a general avoidance of faces and eyes in ED groups (see Kerr-Gaffney et al, 2019). However, there is disagreement amongst the literature as to whether this is a core or consequential behaviour in EDs, as this has been found to be more pronounced in the more acute stages of AN (Harrison et al, 2018; Dinkler et al, 2019; Kerr-Gaffney et al, 2020a) and the presence of co-occurring autism has been argued to influence these behaviours (Dinkler et al, 2019). Eye gaze behaviour has received considerably more research attention in autism, with a general pattern of atypical eye gaze

behaviours in autism including avoidance of faces and eyes supported (Stuart et al, 2022; Klin et al, 2020). Indeed, the most replicated early predictor of autism is reduced eye gaze behaviours (Stuart et al, 2022; Tiede & Walton, 2020). Therefore, it is even more surprising that these were not found to emerge as a significant non-verbal behaviour in any of the participant groups. It could mean that the role of gaze behaviours has been previously overestimated, however, the current study indicates that eye gaze should not be entirely discounted. Several large effect sizes were observed, with participants in the Autism and AN group showing the lowest proportion of time spent looking at the researcher across conditions, as well as the highest proportion of time looking down. Thus, it is possible that the lack of significant results reported here may reflect the study being notably underpowered with small and uneven sample sizes. Another contributing factor could be that the scope of the behavioural coding scheme was too broad to pick up on subtle nuances in eye gaze behaviours. Future studies could focus on alternative approaches to measuring eye gaze behaviours, such as behavioural studies that focus on gaze aversion, differentiating between on and averted only as opposed to on, down and away (Doherty-Sneddon, Whittle & Riby, 2013), or more controlled experimental methodologies, such as eye tracking (Kerr-Gaffney et al, 2020; Dinkler et al, 2019).

Contrary to previous literature, the current study did not find any group differences on the use of hand gestures, nor did it find an effect of condition on hand gestures. Monteleone et al (2022) reported hand gestures to be significantly reduced during periods of stress in participants with EDs and Harrison (2021) reported a generalized reduction of hand gestures in those with EDs compared to non-ED controls. Currently, non-verbal social communication behaviours in EDs remain largely under-researched, however the existing evidence base does suggest that hand gestures may be reduced in those with EDs, and current findings do not support this. Furthermore, there was a lack of significant differences on hand gestures for Autistic participants. This is also surprising, given previous evidence to suggest an increased use of hand gestures in autism (de Marchena & Eigsti, 2010; Garcia-Perez, Lee & Hobson, 2007; Morett, O'Hearn, Luna & Ghuman, 2016). However, a recent study exploring hand gestures in Autistic adults concluded that significant differences in hand gestures in autism are evidenced but marginal (de Marchena et al, 2019), suggesting that such differences may not always be evident or even present across Autistic individuals.

Furthermore, such studies include more detailed coding of hand gestures, accounting for other important factors not included in the current analysis, such as gesture height, gesture size, hands used to gesticulate and gesture functions (de Marchena et al, 2019). Thus, future research should perhaps focus on hand gestures and develop a more comprehensive and multi-faceted coding scheme to further elucidate the role that hand gestures may play as a function of social communication in autism and AN.

A final consideration, given the robust non-significant findings across non-verbal behaviours, may be the role of social camouflaging. Social camouflaging is a behaviour frequently displayed by Autistic people and refers to attempts to 'mask' or 'compensate' social behaviours by attuning to the behaviours of others around them (Aime et al, 2021). Heightened evidence of social camouflaging has been consistently linked with higher Autistic traits (Hull et al, 2019), and such coping strategies are proposed to be commonly utilised to navigate the challenges of being an Autistic person in neurotypical social environment (Cook et al, 2021). A recent study by Cook et al (2022) filmed Autistic participants during a short social interaction task and then replayed the video with the participants to collaboratively identify and describe social camouflaging behaviours. A broad range of behaviours were implicated, including deliberately reducing non-verbal behaviours such as hand and body movements, maintaining eye contact and mirroring the body position of the conversational partner (Cook et al, 2022). It could be that participants in the current were employing social camouflaging strategies during the social communication task, thus accounting for non-significant group differences. This may be particularly relevant in light of evidence to suggest that female and non-binary Autistic people report higher levels of social camouflaging than males (Hull et al, 2017; Cage & Troxell-Whitman, 2019), and the high proportion of female and non-binary participants in the current sample. There were no significant effects of condition on any of the non-verbal behaviours, and thus none of the secondary hypotheses of the study were supported. This runs contrary to the two previous studies that have explored non-verbal behaviours in EDs, which suggest that gaze aversion is associated with negative or stressful interactions (Monteleone et al, 2022; Harrison, 2021). Eye gaze has received considerably more attention in the autism research, with studies suggesting that feelings of negative emotions and distress lead to gaze aversion (Senju et al, 2009; see Stuart et al, 2022). Gaze on the researcher had a large effect size in

the AN only group, however it was the neutral condition and not the negative condition that was ranked as having the lowest proportion. At this stage, no inferences can be made about these observed effect sizes beyond the fact that future studies with larger samples and more powered analyses should not discount the role of eye gaze on EDs. With regards to Autistic participants, the current study did not evidence to suggest that conditions influenced eye gaze behaviours. Interestingly, qualitative studies suggest that it is the experience of maintained eye contact itself that leads to feelings of distress and gaze aversion (Trevisan et al, 2017), as opposed to the topic or valance of conversation. This could be an interesting avenue for future research; perhaps mixed-method studies can draw on observational data and qualitative experiences to generate a more sensitive and comprehensive understanding of the interplay between emotion and non-verbal behaviours in autism and AN.

Due to the inclusion of Autistic participants in the current study, a number of novel codes were included in the Harrison (2021)'s original non-verbal behavioural coding scheme. The most relevant to Autistic participants was the inclusion of the Repetitive Movement code, which were not to be significantly different between groups, nor were they found to be significantly influenced by condition. Conceptually, restrictive and repetitive behaviours (RRB's) are four behaviours associated with repetitive movements in autism: repetitive movements, speech, or use of objects; insistence on sameness; restricted interests; and sensory processing abnormalities (Sellick, Ure & Williams, 2021). The current study focused on the first of these which has been increasingly linked with anxiety, leading to the suggestion that repetitive movements are a maladaptive response to negative affect (Baribeau et al, 2021; Lidstone et al, 2015; Rodgers et al, 2012; Spiker et al, 2012). It should be noted that engaging in repetitive movements had large effect sizes in the negative condition, with AN participants showing a tendency to spend the most amount of time engaging in repetitive hand movements. Similar observations were reported in the AN group for touching their clothes and nose overall, indicative of a greater use of fidgeting behaviours. Perhaps the included code of repetitive hand movements was not sensitive enough to pick up on autism-specific RRB's and were instead detecting general fidgeting behaviours. Alternatively, repetitive movements may also be important for non-Autistic individuals with AN, although the current study observed only effect sizes and thus no

inferences can be drawn beyond conjecture. Future studies should seek to focus on RRB's as a non-verbal social communication behaviour, and the possible role these may have in both autism and AN. This could be through the development of a more rigorously developed behavioural coding scheme, or the administration of relevant questionnaires to Autistic and non-Autistic individuals with AN in an effort to begin to untangle common or condition-specific presentations.

With regards to interest into the feasibility of recruiting for the study, at first glance the low participant numbers may raise notable concerns. However, the issues with recruitment were felt to stem from both practical and broader conceptual challenges as opposed to with the design of the study itself. For example, there were delays to the opening of the Clinical Psychology labs where the study was conducted, reducing the timeline of the already limited timeline of research conducted for a PhD. Furthermore, it was anticipated that there would be difficulty recruiting the co-occurring autism and AN group and this was not found to be the case; instead, it was the AN only group that had the small sample size. The reasons for this lack of interest in the study are speculative, but it could be that the focus of the study on autism-specific mechanisms meant that non-Autistic participants did not think they could make valuable contributions or that the results would not be translated into meaningful outcomes for themselves personally. Careful consideration of recruitment advertising and strategic outreach into clinical services is advised in future research in these samples. Finally, while the study failed to find significant group differences, the limitations associated with the data (e.g., small sample size, underpowered analyses) are a more likely explanation that the utility of the task itself. Participants did not report any negative experiences and, subject to future modification regarding the autism-specific behaviours outlined above, it is recommended that future research continues to explore more these ecologically valid measures of social communication.

Although not a main research question posed by the current study, there were interesting observations made on preliminary analyses on demographics and self-report measures between participant groups. Similar levels of eating disorder symptomology were reported in the Autism and AN group and the AN only group, suggesting that Autistic individuals with AN do not have greater ED severity than non-Autistic individuals with AN. This is in line with

other studies that have reported Autistic characteristics have no impact on eating disorder symptomology as measured by the EDE-Q (Huke et al, 2013; Nazar et al, 2018; Stewart et al, 2017; Li et al, 2022a). All of these studies explored this association in samples with elevated Autistic traits as opposed to those who have a diagnosis of autism, with this study extending these findings even further to include those with diagnostically co-occurring autism and AN. However, not all evidence agrees with this, with some studies reporting more severe and enduring ED symptoms in Autistic individuals with EDs (Leppanen et al, 2022; Suare et al, 2020). There is general consensus amongst the literature that Autistic individuals with AN have poorer treatment outcomes and experiences (Nazar et al, 2018; Stewart et al, 2017; Tchanturia et al, 2021; Kinnaird et al, 2019). Qualitative studies cite a number of reasons for this, including a lack of awareness and misunderstanding of how Autistic traits impact EDs (e.g., Babb et al, 2021), and that similar observable eating behaviours, such as the avoidance of certain foods, may have different underlying mechanisms (e.g., sensory differences) in Autistic individuals (Nimbley et al, 2022). It could be that discrepancies in the literature may reflect the fact that current measures of ED symptomology were developed to measure neurotypical presentations of AN, and more sensitive psychometric assessments are urgently needed that are developed within autism frameworks that can detect these different underlying mechanisms across the autism spectrum.

Participants in the Autism and AN, Autism only and AN only groups were found to have higher rates of self-reported interoceptive difficulties and alexithymia compared to their NT/HC peers. This in line with previous research that implicates interoception difficulties (Williams et al, 2023; Jacquemot & Park, 2020; Kinnaird et al, 2020c) and alexithymia (Kinnaird et al, 2019c; Westwood et al, 2017; Poquérusse, Pastore, Dellantonio & Esposito, 2022) as important targets in understanding both autism and AN. However, there were no differences detected between the groups, suggesting that in this sample such difficulties were reported to be equally high and none of the variables could successfully discriminate between groups. Due to small sample sizes, it was not possible to conduct statistical analyses that could control for these variables, which would have been particularly interesting within the context of condition. Thus, while overall rates of interoception and alexithymia may not significantly differ overall, it could be that they exert independent influences on social communicative behaviours in Autistic and non-Autistic individuals. It

would be interesting for future research to explore this potential link between social communication and emotion and sensory processing and seek to understand how these processes may influence the expression of EDs in Autistic and non-Autistic individuals. These findings contribute to a sparse evidence base exploring social communication as a possible underlying mechanism in the overlap between autism and AN and has a number of potential clinical implications. While current findings did not find evidence to support group differences on non-verbal behaviours overall or across conditions, this does not mean that future studies should not seek to improve and extend research exploring the role of non-verbal social communication. The implications of determining and accounting for social communication differences are clear, in both clinical and community settings. For example, a lack of understanding in non-verbal social communication can lead to a poor therapeutic alliance, as reported in previous qualitative studies (e.g., Babb et al, 2021). It could be that differences in body language, such as leaning or facing away from the clinician, may appear to be atypical if viewed through a neurotypical lens, and thus warrants intervention; however, for an Autistic individual this may their norm and seeking to correct this may delay or harm the therapeutic process. Ensuring that non-verbal social communicative behaviours are understood through a neurodivergent lens will be an important consideration in ensuring optimum clinical support for Autistic individuals with AN. It could also have important implications on community services, such as peer mentor schemes, ensuring that individuals are matched with someone with similar experiences and communication styles. Finally, non-verbal behaviours are an integral part of social communication and social affiliations (Lakin & Chatrand, 2003; Harrison, 2021; Burgoon et al, 2021), and thus could form a promising component of interventions targeted at developing interpersonal skills that have been consistently implicated in AN (Schmidt & Treasure, 2003; Treasure & Schmidt, 2013; Fairburn, 2008).

The current study was not without limitations. As mentioned throughout the discussion, a small sample size and unequal sample sizes across groups limited both study design and the interpretation of study findings. The study did not meet initial sample size calculations, and so the statistical analyses had to be changed. This meant that more robust inferential statistical analyses, such as a mixed factorial ANOVA or ANCOVA, could not be conducted. This leads to significantly underpowered analyses and concerns over the validity of

inferences from the results. Any reported effect size throughout the current study should be interpreted as an observation of effect only and not as an inference of the impact of group or condition on non-verbal behaviours.

There were also several limitations regarding sample demographics. Due to the nature of the social interaction task, participants were required to be verbal. While this was necessary for task demands, this meant that Autistic individuals who are non-speaking were not able to take part in the study. This unfortunately reflects a field-wide neglect of research into non-speaking Autistic children (Jack & Pelphrey, 2017; Russell et al, 2019; Tager-Flusberg & Kasari, 2013; McKinney et al, 2021), with non-speaking Autistic adults almost completely ignored (Tager-Flusberg et al, 2017). There was also a lack of males across all groups. Widespread gender disparity in EDs has been reported, with recent challenges to traditional assumptions of a female gender bias in light of emerging consensus that males are clinically underrepresented and undiagnosed with EDs (Raevouri, Keski-Rahkonen & Hoek, 2013; Sweeting et al, 2015; Strother et al, 2012; Gorrell & Murray, 2019). Males in EDs have also been found to be neglected in ED research, with less than 1% of current peer-reviewed, published articles relate specifically to male presentation of AN (Murray, Griffiths & Mond, 2016). Of note, the current study recruited a number of non-binary/third gender participants in the Autism and AN group and in the Autism only group. Gender diversity has previously been largely ignored in the ED literature, despite evidence to suggest that this group are at an even higher risk of developing an ED than their cisgender counterparts (Diemer et al, 2015; Riddle & Safer, 2022). Gender diversity has also been found to be highly common in autism (Nabbijohn et al, 2018; van der Miesen et al, 2018; Corbett et al, 2023). Thus, continuing to adopt a gender diversity affirming approach by including the broad range of genders will also be imperative in future autism and ED research. There was also an entirely white sample in the groups containing participants with AN, raising significant concerns over the ethnic diversity of the sample. In a similar vein, while demographic information such as level of education and level of employment was collected, no group differences were calculated on these variables. The stereotype that ED only affect white, young females is being increasingly challenged with recent evidence suggesting that ED symptomology is evenly represented across all levels of socio-economics status (Mulders-Jones, Mitchison, Girosi & Hay, 2017). A lack of ethnic and socio-economic diversity has

been identified as an ED-wide issue (e.g., Halbeisen, Brandt & Paslakis, 2022; Strauch et al, 2023), and it should be a future research priority to rectify this.

Fundamentally, future studies will require larger sample sizes with more controlled and sensitive analyses to allow for direct group comparisons and account for a range of confounding factors. As social communication is a multi-faceted concept, it would be interesting to explore non-verbal behaviours in the context of other factors inherent to social interactions and communication, such as turn taking. The role of turn taking has been explored in autism, however this has focused exclusively on toddlers and child-caregiver interventions (e.g., Grzadzinski et al, 2016*)*. No study to date has looked at this in Autistic adults and, to our knowledge, explored the role of turn taking in AN. Furthermore, future studies could also work towards developing new behavioural coding schemes rooted in neurodiverse frameworks and co-produced by Autistic individuals, instead of modifying pre-existing neurotypical behavioural coding schemes. These approaches would be particularly useful in shedding insights into the current study's lack of significant evidence to support the inclusion of the Repetitive Movement codes in Autistic participants. A possible approach to developing these coding schemes could be Grounded Theory (Glaser & Strauss,1999), which has recently been applied to developing behavioural coding schemes in Autistic children (Hancock, 2020). Similarly, future research could also utilise non-verbal behaviours as a means to provide empirical support for contemporary social theories, such as the Double Empathy theory (Milton, 2012). For example, it would be interesting to explore possible communication styles orpatterns in autism and AN, using techniques such as cluster analysis to identify possible subgroups and contribute towards attempts to untangle the co-occurring conditions, as well as looking to explore the impact of matched compared with mismatched neurotypes and their associated communication styles.

In conclusion, the current study sought to explore non-verbal social communication behaviours in autism and AN. No significant group differences were detected on non-verbal behaviours, and condition was not found to significantly influence non-verbal behaviours. Despite non-significant findings, future research should continue attempts to understand the possible role of non-verbal communication in the context of co-occurring autism and AN. It could be that current non-significant findings suggest that non-verbal social

communication behaviours may not be a leading factor in the overlap between autism and AN, and future research may replicate these findings. Alternatively, the limitations of the current study may mean that there may yet be differences. Generating a more comprehensive understanding of non-verbal social communication behaviours will allow researchers to further elucidate the nature of social differences in Autistic and non-Autistic individuals and may in turn have important implications on improving communication within clinical and community ED services.

Chapter 7 – The relationship between non-verbal social communication behaviours and sensory, social and emotional factors in Autistic and non-Autistic young adults with AN

Abstract

Background: Despite an increasing evidence base to support an overlap between autism and anorexia nervosa (AN), the underlying mechanisms of this overlap remain poorly understood. Several candidate mechanisms that have been observed in both autism and AN, such as social, sensory and emotional difficulties, have been proposed as key targets for untangling the overlap between the two conditions. To date, however, few studies have empirically explored the role of non-verbal social communication, and no study has looked at how non-verbal communication is associated with other implicated factors. This study therefore sought to investigate the relationships between non-verbal behaviours and interoception, alexithymia and comorbid psychopathology.

Methods: The study recruited four participant groups: (1) Autism and AN; (2) Autism only; (3) AN only; and (4) neurotypical/healthy controls (NT/HC). A total of 28 participants were recruited at the time of analyses. A short, structured social communication task was conducted, guided by a researcher through positive, negative and neutral conditions. Non-verbal behaviours expressed during the task were recorded and coded using a modified non-verbal behavioural coding scheme. Spearman's correlations were conducted to explore the relationship between each non-verbal behaviour and associated factors.

Results: Little evidence was found to support an association between non-verbal behaviours and associated factors. Significant relationships were reported only in the AN group, with tentative evidence to support the role of alexithymia in body language and depression and anxiety in eye gaze behaviours. Hand gestures were found to be associated with Autistic traits in the AN group but were not found to be significant in Autistic participant groups.

Discussion: The current study makes tentative contributions to a sparse evidence base exploring non-verbal behaviours in autism and AN. Future studies with larger and more equal sample sizes should seek to explore these relationships using more advanced statistical models, which can explore the direction and causality of the relationships, as well as control for possible confounding factors. Increased awareness and understanding of the complex interplay between sensory, social and emotional factors will have important

implications on clinical practice, including the management of treatment delivery and recovery expectations in Autistic and non-Autistic young adults with AN.

Introduction

It has been reported that around a third of individuals with AN are Autistic (Anckarsater et al, 2012; Huke et al, 2013; Westwood et al, 2016; Inoue et al, 2021; Westwood & Tchanturia, 2017), while EDs have been reported to be twice as common in Autistic individuals than their neurotypical peers (Sedgewick et al, 2021). Autistic individuals with EDs have also been reported to experience a broad range of detrimental outcomes, such as the utilisation of a higher range and frequency of ED services (Nazar et al, 2018; Babb et al, 2022; Bentz et al, 2022; Zhang et al, 2022), as well as longer treatment duration (Babb et al, 2022; Stewart et al, 2017; Tchanturia et al, 2016). They also have been reported to have higher rates of psychological comorbidities such as OCD and mood disorders, (i.e., anxiety and depression, Li et al, 2020; Nazar et al, 2018; Pruccolli et al, 2012; Godart et al, 2015; Sander, Moessner & Bauer, 2022), as well as psychosocial functioning difficulties compared to non-Autistic peers (Neilsen et al, 2015; 2022; Li et al, 2022). It therefore appears that current, standard ED interventions do not meet the unique needs and experiences of this cohort, and to provide more effective treatments for this population, a more comprehensive understanding of possible common and autism-specific factors must be obtained (Beygui & Cascio, 2022).

Several mechanisms have been proposed as key targets in understanding the overlap between autism and AN, spanning a broad range of social, sensory and emotional factors. Social factors have emerged as a leading factor in models of AN (Treasure & Schmidt, 2013; Fairburn, 2008), in autism (Milton, 2012) and in recent models of autism and AN (Brede et al, 2020; Kinnaird & Tchanturia, 2021). Difficulties with social communication have been reported in AN (Davies et al, 2016; Harrison et al, 2014; 2021), and these have been proposed to play a role in the manifestation of broader social difficulties (Harrison et al, 2014). This has been supported by qualitative research, whereby individuals with AN report that difficulties with social communication have significantly impacted their perceptions of friendships and social interactions (Westwood et al, 2016). Recently, more objective and ecological indicators of social communication, such as the use of non-verbal behaviours to facilitate communication, have been tentatively explored. Two studies to date have explored this in EDs, finding preliminary evidence for the aversion of gaze and body

positioning, as well as the reduced use of hand gestures (Harrison, 2021; Monteleone et al, 2022). However, these studies met with several limitations that require consideration. Firstly, the studies used broad ED samples and did not focus on specific classifications, such as AN. Secondly, there is contention in the literature as to the exact role of social communication difficulties in ED trajectories, with some arguing that there may be a sub-group within AN characterised by these difficulties that reflects underlying autism (Anackster et al, 2012; Harrison, 2021).

Differences in social communication are a hallmark and diagnostic feature of autism (APA, 2013); thus, there is a considerably larger body of empirical research that has sought to elucidate differences in social communication. A heterogenous presentation of social communication difficulties have been reported, ranging from difficulties with the physical production of speech to difficulties with the interpretation and function of speech (Tager-Flasburg et al, 2005; Levy et al, 2010; Baird et al, 2006; Riches et al, 2010; Georgiou & Spandoudis, 2021; Costescu et al, 2022). Non-verbal behaviours have also received considerable research attention. Studies have reported differences in eye gaze behaviours when compared to neurotypical peers, such as mutual eye contact (see Stuart et al, 2022) and aversion to faces and eyes (Papagiannoipoulou et al, 2013; Ma et al, 2021), as well as the overuse of hand gestures (Morett et al, 2016; de Marchena et al, 2019). Importantly, contemporary social theories of autism, such as the Double Empathy theory (Milton, 2012) reconceptualise differences in social communication as a mismatch in communication styles between neurotypical and Autistic individuals, instead of being a core difficulty associated with autism. Thus, it is important when conducting research into social communication in autism to acknowledge these contemporary perspectives, seeking to identify differences and not deficits, and accounting for behaviours associated with autism not as atypical behaviours but as autism-specific behaviours.

Several sensory factors have been implicated in the overlap between autism and AN, such as interoception (Adams et al, 2022). Interoception refers to the identification and interpretation of internal body sensations, such as pain, hunger or thirst (Craig, 2002; 2003; Critchley & Garfinkel, 2017). While it is now generally accepted that interoceptive difficulties are a key factor in the pathology of AN (see Jacquemot & Park, 2020), there are

inconsistencies in research methodologies that make firm conclusions hard to draw. For example, while there is argued to be an over-reliance on self-report measures, objective measures are found to be influenced by factors such as BMI and prior beliefs about interoceptive abilities (Murphy et al, 2018; Pollastos et al, 2008; Eshkeravi et al, 2016; Kinnaird, Stewart & Tchanturia, 2020). The role of interoception in autism is equally controversial. Studies have reported inconsistent findings on both self-report and more objective tasks, with a recent systematic review and meta-analysis concluding that Autistic individuals demonstrate differences in both self-report (Fiene & Brownlow, 2015; Garfinkel et al, 2016; Mul et al, 2018; Palser et al, 2018; Pickard et al, 2020) and objective (Garfinkel et al, 2016; Nicholson et al, 2018; Palser et al, 2018; Mul et al, 2018; Schauder et al, 2016; Nicholson et al, 2019; Pickard et al, 2020) interoceptive outcomes. A recent systematic review and meta-analysis by Williams et al (2023) concluded that Autistic individuals exhibit differences in multiple interoceptive outcomes, including objective (e.g., heartbeat counting task) and self-report (e.g., confidence ratings) measures, when compared to neurotypical controls. However, overall, authors concluded that more sensitive measures need to be developed and future studies need to account for potential confounding factors, such as IQ (Williams et al, 2023). Furthermore, due to the small magnitude of differences and inconsistent findings, authors conclude that interoception may not constitute a core feature of autism (Williams et al, 2023). Instead, it could be that differences in interoceptive abilities are more important through their contribution to the development of commonly co-occurring conditions, such as EDs (Adams et al, 2022).

Difficulties with interoception have also been proposed as an important mechanism in the development and treatment of EDs, particularly in AN (Jacquemot & Park, 2020; Phillipou, Rossell, Castle & Gurvich, 2022), however, much like the autism literature, there are inconsistencies reported across methodologies and measures of interoception. Subjective self-report measures have generally reported poorer interoceptive abilities in AN (Monteleone et al, 2020; Phillipou et al, 2022; Fischer et al, 2016), while objective measures, such as heartbeat tracking tasks, have led to mixed findings. Of note, there seems to be an over-reliance across interoceptive research on the heartbeat tracking task (Kormendi, Ferentzi & Koeteles, 2022), and studies have found them to be influenced by factors such as BMI or prior beliefs about their heart rate (Kinnaird et al, 2020; Murphy et al, 2018). There is

a lack of research investigating interoception, both in AN and in autism, that considers range of these implicated factors, as well as other important factors implicated in the overlap between autism and AN.

Alexithymia is defined as the ability to detect, describe and communicate about emotions (Longardo et al, 2015; Brewer, Cook & Bird, 2016; Murphy et al, 2018). Alexithymia has been reported to be elevated in AN samples compared to healthy controls (Westwood, Kerr-Gaffney, Stahl & Tchanturia, 2017) and plays a key role in the development and maintenance of AN (Nowakkowski, Farlane & Cassin, 2013; Gramaglia, Gambara & Zeppegno, 2019). Autism research has also found elevated rates of alexithymia (Bird et al, 2013; Brewer et al, 2015), although a systematic review and meta-analysis of studies concluded that alexithymia may represent a sub-group of autism, as opposed to being a universal difficulty (Kinnaird et al, 2019). Interestingly, alexithymia has previously been found to mediate the relationship between Autistic traits and eating disorder symptomology in a student community sample (Vuillier et al, 2020), leading to the suggestion that alexithymia may play an important role in untangling the overlap between autism and AN (Miniati, Marazziti & Palagini, 2022). Accordingly, recent studies have begun to explore interoceptive difficulties in individuals with elevated Autistic traits and AN. Using an objective measure known as the heartbeat detection task, Kinnaird et al (2020) found that individuals self-reported heightened rates of interoception but did not score differently to controls on the heartbeat detection task. This would suggest that interceptive performance may not be different in EDs, although they perceive themselves to have poorer interoception compared to healthy controls. However, authors note that further research is required with a more robust measure of interoception, as well as considering the potential role of social and emotional factors (Kinnaird et al, 2020).

The complex interplay between social, sensory and emotional factors has been explored in autism, with a systematic review finding evidence to support a relationship between sensory processing and both social communication and emotional functioning (Glod et al, 2012). Subsequent research supports this, with studies suggesting that emotion regulation is correlated with social communication difficulties and sensory differences (Samson et al, 2014), while Thye et al (2018) proposed that early differences in sensory processing may

give rise to observed social difficulties later in development. Models of AN have similarly proposed that social and emotional difficulties are inherently linked (Fairburn, 2008; Oldershaw et al, 2019; Treasure & Schmidt, 2013), although the possible role of sensory factors has been under researched in AN populations. Theoretical frameworks of autism and AN have also proposed that social, sensory and emotional factors play an important role (Brede et al, 2020; Kinnaird & Tchanturia, 2021), while a recent study reported that combining measures of auditory processing, social camouflaging and alexithymia demonstrated high evidence of discriminant validity in screening for Autistic compared to non-Autistic women with restrictive eating disorders (Adamson et al, 2022). What is missing from the literature however is an empirical investigation into understanding how these factors are associated with one another.

The current study therefore will seek to address gaps in previous literature to investigate the relationship between social communication and both sensory and emotional factors in the overlap between autism and AN. Using a modified version of a behavioural coding scheme previously utilised in ED samples (Harrison (2021), the study also sought to be the first of its kind to explore social communication, as measured by non-verbal behaviours, and interoception, alexithymia, and depression and anxiety. It was hypothesised that (i) higher self-reported eating disorder symptomology will be correlated with gaze aversion, body positioning and reduced use of hand gestures in Autism and AN and the AN only group but not in the Autism only or neurotypical/healthy control (NT/HC) group; and (ii) higher self-reported Autistic traits will be correlated with gaze aversion and increased use of hand gestures in the Autism and AN and the Autism only group, but not in the AN only or NT/HC group.

With regards to interoception, alexithymia and depression and anxiety, the novel nature of the study mean that analyses were predominantly exploratory however it was anticipated that: (i) higher self-reported interoception will be correlated with non-verbal social communication behaviours such as gaze avoidance and leaning or facing away from the conversational partner in Autism and AN, Autism only and AN only; (ii) higher rates of self-reported alexithymia will be correlated with non-verbal social communication behaviours such as gaze avoidance and leaning or facing away from the conversational partner in

Autism and AN, Autism only and AN only; and (iii) depression and anxiety will similarly be correlation with non-verbal social communication behaviours such as gaze avoidance and leaning or facing away from the conversational partner in Autism and AN, Autism only and AN only.

Methods

Design

A cross-sectional, observational design was adopted for the current study. The study was a single-centre study, with the observational task taking place in the University of Edinburgh observational labs. Core study methods are outlined in Chapter 5.

Data analysis

A detailed overview of how non-verbal behavioural data was coded, and how demographic and self-report measures were prepared for analyses can be found in Chapter 6, Section 6.2.2. Information regarding descriptive statistics, normality assumptions and between-group differences on demographic information and self-report measures can also be found in Chapter 6, Section 6.2.2.

The intended and most suitable inferential statistics to test for study hypotheses would have been a hierarchal regression, accounting for interoception, alexithymia, and depression and anxiety, as well as possible confounding variables (e.g., BMI). However, given the low sample size this was not deemed possible. Therefore, correlational analyses were between each individual non-verbal behaviour and interoception, alexithymia, and depression and anxiety.

Non-parametric Spearman's correlations were run to explore the relationship between self-report measures and non-verbal behaviours as all non-verbal behaviours were found to violate assumptions of normality. Due to concerns of inflating Type I error, or a heightened risk of reporting false-positives, multiple testing adjustments were performed in instances of significant correlations. Family-wise-error-rates (FWRE) approaches, such as running

Bonferroni corrections, were decided against, due to consensus that such adjustments lead to overly conservative results and increasing the risk of Type II, or heightened risk of reporting false-negatives (Chen et al, 2017). Instead, the false-discovery-rate (FDR) was calculated using Benjamini-Hochberg adjustments (Benjamini & Hochberg, 1995).

Results

Please see Chapter 6 Section 6.3.1. and Section 6.3.2. for participant characteristics and between-group differences on demographic information and self-report questionnaires. Please see Appendix M for Study 3 SPSS syntax.

Autism and AN

In the Autism and AN group (n=8), there were no significant correlations reported between any of the non-verbal social communication codes and any of the included self-report measures (Table 1).

Table 1.

Correlations between non-verbal social communication behaviours and self-report measures in the Autism and AN group.

	R (p=)				
	EDE-Q	SRS-2	ISQ-8	HADS	TAS-20
Body Positioning					
Facing	.	.	.	.	.
44	.	.	.	.	.
45 to 90	.	.	.	.	.
>90	.	.	.	.	.
Legs					
Crossed	.210 (.618)	.289 (.488)	-.183 (.665)	-.231 (.582)	.323 (.436)
Uncrossed	-.210 (.618)	-.289 (.488)	.183 (.665)	.231 (.582)	-.323 (.436)
Trunk					
Upright	-.188 (.656)	-.012 (.977)	-.060 (.887)	.555 (.153)	-.230 (.584)
Forwards	.270 (.518)	.218 (.603)	.281 (.500)	-.297 (.475)	.375 (.360)
Backwards	-.204 (.628)	.439 (.276)	.218 (.604)	-.024 (.956)	.490 (.217)
Other	-.039 (.927)	.110 (.796)	.109 (.797)	-.189 (.653)	.040 (.925)
Gaze					
On	.335 (.417)	-.275 (.509)	-.738 (.037)	-.289 (.487)	-.209 (.620)

Down	-.205 (.627)	.542 (.165)	.874 (.005)*	.388 (.342)	.333 (.420)
Away	.060 (.888)	-.527 (.180)	-.476 (.233)	.108 (.798)	-.405 (.319)
Hands					
Beats	0.110 (.796)	-.027 (.949)	-.355 (.389)	-.525 (.182)	.169 (.690)
Deictics	.	.	.	.	.
Iconics and Metaphors	-.288 (.489)	.617 (.103)	.245 (.558)	-.428 (.290)	.802 (.017)*
Head	.083 (.845)	.581 (.131)	.577 (.134)	.167 (.693)	.510 (.196)
Chin	.	.	.	.	.
Neck	-.166 (.695)	.332 (.422)	.082 (.846)	-.501 (.206)	.510 (.196)
Hair	-.031 (.941)	-.298 (.474)	.482 (.225)	.418 (.303)	-.386 (.345)
Cheeks	.083 (.845)	.581 (.131)	.577 (.134)	.167 (.693)	.510 (.196)
Nails	.	.	.	.	.
Eyes	.083 (.845)	.581 (.131)	.577 (.134)	.167 (.693)	.510 (.196)
Clothes	.295 (.479)	.025 (.954)	.195 (.643)	-.111 (.793)	.189 (.655)
Nose	-.810 (.015)*	.151 (.721)	-.027 (.949)	-.179 (.671)	.155 (.715)
Ears	-.166 (.695)	.332 (.422)	.082 (.846)	-.501 (.206)	.510 (.196)
Jewellery	.261 (.533)	-.878 (.004)*	-.436 (.280)	-.345 (.402)	-.788 (.020)*
Mouth	.581 (.131)	.332 (.422)	-.082 (.846)	.584 (.128)	.255 (.542)
Arms	.102 (.810)	-.268 (.521)	-.089 (.834)	-.077 (.856)	-.046 (.914)
Legs	-.098 (.817)	.785 (.021)*	.415 (.307)	.531 (.176)	.591 (.123)
Trunk	-.039 (.927)	.713 (.047)	.546 (.162)	-.189 (.653)	.771 (.025)*
Sitting	-.086 (.839)	.666 (.071)	.452 (.261)	-.316 (.446)	.771 (.025)*
Repetitive Movements					
Hands	-.134 (.752)	-.842 (.009)*	-.812 (.014)	-.578 (.134)	-.680 (.063)
Legs	.243 (.562)	.502 (.205)	.016 (.971)	-.039 (.926)	.603 (.114)
Trunk/Whole Body	.083 (.845)	.581 (.131)	.577 (.134)	.167 (.693)	.510 (.196)

EDE-Q = Eating Disorder Examination Questionnaire, SRS-2 = Social Responsiveness Scale – 2nd Edition, ISQ-8 = Interoceptive Scale Questionnaire – 8-item, HADS = Hospital Anxiety and Depression Scale, TAS-20 = Toronto Alexithymia Scale

**Did not retain significance after testing for multiple adjustments*

Autism only

In the Autism only group (n=7), there were no significant correlations between any of the non-verbal behaviour codes of the self-report measures (see Table 2).

Table 2.

Correlations between self-report measures and non-verbal social communication behaviours in the Autism only group.

	Correlation (p=)				
	EDE-Q	**SRS-2**	**ISQ-8**	**HADS**	**TAS-20**
Body Positioning					
Facing	-.612 (.144)	.206 (.658)	-.208 (.655)	.412 (.358)	.208 (.655)
44	.516 (.144)	-.208 (.658)	.208 (.655)	-.412 (.358)	-.208 (.655)
45 to 90	.	.	.	.	.
>90	.	.	.	.	.
Legs					
Crossed	.114 (.758)	-.218 (.638)	.073 (.876)	.218 (.638)	-.073 (.876)
Uncrossed	-.144 (.758)	.218 (.638)	-.073 (.876)	-.218 (.638)	.073 (.876)
Trunk					
Upright	-.120 (.799)	-.241 (.602)	.030 (.948)	.211 (.650)	-.091 (.846)
Forwards	.632 (.127)	.080 (.865)	.564 (.188)	.160 (.733)	.322 (.481)
Backwards	-.438 (.325)	.161 (.731)	-.619 (.139)	-.352 (.439)	-.355 (.463)
Other	.	.	.	.	.
Gaze					
On	-.714 (.071)	-.523 (.229)	.145 (.756)	-.487 (.268)	.073 (.877)
Down	.111 (.812)	.122 (.811)	-.547 (.204)	.673 (.097)	-.453 (.307)
Away	.929 (.003)	.360 (.427)	.182 (.696)	-.072 (.878)	-.073 (.877)
Hands					
Beats	.259 (.574)	-.748 (.053)	-.189 (.685)	.093 (.842)	.528 (.223)
Deictics	.	.	.	.	.
Iconics and Metaphors	.259 (.574)	-.785 (.036)*	.283 (.538)	-.430 (.335)	-.585 (.168)
Head	.	.	.	.	.
Chin	.	.	.	.	.

Neck	.	.	.	.	.
Hair	-.612 (.144)	-.412 (.358)	-.524 (.135)	.103 (.826)	-.520 (.232)
Cheeks	.	.	.	.	.
Nails	.	.	.	.	.
Eyes	.	.	.	.	.
Clothes	-.612 (.144)	-.412 (.358)	-.624 (.135)	.103 (.826)	-.520 (.232)
Nose	.	.	.	.	.
Ears	.	.	.	.	.
Jewellery	-.612 (.144)	-.412 (.358)	-.624 (.135)	.103 (.826)	-.520 (.232)
Mouth	.	.	.	.	.
Arms	-.217 (.641)	-.616 (.141)	-.040 (.932)	.000 (1.000)	-.632 (.128)
Legs	.122 (.811)	.500 (.253)	.229 (.622)	-.189 (.685)	.552 (.198)
Trunk	-.401 (.373)	.000 (1.000)	-.771 (.042)*	.427 (.339)	-.249 (.590)
Sitting	.	.	.	.	.
Repetitive Movements					
Hands	.775 (.041)*	-.109 (.816)	.055 (.907)	.218 (.638)	-.431 (.334)
Legs	-.204 (.661)	.618 (.139)	-.104 (.825)	-.618 (.139)	.416 (.354)
Trunk/Whole Body	-.401 (.373)	.000 (1.000)	-.771 (.042)*	.427 (.339)	-.249 (.590)

EDE-Q = Eating Disorder Examination Questionnaire, SRS-2 = Social Responsiveness Scale – 2nd Edition, ISQ-8 = Interoceptive Scale Questionnaire – 8-item, HADS = Hospital Anxiety and Depression Scale, TAS-20 = Toronto Alexithymia Scale

**Did not retain significance after testing for multiple adjustments*

AN only

Several significant correlations were found in the AN only group (n=3) that retained their significance after multiple adjustments (see Table 3). It should be noted that there was a very small sample size in this group and any significant correlations should be interpreted with caution.

Within the Trunk category, TAS-20 scores were found to be negatively correlated with sitting upright ($r(1) = -1.000$, $p = .001$) and positively correlated with leaning backwards ($r(1) = 1.000$, $p = .01$). This would suggest that higher self-reported alexithymia is associated with

a greater proportion of time leaning back, while lower self-report alexithymia is associated with sitting upright.

A similar pattern was observed within the Gaze category with HADS scores, with a significant positive correlation found between looking at the researcher and HADs scores ($r(1) = 1.000$, $p = .001$) and a negative correlation reported between looking away from the researcher and HADs scores ($r(1)$ -1.000, $p = .001$). This would suggest that higher self-reported depression and anxiety is associated with maintained eye contact, while lower self-reported interoceptive difficulties is associated with gaze aversion.

There were several Hand codes found to be significantly correlated with self-report measures. Specifically, higher EDE-Q scores were associated with reduced use of iconics and metaphors ($r(1) = -1.000$, $p = .01$), while higher SRS-2 scores and ISQ-8 scores were associated with increased use of iconics and metaphors (both $r(1) = 1.000$, $p = .01$). This indicates that higher self-reported eating disorder symptomology is associated with reduced use of hand gestures, while higher self-reported Autistic traits and interoceptive abilities are associated with the increased use of hand gestures. Additionally, total TAS-20 scores were negatively correlated with time spent touching clothes ($r(1) = -1.000$, $p = .01$), suggesting that higher self-reported alexithymia is associated with a reduced amount of time spent touching clothing.

Interestingly, several Repetitive Movement codes were found to be significantly correlated with self-report measures. Specifically, Repetitive Movement Hands were found to be negatively correlated with HADS scores ($r(1) = -1.00$, p .001), while Repetitive Movements Trunk/Whole Body was negatively associated with TAS-20 scores (both $r(1) = -1.00$, $p = .001$). This suggests that higher self-reported depression and anxiety is associated with less time engaging in repetitive hand movements, while higher self-reported alexithymia is associated with a lower proportion of time engaging in repetitive full body movements.

Table 3.

Correlations between self-report measures and non-verbal social communication behaviours in the AN only group.

	Correlation (p=				
	EDE-Q	SRS-2	ISQ-8	HADS	TAS-20
Body Positioning					
Facing	.	.	.	.	.
44	.	.	.	.	.
45 to 90	.	.	.	.	.
>90	.	.	.	.	.
Legs					
Crossed	.000 (1.000)	.000 (1.000)	.000 (1.000)	.866 (.333)	-.500 (.667)
Uncrossed	.000 (1.000)	.000 (1.000)	.000 (1.000)	-.866 (.333)	.500 (.667)
Trunk					
Upright	.866 (.333)	-.866 (.333)	-.866 (.333)	.000 (1.000)	**-1.000 (.01)***
Forwards	.	.	.	.	**.**
Backwards	-.866 (.333)	.866 (.333)	.866 (.333)	.000 (1.000)	**1.000 (.01)***
Other	.	.	.	.	.
Gaze					
On	-.500 (.667)	.500 (.667)	.500 (.667)	**1.000 (.01)***	.000 (1.000)
Down	.	.	.	.	.
Away	.500 (.667)	-.500 (.667)	-.500 (.667)	**-1.000 (.01)***	.000 (1.000)
Hands					
Beats	-.866 (.333)	.866 (.333)	.866 (.333)	.866 (.333)	.500 (.667)
Deictics	.	.	.	.	.
Iconics and Metaphors	**-1.000 (.01)***	**1.000 (.01)***	**1.000 (.01)***	.500 (.667)	.866 (.333)
Head	-.866 (.333)	.866 (.333)	.866 (.333)	.866 (.333)	.500 (.667)
Chin	.	.	.	.	.
Neck	.	.	.	.	.
Hair	-.866 (.333)	.866 (.333)	.866 (.333)	.866 (.333)	.500 (.667)
Cheeks	.	.	.	.	.
Nails	.	.	.	.	.
Eyes	.	.	.	.	.
Clothes	.866 (.333)	-.866 (.333)	-.866 (.333)	.000 (1.000)	**-1.000 (.01)***

Nose	.500 (.667)	-.500 (.667)	.500 (.667)	.500 (.667)	-.866 (.333)
Ears	.000 (1.000)	.000 (1.000)	.000 (1.000)	-.866 (.333)	.500 (.667)
Jewellery	.	.	.	.	.
Mouth	-.866 (.333)	.866 (.333)	.866 (.333)	.866 (.333)	.500 (.667)
Arms	.000 (1.000)	.000 (1.000)	.000 (1.000)	-.866 (.333)	.500 (.667)
Legs	-.866 (.333)	.866 (.333)	.866 (.333)	.866 (.333)	.500 (.667)
Trunk	.500 (.667)	-.500 (.667)	-.500 (.667)	.500 (.667)	-.866 (.333)
Sitting	.	.	.	.	.
Repetitive Movements					
Hands	.500 (.667)	-.500 (.667)	-.500 (.667)	**-1.000 (.01)***	.000 (1.000)
Legs	.		.	.	.
Trunk/Whole Body	.866 (.333)	-.866 (.333)	-.866 (.333)	.000 (1.000)	**-1.000 (.01)***

EDE-Q = Eating Disorder Examination Questionnaire, SRS-2 = Social Responsiveness Scale – 2nd Edition, ISQ-8 = Interoceptive Scale Questionnaire – 8-item, HADS = Hospital Anxiety and Depression Scale, TAS-20 = Toronto Alexithymia Scale

**Retained significance after testing for multiple adjustments*

NT/HC

In the NT/HC group (n=10), no significant correlations were reported between any of the non-verbal behaviour codes and self-report measures (Table 4).

Table 4.

Correlations between self-report measures and non-verbal social communication behaviours in the NT/HC group.

	Correlation (p=				
	EDE-Q	SRS-2	ISQ-8	HADS	TAS-20
Body Positioning					
Facing	.234 (.516)	-.059 (.872)	.418 (.230)	.120 (.742)	.290 (.416)
44	-.234 (.516)	.059 (.872)	-.418 (.230)	-.120 (.742)	-.290 (.416)
45 to 90	.	.	.	.	.
>90	.	.	.	.	.

Legs					
Crossed	.033 (.928)	-.007 (.986)	.155 (.669)	-.034 (.926)	-.020 (.957)
Uncrossed	-.033 (.928)	.007 (.986)	-.155 (.669)	.034 (.926)	.020 (.957)
Trunk					
Upright	-.27 (.940)	.420 (.226)	-.197 (.586)	.321 (.367)	.239 (.506)
Forwards	-.742 (.014)*	-.548 (.101)	-.525 (.119)	-.327 (.357)	-.459 (.182)
Backwards	.297 (.405)	.013 (.972)	.181 (.617)	-.236 (.511)	-.031 (.931)
Other	-.525 (.119)	-.059 (.872)	-.060 (.870)	-.539 (.108)	-.406 (.244)
Gaze					
On	-.482 (.159)	.116 (.749)	-.418 (.230)	.013 (.973)	-.188 (.603)
Down	.091 (.802)	-.150 (.679)	.193 (.594)	-.247 (.492)	.162 (.656)
Away	.402 (.249)	-.135 (.711)	.349 (.323)	-.069 (.850)	.103 (.777)
Hands					
Beats	-.019 (.96)	.180 (.620)	-.581 (.078)	.139 (.701)	-.043 (.906)
Deictics	.	.	.	.	.
Iconics and Metaphors	-.511 (.131)	-.429 (.215)	-.535 (.111)	-.289 (.419)	-.426 (.220)
Head	.	.	.	.	.
Chin	.	.	.	.	.
Neck	.	.	.	.	.
Hair	.199 (.581)	-.355 (.314)	-.091 (.802)	.120 (.742)	-.259 (.469)
Cheeks	.525 (.119)	.234 (.515)	.239 (.507)	.419 (.228)	.522 (.122)
Nails	.	.	.	.	.
Eyes	-.409 (.241)	-.527 (.117)	-.060 (.870)	-.120 (.742)	-.058 (.873)
Clothes	.000 (1.000)	.234 (.515)	.239 (.507)	-.419 (.228)	.058 (.873)
Nose	.513 (.129)	.122 (.737)	.721 (019)*	.263 (.462)	.415 (.233)
Ears	-.234 (.516)	-.410 (.239)	-.428 (.230)	-.120 (.742)	-.174 (.631)
Jewellery	-.074 (.839)	-.493 (.147)	-.383 (.275)	.022 (.951)	-.493 (.148)
Mouth	-.234 (.516)	-.410 (.239)	-.418 (.230)	-.120 (.742)	-.174 (.631)
Arms	.049 (.892)	-.297 (.404)	.019 (.959)	.354 (.315)	-.031 (.933)
Legs	.488 (.153)	.098 (.788)	.000 (1.000)	.427 (.219)	.343 (.322)
Trunk	-.431 (.214)	.109 (.764)	.111 (.760)	-.723 (.018)*	-.294 (.409)
Sitting	.525 (.119)	.234 (.515)	.239 (.507)	.419 (.228)	.522 (.122)
Repetitive Movements					
Hands	-.135 (.710)	-.715 (.020)	.115 (.752)	-.231 (.521)	-.007 (.984)
Legs	-.234 (.516)	-.410 (.239)	-.418 (.230)	-.120 (.742)	-.174 (.631)

Trunk/Whole Body	-.352 (.318)	.153 (.674)	.156 (.668)	-.705 (.023)*	-.225 (.532)

EDE-Q = Eating Disorder Examination Questionnaire, SRS-2 = Social Responsiveness Scale – 2nd Edition, ISQ-8 = Interoceptive Scale Questionnaire – 8-item, HADS = Hospital Anxiety and Depression Scale, TAS-20 = Toronto Alexithymia Scale

**Did not retain significance after testing for multiple adjustments*

Discussion

The current study sought to understand the relationship between non-verbal behaviours and alexithymia, interoception and depression and anxiety in autism and AN. Only the AN group were found to have significant associations between non-verbal behaviours and associated factors, and caution is warranted in the interpretation of these findings given the very small sample size of the AN only group. Collectively, the current study found minimal evidence to support associations between non-verbal behaviours and associated factors and found preliminary contradictory evidence regarding the role of repetitive movements in autism. Study findings provide tentative evidence to a sparse evidence base exploring the role of social communication in autism and AN, and the possible influence of implicated factors such as interoception and alexithymia.

Gaze behaviours were found to be associated with depression and anxiety in the AN group. Specifically, higher self-reported rates of depression and anxiety were found to be associated with a greater proportion of time spent looking away from the researcher, and with less time looking at the researcher. Higher incidences of anxiety and depression has been consistently implicated in AN compared to non-ED peers (Godart et al, 2015; Sander, Moessner & Bauer, 2021), with a recent study finding that, in a sample of 15–25-year-old females, those with lifetime anxiety or major depressive disorders were four times more likely than the general population to have an ED (Garcia et al, 2020). Gaze avoidance has been previously reported in mood disorders, such as depression and social anxiety (Schneier et al, 2013; Gao et al 2023), and current findings implicate that they may also play a role in subclinical presentations within AN populations. Thus, it could be that considering rates of depression and anxiety within the wider context of social interactions and communication

may provide novel insights into social trajectories of AN. The importance of eye gaze studies has been increasingly acknowledged in recent studies exploring the overlap between autism and AN, with a focus on eye tracking methodologies (Kerr-Gaffney et al, 2020a; Dinkler et al, 2019). However, collectively these studies have suggested that that Autistic traits account for gaze aversion from eyes or from faces, while findings from the current study did not find any significant associations between eye gaze and Autistic traits in the AN sample or in any other participant group. It could be that considering depression and anxiety may help further understand this relationship. Future studies could combine mixed-method data from experimental and observational approaches to further elucidate the relationship between eye gaze behaviours and rates of depression and anxiety.

Participants in the AN group were also found to have associations between hand gestures and both Autistic traits and ED symptoms. Specifically, less use of hands to gesture a real (iconic) or hypothetical or imagined (metaphor) image, action or object was found to be associated with higher ED symptoms and with lower Autistic traits. The importance of hand gestures has been implicated in previous observational studies in ED samples, which have suggested an overall reduction in use (Harrison, 2021; Monteleone et al, 2022). Conversely, studies exploring the role of hand gestures in autism suggest an over-use of hand gesticulation (Morett et al, 2016; de Morchena et al, 2019). Current study findings would support this within the context of ED symptomology and Autistic traits within AN samples. However, no other significant findings were reported between hand gestures and Autistic traits or ED symptoms in either the Autism and AN or the Autism only group. Therefore, it is not possible to draw conclusions about whether the use of hand gestures may be used as a discriminatory factor in untangling the overlap between autism and AN. Interestingly, higher self-reported interoceptive difficulties were also found to be associated with reduced use of hand gestures in the AN only group. Larger and more controlled future studies are warranted further exploring the use of hand gestures in autism and AN and the possible interplay between eating disorder symptomology, Autistic traits and interoceptive abilities.

Trunk positioning was found to be associated with alexithymia in AN participants only. Specifically, higher self-reported alexithymia was associated with more time spent leaning

backwards, while lower self-reported alexithymia was associated with more time sitting upright. These findings extend previous findings that found trunk positioning in EDs to be influenced by negative emotions (e.g., Harrison, 2021; Monteleone et al, 2022), suggesting that a broader understanding of the role of emotions should consider factors such as the ability to recognise your own emotions. Alexithymia has been consistently implicated as a core feature of AN (Courty et al, 2013; Gramaglia et al, 2019) and has also been suggested to play a significant role in the overlap between autism and AN (Miniati et al, 2022; Vuillier et al, 2020). The current study therefore suggests that a multi-faceted and integrated understanding of emotion and social functioning should be considered when engaging with AN patients. This may be particularly relevant in understanding body language during clinical sessions or interventions, and future studies should seek to further explore the links between subtle non-verbal behaviours and possible emotion difficulties in AN.

There were limited results on the Repetitive Movements codes. Interestingly, and contrary to expectations, this latter code was not found to be associated with any self-report measures in either the Autism and AN or Autism only group and was not found to be associated with increased Autistic traits in any group. In fact, a greater use of Repetitive Movements was found to be associated with lower self-report alexithymia and depression and anxiety the AN group only. There could be several reasons for this finding. It could be that the small sample size did not allow for the detection of significant findings. It could also be that repetitive behaviours were not evident during the social interaction of the task; however, they could manifest in other environments and behaviours not specific to non-verbal social communication. This latter interpretation may be particularly relevant for Autistic individuals. Alternatively, it could mean that the modifications on the coding scheme need revisiting. The rationale behind the inclusion of the Repetitive Movement category was rooted in the prevalence of restricted and repetitive movements as a core feature of autism (APA, 2013) and on previous studies exploring non-verbal behaviours using behavioural coding schemes in the autism literature (e.g., BOSCC; Grzadzinki et al, 2016). However, a notable criticism of such coding schemes is that they are developed within neurotypical frameworks, conceptualising repetitive behaviours as divergence from typical behaviours. This can also be applied to the current coding scheme; while it was

deemed important to account for autism-specific behaviours, this was done by modifying an existing coding scheme. Future research could work towards developing and validating behavioural coding schemes for and with Autistic individuals, and apply these to studies that seek to understand the role of non-verbal behaviours in autism and AN.

These findings make tentative but novel contributions to understanding the role of social communication in autism and AN. To our knowledge, this is the first study of its kind to explore non-verbal behaviours in this population, and to explore the possible relationships between these behaviours with other factors implicated in the co-occurrence of these conditions. With further investigation, results from the current study could have important clinical and practice implications within the field. For example, study findings regarding the association between eye gaze behaviours and depression and anxiety in AN suggest that rates of co-occurring mood disorders may influence gaze behaviours in this group. Theoretically, this could be due to notable distress caused by low mood or anxiety leading to interpersonal or attention difficulties, although there is no evidence to support this beyond mere conjecture. Nonetheless, the link between these two could have implications for healthcare professionals working with individuals with AN, as atypical gaze behaviours may indicate high rates of depression and anxiety in service users that may warrant investigation. Similarly, developing interventions that focus on improving low mood or heightened anxiety may be a promising component of broader interventions seeking to improve interpersonal functioning in this group.

Study findings would also support the importance of considering the role of emotions when conducting social communication research or developing interventions. Alexithymia emerged as an important factor in the AN group, particularly in the context of trunk positioning. Emotion-focused interventions, such as emotion skills training, have previously been applied to adult AN patients with high Autistic traits, with evidence to suggest that both groups respond and show improved levels of alexithymia (Adamson et al, 2018). It would be interesting to see how these interventions may lead to changes in non-verbal behaviours, such as body language, and if these interventions in turn work towards improving ED outcomes and behaviours. Elements of emotion skills training can also be

found in Radically Open-Dialectical Behaviour Therapy (RO-DBT), a transdiagnostic intervention that contends emotional loneliness leads to overly controlling behaviours observed in AN (Lynch, 2018; Lynch, Gray, Hempel, Titley, Chen & O'Mahen, 2013). RO-DBT strategies are informed by a neurophysiological heightened threat sensitivity that influences non-verbal communication behaviours, such as eye gaze, and broader social and emotional difficulties (Lynch et al, 2013). Thus, within RO-DBT frameworks, developing emotion skills is a promising target to alleviating not only emotional difficulties, but social communication behaviours such as gaze aversion and broader social difficulties implicated in AN (Davies et al, 2016; Harrison et al, 2014, 2021; Westwood et al, 2016).

The current study does meet with notable limitations. Small and uneven sample sizes prevented the use of parametric analyses that would have allowed for a more robust analyses of the relationship between non-verbal behaviours and associated factors. Correlational analyses are a good starting point for identifying initial relationships, however they do not allow for these relationships to be understood in the context of another factor. For example, in the current study gaze aversion was associated with depression and anxiety in the AN sample, but analyses were unable to explore whether this relationship was influenced by alexithymia or control for other potential influencing factors, such as BMI (Murphy et al, 2018a). Future research should be conducted using more robust inferential statistics, such as hierarchal regressions to explore which relationships remain significant when accounting for other implicated or confounding factors.

There were also several methodological limitations. The current study was cross-sectional, which meant that both the direction and the causality of the relationship between non-verbal behaviours and associated factors could not be inferred. Furthermore, the reliance on self-report measures raises several concerns. Autistic participants may have had difficulties interpreting certain items when language use was vague, ambiguous or too generalized, or when asked to perform hierarchal thinking or prioritising such as indicating their agreement with a statement on a Likert scale of 1 to 5. Additionally, the use of self-report may be a limitation on the interpretation of the data. While these can be useful for time management and large-scale data collection, it could be that response bias introduced by self-report measures may have in turn biased the results. This may be particularly

relevant for both interoception and alexithymia. There have been inconsistent results reported between self-report and objective measures in both interoception (Jacquemot & Park, 2020; Williams et al, 2023; Kinnaird et al, 2020) and alexithymia (Ryan et al, 2020; Vuillier et al, 2020) measures, with the general consensus of an over-inflation of self-reported difficulties across both factors. In a similar vein, there was a degree of overlap between items on several of the measures used; for example, several items on the TAS-20 (alexithymia) ask about identifying physical sensations and are notably similar to items on the ISQ-8 (interoception). This raises specificity concerns and is something worthy of untangling in future research, particularly when considering the emerging literature suggesting that alexithymia is a facet of interoception (e.g., Brewer et al, 2016). More objective and sensitive measures are urgently needed for future research in order to untangle both the overlap and the possible role each factor may play individually in autism and EDs.

With regards to the coding scheme, while the inclusion of new codes to the behavioural coding scheme were important in their consideration of autism-specific behaviours, they were not previously validated in Autistic samples. Finally, several demographic limitations were observed in the current sample. There was a lack of male and trans/nonbinary participants recruited, despite higher rates of EDs in these populations than previously proposed (Ravouri et al, 2013; Gorrell & Murray, 2019), and a lack of ethnic diversity in the ED samples. These are both widespread issues in the ED literature (Murray et al, 2016; Halbeisen et al, 2022), and considerable effort should be put into conducting more ethnically- and gender-diverse samples in the future.

While the ability to draw firm conclusions from the current study is limited by a number of factors, it does highlight several possible avenues for future research. Importantly, several important relationships have been identified between non-verbal behaviours, such as eye gaze, body language and hand gestures, and associated factors implicated in the overlap between autism and AN, including interoception and alexithymia. This will hopefully provide a tentative starting point for future studies from two similar but diverging perspectives. Firstly, future studies should seek to further elucidate the role of non-verbal behaviours in the overlap between autism and AN. This could be achieved through the development of

novel, neurodiverse-affirming behavioural coding schemes, adopting rigorous methodologies such as Grounded Theory approaches (Glaser & Strauss, 1999). In such approaches, an iterative and systematic approach to behavioural coding allows for the generation of theory from the data collected (e.g., Hancock, 2020), ensuring that coding schemes are firmly rooted in Autistic perspectives. Furthermore, it may be more conducive to develop more focused behavioural coding schemes. This could involve focusing on one or two aspects of non-verbal communication (e.g., gaze behaviours) and developing more in-depth codes that pick up on more subtle but equally important nuances in behaviour. The second line of enquiry could be the role that factors associated in autism and AN play in non-verbal social communication behaviours, and how these may help us work towards untangling shared and condition-specific differences. While the study focused on interoception and alexithymia, as well as depression and anxiety, future studies could incorporate other factors proposed by current models (e.g., Brede et al, 2020; Kinnaird & Tchanturia, 2021). For example, it would be interesting to explore the role of modality-specific differences in sensory processing, or more cognitive-orientated factors such as cognitive inflexibility and rigidity. Furthermore, it could be interesting to consider the association of non-verbal social communication with broader social functioning and differences.

The current study sought to explore the relationship between non-verbal social communication behaviours and a range of associated factors, including interoception and alexithymia and anxiety and depression, in autism and AN. While there were no significant findings in the Autistic groups, several associations were found in non-Autistic participants with AN. Eye gaze was found to be associated with depression and anxiety while body language was associated with alexithymia. Hand gestures were found to be associated with both ED symptoms and with Autistic traits. Future studies are needed with larger sample sizes and more robust statistical analyses to explore the direction and causality of these associations. Increased awareness of the complex interplay between social communication, emotion and sensory processing should be incorporated into clinical practice, managing treatment and recovery expectations for Autistic individuals with AN and highlighting novel approaches to emotion-, interoceptive- and interpersonal-focused interventions.

Chapter 8 – Discussion

Summary of thesis aims and key findings

The overall aim of the current thesis was to conduct an in-depth, mixed-method exploration into the possible role of sensory, social and emotional factors in the overlap between autism and AN. Specifically, research interest lay in identifying key similarities and differences across these factors, and using these differences to work towards discriminating between Autistic and non-Autistic individuals with AN. Despite increasing evidence to support a true overlap between the two conditions, underlying mechanisms remain poorly understood, and providing insight into how implicated factors are experienced and interact will support the development of targeted and effective interventions for both Autistic and non-Autistic individuals.

Systematic Review – Sensory processing and eating behaviours in autism: A systematic review

Chapter 3 outlines a systematic review exploring the relationship between sensory processing and eating behaviours across the lifespan in autism. Despite a significant number of empirical studies exploring this relationship, no attempts had been previously made to systematically collate and evaluate these studies. Thus, the review aimed to identify, evaluate and synthesise literature exploring the relationship between sensory processing and a broad range of eating behaviours in autism.

Across 25 included studies, there was consistent evidence of a relationship between sensory processing and a range of mealtime behaviours, as well as behaviours associated with food repertoire and food neophobia. Taste/smell sensitivities were particularly implicated and there was tentative evidence to suggest hypersensitivities may play a particular role. However, there were several limitations observed across studies that limit our ability to draw firm conclusions. There was an over-reliance on parent-report and self-report measures, and a lack of controlled studies. Additionally, there was almost a lack of investigation into sensory processing beyond childhood and with regards to disordered

eating or feeding outcomes. Review findings have important implications on the development of sensory-based eating or feeding interventions, as well as the development of eating disorders, however studies are needed to investigate a broader range of multi-sensory issues and clearly defined eating behaviours and outcomes.

Study 1 - "It's not about wanting to be thin or look small, it's about the way it feels": an IPA analysis of social and sensory differences in Autistic and non-Autistic individuals with anorexia and their parents

Chapter 4 outlines Study 1, a qualitative study exploring the possible role of sensory and social factors in autism and AN. Building on the role of sensory processing and its associations with social and emotional factors identified in Chapter 1, the study sought to further elucidate the role of these factors from lived/living experience perspectives. The study adopted a novel dyadic approach, drawing on multi-perspectives from those with lived/living experience of AN and their parents, to further understand the role of sensory, social and socio-emotional factors in AN. The study also sought to compare experiences of these factors between groups, seeking to untangle possible shared or condition-specific differences.

Interpretative Phenomenological Analysis (IPA) revealed similarities between groups on social factors, such as a desire for social connection and socio-emotional difficulties, however the underlying mechanisms of these factors were fundamentally different. Autistic participants reflected that feeling 'defective' underpinned social difficulties, while non-Autistic participants discussed the negative impacts of social comparisons. Sensory factors emerged as being unique, prevalent and persistent for Autistic adults, while any sensory sensitivities or interoceptive difficulties were reported to disappear once recovered from AN in the non-Autistic group. These notable differences have important implications on the development of ED interventions, particularly for Autistic people whose experiences and

needs may differ from traditional ED treatment. These implications should be acknowledged across sensory, emotion and communication-based interventions.

Study 2 and 3 – Non-verbal social communication in Autistic and non-Autistic young adults with AN, and their relationship with sensory, social and emotional factors

Chapter 6 and 7 report on Study 2 and 3. Both studies report findings from an observational study interested in the role of non-verbal social communication behaviours and their possible association with key sensory (interoception) and emotional (alexithymia) factors. To our knowledge, no study to date has focused on social communication or drawn on observational methodologies to investigate the overlap between autism and AN. Study 2 sought to investigate and compare non-verbal behaviours in autism and AN, as well as explore the impact of positive, negative and neutral discussions, while Study 3 aimed to understand how non-verbal behaviours were associated with implicated factors such as interoception and alexithymia. Due to the novel design of the study for the target population, interest also lay in the feasibility in recruiting for and conducting for observational study as a means of exploring non-verbal social communication.

Study 2 did not find any significant group differences on non-verbal behaviours. While several notable effect sizes were reported for trunk positioning and eye gaze between group, interpretation of these were limited. No evidence was found to support an effect of condition on non-verbal behaviours for each of the participant groups. Despite non-significant findings and low participant numbers, this was felt to be down to factors not specific to study design; therefore, overall, the author recommends observational study designs as a feasible approach to social communication research in autism and AN. Study 3 found tentative evidence to suggest a link between alexithymia and body language, as well as depression and anxiety with eye gaze behaviours in the AN only group. Both studies contribute to a sparse evidence base exploring the role of social communication in autism and AN, while also highlighting the importance of conducting more robust, controlled

research in larger samples. Understanding the role of social communication and the interplay it may have with emotion and sensory factors has important implications, particularly in contributing to untangling common and autism-specific mechanisms of AN or in the development or modification of interpersonal ED interventions in clinical and community contexts.

Synthesis with existing literature

The role of sensory factors

Findings from the systematic review and Study 1 and 3 suggest a prominent yet complex role of sensory factors in understanding the overlap between autism and AN. Importantly, these sensory differences were multi-faceted, reflecting exteroceptive sensitivities towards taste and smell particularly (Systematic Review and Study 1), as well as interoceptive sensitivities to the detection of hunger, fullness and temperatures (Study 1 and 3). Collectively, thesis findings are generally in accordance with previous literature. Kinnaird et al (2019) interviewed Autistic adult women about their eating habits, and sensory sensitivities were reported to be a leading influential factor, particularly for participants with disordered eating. Kinnaird and Tchanturia (2021)'s clinical framework presented comparative differences in sensory processing between Autistic and non-Autistic individuals with AN, while differences in sensory processing, such as sensory overload, taste and smell sensitivities, and interoceptive difficulties, were also identified as a leading factor in Brede et al (2020)'s model of autism-specific mechanisms underlying restrictive eating disorders. The current thesis supports and extends these findings, offering an empirical comparison between Autistic and non-Autistic groups on the perceived role of sensory differences. Of particular relevance here are findings from the multi-perspective IPA analyses in Study 1 that suggested differences in sensory processing may be an important factor in discriminating between Autistic and non-Autistic individuals with AN.

Additionally, findings from the current thesis suggest that these potential autism-specific differences in sensory processing may influence other traits implicated in the overlap

between autism and AN. Specifically, in Study 1, Autistic participants reflected on lifelong and multi-modal sensory differences that were felt to influence social interactions and their emotions. Sensory factors have been associated with a broad range of clinical and behavioural features of autism (see Glod et al, 2015), with a recent comprehensive review finding evidence to support a multi-modal association between sensory processing and social communication (Thye et al, 2018). However, to our knowledge there has been little to no research conducted empirically investigating the relationship between sensory processing and social factors in autism and AN specifically. Furthermore, findings would also suggest differences in sensory processing are integral to Autistic experiences of AN and may be the core factor not only in discriminating between Autistic and non-Autistic individuals with AN, but also in understanding and untangling shared social differences.

Somewhat contradictory to these findings was Study 3, which did not find evidence for an association between interoception and non-verbal social communication in Autistic participants with AN but found an association between interoception and reduced use of hand gestures in non-Autistic participants. Methodological limitations to Study 3 mean that findings are by no means conclusive, however this does highlight an important caution to discounting the role of interoception in non-Autistic participants entirely. Future, more robust research into sensory profiles in Autistic and non-Autistic individuals with AN and their association with social differences will provide further insights.

The role of social factors

The current thesis also provides novel insights into the role of a broad range of social factors across all empirical studies (Study 1, 2 and 3). Firstly, social differences were consistently implicated across studies, and important group differences were observed. Study 1 found important shared social experiences, with both Autistic and non-Autistic dyads reflecting on a social sense of self and on the importance of social connections. Importantly however, these similarities were only at surface-level, with the underlying mechanisms and presentations of these difficulties different. Specifically, Autistic individuals reflected on a keen sense of social-self defectiveness, while non-Autistic participants discussed social

comparison as a key driving factor. Group differences were not found in Study 2, however it should be noted that these findings were limited in their discriminatory power due to concerns with sample sizes and underpowered statistical analyses. Collectively, evidence from the current thesis would suggest that social factors, particularly social interactions and communication, are a promising target for untangling the overlap between autism and AN. This supports and extends findings from a recent comparative study, which identified differences in social reciprocity, or the back-and-forth nature of social interactions and communication, as the sole discriminatory feature in Autistic and non-Autistic individuals with AN (Kerr-Gaffney et al, 2021).

Social factors were also suggested to overlap between other factors explored in the thesis, particularly that of emotions. Both Autistic and non-Autistic participants in Study 1 often reflected on difficulties with managing and interpreting emotions during social interactions. Furthermore, Study 3 found an association between increased use of hand gestures and higher rates of self-reported alexithymia in non-Autistic young adults with AN, further suggesting a complex interplay between social and emotional factors in AN. The intersection of social and emotional difficulties has been previously explored as a key mechanism in the overlap between autism and AN, with several studies exploring potential differences in socio-emotional processing, such as emotion recognition (Courty et al, 2013; Kerr-Gaffney et al, 2020; Dinkler et al, 2019). Beyond this, however, the impact of emotion on broader social functioning, such as social interactions and communication, hasn't been empirically investigated, and thesis findings suggest that such considerations may be integral in understanding the overlap between autism and AN.

The role of emotion factors

The role of emotion was implicated across the systematic review and Study 1 and 3. Emotions were found to be implicated in the associations between sensory processing and a range of eating behaviours in the systematic review, specifically restrictive eating behaviours (Kral et al, 2015). Study 1 provided empirical evidence to further highlight the importance of emotion factors in both Autistic and non-Autistic individuals with AN.

Specifically, Study 1 found that both Autistic and non-Autistic participants had difficulties interpreting emotions in other people, however for Autistic participants, this was felt to be a core difficulty that extended to their own emotions. This latter experience – difficulties with identifying your own emotions, known as alexithymia – was further explored in Study 3. Higher rates of alexithymia were correlated with leaning away from their conversational partner in non-Autistic participants with AN, while no associations were reported in Autistic samples. This would tentatively suggest that alexithymia may exert an influence on body language in non-Autistic individuals with AN. While not solely an emotional factor, higher self-reported depression and anxiety was also found to be correlated with gaze aversion in non-Autistic participants, highlighting the possible role that mood disorders may have for social communication in AN. Notable methodological limitations of Study 3 prevent firm conclusions being drawn, however future research should seek to further investigate possible nuances in the possible influence of alexithymia and co-occurring mood disorders on social differences.

Clinical implications and suggestions for future research

The clinical implications of thesis findings are discussed throughout, but key implications will be presented briefly in the following section. The overarching thesis aims focused on identifying key factors implicated in the overlap between autism and AN, with a view to generate understandings of shared and condition-specific factors. This was tentatively but encouragingly achieved, shedding novel insights into the role of sensory, social and emotional factors. Fundamentally, the current thesis highlights the important of accounting for unique Autistic needs when it comes to ED interventions, something keenly highlighted by Autistic people in previous qualitative studies (Kinnaird et al, 2019; Babb et al, 2021). This could involve modifying current ED interventions to account for Autistic needs, such as making environmental changes and ensuring scheduling transparency as much as is feasible. Clinicians should also be aware that Autistic and non-Autistic individuals may be responsive to different treatments entirely. For example, Autistic people have previously discussed how they do not feel they respond to Cognitive Behavioural Therapy (CBT), favouring instead emotion-focused or more practical-focused interventions such as Dialectic Behavioural Therapy (Babb et al, 2021), while Tchanturia et al (2016) found AN patients with high

Autistic traits showed no improvement following Cognitive Remediation Therapy (CRT). Subsequently, emotion-focused interventions have been found to lead to significantly improve rates of alexithymia in those with higher Autistic traits (Adamson et al, 2018).. Most importantly however, accounting for autism-specific factors in ED treatments should also involve the development of novel interventions developed within neurodiverse-affirming frameworks and led by Autistic individuals with lived/living experience of EDs.

Developing more meaningful and translatable research will require the involvement of lived/living experience perspectives, both as participants and through participatory designs. This should be applied both to conducting research and to developing clinical interventions. It should also be noted that while studies sought to identify target factors that may help us discriminate between Autistic and non-Autistic individuals, the possible dichotomous interpretation of this should be treated with caution. Importantly, findings from the current thesis also highlight the potential heterogeneity and multi-dimensional trajectories of AN in Autistic and non-Autistic individuals. Thus, future ED treatments and interventions should develop a more individualised approach where possible, working in collaboration to acknowledge and account for different perspectives. A recent Delphi study asked participants with relevant expertise as a researcher, clinician, or expert by experience how to improve eating disorder treatment for Autistic women with AN, noting that factors such as sensory sensitivities and differences in social communication are of notable importance in developing and delivering effective care (Field, Fox, Jones & Williams, 2023). Thus, while the current thesis supports suggestions to develop more sensory- and social-focused interventions, it also highlights the importance of tailoring such interventions to the unique needs of the individual.

Current findings also highlight several exciting and important avenues for future research. Broadly speaking, research should continue to draw on multiple methodologies and data collection approaches, however future studies could seek to do this simultaneously, collecting and contextualising both quantitative and qualitative data within the scope of the same study or research questions. This is particularly relevant when considering findings

from Study 1, where both Autistic and non-Autistic groups discussed similar social difficulties, as well as key differences in the experience of these difficulties that may be missed by solely quantitative responses. Mixed methods approaches are being increasingly adopted in health and psychological research (Regnault et al, 2018; Creamer & Repping, 2020), generating findings that are rooted in patient-identified priorities and generating improved clinical outcomes. Another interesting avenue for future research could be applying novel methodological and statistical approaches to current understandings of sensory, social and emotional factors. For example, techniques such as cluster analysis could be used to identify key differences between groups or possible sub-groups on the basis of sensory profiles that account for both exteroceptive and interoceptive sensory differences, as well as considering the influence of different sensory patterns. This latter inclusion may be particularly relevant moving the field of autism and ED forwards beyond AN towards understanding the overlap between autism and other EDs. It could be that the importance of hypersensitivities identified in the systematic review may be specific to AN, or it may also play a role in other restrictive eating disorders, such as ARFID. Conversely, other sensory patterns, such as hyposensitivity's or sensory seeking, may lead to more binge/purging behaviours characteristic of BN or BED.

A final potential avenue for future research is the development of testable theories or models of autism and AN. While previous attempts have been instrumental in advancing our understanding of the co-occurring conditions, they have either been proposed based on comparative clinical observation (Kinnaird & Tchanturia, 2021) or require subsequent empirical investigation (Brede et al, 2020). Such theories should be co-produced, involving Autistic researchers with lived/living experience of AN in the conceptualisation, development and investigation, ensuring that future models of autism and AN will be developed with neurodiverse-affirming frameworks. An intuitive approach to such models would be through Grounded Theory (Glaser & Strauss, 1967), a qualitative approach whereby theories are constructing from a rigorous and iterative process. Such approaches also do not have to be limited to generating overarching theories of the overlap, but can also be applied to specific methodologies to explore how we enhance of understanding of different facets of autism and AN. For example, a Grounded Theory approach has been

previously utilised in the development of a non-verbal behavioural coding scheme exploring play behaviours in Autistic children (Hancock, 2020). Such alternative approaches offer just one of many ways we can seek to extend our understandings of autism and AN, and co-produced, novel approaches to such research should be a research priority in advancing the field.

Limitations

The current thesis is not without limitations. Studies 1, 2 and 3 adopted a cross-sectional design, which limits our ability to make inferences about direction and causality of relationships. While in Study 1 there were attempts to encourage a developmental approach, this was still done at one moment in time and retrospectively, therefore increasing the risk of memory distortion. Longitudinal quantitative and qualitative data collection would allow us to further understand the trajectories and influences of sensory, social and emotional factors, as well as identifying any other potential factors not yet explored. There were also concerns of a recruitment bias for study 2, with the online nature of the study and the dyadic nature of the interviews leading to potential accessibility issues. This latter point brings up a particularly notable limitation, which for some individuals was felt to be at odds with the over-arching principle of neurodiverse-affirming research. Specifically, this meant that participants were only able to take part if they had a parent or caregiver that was able to take part with them. This was met by significant backlash during recruitment from some members of the Autistic community, as they were not able to take part in the study individually. While the purpose of the dyads was then explained and generally accepted, it is still worth noting the possible risk of recruitment bias this placed on the study sample. Concerns of bias also arise when considering the use of self-report measures in Studies 3 and 4. While a more efficient option for collecting data, self-report measures run the risk of response bias (Rosenman, Tennekoon & Gill, 2011), with participants often reporting higher rates of the behaviour in question than warranted (Brenner & DeLamater, 2016). There are widespread concerns regarding the over-reliance on self-report measures of both interoception (Kinnaird et al, 2020c) and alexithymia (Preece et al, 2020), particularly with inconsistent results reported between self-report and more objective measures of both factors (Kinnaird et al, 2020; Ryan et al, 2021).

Encouraging progress has been made with regards to more objective measures of gastrointestinal interoception (Khalsa et al, 2022) and skin conductance as an indicator of alexithymia (e.g., Gaigg et al, 2018), however considerably less research has been done validating and fine tuning these approaches.

Another possible limitation of the current thesis is the focus on AN and the subsequent neglect of other EDs. The consideration and exploration of other restrictive eating disorders (REDs), such as Avoidant and Restrictive Food Intake Disorder (ARFID), will be integral in deepening our understandings of the overlap between autism and EDs. There is increasing evidence to support elevated Autistic traits in ARFID populations (Inoue et al, 2021; Koomar et al, 2021). However, ARFID is a relatively new addition to the DSM-5 (APA, 2013) and remains poorly understood as an ED diagnosis, let alone as a co-occurring condition with autism. Investigating the overlap between autism and ARFID, as well as further exploring the role of implicated factors such as sensory processing, should be considered a research priority in the field of autism and EDs. Furthermore, there is a lack of consideration, both in the current thesis and in the broader field, on other EDs, such as Bulimia Nervosa (BN) or Binge Eating Disorder (BED). Recent evidence suggests that there are elevated Autistic traits in both BN and BED (Gesi et al, 2020; Huke et al, 2013; Karjalainen et al, 2016; Numata et al, 2021). It would be interesting to explore the role of sensory, social and emotional factors in Autistic individuals across the ED spectrum. For example, it could be that hypersensitivity's to certain tastes or smells may play more of a role in restrictive eating behaviours, while hyposensitivity's and sensory seeking may lead to binge/purge eating behaviours. Emotion factors could also have complex, nuanced influences on disordered eating behaviours. It could be that both restrictive eating and binge/purge eating behaviours function as a form of emotion regulation, manifesting as different eating patterns. Future research exploring sensory, social and emotional factors across ED diagnosis in Autistic individuals will contribute to a sparse evidence base, with the possibility of identifying transdiagnostic trajectories and of encouraging research into under researched ED populations.

Finally, while the rationale for choosing not to differentiate between current and recovered AN on the basis of weight has been provided in earlier chapters, it is worth noting that this could be considered a limitation in terms of interpreting thesis findings. This is less of a concern for the qualitative and developmental approach adopted in Study 1, where the influence of certain factors were discussed across the AN trajectory and the lived/living experience allowed insight into how sensory and social factors differed between current and recovered stages of AN. However, with regards to the observational study, caution should be warranted. Due to the small, uneven sample sizes and underpowered analyses, BMI could not be controlled for. For future researchers similarly hoping to move away from weight-focused criteria for AN, it will be a necessity to control for BMI in statistical analyses, particularly in studies that explore phenomena influenced by starvation, such as cognitive or socio-emotional processing (Treasure, 2013).

On a related note, there were several reasons for the small sample size that are worth reflecting on, particularly with regards to recruitment. Despite being a PhD in Clinical Psychology, my doctorate was based in an academic institution and did not have any official associations with clinical services in the NHS Lothian. One of my supervisors was a Clinical Psychologist in CAMHS which as indispensable within child and adolescent services, but given the range of my sample (16-25 years old the majority of my participants were needed from adult services. Given that these services are already under a tremendous amount of pressure it was commendable they agreed to facilitate participation in the first place, but there was only so much that could be done. Adverts and flyers were placed in waiting rooms, however in preparation for future recruitments I plan to prioritise developing contacts and professional relationships with clinicians working with ED services across Scotland. There were also practical issues with recruitment, chiefly that the Clinical Psychology labs at the University of Edinburgh were delayed in their reopening from October 2022 to February 2023, halting recruitment for three months. These systemic and institutional issues are inherent to the nature of the PhD and can often confer more significant but less discussed limitations on research than are not typically discussed in the write up of studies. However, such issues are a fundamental part of academic life, and adjusting to delays and changes in proposed timelines are lessons worth learning. I should

also note that the methodological and statistical challenges of working with a small sample and complex data set are an aspect of my PhD that I found to be the most insightful and rewarding, ultimately improving my confidence and abilities in data literacy and analysis.

Strengths

There were several notable strengths of the current thesis. As stated in chapter 1, all empirical studies involved some element of co-production. This is best reflected in Study 1, where an Autistic researcher with lived/living experience of AN (EM) was involved across the research process, through study design, data analysis and write up. The co-production process was felt by both to be hugely beneficial and productive. I found the process to be invaluable, as the act of collaborating shed novel insights into experiences and interpretations that are out with my limited neurotypical perspectives. For example, during the development of themes in Study 1, I initially interpreted instances of body checking as something physical and associated with body image, while EM interpreted this as a safety behaviour; less of a physical act than one of reassurance. Feedback from EM has also been very positive, particularly with regards to the responsiveness and commitment to participatory research values in myself and the broader research team. Over the course of my PhD, I feel I have learned so much from this collaboration, and it is probably the aspect of this thesis that I am the proudest of.

Another strength of the thesis is the inclusion of novel and multiple-research methods. This is a notable strength both in its contribution to the literature and in its influence on my continuing professional development. By drawing on a number of different methodologies – systematic reviews, qualitative methods and observational methods – the current thesis provides a nuanced and multi-faceted understanding of sensory, social and emotional factors. Starting with a systematic and rigorous design, the thesis went on to further explore identified factors through the inclusion of lived/living experience perspectives and the use of ecologically valid observational methods. Furthermore, the use of methods in Study 2, 3 and 4 were entirely novel to the field. To date, no study has conducted qualitative research with Autistic adults with AN and their parents at the same time, nor conducted multi-

perspective IPA on qualitative data in this population. Indeed, to our knowledge no study to date had also included data triangulation with a lived/living experience researcher perspective. Study 3 and 4 were also the first to explore non-verbal social communication behaviours in autism and AN, as well as the first to apply and modify the non-verbal behavioural coding scheme to this same population. In a similar vein, the final leading strength of the thesis is the inclusion of an Autism and AN sample. While this has been done in qualitative studies (e.g., Kinnaird et al, 2019; Brede et al, 2020), previous quantitative studies have relied on measuring Autistic traits as an indicator of autism and Autism only samples as a comparator group (e.g., Kerr-Gaffney et al, 2020a; Dinkler et al, 2019). By including a co-occurring autism and AN group, this allows a more controlled and direct comparison between groups and will be imperative for future studies seeking to understand the role of sensory, social and emotional factors in the overlap between the two conditions.

Reflections on participatory research

The current thesis operated within an over-arching framework of participatory research principles. In Chapter 1, Section 1.3.2., this was defined as "*a shared culture of power and citizenship, embedded across multiple contexts and promoting the active involvement of communities in all stages of the decision-making process".* Furthermore, it was posited that true participatory research will incorporate these principles to involved those with lived/living experience at all stages of the research process, from *co-production* (e.g., study design and delivery), *co-interpretation* (e.g., interpreting the data) and *co-dissemination* (sharing study findings). It is worth reflecting on the application of these principles to the current thesis, highlighting what worked, what didn't and what can be done better in future research projects.

EM was involved as an Autistic researcher with lived/living experience of AN across all included studies. She played a key consultation role in the reviewing protocols for all empirical studies (*co-production*), as well as in the recruitment and dissemination of study findings (*co-dissemination*). In Study 1, EM was involved in the analysis of qualitative data,

offering a data triangulation perspective in the development of themes (*co-interpretation*). I believe that this approach is a leading strength of the thesis and is the best example of participatory research approach advocated by the project. It led to a collaborative relationship and the generation of meaningful themes and findings that more closely align with the community than I could have achieved from a singular, neurotypical perspective. Importantly, both EM and I found the process to be rewarding and beneficial – EM by being trained in qualitative analysis and all aspects of the research process, and myself by challenging my view of the world and the potential biases I may bring to the interpretation of data. For example, I viewed emerging themes regarding the identification and labelling of sensory factors and of emotions as separate themes and experiences, allocating them to discussions over sensory and socio-emotional factors respectively. Following EM's input, these themes were merged into a singular superordinate theme unique to the Autistic experience of AN, whereby feeling able to sense but not identify sensations and emotions gave rise to the same experience of confusion and distrust in the self.

While I believe this is a leading example of EM's involvement, it is also worth noting that EM made invaluable contributions across all aspects of her involvement in the thesis. EM's involvement ensured that research aims were aligned with the Autistic community, and I believe that the positive reaction from the Autistic and ED community of findings from published studies (Chapters 3 and 4) was fundamentally down to her input. I have enjoyed and benefited hugely from having EM as a collaborator and as a friend, and I will be eternally grateful for her guidance.

It is in this gratitude for her role in the current thesis that I also feel the need to reflect on possible tensions that can arise from conducting participatory research. Specifically, EM was involved in a considerable amount of work, but did not receive any payment for this involvement. This was made clear to EM from the outset, and yet this still does not sit right and is at odds with true participatory research designs. Imbalanced power dynamics are often at the heart of tokenistic participatory research and ensuring that lived/living experience researchers are compensated for their work is an inherently simple yet often

overlooked aspect of these designs. There are several reasons for this lack of payment – resources, limited time frames, lack of experience and foresight – however these are reasons, not excuses. EM was an author on Study 1, which was an important acknowledgement of her contribution in the data analyses and could be viewed as an adequate interim measure, but emphasis here should be on interim. It is also worth noting that doing so should not become the norm, or the sum of compensation for lived/living experience researchers, as it has the potential to become a tokenistic gesture that fundamentally undermines principles of shared power and citizenship.

In a similar vein, it should be noted that EM was not involved in the co-production stage of studies 2 and 3. This was because she was involved in the development of the protocol and was thus not blinded to the study aims, which is a requirement in the involvement of a second coder whilst refining a behavioural coding scheme. This therefore meant that a lived/living experience perspective was not involved in the development of the non-verbal behavioural coding scheme, which is a particular limitation when considering the aim of including autism-specific behaviours. Due a lack of funding within the PhD, and a lack of foresight from myself, I did not have the funds to compensate another lived/living experience researcher to collaborate with on the coding scheme. This raised another source of tension regarding compensation for participatory research designs – what to do when participatory research roles are important but financial compensation is not an option. As stated above, relying on offering co-authorship as compensation undermines the principle of participatory research designs, however this does not mean that it cannot be administered on a case-by-case basis, subject to the individual's preferences. Fundamentally, the Autistic and ED community should be consulted as to their preferred means of compensation and, in line with the true values of shared power and citizenship, should be awarded the agency to make this choice where possible.

A final source of tension that may arise can come from establishing boundaries in the role and skillset of those with lived/living experience in participatory designs. I was conscious throughout to not overload EM, attempting to draw on her expertise when relevant without overloading her or asking things of her beyond her expertise. Currently, the parameters of these roles are poorly defined, with the line between lived/living experience input and the

requirements of a research skillset often blurred and hard to navigate. This is something that urgently needs to be addressed within the infrastructure of academic and research institutions. There needs to be clear guidance for researchers working with participatory research designs in how and when to draw on these similar yet converging roles, as well as clear guidance, support and development opportunities for those with lived/living experience seeking to get involved in participatory research designs.

These reflections have keenly highlighted to me a number of limitations associated with participatory research designs. Across my PhD, I have observed notable disparity between the ideals and principles of co-production and how these translate into the reality of conducting participatory research. This could be attributable to a number of bi-directional concerns. A particularly relevant example for my research was time and resources. Time and resources required for meaningful participatory research is extensive and often at odds with the realities of research culture and the lived/living experience community. Another one reflected on above is establishing clear roles and managing expertise. While there are emerging guidelines for how to conduct participatory research, these are often vague and without examples or practical applications. Establishing best practice guidelines would help navigate this, for both researchers and for those with lived/living experience. It is also important to consider the unique context of specific populations, and work towards developing targeted participatory research guidelines, developed by and for Autistic individuals with EDs. Fundamentally, to address current limitations associated with participatory research designs, clear guidelines with practical applications are required that account and tailor for the needs of all parties – the individual, the broader community and the researcher themselves.

Conclusions

To conclude, findings from the current thesis provide novel insights into the role of sensory, social and emotional factors, as well as the complex interplay between the domains. The systematic review focused on understanding the role of sensory processing and eating behaviours in autism, before the remaining mixed-method studies explored this and other

associated factors in AN populations. Sensory processing was consistently implicated in autism and AN, with evidence across Study 1 suggesting that sensory factors may be important in future attempts to discriminate between Autistic and non-Autistic individuals with AN. Study 1 and 3 also highlighted the importance of social factors, suggesting key differences in experiences of social interactions and communication (Study 1), although this was not supported in Study 2. Finally, emotion difficulties were associated with both sensory (systematic review) and social (Study 1 and 3) factors.

Thesis findings highlight the importance of increasing awareness and understanding of the unique needs of Autistic people within ED services, and the importance of accounting for these needs whilst delivering ED interventions. Not only can this involve modifying current interventions or changing treatment targets, but researchers and clinicians should also seek to develop novel interventions, co-produced with Autistic individuals with lived/living experience of AN. Future research should adopt mixed method approaches in a broader range of ED diagnoses, drawing on lived/living experience perspectives to contextualise quantitative outcomes across ED experiences. Such research should also be co-produced, ensuring that research priorities are rooted in lived/living experience and that are translated into measurable and improved clinical outcomes. These approaches could also be utilised to develop neurodiverse-affirming theories or models of the overlap between autism and AN, generated by Autistic individuals with AN, for Autistic individuals with AN.

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Appendices

Appendix A. Study 1 ethical approval

SCHOOL *of* HEALTH IN SOCIAL SCIENCE

The University of Edinburgh
Medical School
Doorway 6, Teviot Place
Edinburgh EH8 9AG

Email ethics.hiss@ed.ac.uk

17 February 2022

Dear Emy Nimbley,

Reference: CLPS064
Project Title: Exploring social and sensory differences in autistic and non-autistic individuals and anorexia nervosa and their parents: a qualitative study

Thank you for submitting the above research project for review by the School of Health in Social Science Research Ethics Committee (REC). I can confirm that the submission has been independently reviewed and has received a favourable opinion on 19th November 2021.

The standard conditions of this are:

I. Conduct the project strictly in accordance with the proposal that you have submitted and that has been granted ethics favourable opinion, including any amendments made to the proposal required by the REC.
II. Advise the REC (by email to ethics.hiss@ed.ac.uk) of any complaints or other issues in relation to the project, which may warrant review of the favourable opinion granted to the project.
III. Make submission for approval of amendments to the project before implementing such changes.
IV. Advise in writing if the project has been discontinued.

The School's Research Ethics Policy and further information and resources are available on the School's website.

Best of luck with your project.

Yours sincerely,

Cecilia Malmberg

Administrative Secretary
School of Health in Social Science

Appendix B. Study 1 recruitment documents (PIS, study advert, study flyer)

Participant Information Sheet

Exploring social and sensory differences in autistic and non-autistic individuals with anorexia nervosa and their parents: a qualitative study

Following your expression of interest, you are being invited to take part in a research study looking at the role of social cognition and sensory processing in autistic and non-autistic individuals with anorexia nervosa. This project is conducted by Emy Nimbley, a PhD student at the University of Edinburgh, and is supervised by Dr Helen Sharpe, Dr Karri Gillespie-Smith and Dr Fiona Duffy. Before you decide to take part, it is important that you are provided with information regarding the purpose of the research and what taking part will involve. Please take time to read the following information carefully. Please do not hesitate to ask if you have any questions. Contact information is provided at the end of this form. Please take a screenshot of the following information for your records.

What is the purpose of the study?

The purpose of this study is to explore what factors affect disordered eating in autistic individuals with anorexia, as well as non-autistic individuals with current and/or lifetime history of anorexia. Particular interest lies in the potential role of differences in social cognition (how we think about social situations) and sensory processing (how our brains process sight, sound, smell, etc).

Why have you been invited to take part?

You have been invited to take part as you are either:

a) An autistic individual with current anorexia nervosa (including atypical anorexia nervosa) OR in recovery/remission from anorexia nervosa (here defined as 3+ years since your most recent, significant acute episode)

(b) A non-autistic individual with current anorexia nervosa (including atypical anorexia nervosa) OR in recovery/remission from anorexia nervosa (here defined as 3+ years since your most recent, significant acute episode)

This study will involve interviews in pairs with you and one of your parents/caregivers. This could be your mother or father, or someone who was primarily responsible for your care when you were growing up. Please note that in the current study both you and your parent/caregiver will be interviewed together, so both of you must agree for you to take part.

Do you have to take part?

No, you do not have to take part in the study. Participation is entirely up to you. If you do decide to take part, you will be asked to complete an informed consent sheet to demonstrate that you fully understand the purposes of the study and that you wish to take part. This study will involve interviewing you at the same time, in your adult-caregiver pairs. Following the interview, you are still able to withdraw your data within a 72-hour window, as your data will be anonymised after this time. Deciding not to take part or withdrawing from the study will not affect you in any way.

What will happen if you decide to take part?

Firstly, you must confirm that the other half of your adult-caregiver pair is willing to participate. Once this has been confirmed, and they have had the chance to read the information sheet, an email will be sent to you with the link to a secure online survey platform (Qualtrics). Through this link, you will have the chance to read the information sheet again and to provide consent before completing some questions regarding demographic information, such as your age and gender. Relevant confirmation of diagnosis (e.g., that you have received a clinical diagnosis of autism/anorexia or that your child has received a clinical diagnosis of autism/anorexia) will be then required. Following this, you will be asked to confirm your email address so that the research team can contact you to arrange a date to carry out the interview. Interviews can be conducted over the phone or using an online video platform, such as MS Teams or Zoom. We encourage you to pick the method of communication that you feel most comfortable with. It is also recommended that you opt for a time and place that allows you privacy and avoids disruption. Please let the researcher know what date and time will suit you best and the interview will be scheduled accordingly when possible.

The interview will last around 45-60 minutes and you will be interviewed at the same time, in your adult-caregiver pairs. The interviewer will ask exploratory questions, to both you and your caregiver, surrounding general factors that are perceived to affect disordered eating. Questions will also be asked about specific differences in social cognition, such as interacting socially or recognizing emotions, and whether such differences are thought to play a role in disordered eating. Finally, questions will be asked regarding the role of differences in sensory processing in both social cognition and in disordered eating. With your consent, the interview will be audio recorded. Following the interview, you will be verbally debriefed by the researcher and an electronic copy of the debrief will be sent to your email address.

What are the benefits of taking part?

There are no direct benefits but by sharing your experiences and insights with us, you will be helping the researchers understand more about the different factors involved in autism and anorexia. It is hoped that the findings of this study will provide a more detailed understanding of these factors and

in doing so, inform current treatments. It could also allow us to identify certain factors that may predispose an autistic individual to developing an eating disorder.

Are there any risks associated with taking part?

It is possible that the topic of the current study cause reflections or insights that may cause some distress. You have the right to pause or stop the interview at any time. If you are distressed following the interview, please contact any of the support networks that will be provided on the debrief sheet. You will be reminded of these options before and after the interview.

What if you no longer want to take part?

As previously noted, you have the right to withdraw from this study at any time, both during and after. However, if you wish to withdraw your data after the interview, you are only able to do this up to 72-hours following the interview. After this time, it will not be possible to withdraw as your interview will have been transcribed and your data will have been anonymised. If you do decide within the 72-hours, please notify one of the researcher supervisors.

Data protection and confidentiality

All the information we collect during the course of the research will be kept confidential and there are strict laws which safeguard your privacy at every stage.

How will we use information about you?

We will need to use information from you for this research project. This information will include your name and contact details. People will use this information to do the research or to check your records to make sure that the research is being done properly. People who do not need to know who you are will not be able to see your name or contact details. Your data will have a code number instead, and your name will be anonymised immediately in the event of transcription.

If you consent to being audio recorded, all recordings will be destroyed once they have been transcribed. Your data will only be viewed by the researcher/research team. All electronic data will be stored on a password-protected computer file and all paper records will be stored in a locked filing cabinet. Your consent information will be kept separately from your responses in order to minimise risk. Once we have finished the study, we will keep some of the data so we can check the results. We will write our reports in a way that no-one can work out that you took part in the study. **We will keep all information about you safe and secure.**

What are your choices about how your information is used?

- You can stop being part of the study at any time, without giving a reason, but we will keep information about you that we already have.
- We need to manage your records in specific ways for the research to be reliable. This means that we won't be able to let you see or change the data we hold about you.

Where can you find out more about how your information is used?

You can find out more about how we use your information at https://www.ed.ac.uk/records-management/privacy-notice-research, or:

- by asking one of the research team
- by sending an email to the University of Edinburgh Data Protection Officer at dpo@ed.ac.uk

As this study is being conducted at the University of Edinburgh, we will act at data controller for this study. This means we are responsible for taking care of your information, provided in order for you to participate in the study, and using it properly with regard to protection and privacy. Any personal, identifiable data will be destroyed after the duration of the study, while anonymized interview data will be kept in a secure online data repository for a minimum of 5 years and may be used in future ethically approved research. For further information please visit:

https://www.ed.ac.uk/records-management/privacy-notice-research

What will happen with the results of this study?

The results of the study will be written up in a PhD thesis, with scope to be used for a scientific paper submitted to an academic journal and/or conference presentation. Research summaries may be written and presented to communities or other interested parties. Findings will also be shared with participants if they so wish. Due to anonymisation, you will not be identifiable in any published study or results.

Who has reviewed the study?

The study has been reviewed and received ethical approval from the School of Health in Social Science at the University of Edinburgh [insert ethical approval]

Who can I contact?

If you wish to take part in our study, please get in touch with Emy Nimbley (see details below). Please also contact Emy Nimbley if you have any questions about the study or research outcomes.

Researcher:

Emy Nimbley

Department of Clinical and Health Psychology

School of Health in Social Science

Email:

Researcher external to the current project:

Dr Emily Newman

Department of Clinical and Health Psychology

School of Health in Social Science

Email:

If you have any complaints, please do contact the Head of School of Health in Social Sciences:

Prof Matthias Schwannauer
Department of Clinical and Health Psychology
School of Health in Social Sciences
Tel: +44 (0)131 651 3954
Email: headofschool.health@ed.ac.uk

Exploring social and sensory differences in autistic and non-autistic individuals with anorexia nervosa and their parents: a qualitative study

What factors affect disordered eating in autistic and non-autistic individuals? Do social or sensory differences play an important role? We would like to explore lived experiences of autistic and non-autistic individuals with anorexia nervosa and their parents/caregivers.

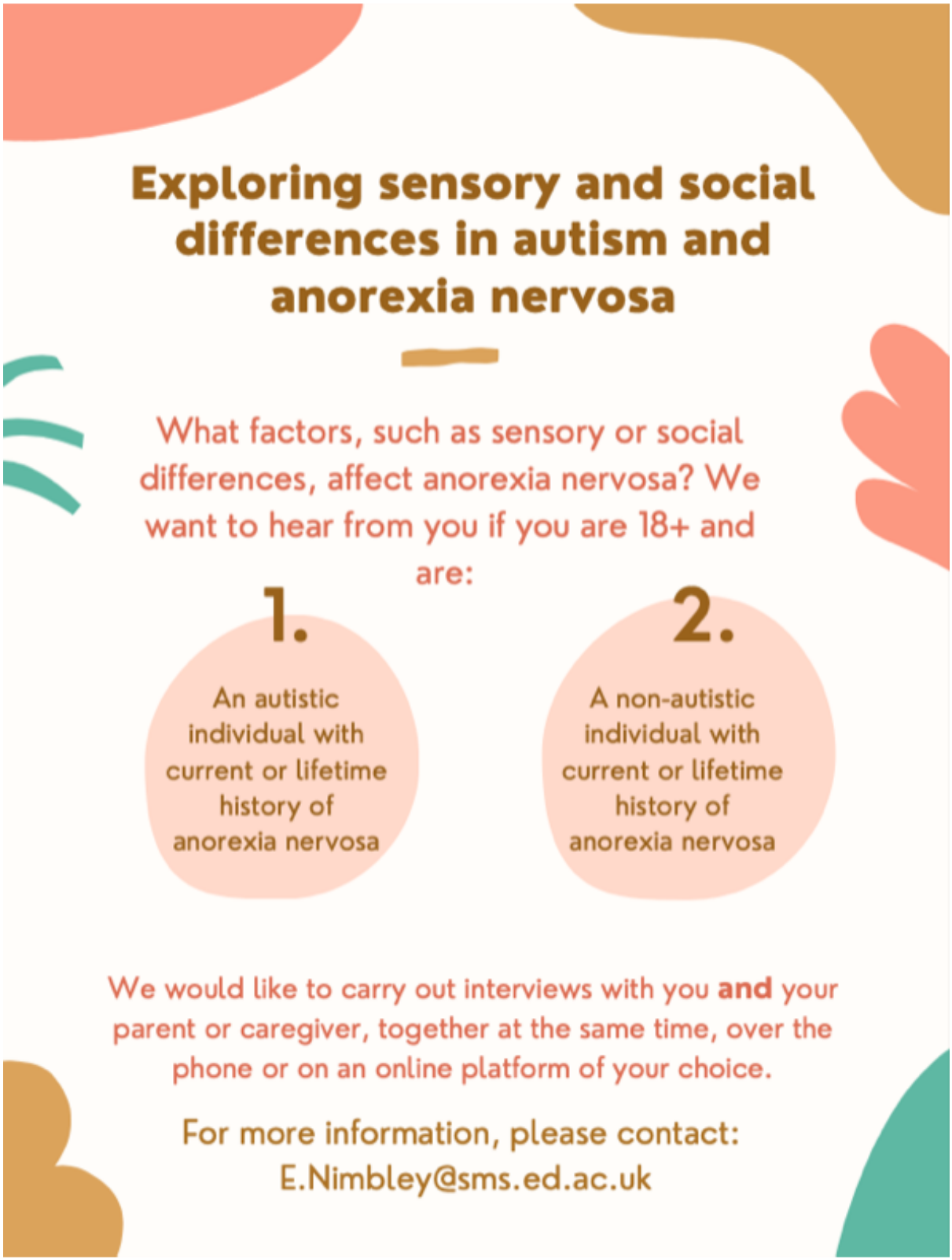
Researchers at the University of Edinburgh would like to hear from you if you are an English-speaking adult (over the age of 18 years old) who is any of the following:

(1) An autistic individual with current anorexia nervosa (including atypical anorexia nervosa) OR in recovery/remission from anorexia nervosa (here defined as 3+ years since your most recent, significant acute episode)

(2) A non-autistic individual with current anorexia nervosa (including atypical anorexia nervosa) OR in recovery/remission from anorexia nervosa (here defined as 3+ years since your most recent, significant acute episode)

This study will involve interviewing you with a parent or caregiver. This could be your mother or father, or someone who was primarily responsible for your care when you were younger. This study involves conducting interviews with you both together, at the same time, therefore both members of your pair must be willing to participate. We aim to carry out interviews over the phone or an online video platform.

If you are interested in participating in this research, please get in touch with the lead researcher Emy Nimbley:


Exploring sensory and social differences in autism and anorexia nervosa
What factors, such as sensory or social differences, affect anorexia nervosa? We want to hear from you if you are 18+ and are:
1.
An autistic individual with current or lifetime history of anorexia nervosa
2.
A non-autistic individual with current or lifetime history of anorexia nervosa
We would like to carry out interviews with you and your parent or caregiver, together at the same time, over the phone or on an online platform of your choice.
For more information, please contact:
E.Nimbley@sms.ed.ac.uk

Appendix C. Study 1 semi-structured interview schedule

Semi-Structured Interview Questions

Hello, my name is Emy Nimbley. I'm going to ask you some questions today about your experiences of having anorexia/having anorexia and being on the autistic spectrum [*delete as appropriate*]. I'm particularly interested in the impact of any social or sensory differences with regard to any disordered eating. If it's okay with you both, I will be recording this interview. This interview will be one of several that I'll be combining to try and generate an over-arching idea of what factors could be affecting disordered eating behaviours or habits. Your names will be anonymised immediately after the interview, so your identities will be protected. We adhere to a strict data management and privacy plan, which you can find details about on your information sheet.

I just want to remind at this point that you have the right to withdraw at any point of the interview today, as well as up to 72-hours after the interview has finished. If this is the case, please let me or one of the other research supervisors know, contact details of which you will be provided with at the end of the interview. Do you have any questions before we get started?

I'll address some questions to each of you directly, but please feel free to chip in if there is anything else you want to add to a particular question.

Note to researchers: many of the questions are worded as if addressed to the autistic/non-autistic individual, due the focus being on their disordered eating and possible co-existing autism. Throughout the course of the interview, tailor questions for parent/caregiver perspectives e.g., did your child experience any sensory differences in early childhood that may have contributed to any disordered eating/social differences? Follow a general pattern of having one member of the dyad answer a question before addressing it to the other.

Topic 1: Experience of getting diagnosed with anorexia.

- Could you give me a brief overview of how you arrived at a diagnosis of anorexia?
    - FOR COMORBIDITY: Which diagnosis came first?
    - Prompt parent/caregiver to contribute – maybe more information about early childhood, etc.

- Prompt individual to provide a rough idea/definition of where they perceive to be at with their anorexia.

Topic 2: General factors/behaviours

General prompts of factors: social interactions/relationships, development of self-concept, thinking styles and coping strategies, etc.

- Can you think of any factors or behaviours that you think affects your anorexia? For example, following our discussion on your experiences of getting diagnosed with anorexia, what kind of factors do you think played a role in that?
- What about factors that are currently sustaining/sustained your anorexia? Are there any differences between how it started and how it is being maintained?
    - Development vs maintenance
- Is there anything that makes it worse?
- Is there anything that makes it better?
- FOR COMORBIDITY: Are there different factors that affect your disordered eating and your autism? Are there any similar factors?

Topic 3: Differences in social cognition

- Do you think that there are any social factors that come into play for your disordered eating? Not so much interaction with others, more along the lines of ways in which you perceive other people and the world around you. This could be recognizing emotion, or being able to put yourselves in other people's shoes?
    - Ideas for prompts: empathising abilities (if this comes up, ask about whether this changes between neurodiverse and neurotypical – probe double empathy); paying attention in social situations; emotional responses to social situation.
    - Specific prompt for parents/caregivers to provide a developmental perspective – any social differences in infancy/childhood?
- FOR COMORBIDITY: Are there different social cognitive factors that affect your disordered eating and your autism? Are there any similar factors?

Topic 4: Differences in sensory processing

- Do you have any differences in social processing?
    - Are you particularly sensitive to any colours/touch/tastes/sounds/smells? This can be either overly or underly sensitive - for example, are you particularly sensitive to any particular smells or tastes?
    - Do you actively seek out certain sensations – for example, do you have certain sounds or noises that you seek out? Certain smells?
    - Do you always know when you feel hungry or full? Hot or cold? Thirsty?
    - Parents/caregivers and a developmental perspective – any social differences in infancy/childhood?

- Do you think that any of these differences play an important role in your disordered eating?

- Do you think these differences play an important role in any of the social cognitive differences we discussed earlier?

Thank you for taking part in the interview today! Do you have any questions for me before you go? I will send a debrief form on this chat, as well as email you both a copy after we have said our goodbyes. This is basically just to go over the aim of the study and to provide you with support resources and contact information should you want to get in touch. Would you like me to retain your email addresses and send you a summary of the results/or the finalised paper of the study once it is finished?

And finally, I would really appreciate if you are in a position to, to spread the word about the study and see if anyone else would meet the criteria would be interested. That's everything from me! Lovely to meet you both. Goodbye.

Appendix D. Study 1 data triangulation process

Table D1.

Summary table of the idiographic IPA approach adopted for the study, including the role of the Autistic researcher with lived/living experience of AN

IPA step	**Details of each IPA step**	**Role of autistic researcher with lived experience of AN**
Step 1: Looking for themes in the transcript	This step involves reading the transcript, re-reading the transcript, using the left-hand margin for note/points of interest and the right-hand margin for emerging themes	
Step 2: Connecting themes in the transcript	This step involves listing emerging themes, clustering the themes into superordinate themes and producing a table of coherently ordered themes with supporting quotes	Reviews the emerging themes and quotes, providing feedback and/or alternative suggestions Feedback is then integrated into subsequent revisions of individual themes
Step 3: Repeat process with all transcripts in group	This step involves repeating steps 1 and 2 for each individual transcripts in the first group of participants	
Step 4: Create table of superordinate themes across group transcripts	This step involves a finalised table of superordinate themes that have emerged across the group from individual transcripts	Reviews the emerging themes and quotes, providing feedback and/or alternative suggestions Feedback is then integrated into subsequent revisions of group themes
Step 5: Repeat previous steps for the second group of participants	This step involves repeating steps 1-4 for the second group of participants	Contributes to steps 2 and 4 outlined above for second group of participants
Step 6: Look for common and distinctive themes between groups of participants	This step refers to the write-up or presentation of the results, as opposed to the analysis; table of themes across groups are compared and similarities and differences are highlighted	Reviews and provides feedback until agreement is reached for final presentation of study results

Appendix E. Study 2 and 3 ethical approvals

Re: 22-23CLPS026_Level 1 application for REC ethically approved research

HR

HiSS Research Ethics <ethics.hiss@ed.ac.uk> Friday, 11 November 2022 at 10:33

To: Emy Nimbley

Dear Emy,

Thank you for your email and for providing us with all the relevant documents. We have now checked that your project adheres to any University governance concerns and your application has been logged. As your project has been reviewed and received a favourable opinion by IRAS it does not require further review by the Clinical Psychology Ethics Committee database.

If you need to make any changes to the protocol these would go through the REC, but I would appreciate if you could also copy University ethics into any correspondence.

Wishing you all the best with your project.

Best wishes,
Ingrid

Ingrid Obsuth, PhD
Lecturer in Clinical Psychology
Ethics & Integrity Lead

Lothian NHS Board

South East Scotland Research
Ethics Committee 02

Waverley Gate
2-4 Waterloo Place
Edinburgh
EH1 3EG
www.hra.nhs.uk

Enquiries to: Eilidh Clifford
Email:

07 February 2023

Miss Emy Nimbley

Dear Miss Nimbley,

Study title:	**Socio-emotional processing, interoception and social communciation in autistic and non-autistic individuals with anorexia nervosa: Exploring the role of eye gaze behaviour**
REC reference:	**22/SS/0092/AM01**
Protocol number:	**CAHSS22007/04**
Amendment number:	**Substantial amendment 1**
Amendment date:	**02 February 2023**
IRAS project ID:	**317643**

The above amendment was reviewed by the Sub-Committee in correspondence.

Ethical opinion

The members of the Committee taking part in the review gave a favourable ethical opinion of the amendment on the basis described in the notice of amendment form and supporting documentation.

The Sub-Committee had no ethical concerns regarding the amendment.

Approved documents

The documents reviewed and approved at the meeting were:

Document	*Version*	*Date*
Completed Amendment Tool [Amendment Tool_Emy Nimbley_317643]	1	02 February 2023
Other [Demographics V3]	V3	02 February 2023
Other [Demographics CLEAN 2 Feb 23]	V3	02 February 2023
Participant consent form [Consent form V3]	V3	02 February 2023
Participant consent form [Consent form CLEAN 2 Feb 23]	3	02 February 2023
Participant information sheet (PIS) [Participant Information Sheet	V3	02 February 2023

Appendix F. Study 2 and 3 recruitment documents

Participant Information Sheet

Socio-emotional processing, interoception and social communication in autistic and non-autistic individuals with anorexia nervosa: Exploring the role of eye gaze behaviour

You are being invited to take part in a research study looking at differences in how autistic and non-autistic young adults with anorexia nervosa process emotions, social cues and body sensations. This project is being run by Emy Nimbley, a PhD student at the University of Edinburgh, and is supervised by Dr Helen Sharpe, Dr Karri Gillespie-Smith and Dr Fiona Duffy. Before you decide if you would like to take part, it is important that you understand why we are doing the research and what you would be asked to do if you take part. Please take time to read this information carefully. If you want more information or aren't sure what something means, please do ask us. Our contact details are provided at the end of this form. Please take a screenshot of this information so you can come back to it later if you want to.

What is the purpose of the study?

The main purpose of this study is to look at how you process emotions and social cues. This includes things like the ability to recognise your own emotions and to identify emotions in other people. We want to explore whether autistic and non-autistic young adults with anorexia process emotions and social cues in the same way or if there are differences. We are also interested in how this may link with people's experience of body sensations (like hunger), and how they communicate with other people. We will also explore how autistic people communicate with other autistic people and compare this with how they communicate with non-autistic ('neurotypical') people. We hope that this study will help us identify some promising targets for future treatments for anorexia nervosa, including treatments for autistic individuals with anorexia nervosa.

Why have you been invited to take part?

You have been invited to take part if you are either:

1. An autistic young adult (16-25 years old) with anorexia nervosa, including atypical anorexia.
2. An autistic young adult (16-25 years old) without anorexia nervosa
3. A non-autistic young adult (16-25 years old) anorexia nervosa, including atypical anorexia.
4. A non-autistic young adult (16-25 years old) who has recovered from anorexia nervosa – here defined as 3+ years since your last most significant, acute episode.
5. A non-autistic young adult (16-25 years old) without anorexia nervosa.

You also need to be fluent in English to take part.

This study will involve a series of tasks, based at the University of Edinburgh. The first of these tasks will involve you completing the task on your own (processing emotion and social cues), while the final task will involve a short, structured conversation with a member of the research team (social communication).

Do you have to take part?

No, you do not have to take part in the study. It is entirely up to you. If you do decide to take part, you will be asked to sign a consent form before we collect any personal or study data to show that you understand what the study is about and that you want to take part. If you do decide to take part, you are still free to withdraw at any time during the study and without giving a reason. If you decide after you have taken part that you want to withdraw your data, you must contact us within 3 days for the first two tasks (processing emotions and social cues) and within 7 days for the data collected in the social communication task. Deciding not to take part or withdrawing from the study will not affect you or the health care you receive in any way.

What will happen if you decide to take part?

Once you have read this information, and we have answered all of your questions, we will first confirm you meet the criteria to take part in the study (e.g., your diagnosis of anorexia). You will then fill in the consent form and will be asked to complete a short survey on a secure online platform (Qualtrics). Through this link, you will have the chance to read this information sheet again, before providing demographic information including your age, gender and, if relevant, details regarding your anorexia diagnosis, age of onset and duration of your anorexia, and medication status. You will also be asked to provide your GP's contact details, so that we can let them know you are taking part in the study. You will then be assigned a unique identifier (a participant number) and asked to confirm your email address.

In the same survey, you will then be asked to complete a series of questionnaires. These questionnaires will ask you about eating disorder symptoms and possible autistic traits and behaviours. There will also be short questionnaires included asking you about depression and anxiety symptoms, as well as questions about how you experience emotions (alexithymia) and body sensations (interoception). Please try to answer all these questions and make sure to take as many breaks as you may need. There will be a resource list at the end of the survey in case responding to these questions causes any upset or distress. Once you have completed the survey, including demographics and questionnaires, the researcher will then get in touch to arrange a date and time using the contact details provided.

The study will take place on the University of Edinburgh campus in Edinburgh, Scotland. When you come to campus, we will check again that you are happy to take part in the study. With your consent we will need to measure your height and weight. You will then be asked to complete three tasks The first two tasks explore how you process emotions and social cues, and you will complete these by yourself on a computer. These two tasks will involve recording your eye gaze behaviours (where you are looking on a screen). The eye tracker machine is built into the screen and will only record *where you are looking* (it will not record you). The last task will look at social communication. For this task you will be paired with a member of the research team for a short, structured conversation, which will last around 15 minutes. With your consent we will video, and audio record this interaction using a university video camera.

The whole study, including the three tasks and questionnaires, will take a maximum of one and a half hours to complete. We will offer breaks throughout the session. At the end of the study, you will have a chance to ask any questions again and the researcher will give you more information about the study. We will also email you a copy of this information so you can look at it later. You will also be given a £20 Amazon voucher as a thank you for taking part in the study.

<u>What are the benefits of taking part?</u>

There are no direct benefits to taking part. However, by sharing your experiences with us, you will be helping the researchers working towards understanding why different people may develop anorexia. We hope that this will help us (and other researchers) to develop better assessments and treatments for anorexia.

<u>Are there any risks associated with taking part?</u>

The study is not designed to make you upset in any way. Our study team includes an autistic member who has lived experience of anorexia who has looked through all the tasks and information. However, it is possible that the topic and nature of the current study may cause distress. It is also important for you to know that we will be calculating your body mass index (your weight and height) when you arrive on the day of the study, and so we will need to weigh you. We are doing this because we need to control for the possible influence

that starvation or being at lower weight may have on the tasks we are exploring. If you are worried about this, please contact us in advance to let us know if there is anything we can do to make this experience less distressing for you.

You should also remember that you have the right to pause or stop taking part at any time. If you have any preferences that may help you feel more comfortable participating in the study – such as specific dates or times, changes we can make to the room or environment, clear communication of task requirements or anything along those lines – we will do our best to make these changes when possible. Please do not hesitate to get in touch with the lead researcher should this be that case. If you are distressed during or following the study, there will be a debrief sheet provided at the of the study with contact details of relevant support networks. There is also small risk of incidental findings, which are unforeseen or unexpected results from participating in the study that may be of clinical significance. If this happens, this information will be clearly communicated to yourself and to your GP.

What if you no longer want to take part?

You have the right to withdraw from participation at any time during the lead up and duration of the study by simply stopping completing the tasks or the questionnaires at any point. We ask that if you want to withdraw during the questionnaires that you notify the lead researcher of this. If you wish to withdraw your data after you have completed the study, you must email a member of the research team within 3 days. After this point your data will be anonymised (we won't be able to identify which is yours) in preparation for analysis. The only exception is the recording from the social communication task (task 3). If you wish to withdraw data from this task, you can email us up to 7 days after completing the task. After this time your data will have begun to be transcribed, coded and analysed, and it will not be possible to withdraw.

Risks of participation (COVID-19)

We have taken specific steps to minimise the risk of exposure to the Coronavirus during the study by following the guidance from the Scottish Government (https://www.gov.scot/coronavirus-covid-19/) You will only interact with researchers who are well, and have had no known contact with COVID-19 positive individuals for the past 14 days. However, even with these control measures, there remains some additional risk of exposure from participating in this study.

What if I am unwell?

If you feel unwell or have been in contact with a COVID-19 positive individual in the past 14 days, then please contact the researcher (see details at the end of the information sheet) and we will postpone or cancel the research interaction.

Will my taking part be kept confidential?

All the information we collect during the study will be kept confidential and there are strict laws which safeguard your privacy at every stage.

How will we use information about you?

We will need to use information from you for this research project.

This information will include your:

- Name
- Contact details (email address, mobile number).

People will use this information to do the research or to make sure that the research is being done properly. People who do not need to know who you are will not be able to see your name or contact details. Your data will have a unique identifying code number instead.

If you consent to being video recorded, all recordings will be destroyed once they have been uploaded to the encrypted and password-protected online platform (Microsoft Sharepoint) and the analysis has been conducted. This will also involve transcribing the data from the recordings (writing out what is said), which will be done by the lead researcher and will be anonymised so that there will be no way that someone could identify you. Your data will only be viewed by the research team. Your consent information will be kept separately from your responses in order to minimise identification risk. Once we have finished the study, we will keep some of the data so we can check the results. We will write our reports in a way that no-one can work out that you took part in the study. **We will keep all information about you safe and secure.**

What are your choices about how your information is used?

- You can stop being part of the study at any time, without giving a reason, but we will keep information about you that we already have. For the main data you will have 72 hours (3 days) to withdraw your data after taking part. For the social communication task, you will have up to 7 days.
- We need to manage your records in specific ways for the research to be reliable. This means that we won't be able to let you see or change the data we hold about you.

Where can you find out more about how your information is used?

You can find out more about how we use your information at

- https://www.ed.ac.uk/records-management/privacy-notice-research, or:

- by asking one of the research team
- by sending an email to the University of Edinburgh Data Protection Officer at dpo@ed.ac.uk

The University of Edinburgh will act at data controller for this study. This means we are responsible for taking care of your information, provided in order for you to participate in the study, and using it properly with regard to protection and privacy. Any personal, identifiable data will be destroyed within 6-12 months of the study finishing. Video recordings may require to be kept for a little longer, as we may need more time to analyse, and they will be deleted no later than July 2024. All anonymized data, including task data, anonymised transcripts and anonymised data from the video recordings, will be kept in a secure online data repository for a minimum of 5 years and may be used in subsequent, ethically approved research.

What will happen with the results of this study?

The results of the study will be written up in a PhD thesis and may be used in a scientific paper submitted to an academic journal and/or conference presentation. Summaries of the research may be written and presented to the general public or specific organisations. Findings may also be shared with participants if you so wish. If you wish to be contacted via email with a summary of research findings, please tell us this at the end of the study and we will share these when they are ready. You will not be identifiable in any published results.

Who has reviewed the study?

All research in the NHS is looked at by an independent group of people called a Research Ethics Committee. A favourable ethical opinion has been obtained from Southeast Scotland REC02. NHS Management Approval has also been given.

Who can I contact?

If you wish to take part in our study, please get in touch with the lead researcher Emy Nimbley (see details below). Please also contact Emy Nimbley if you have any questions about the study or research outcomes.

Researcher:

Emy Nimbley

Department of Clinical and Health Psychology

School of Health in Social Science

Email:

If you would like to discuss this study with someone independent of the study, please contact:

Dr Emily Newman

Department of Clinical and Health Psychology

School of Health in Social Science

Email:

If you have any complaints, please do contact the Head of School of Health in Social Sciences:

Prof Matthias Schwannauer

Department of Clinical and Health Psychology

School of Health in Social Sciences

Tel: +44 (0)131 651 3954

Email: headofschool.health@ed.ac.uk

Socio-emotional processing, interoception and social communication in autistic and non-autistic individuals with anorexia nervosa: Exploring the role of eye gaze behaviour

RESEARCH STUDY AT THE UNIVERSITY OF EDINBURGH

Do autistic and non-autistic individuals with anorexia have differences how they process emotions? And what do these differences have to do with how you identify and interpret experiences of body sensations, such as hunger or fullness, otherwise known as interoception, or how you communicate in social situation? We would like to investigate this possible relationship in autistic and non-autistic young adults with current or prior history of anorexia nervosa.

Please get in touch if you are a fluent English-speaking individual between the ages of 16 and 25 years old that falls into any of the following groups:

1. An autistic individual with anorexia nervosa, including atypical anorexia.
2. An autistic individual without current or prior history of anorexia nervosa
3. A non-autistic individual with anorexia nervosa, including atypical anorexia.
4. A non-autistic individual who has recovered from anorexia nervosa – here defined as 3+ years since your last most significant, acute episode.
5. A non-autistic individual without experience of anorexia nervosa

You will be invited to take part in a series of experimental tasks looking at emotion processing, followed by a short social communication task with a member of the research team. The study will take place on the University of Edinburgh campus, and it is estimated that total participation time will be a maximum of 2 hours. You will be thanked for your time with a £20 amazon voucher.

If you are interested in participating in this research, please get in touch with Emy Nimbley at the following email address:

Socio-emotional processing in autism and anorexia

Purpose

Researchers at the University of Edinburgh are looking to explore how autistic and non-autistic people process emotions, and the possible links with interoception (identifying internal bodily signals, like hunger and satiety) and social communication.

What does the study involve?

Taking part will involve a series of tasks at the University of Edinburgh exploring socio-emotional processing and possible links with interoception (internal bodily senses) and different social communication styles. You will be offered a £20 Amazon voucher for your time!

Eligibility

You are eligible to take part if you are aged 16-25 and fluent in English. You are also eligible if you are:

- Autistic, with or without anorexia
- Non-autistic with current or recovered anorexia
- Non-autistic with no history of anorexia

For more information, please contact: emy.nimbley@ed.ac.uk

Appendix G. Study 2 and 3 self-report measures

Eating Disorder Examination Questionnaire (EDE-Q 6.0)

Instructions: The following questions are concerned with the past four weeks (28 days) only. Please read each question carefully. Please answer all the questions. Thank you.

Questions 1 to 12: Please circle the appropriate number on the right. Remember that the questions only refer to the past four weeks (28 days) only.

	ON HOW MANY OF THE PAST 28 DAYS ...	NO DAYS	1-5 DAYS	6-12 DAYS	13-15 DAYS	16-22 DAYS	23-27 DAYS	EVERY DAY
1	Have you been deliberately trying to limit the amount of food you eat to influence your shape or weight (whether or not you have succeeded)?	0	1	2	3	4	5	6
2	Have you gone for long periods of time (8 waking hours or more) without eating anything at all in order to influence your shape or weight?	0	1	2	3	4	5	6
3	Have you tried to exclude from your diet any foods that you like in order to influence your shape or weight (whether or not you have succeeded)?	0	1	2	3	4	5	6
4	Have you tried to follow definite rules regarding your eating (for example, a calorie limit) in order to influence your shape or weight (whether or not you have succeeded)?	0	1	2	3	4	5	6
5	Have you had a definite desire to have an empty stomach with the aim of influencing your shape or weight?	0	1	2	3	4	5	6
6	Have you had a definite desire to have a totally flat stomach?	0	1	2	3	4	5	6
7	Has thinking about food, eating or calories made it very difficult to concentrate on things you are interested in (for example, working, following a conversation, or reading)?	0	1	2	3	4	5	6
8	Has thinking about shape or weight made it very difficult to concentrate on things you are interested in (for example, working, following a conversation, or reading)?	0	1	2	3	4	5	6
9	Have you had a definite fear of losing control over eating?	0	1	2	3	4	5	6

10	Have you had a definite fear that you might gain weight?	0	1	2	3	4	5	6
11	Have you felt fat?	0	1	2	3	4	5	6
12	Have you had a strong desire to lose weight?	0	1	2	3	4	5	6

Questions 13-18: Please fill in the appropriate number in the boxes on the right. Remember that the questions only refer to the past four weeks (28 days).

13	**Over the past 28 days, how many times have you eaten what other people would regards as an unusually large amount of food (given the circumstances)?**	
14	... On how many of these times did you have a sense of having lost control over your eating (at the time you were eating)?	
15	Over the past 28 days, on how many DAYS have such episodes of overeating occurred (i.e. you have eaten an unusually large amount of food and have had a sense of loss of control at the time)?	
16	Over the past 28 days, how many times have you made yourself sick (vomit) as a means of controlling your shape or weight?	
17	Over the past 28 days, how many times have you taken laxatives as a means of controlling your shape or weight?	
18	Over the past 28 days, how many times have you exercised in a "driven" or "compulsive" way as a means of controlling your weight, shape or amount of fat, or to burn off calories	

Questions 19 to 20: Please circle the appropriate number. Please note that for these questions the term "binge eating" means eating what others would regard as an unusually large amount of food for the circumstances, accompanied by a sense of having lost control over eating.

	ON HOW MANY OF THE PAST 28 DAYS ...	NO DAYS	1-5 DAYS	6-12 DAYS	13-15 DAYS	16-22 DAYS	23-27 DAYS	EVERY DAY
19	Over the past 28 days, on how many days have you eaten in secret (ie, furtively)?.....Do not count episodes of binge eating	0	1	2	3	4	5	6

		NONE OF THE TIMES	A FEW OF THE TIMES	LESS THAN HALF	HALF OF THE TIMES	MORE THAN HALF	MOST OF THE TIME	EVERY TIME
20	On what proportion of the times that you have eaten have you felt guilty (felt that you've done wrong) because of its effect on your shape or weight? ... Do not count episodes of binge eating.	0	1	2	3	4	5	6

In the past 28 days…

		NOT AT ALL	NOT MUCH	A LITTLE BIT	MODER-ATELY	QUITE A BIT	VERY MUCH	MARKED-LY
21	How concerned have you been about other people seeing you eat? (Do not count episodes of binge eating)	0	1	2	3	4	5	6
22	Has your weight influenced how you think about (judge) yourself as a person?	0	1	2	3	4	5	6
23	Has your shape influenced how you think about (judge) yourself as a person?	0	1	2	3	4	5	6
24	How much would it have upset you if you had been asked to weigh yourself once a week (no more, or less, often) for the next four weeks?	0	1	2	3	4	5	6
25	How dissatisfied have you been with your weight?	0	1	2	3	4	5	6
26	How dissatisfied have you been with your shape?	0	1	2	3	4	5	6
27	How uncomfortable have you felt seeing your body (for example, seeing your shape in the mirror, in a shop window reflection, while undressing or taking a bath or shower)?	0	1	2	3	4	5	6
28	How uncomfortable have you felt about others seeing your shape or figure (for example, in communal changing rooms,	0	1	2	3	4	5	6

	when swimming, or wearing tight clothes)?							

What is your weight at present? (Please give your best estimate.): _____

What is your height? (Please give your best estimate.): _____

If female: Over the past three to four months have you missed any menstrual periods?

☐ Yes ☐ No

If so, how many? _____

Have you been taking the "pill"? ☐ Yes ☐ No

Social Responsiveness Scale ©
Second Edition
SRS-2
John N. Constantino, MD and Christian P. Gruber, PhD

Reference

Constantino, J. N., & Gruber, C. P. (2012). *Social Responsiveness Scale, Second Edition (SRS-2)* [Manual]. Torrence, CA: Western Psychological Services.

Instructions: For each question, please select the answer that best describes your behaviour over the past 6 months.

		0 Not True	1 Some-times True	2 Often True	3 Almost Always True	Median value (do not include this column for participants)
1	I am much more uncomfortable in social situations than when I am by myself.					0
2	My facial expressions send the wrong message to others about how I actually feel.					0
3	I feel self-confident when interacting with others.					1
4	When under stress, I engage in rigid or inflexible patterns of behaviour that seem odd to people.					0
5	I do not recognize when others are trying to take advantage of me.					0
6	I would rather be alone than with others.					0
7	I am usually aware of how others are feeling.					1
8	I behave in ways that seem strange or bizarre to others.					0
9	I am overly dependent on others for help with meeting my everyday needs.					0
10	I take things too literally, and because of that, I misinterpret the intended meaning of part of a conversation.					0
11	I have good self-confidence.					1
12	I am able to communicate my feelings to others.					1

13	I am awkward in turn-taking interactions with others (for example, I have a hard time keeping up with the give-and-take of a conversation).					0
14	I am not well coordinated.					0
15	When people change their tone or facial expression, I usually pick up on that and understand what it means.					0
16	I avoid eye contact or am told that I have unusual eye contact.					0
17	I recognize when something is unfair.					0
18	I have difficulty making friends, even when trying my best.					0
19	I get frustrated trying to get ideas across in conversations.					0
20	I have sensory interests that others find unusual (for example, smelling or looking at things in a special way).					0
21	I am able to imitate other's actions and expressions when it is socially appropriate to do so.					0
22	I interact appropriately with other adults.					0
23	I do not join group activities or social events unless prompted or strongly urged to do so.					0
24	I have more difficulty than others with changes in my routine.					0
25	I do not mind being out of step with or "not on the same wavelength" as others.					1
26	I offer comfort to others when they are sad.					1
27	I avoid starting social interaction with other adults.					0
28	I think or talk about the same thing over and over.					0
29	I am regarded by others as odd or weird.					0
30	I become upset in situations with lots of things going on.					0
31	I can't get my mind off something once I start thinking about it.					0

32	I have good personal hygiene.					0
33	My behaviour is socially awkward, even when I am trying to be polite.					0
34	I avoid people who want to be emotionally close to me.					0
35	I have trouble keeping up with the flow of a normal conversation.					0
36	I have difficulty relating to family members.					0
37	I have difficulty relating to adults outside of my family.					0
38	I respond appropriately to mood changes in others (for example, when a friend's mood changes from happy to sad).					1
39	People think I am interested in too few topics, or that I get too carried away with those topics.					0
40	I am imaginative.					0
41	I sometimes seem to wander aimlessly from one activity to another.					0
42	I am overly sensitive to certain sounds, textures, or smells.					0
43	I enjoy small talk (casual conversation with strangers).					0
44	I have more trouble than most people with understanding chains of conversation (in other words, how events are related to one another).					0
45	When others around me are paying attention to something, I get interested in what they are attending to.					1
46	Others feel that I have overly serious facial expressions.					0
47	I laugh at inappropriate times.					0
48	I have a good sense of humour and can understand jokes.					0
49	I do extremely well at certain kinds of intellectual tasks, but do not do as well at most other tasks.					0

50	I have repetitive behaviours that others consider odd.					0
51	I have difficulty answering questions directly and end up talking around the subject.					0
52	I get overly loud without realizing it.					1
53	I tend to talk in a monotone voice (in other words, less inflection of voice than most people demonstrate).					0
54	I tend to think about other people in the same way I do objects.					0
55	I get too close to others or invade their personal space without realizing it.					1
56	I sometimes make the mistake of walking between two people who are trying to talk to one another.					0
57	I tend to isolate myself.					0
58	I concentrate too much on parts of things rather than seeing the whole picture.					0
59	I am more suspicious than most people.					0
60	Other people think I am emotionally distant and do not show my feelings.					0
61	I tend to be inflexible.					0
62	When I tell someone my reason for doing something, it strikes the person as unusual or illogical.					0
63	My way of greeting another person is unusual.					0
64	I am much more tense in social settings than when I am by myself.					0
65	I find myself staring or gazing off into space.					0

Interoception Sensory Questionnaire (ISQ-8)

Derived from 20-item ISQ (Fiene & Brownlow, 2018) by Zachary Williams

Directions: Please rate how true each statement is of you by marking one box per row.

	Not true at all of me				**Very true** of me
1. I have difficulty making sense of my body's signals unless they are very strong.	☐	☐	☐	☐	☐
2. I have difficulty feeling my bodily need for food.	☐	☐	☐	☐	☐
3. I'm not sure how my body feels when it's a hot day.	☐	☐	☐	☐	☐
4. I find it difficult to describe feelings like hunger, thirst, hot or cold.	☐	☐	☐	☐	☐
5. There are times when I am only aware of changes in my body because of the reactions of other people.	☐	☐	☐	☐	☐
6. I find it difficult to identify some of the signals that my body is telling me (e.g., If I'm about to faint or I've overexerted myself).	☐	☐	☐	☐	☐
7. I have difficulty locating injury in my body.	☐	☐	☐	☐	☐
8. Even when I know that I am physically uncomfortable, I do not act to change my situation.	☐	☐	☐	☐	☐

TORONTO ALEXITYMIA SCALE (TAS-20)

1	2	3	4	5
Strongly Disagree	**Disagree**	**Neither Disagree or Agree**	**Agree**	**Strongly Agree**

_____ 1. I am often confused about what emotion I am feeling.

_____ 2. It is difficult for me to find the right words for my feelings.

_____ 3. I have physical sensations that even doctors don't understand.

_____ 4. I am able to describe my feelings easily

_____ 5. I prefer to analyze problems rather than just describe them. _____ 6. When I am upset, I don't know if I am sad, frightened, or angry _____ 7. I find it hard to describe how I feel about people.

_____ 8. I prefer to just let things happen rather than to understand why they turned out that way.

_____ 9. I have feelings that I can't quite identify.

_____ 10. Being in touch with emotions is essential.

_____ 11. I am often puzzled by sensations in my body.

_____ 12. People tell me to describe my feelings more.

_____ 13. I don't know what's going on inside me.

_____ 14. I often don't know why I am angry.

_____ 15. I prefer talking to people about their daily activities rather than their feelings.

_____ 16. I prefer to watch "light" entertainment shows rather than psychological dramas.

_____ 17. It is difficult for me to reveal my innermost feelings, even to close friends.

_____ 18. I can feel close to someone, even in moments of silence.

_____ 19. I find examination of my feelings useful in solving personal problems

_____ 20. Looking for hidden meanings in movies or plays distracts from their enjoyment.

Hospital Anxiety and Depression Scale (HADS)

Tick the box beside the reply that is closest to how you have been feeling in the past week.
Don't take too long over you replies: your immediate is best.

D	A		D	A	
		I feel tense or 'wound up':			**I feel as if I am slowed down:**
	3	Most of the time	3		Nearly all the time
	2	A lot of the time	2		Very often
	1	From time to time, occasionally	1		Sometimes
	0	Not at all	0		Not at all
		I still enjoy the things I used to enjoy:			**I get a sort of frightened feeling like 'butterflies' in the stomach:**
0		Definitely as much		0	Not at all
1		Not quite so much		1	Occasionally
2		Only a little		2	Quite Often
3		Hardly at all		3	Very Often
		I get a sort of frightened feeling as if something awful is about to happen:			**I have lost interest in my appearance:**
	3	Very definitely and quite badly	3		Definitely
	2	Yes, but not too badly	2		I don't take as much care as I should
	1	A little, but it doesn't worry me	1		I may not take quite as much care
	0	Not at all	0		I take just as much care as ever
		I can laugh and see the funny side of things:			**I feel restless as I have to be on the move:**
0		As much as I always could		3	Very much indeed
1		Not quite so much now		2	Quite a lot
2		Definitely not so much now		1	Not very much
3		Not at all		0	Not at all
		Worrying thoughts go through my mind:			**I look forward with enjoyment to things:**
	3	A great deal of the time	0		As much as I ever did
	2	A lot of the time	1		Rather less than I used to
	1	From time to time, but not too often	2		Definitely less than I used to
	0	Only occasionally	3		Hardly at all
		I feel cheerful:			**I get sudden feelings of panic:**
3		Not at all		3	Very often indeed
2		Not often		2	Quite often
1		Sometimes		1	Not very often
0		Most of the time		0	Not at all

		I can sit at ease and feel relaxed:			**I can enjoy a good book or radio or TV program:**
	0	Definitely	0		Often
	1	Usually	1		Sometimes
	2	Not Often	2		Not often
	3	Not at all	3		Very seldom

Please check you have answered all the questions

Appendix H. Study 2 and 3 observational task script

Baseline:

Researcher: Hello! Nice to meet you, my name is [researcher name and background], and we will just be a having a short conversation to finish off today's study. Could you tell me a little bit more about yourself?

Participant:

Researcher: Thank you! And thanks for coming along today. Did you get here okay? How did you travel to the university? Did you find the building okay?

Participant:

Positive:

Researcher: Thank you. Could you possibly tell me about a positive experience you have had recently? Something that you enjoyed or made you happy?

Participant:

Researcher: (after unscripted back and forth) that sounds lovely! I think my most positive experience recently would be my brother's wedding. It was in Italy, and it was a beautiful setting – very romantic!

Participant:

Negative:

Researcher: We've just talked about a positive experience that we have both had recently; now I'm going to ask you to share a negative experience that you have had recently. Something that made you feel down or upset?

Participant:

Researcher: Thank you for sharing that. Recently I have had a pretty negative experience too. I fell over running for the bus and really hurt my knee. I ended up confined to the sofa – feeling pretty sorry for myself.

Participant:

Neutral:

Researcher: Great. So, after you have finished taking part in the study today, have you got any plans for the rest of the week or the weekend?

Participant:

Researcher: Sounds fun! I will be seeing a few more participants this week and then hopefully relaxing over the weekend. Nothing much planned at all really [change this to discuss actual weekend plans]

Participant:

Baseline:

Researcher: Well, thank you very much chatting with me today. How are you planning on travelling from the university after this?

Participant:

Researcher: I'll be here for a little longer and then walk home or take the bus.

Participant:

End:

Researcher: That's our short discussion over with. Thank you very much for taking part in it, and for taking part in the whole study today. It was lovely to meet you.

Appendix I. Study 2 and 3 Non-verbal behavioural coding manual

NON-VERBAL BEHAVIOURAL CODING: MANUAL

Adapted from Harrison (2021)

The following manual outlines a non-verbal communication behavioural coding scheme for use in a short, structured observational task between participant and researcher. Each category will be in ***bold italics***, before the relevant codes are included in the same column below. Operational definitions are then provided in the right-hand column (see Table 1).

Note that this is an event-based coding scheme, and as such codes should be assigned in a mutually exclusive way (e.g., only one code per category can be assigned at any given time). In other words, ensure that no two behaviours within the same category (e.g., Body Orientation) are coded for during the same time period.

When coding using the Excel spreadsheet, please ensure that you time stamp each behaviour, with a new time stamp on each row and the corresponding behavioural duration under the relevant code column. Similarly, as this is an events-based coding scheme, not two codes within the same category can be coded at the same time stamp; different categories can however be coded from the same time stamp. Repetitive Movements are the exception to this rule.

Body Orientation, Legs, Trunk Lean, Gaze, Hands and Repetitive Movement codes will be measured as **duration** codes (seconds/milliseconds). Please use a suitable timer to record these behaviours of interest (e.g., sports timer, timer application). Record the starting time as the Time Stamp and put the total duration (00:00.00) * in the relevant columns.

The coding scheme follows a Time-Event Sequential Coding approach, which allows to capture both the frequency and duration of target behaviours within a certain time frame. For the purposes of the current study, treat each condition as an independent sequence, and code the duration of behaviours within each condition independently – for example, if Hands are coded as on Legs at the end of the Positive condition, stop the timer at the end of the condition and reset as a new time stamp at the start of the Negative condition.

* Note: when inputting duration in Excel, the format of the cells will need to be changed in order to compute total duration. Do this by highlighting the relevant cells, right clicking > Format Cells > Custom > scroll down to mm:ss.0 > change to mm:ss.00 in the Type box > OK.

Table I1.

Non-verbal social communication codes.

Codes	Definition
Body Orientation	*Direction of the body in relation to conversational partner*
1. Facing	Directly facing conversational partner
2. Up to 44 °	Body angled up to 44° away from conversational partner
3. 45-90°	Body angled 45-90° away from conversational partner
4. >90°	Body angled >90° away from conversational partner
Legs	*Placement of legs*
1. Crossed	Legs are crossed over one another at either the knee, calf or ankles
2. Uncrossed	Legs are uncrossed and parallel to one another
Trunk Lean	*Trunk/Upper body position*
1. Upright	Upright seated position
2. Forwards	Trunk is slanted forwards from the hips
3. Backwards	Trunk is slanted backwards from the hips
4. Other	Trunk is leaning to the right or left
Gaze	*Gaze position*
1. On	Gaze is positioned directly towards conversational partner
2. Down	Gaze is positioned downwards
3. Away	Gaze is turned away from conversational partner, including ceiling
Hands	*Use of hands including position and gestures*
1. Beats	Hands move rhythmically along with the speech
2. Deictics	Hands gesture an object, point towards something of interest to direct attention
3. Iconics and metaphors	Hands gesture a real (iconics) or hypothetical/imagined (metaphors) spatial image, action or object
4. Head	Hand(s) touches the forehead or back of the head
5. Chin	Hand(s) touches the chin
6. Neck	Hand(s) touch the neck, including the back of the neck
7. Hair	Hand(s) touch or play with hair
8. Cheeks	Hand(s) touch the cheeks
9. Nails	Hand(s) play with, pick touches nails; person bites nails
10. Eyes	Hand(s) touch the eyes, including the eyebrows
11. Clothes	Hand(s) play with clothes, including hats
12. Nose	Hand(s) touch the nose
13. Ears	Hand(s) touch the ears or play with earrings
14. Jewellery	Hand(s) touch or play with a necklace, bracelet, earring or other item of jewellery
15. Mouth	Hand(s) touch the mouth
16. Arms	Hand(s) touch arms or hands clasped or held
17. Legs	Hand(s) rest on or touch any part of the legs, including lap. Only code for Table if the hands are unclasped; if they are clasped, code for Hands.
18. Trunk	Hand(s) touch any part of the trunk from the waist up to the base of the neck, including the shoulders
19. Sitting	Hand(s) touching chair or sat on (placed under rear on chair)

Repetitive Movements	*A similar movement or motion of the limbs, trunk or whole body that is repeated 3+ times OR over 3 times in the allocated timeframe (condition) - if the latter, code as total duration.*
1. Hands	Hand(s) engage in repetitive movements with each other, such as fidgeting or finger pulling, with other areas of the body, such as the hair, or with clothing, such as sleeves
2. Legs	Leg(s) and/or feet engage in repetitive movements, such as leg bobbing or foot tapping
3. Trunk/Whole Body	Trunk, including the arms, shoulders and torso, engages in repetitive movements, such as swaying or rocking.

Appendix J. Descriptive statistics for non-verbal behaviour data

Table J1.

Median and interquartile ranges (IQRs) for non-verbal behaviour codes across all conditions.

	Autism and AN	**Autism only**	**AN only**	**NT/HC**
	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)
Body Position				
Facing	1.0000 (.00)	1.0000 (.00)	1.0000 (.00)	1.0000 (.00)
Up to 44	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
45-90	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
>90	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Legs				
Crossed	.4068 (1.00)	.0000 (1.00)	1.0000 (.)	.3364 (1.00)
Uncrossed	.5932 (1.00)	1.0000 (1.00)	.0000 (.)	.6636 (1.00)
Trunk				
Upright	.6963 (.98)	.0000 (1.00)	.0000 (.)	.0000 (.45)
Forwards	.2921 (.91)	.0000 (1.00)	.0000 (.00)	.0067 (.13)
Backwards	.0000 (.01)	.0000 (1.00)	1.0000 (.)	.7807 (.81)
Other	.0000 (.02)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Gaze				
On	.5967 (.18)	.6934 (.41)	.7936 (.)	.8479 (.12)
Down	.1049 (.39)	.0268 (.45)	.0000 (.00)	.0024 (.01)
Away	.2280 (.25)	.1636 (.20)	.2064 (.)	.1462 (.11)
Hands				
Beats	.0000 (.04)	.0064 (.04)	.0000 (.)	.0098 (.09)
Diectics	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Iconics and metaphors	.0000 (.02)	.0096 (.04)	.0839 (.)	.0314 (.05)
Head	.0000 (.00)	.0000 (.00)	.0000 (.)	.0000 (.00)
Chin	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Neck	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Hair	.0000 (.01)	.0000 (.00)	.0000 (.)	.0000 (.01)
Cheeks	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Nails	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Eyes	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Clothes	.0264 (.18)	.0000 (.00)	.0000 (.)	.0000 (.00)
Nose	.0000 (.00)	.0000 (.00)	.0113 (.)	.0000 (.00)
Ears	.0000 (.00)	.0000 (.00)	.0000 (.)	.0000 (.00)
Jewellery	.0000 (.25)	.0000 (.00)	.0000 (.)	.0000 (.00)
Mouth	.0000 (.00)	.0000 (.00)	.0000 (.)	.0000 (.00)
Arms	.1602 (.57)	.0000 (.81)	.0000 (.)	.3635 (.94)
Legs	.1598 (.83)	.0373 (1.00)	.0000 (.)	.0565 (.59)
Trunk	.0000 (.01)	.0000 (.01)	.0152 (.)	.0000 (.21)
Sitting	.0000 (.01)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Repetitive Movements				
Hands	.0520 (.29)	.1714 (.18)	.2637 (.)	.0000 (.05)
Legs	.0000 (.06)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Whole Body	.0000 (.00)	.0000 (.01)	.0000 (.)	.0000 (.08)

Table J2.

Median and interquartile ranges (IQRs) for non-verbal behaviour codes in the positive condition.

	Autism and AN	**Autism only**	**AN only**	**NT/HC**
	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)
Body Position				
Facing	1.0000 (.00)	1.0000 (.00)	1.0000 (.00)	1.0000 (.00)
Up to 44	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
45-90	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
>90	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Legs				
Crossed	.2710 (1.00)	.0000 (.00)	1.0000 (.)	.0000 (1.00)
Uncrossed	.7290 (1.00)	1.0000 (1.00)	.0000 (.)	1.0000 (1.00)
Trunk				
Upright	.5546 (.99)	.0000 (1.00)	.0000 (.)	.0000 (1.00)
Forwards	.3001 (.97)	.0000 (1.00)	.0000 (.00)	.0000 (.01)
Backwards	.0000 (.00)	.0000 (1.00)	1.0000 (1.00)	.6667 (.100)
Other	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Gaze				
On	.5666 (.36)	.8190 (.29)	.8751 (.90)	.8435 (.20)
Down	.1247 (.41)	.0279 (.41)	.0000 (.00)	.0000 (.00)
Away	.2411 (.29)	.0925 (.23)	.1249 (.)	.1518 (.20)
Hands				
Beats	.0000 (.00)	.0000 (.02)	.0000 (.)	.0000 (.08)
Diectics	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Iconics and metaphors	.0000 (.01)	.0000 (.02)	.0000 (.)	.0000 (.06)
Head	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Chin	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Neck	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Hair	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Cheeks	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Nails	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Eyes	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Clothes	.0000 (.08)	.0000 (.00)	.0000 (.)	.0000 (.00)
Nose	.0000 (.00)	.0000 (.00)	.0000 (.)	.0000 (.00)
Ears	.0000 (.00)	.0000 (.00)	.0000 (.)	.0000 (.00)
Jewellery	.0000 (.25)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Mouth	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Arms	.0851 (.50)	.0000 (.89)	.0000 (.)	.0000 (.95)
Legs	.2655 (.87)	.0000 (1.00)	.0000 (.)	.0250 (.95)
Trunk	.0000 (.00)	.0000 (.00)	.0000 (.)	.0000 (.23)
Sitting	.0000 (.03)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Repetitive Movements				
Hands	.1663 (.95)	.0000 (.54)	.0000 (.)	.0000 (.00)
Legs	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Whole Body	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)

Table J3.

Median and interquartile ranges (IQRs) for non-verbal behaviour codes in the negative condition.

	Autism and AN	**Autism only**	**AN only**	**NT/HC**
	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)
Body Position				
Facing	1.0000 (.00)	1.0000 (.00)	1.0000 (.00)	1.0000 (.00)
Up to 44	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
45-90	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
>90	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Legs				
Crossed	.5000 (1.00)	0000 (1.00)	1.0000 (.)	.5000 (1.00)
Uncrossed	.5000 (1.00)	1.0000 (1.00)	.0000 (1.00)	.5000 (1.00)
Trunk				
Upright	.6654 (.97)	.0000 (1.00)	.0000 (.)	.0000 (.46)
Forwards	.2931 (.90)	.0000 (1.00)	.0000 (.00)	.0070 (.32)
Backwards	.0000 (.00)	.0000 (1.00)	1.000 (.)	.7702 (1.00)
Other	.0000 (.04)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Gaze				
On	.6481 (.18)	.5547 (.56)	.7783 (.)	.8130 (.14)
Down	.0950 (.31)	.0000 (.51)	.0000 (.)	.0000 (.01)
Away	.1792 (.28)	.1666 (.30)	.2271 (.)	.1870 (.10)
Hands				
Beats	.0000 (.04)	.0000 (.13)	.0000 (.00)	.0196 (.09)
Diectics	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Iconics and metaphors	.0000 (.02)	.0000 (.02)	.0925 (.)	.0360 (.11)
Head	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Chin	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Neck	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Hair	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.02)
Cheeks	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Nails	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Eyes	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Clothes	.0000 (.19)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Nose	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Ears	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Jewellery	.0000 (.33)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Mouth	.0000 (.00)	.0000 (.00)	.0000 (.)	.0000 (.00)
Arms	.0641 (.52)	.0000 (.79)	.0000 (.)	.3154 (.88)
Legs	.0000 (.79)	.0471 (1.00)	.0000 (.)	.1028 (.59)
Trunk	.0000 (.00)	.0000 (.02)	.0000 (.)	.0000 (.21)
Sitting	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Repetitive Movements				
Hands	.0000 (.10)	.0888 (.20)	.2238 (.)	.0000 (.00)
Legs	.0000 (.14)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Whole Body	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)

Table J4.

Median and interquartile ranges (IQRs) for non-verbal behaviour codes in the neutral condition.

	Autism and AN	**Autism only**	**AN only**	**NT/HC**
	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)
Body Position				
Facing	1.0000 (.00)	1.0000 (.00)	1.0000 (.00)	1.0000 (.00)
Up to 44	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
45-90	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
>90	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Legs				
Crossed	.5000 (1.00)	.0000 (1.00)	1.0000 (.)	.0000 (1.00)
Uncrossed	.5000 (1.00)	1.0000 (1.00)	.0000 (.)	1.0000 (1.00)
Trunk				
Upright	.9718 (1.00)	.0000 (1.00)	.0000 (.)	.0000 (.13)
Forwards	.0000 (1.00)	.0000 (1.00)	.0000 (.00)	.0000 (.03)
Backwards	.0000 (.00)	.0000 (1.00)	1.0000 (.)	.9709 (.40)
Other	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Gaze				
On	.6913 (.19)	.6758 (.35)	.6101 (.)	.8535 (.15)
Down	.1287 (.44)	.0000 (.39)	.0000 (.00)	.0000 (.01)
Away	.1607 (.27)	.1554 (.21)	.3899 (.)	.1465 (.15)
Hands				
Beats	.0000 (.00)	.0000 (.05)	.0000 (.00)	.0070 (.07)
Diectics	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Iconics and metaphors	.0000 (.00)	.0000 (.00)	.0502 (.)	.0000 (.09)
Head	.0000 (.00)	.0000 (.00)	.0000 (.)	.0000 (.00)
Chin	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Neck	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Hair	.0000 (.00)	.0000 (.00)	.0000 (.)	.0000 (.00)
Cheeks	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Nails	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Eyes	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Clothes	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Nose	.0000 (.00)	.0000 (.00)	.0280 (.)	.0000 (.00)
Ears	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Jewellery	.0000 (.04)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Mouth	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Arms	.3744 (.97)	.2962 (.93)	.0000 (.)	.8290 (.99)
Legs	.0554 (.95)	.0627 (1.00)	.0000 (.)	.0000 (.00)
Trunk	.0000 (.00)	.0000 (.00)	.0647 (.)	.0000 (.12)
Sitting	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Repetitive Movements				
Hands	.0000 (.00)	.0000 (.00)	.0000 (.)	.0000 (.00)
Legs	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)
Whole Body	.0000 (.00)	.0000 (.00)	.0000 (.00)	.0000 (.00)

Appendix K. Study 2 example syntax

```
* Encoding: UTF-8.

DATASET ACTIVATE DataSet1.

**TESTING FOR NORAMALITY.
*Assumptions of normality for demographics and questionnaire data .

EXAMINE VARIABLES=Age AN_agediagnosis AN_duration BMI WASI EDEQ_TOTAL SRS2_TOTAL
    ISQ8_TOTAL HADS_TOTAL TAS20_TOTAL
  /PLOT BOXPLOT STEMLEAF HISTOGRAM NPPLOT
  /COMPARE GROUPS
  /STATISTICS DESCRIPTIVES EXTREME
  /CINTERVAL 95
  /MISSING LISTWISE
  /NOTOTAL.

*Between group differences for demographic and questionnaire variables that meet the assumption
of normality .

ONEWAY AN_duration BMI WASI EDEQ_TOTAL SRS2_TOTAL ISQ8_TOTAL HADS_TOTAL
TAS20_TOTAL BY Group
  /STATISTICS DESCRIPTIVES HOMOGENEITY
  /MISSING ANALYSIS
  /CRITERIA=CILEVEL(0.95)
  /POSTHOC=TUKEY ALPHA(0.05).

*Assumptions of normality for non-verbal behaviours overall .

EXAMINE VARIABLES=overall_proportion_bodypos_facing overall_proportion_bodypos_44
    overall_proportion_bodypos_45_90 overall_proportion_bodypos_90
overall_proportion_legs_crossed
```

```
    overall_proportion_legs_uncrossed overall_proportion_trunk_upright
    overall_proportion_trunk_forwards overall_proportion_trunk_backwards
overall_proportion_trunk_other
    overall_proportion_gaze_on overall_proportion_gaze_down overall_proportion_gaze_away
    overall_proportion_hands_beats overall_proportion_hands_diectic
overall_proportion_hands_iconics
    overall_proportion_hands_head overall_proportion_hands_chin overall_proportion_hands_neck
    overall_proportion_hands_hair overall_proportion_hands_cheeks overall_proportion_hands_nails
    overall_proportion_hands_eyes overall_proportion_hands_clothes
overall_proportion_hands_nose
    overall_proportion_hands_ears overall_proportion_hands_jewellery
overall_proportion_hands_mouth
    overall_proportion_hands_arms overall_proportion_hands_legs overall_proportion_hands_trunk
    overall_proportion_hands_sitting overall_proprotion_RM_hands overall_proprotion_RM_legs
    overall_proprotion_RM_trunk
  /PLOT BOXPLOT STEMLEAF HISTOGRAM NPPLOT
  /COMPARE GROUPS
  /STATISTICS DESCRIPTIVES EXTREME
  /CINTERVAL 95
  /MISSING LISTWISE
  /NOTOTAL.
```

**Assumptions of normality for non-verbal behaviours in the positive condition .*

```
EXAMINE VARIABLES=pos_proprotion_bodypos_facing pos_proprotion_bodypos_44
    pos_proprotion_bodypos_45_90 pos_proprotion_bodypos_90 pos_proprotion_legs_crossed
    pos_proprotion_legs_uncrossed pos_proprotion_trunk_upright pos_proprotion_trunk_forwards
    pos_proprotion_trunk_backwards pos_proprotion_trunk_other pos_proprotion_gaze_on
    pos_proprotion_gaze_down pos_proprotion_gaze_away pos_proprotion_hands_beats
    pos_proprotion_hands_diectics pos_proprotion_hands_iconics pos_proprotion_hands_heads
    pos_proprotion_hands_chin pos_proprotion_hands_neck pos_proprotion_hands_hair
    pos_proprotion_hands_cheeks pos_proprotion_hands_nails pos_proprotion_hands_eyes
    pos_proprotion_hands_clothes pos_proprotion_hands_nose pos_proprotion_hands_ears
    pos_proprotion_hands_jewellery pos_proprotion_hands_mouth pos_proprotion_hands_arms
```

```
  pos_proprotion_hands_legs pos_proprotion_hands_trunk pos_proprotion_hands_sitting
  pos_proportion_RM_hands pos_proportion_RM_legs pos_proportion_RM_trunk
 /PLOT BOXPLOT STEMLEAF HISTOGRAM NPPLOT
 /COMPARE GROUPS
 /STATISTICS DESCRIPTIVES EXTREME
 /CINTERVAL 95
 /MISSING LISTWISE
 /NOTOTAL.
```

**Assumption of normality for non-verbal behaviours in the negative condition*

```
EXAMINE VARIABLES=neg_proprotion_bodypos_facing neg_proprotion_bodypos_44
  neg_proprotion_bodypos_45_90 neg_proprotion_bodypos_90 neg_proprotion_legs_crossed
  neg_proprotion_legs_uncrossed neg_proprotion_trunk_upright neg_proprotion_trunk_forwards
  neg_proprotion_trunk_backwards neg_proprotion_trunk_other neg_proprotion_gaze_on
  neg_proprotion_gaze_down neg_proprotion_gaze_away neg_proprotion_hands_beats
  neg_proprotion_hands_diectics neg_proprotion_hands_iconics neg_proprotion_hands_head
  neg_proprotion_hands_chin neg_proprotion_hands_neck neg_proprotion_hands_hair
  neg_proprotion_hands_cheeks neg_proprotion_hands_nails neg_proprotion_hands_eyes
  neg_proprotion_hands_clothes neg_proprotion_hands_nose neg_proprotion_hands_ears
  neg_proprotion_hands_jewellery neg_proprotion_hands_mouth neg_proprotion_hands_arms
  neg_proprotion_hands_legs neg_proprotion_hands_trunk neg_proprotion_hands_sitting
  neg_proportion_RM_hands neg_proportion_RM_legs neg_proportion_RM_trunk
 /PLOT BOXPLOT STEMLEAF HISTOGRAM NPPLOT
 /COMPARE GROUPS
 /STATISTICS DESCRIPTIVES EXTREME
 /CINTERVAL 95
 /MISSING LISTWISE
 /NOTOTAL.
```

**Assumptions of normality for non-verbal behaviours in the neutral condition*

```
EXAMINE VARIABLES=neut_proportion_bodypos_facing neut_proportion_bodypos_44
   neut_proportion_bodypos_45_90 neut_proportion_bodypos_90 neut_proportion_legs_crossed
   neut_proportion_legs_uncrossed neut_proportion_trunk_upright
neut_proportion_trunk_forwards
   neut_proportion_trunk_backwards neut_proportion_trunk_other neut_proportion_gaze_on
   neut_proportion_gaze_down neut_proportion_gaze_away neut_proportion_hands_beats
   neut_proportion_hands_diectics neut_proportion_hands_iconics neut_proportion_hands_head
   neut_proportion_hands_chin neut_proportion_hands_neck neut_proportion_hands_hair
   neut_proportion_hands_cheeks neut_proportion_hands_nails neut_proportion_hands_eyes
   neut_proportion_hands_clothes neut_proportion_hands_nose neut_proportion_hands_ears
   neut_proportion_hands_jewellery neut_proportion_hands_mouth neut_proportion_hands_arms
   neut_proportion_hands_legs neut_proportion_trunk neut_proportion_sitting
neut_proportion_RM_hands
   neut_proportion_RM_legs neut_proportion_RM_trunk
  /PLOT BOXPLOT STEMLEAF HISTOGRAM NPPLOT
  /COMPARE GROUPS
  /STATISTICS DESCRIPTIVES EXTREME
  /CINTERVAL 95
  /MISSING LISTWISE
  /NOTOTAL.
```

***BETWEEN GROUP DIFFERENCES .*

**Between-group differences for demographic and questionnaire variables that violated assumptions of normality .*

```
NPTESTS
  /INDEPENDENT TEST (Age AN_agediagnosis) GROUP (Group)
KRUSKAL_WALLIS(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.

NPTESTS
```

```
  /INDEPENDENT TEST (Age) GROUP (Group) KRUSKAL_WALLIS(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.
```

**Between-group differences for categorial demographic and questionnaire variables .*

```
CROSSTABS
  /TABLES=Gender BY Group
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT EXPECTED
  /COUNT ROUND CELL
  /METHOD=EXACT TIMER(5).

CROSSTABS
  /TABLES=Medication BY Group
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT EXPECTED
  /COUNT ROUND CELL
  /METHOD=EXACT TIMER(5).
```

**EXAMPLE: Non-parametrics independent samples between-group differences for overall non-verbal behaviours: hands category*

```
NPTESTS
  /INDEPENDENT TEST (overall_proportion_hands_beats overall_proportion_hands_diectic
    overall_proportion_hands_iconics overall_proportion_hands_head
overall_proportion_hands_chin
    overall_proportion_hands_neck overall_proportion_hands_hair overall_proportion_hands_cheeks
    overall_proportion_hands_nails overall_proportion_hands_eyes
overall_proportion_hands_clothes
    overall_proportion_hands_nose overall_proportion_hands_ears
overall_proportion_hands_jewellery
```

```
   overall_proportion_hands_mouth overall_proportion_hands_arms
overall_proportion_hands_legs
   overall_proportion_hands_trunk overall_proportion_hands_sitting) GROUP (Group)
   KRUSKAL_WALLIS(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.


* EXAMPLE: Benjamini-Hochberg multiple adjustments .

sort cases by p (a).
compute i=$casenum.
sort cases by i (d).
compute q=.05.
compute m=max(i,lag(m)).
compute crit=q*i/m.
compute test=(p le crit).
compute test=max(test,lag(test)).
execute.
formats i m test(f8.0) q (f8.2) crit(f8.6).
value labels test 1 'Significant' 0 'Not Significant'.


*EXAMPLE: Calculating effect size (Epsilon squared) for Kruskal-Wallis test in the hands category .

DATASET ACTIVATE DataSet1.
RANK VARIABLES=overall_proprotion_hands_beats overall_proprotion_hands_diectics
   overall_proprotion_hands_iconics overall_proprotion_hands_heads
overall_proprotion_hands_chin
   overall_proprotion_hands_neck overall_proprotion_hands_hair overall_proprotion_hands_cheeks
   overall_proprotion_hands_nails overall_proprotion_hands_eyes
overall_proprotion_hands_clothes
   overall_proprotion_hands_nose overall_proprotion_hands_ears
overall_proprotion_hands_jewellery
```

```
   overall_proprotion_hands_mouth overall_proprotion_hands_arms
overall_proprotion_hands_legs
   overall_proprotion_hands_trunk overall_proprotion_hands_sitting (A)
  /RANK
  /PRINT=YES
  /TIES=MEAN.

MEANS TABLES=Rank_pos_HandsBeats Rank_pos_HandsDiectics Rank_pos_HandsIconics
Rank_pos_HandsHead
   Rank_pos_HandsChin Rank_pos_HandsNeck Rank_pos_HandsHair Rank_pos_HandsCheeks
Rank_pos_HandsNails
   Rank_pos_HandsEyes Rank_pos_HandsClothes Rank_pos_HandsNose Rank_pos_HandsEars
   Rank_pos_HandsJewellery Rank_pos_HandsMouth Ranks_pos_HandsArms Rank_pos_HandsLegs
   Rank_pos_HandsTrunk Rank_pos_HandsSitting BY Group
  /CELLS=MEAN COUNT STDDEV
  /STATISTICS ANOVA.
```

***WITHIN GROUP DIFFERENCES .*

**EXAMPLE: Non-parametric within-group differences across conditions - hands category .*

**Nonparametric Tests: Related Samples.*

```
NPTESTS
  /RELATED TEST(pos_proprotion_hands_diectics neg_proprotion_hands_diectics
    neut_proportion_hands_diectics) KENDALL(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.
```

**Nonparametric Tests: Related Samples.*

```
NPTESTS
  /RELATED TEST(pos_proprotion_hands_iconics neg_proprotion_hands_iconics
    neut_proportion_hands_iconics) KENDALL(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.
```

```
*Nonparametric Tests: Related Samples.
NPTESTS
  /RELATED TEST(pos_proprotion_hands_head neg_proprotion_hands_head
neut_proportion_hands_head)
    KENDALL(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.

*Nonparametric Tests: Related Samples.
NPTESTS
  /RELATED TEST(pos_proprotion_hands_chin neg_proprotion_hands_chin
neut_proportion_hands_chin)
    KENDALL(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.

*Nonparametric Tests: Related Samples.
NPTESTS
  /RELATED TEST(pos_proprotion_hands_neck neg_proprotion_hands_neck
neut_proportion_hands_neck)
    KENDALL(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.

*Nonparametric Tests: Related Samples.
NPTESTS
  /RELATED TEST(pos_proprotion_hands_hair neg_proprotion_hands_hair
neut_proportion_hands_hair)
    KENDALL(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.

*Nonparametric Tests: Related Samples.
```

```
NPTESTS
  /RELATED TEST(pos_proprotion_hands_cheeks neg_proprotion_hands_cheeks
    neut_proportion_hands_cheeks) KENDALL(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.

*Nonparametric Tests: Related Samples.
NPTESTS
  /RELATED TEST(pos_proprotion_hands_nails neg_proprotion_hands_nails
neut_proportion_hands_nails)
    KENDALL(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.

*Nonparametric Tests: Related Samples.
NPTESTS
  /RELATED TEST(pos_proprotion_hands_eyes neg_proprotion_hands_eyes
neut_proportion_hands_eyes)
    KENDALL(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.

*Nonparametric Tests: Related Samples.
NPTESTS
  /RELATED TEST(pos_proprotion_hands_clothes neg_proprotion_hands_clothes
    neut_proportion_hands_clothes) KENDALL(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.

*Nonparametric Tests: Related Samples.
NPTESTS
  /RELATED TEST(pos_proprotion_hands_nose neg_proprotion_hands_nose
neut_proportion_hands_nose)
    KENDALL(COMPARE=PAIRWISE)
```

```
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.

*Nonparametric Tests: Related Samples.
NPTESTS
  /RELATED TEST(pos_proprotion_hands_ears neg_proprotion_hands_ears
neut_proportion_hands_ears)
    KENDALL(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.

*Nonparametric Tests: Related Samples.
NPTESTS
  /RELATED TEST(pos_proprotion_hands_jewellery neg_proprotion_hands_jewellery
    neut_proportion_hands_jewellery) KENDALL(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.

*Nonparametric Tests: Related Samples.
NPTESTS
  /RELATED TEST(pos_proprotion_hands_mouth neg_proprotion_hands_mouth
neut_proportion_hands_mouth)
    KENDALL(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.

*Nonparametric Tests: Related Samples.
NPTESTS
  /RELATED TEST(pos_proprotion_hands_arms neg_proprotion_hands_arms
neut_proportion_hands_arms)
    KENDALL(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.
```

```
*Nonparametric Tests: Related Samples.
NPTESTS
  /RELATED TEST(pos_proprotion_hands_legs neg_proprotion_hands_legs
neut_proportion_hands_legs)
    KENDALL(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.

*Nonparametric Tests: Related Samples.
NPTESTS
  /RELATED TEST(pos_proprotion_hands_trunk neg_proprotion_hands_trunk
neut_proportion_hands_trunk)
    KENDALL(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.

*Nonparametric Tests: Related Samples.
NPTESTS
  /RELATED TEST(pos_proprotion_hands_sitting neg_proprotion_hands_sitting
    neut_proportion_hands_sitting) KENDALL(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.


* EXAMPLE: Benjamini-Hochberg multiple adjustments .

sort cases by p (a).
compute i=$casenum.
sort cases by i (d).
compute q=.05.
compute m=max(i,lag(m)).
compute crit=q*i/m.
compute test=(p le crit).
compute test=max(test,lag(test)).
```

```
execute.
formats i m test(f8.0) q (f8.2) crit(f8.6).
value labels test 1 'Significant' 0 'Not Significant'.
```

**Calculating effect size (Kendall's W) for Kruskal-Wallis test in the hands category using the beats code as an example .*

```
NPTESTS
  /RELATED TEST(pos_proprotion_hands_beats neg_proprotion_hands_beats
neut_proportion_hands_beats)
    KENDALL(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.
```

Appendix L. Study 2 effect of condition on non-verbal behaviours

Autism and AN

Table L1.

Autism and AN within-group differences on Body Positioning codes.

	Mean rank	df	Chi-square	Kendall's W
Body Positioning				
Facing				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
<44				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
45 to 90				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
>90				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			

Table L2.

Autism and AN within-group differences on Legs codes.

	Mean rank	df	Chi-square	Kendall's W
Crossed	1.88	2	2.000	.125
Positive	2.06			
Negative	2.06			
Neutral				
Uncrossed				
Positive	2.13	2	2.000	.125
Negative	1.94			
Neutral	1.94			

Table L3.

Autism and AN within-group differences on Trunk codes.

	Mean rank	df	Chi-square	Kendall's W
Upright				
Positive	2.00	2	.143	.009
Negative	2.06			
Neutral	1.94			
Forwards				
Positive	2.13	2	1.000	.063
Negative	1.88			
Neutral	2.00			
Backwards				
Positive	2.06	2	.286	.018
Negative	1.94			
Neutral	2.00			
Other				
Positive	1.88	2	4.000	.250
Negative	2.25			
Neutral	1.88			

Table L4.

Autism and AN within-group differences on Gaze codes.

	Mean rank	df	Chi-square	Kendall's W
On				
Positive	1.63	2	2.250	.141
Negative	2.38			
Neutral	2.00			
Down				
Positive	2.00	2	.091	.006
Negative	1.94			
Neutral	2.06			
Away				
Positive	2.25	2	2.000	.125
Negative	2.13			
Neutral	1.63			

Table L5.

Autism and AN within-group differences on Hands codes.

	Mean rank	df	Chi-square	Kendall's W
Beats	1.94	2	.545	.034
Positive	2.13			
Negative	1.94			
Neutral				
Diectics				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Iconics/Metaphors				
Positive	1.94	2	1.400	.088
Negative	2.19			
Neutral	1.88			
Head				
Positive	1.94	2	2.000	.125
Negative	2.13			
Neutral	1.94			
Chin	2.00	2	.	.000
Positive	2.00			
Negative	2.00			
Neutral				
Neck				
Positive	2.13	2	2.000	.125
Negative	1.94			
Neutral	1.94			
Hair				
Positive	2.00	2	.286	.018
Negative	1.94			
Neutral	2.06			
Cheeks				
Positive	1.94	2	2.000	.125
Negative	2.13			
Neutral	1.94			

Nails	2.00	2	.	.000
Positive	2.00			
Negative	2.00			
Neutral				
Eyes				
Positive	2.13	2	2.000	.125
Negative	2.00			
Neutral	1.88			
Clothes				
Positive	2.13	2	1.412	.088
Negative	2.13			
Neutral	1.75			
Nose	2.00	2	.	.000
Positive	2.00			
Negative	2.00			
Neutral				
Ears				
Positive	2.13	2	2.000	.125
Negative	1.94			
Neutral	1.94			
Jewellery				
Positive	1.94	2	3.714	.232
Negative	2.25			
Neutral	1.81			
Mouth				
Positive	1.94	2	2.000	.125
Negative	1.94			
Neutral	2.13			
Arms				
Positive	2.00	2	2.000	.125
Negative	1.75			
Neutral	2.25			
Legs				
Positive	2.00	2	.118	.007
Negative	1.94			
Neutral	2.06			

Trunk	2.06	2	1.000	.063
Positive	1.88			
Negative	2.06			
Neutral				
Sitting				
Positive	2.13	2	2.000	.125
Negative	2.06			
Neutral	1.81			

Table L6.

Autism and AN within-group differences on Repetitive Movement codes.

	Mean rank	**df**	**Chi-square**	**Kendall's W**
Hands				
Positive	2.38	2	5.1443	.321
Negative	2.00			
Neutral	1.63			
Legs				
Positive	2.06	2	2.000	.125
Negative	2.13			
Neutral	1.81			
Whole Body/Trunk				
Positive	2.13	2	2.000	1.25
Negative	2.00			
Neutral	1.88			

Autism only

Table L7.

Autism only within-group differences on Body Positioning codes.

	Mean rank	df	Chi-square	Kendall's W
Facing				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
<44				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
45 to 90				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
>90				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			

Table L8.

Autism only within-group differences on Legs codes.

	Mean rank	df	Chi-square	Kendall's W
Crossed	2.00	2	.	.000
Positive	2.00			
Negative	2.00			
Neutral				
Uncrossed				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			

Table L9.

Autism only within-group differences on Trunk codes.

	Mean rank	df	Chi-square	Kendall's W
Upright				
Positive	2.00	2	2.000	.143
Negative	2.14			
Neutral	1.88			
Forwards				.000
Positive	2.00	2	.	
Negative	2.00			
Neutral	2.00			
Backwards				
Positive	2.00	2	2.000	.143
Negative	1.86			
Neutral	2.14			
Other				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			

Table L10.

Autism only within-group differences on Gaze codes.

	Mean rank	df	Chi-square	Kendall's W
On				
Positive	2.14	2	.857	.061
Negative	2.14			
Neutral	1.71			
Down				
Positive	2.14	2	.933	.067
Negative	2.07			
Neutral	1.79			
Away				
Positive	1.57	2	2.571	.184
Negative	2.00			
Neutral	2.43			

Table L11.

Autism only within-group differences on Hands codes.

	Mean rank	df	Chi-square	Kendall's W
Beats				
Positive	2.14	2	.615	.044
Negative	2.00			
Neutral	1.86			
Diectics				.000
Positive	2.00	2	.	
Negative	2.00			
Neutral	2.00			
Iconics/Metaphors				
Positive	2.14	2	.615	.044
Negative	2.00			
Neutral	1.86			
Head				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Chin				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Neck				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Hair				
Positive	1.86	2	2.000	.143
Negative	2.00			
Neutral	2.14			
Cheeks				

Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Nails				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Eyes				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Clothes				
Positive	2.00	2	2.000	.143
Negative	2.14			
Neutral	1.86			
Nose				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Ears				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Jewellery				
Positive	1.86	2	2.000	.143
Negative	2.00			
Neutral	2.14			
Mouth				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Arms				
Positive	2.14	2	.667	.048
Negative	1.86			
Neutral	2.00			
Legs				
Positive	1.71	2	3.714	.265

Negative	2.07			
Neutral	2.21			
Trunk				
Positive	1.70	2	3.000	.214
Negative	2.21			
Neutral	2.00			
Sitting				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			

Table L12.

Autism only within-group differences on Repetitive Movement codes.

	Mean rank	**df**	**Chi-square**	**Kendall's W**
Hands				
Positive	2.00	2	1.059	.076
Negative	2.21			
Neutral	1.79			
Legs				
Positive	2.00	2	2.000	.143
Negative	1.86			
Neutral	2.14			
Whole Body/Trunk				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			

AN only

Table L13.

AN only within-group differences on Body Positioning codes.

	Mean rank	df	Chi-square	Kendall's W
Facing	2.00	2	.	
Positive	2.00			.000
Negative	2.00			
Neutral				
<44				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
45 to 90				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
>90				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			

Table L14.

AN only within-group differences on Legs codes.

	Mean rank	df	Chi-square	Kendall's W
Crossed	2.00	2	.	.000
Positive	2.00			
Negative	2.00			
Neutral				
Uncrossed				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			

Table L15.

AN only within-group differences on Trunk codes.

	Mean rank	df	Chi-square	Kendall's W
Upright				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Forwards				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Backwards				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Other				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			

Table L16.

AN only within-group differences on Gaze codes.

	Mean rank	df	Chi-square	Kendall's W
On				
Positive	3.00	2	6.000	1.000
Negative	2.00			
Neutral	1.00			
Down				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Away				
Positive	1.00	2	6.000	1.000
Negative	2.00			
Neutral	3.00			

Table L17.

AN only within-group differences on Hands codes.

	Mean rank	df	Chi-square	Kendall's W
Beats				
Positive	2.33	2	2.000	.333
Negative	1.83			
Neutral	1.83			
Diectics				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Iconics/Metaphors				
Positive	1.67	2	3.000	.500
Negative	2.67			
Neutral	1.67			
Head				
Positive	1.83	2	2.000	.333
Negative	1.83			
Neutral	2.33			
Chin				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Neck				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Hair				
Positive	1.83	2	2.000	.333
Negative	1.83			
Neutral	2.33			
Cheeks				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			

Nails				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Eyes				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Clothes				
Positive	2.33	2	2.000	.333
Negative	1.83			
Neutral	1.83			
Nose				
Positive	2.17	2	2.000	.333
Negative	1.50			
Neutral	2.33			
Ears				
Positive	2.33	2	2.000	.333
Negative	1.83			
Neutral	1.83			
Jewellery				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Mouth				
Positive	1.83	2	2.000	.333
Negative	2.33			
Neutral	1.83			
Arms				
Positive	1.67	2	2.000	.333
Negative	2.00			
Neutral	2.33			
Legs				
Positive	2.33	2	2.000	.333
Negative	1.67			
Neutral	2.00			
Trunk				

Positive	1.50	2	2.000	.333
Negative	2.17			
Neutral	2.33			
Sitting				
Positive	2.00	2	1.000	.000
Negative	2.33			
Neutral	1.67			

Table L18.

AN only within-group differences on Repetitive Movement codes.

	Mean rank	**df**	**Chi-square**	**Kendall's W**
Hands				
Positive	2.00	2	1.000	.167
Negative	2.33			
Neutral	1.67			
Legs	2.00	2	.	.000
Positive	2.00			
Negative	2.00			
Neutral				
Whole Body/Trunk				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			

Neurotypical/Healthy controls

Table L19.

NT/HC within-group differences on Body Positioning codes.

	Mean rank	df	Chi-square	Kendall's W
Facing				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
<44				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
45 to 90				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
>90				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			

Table L20.

NT/HC within-group differences on Legs codes.

	Mean rank	df	Chi-square	Kendall's W
Crossed				
Positive	1.95	2	1.000	.050
Negative	2.10			
Neutral	1.95			
Uncrossed				
Positive	2.05	2	1.000	.050
Negative	1.90			
Neutral	2.05			

Table L21.

NT/HC within-group differences on Trunk codes.

	Mean rank	df	Chi-square	Kendall's W
Upright				
Positive	2.30	2	5.638	.282
Negative	1.95			
Neutral	1.75			
Forwards				
Positive	1.75	2	4.133	.207
Negative	2.30			
Neutral	1.95			
Backwards				
Positive	1.85	2	1.733	.087
Negative	1.95			
Neutral	2.20			
Other				
Positive	1.95	2	2.000	.100
Negative	2.10			
Neutral	1.95			

Table L22.

NT/HC within-group differences on Gaze codes.

	Mean rank	df	Chi-square	Kendall's W
On				
Positive	2.10	2	8.600	.430
Negative	1.30			
Neutral	2.60			
Down				
Positive	1.80	2	1.625	.081
Negative	2.15			
Neutral	2.05			
Away				
Positive	2.00	2	5.000	.250
Negative	2.50			
Neutral	1.50			

Table L23. Table

NT/HC within-group differences on Hands codes.

	Mean rank	df	Chi-square	Kendall's W
Beats				
Positive	1.80	2	1.333	.067
Negative	2.00			
Neutral	2.20			
Diectics				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Iconics/Metaphors				
Positive	1.75	2	2.138	.107
Negative	2.30			
Neutral	1.95			
Head				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Chin				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Neck				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Hair				
Positive	1.80	2	3.500	.175
Negative	2.25			
Neutral	1.95			
Cheeks				
Positive	1.95	2	2.000	.100
Negative	1.95			
Neutral	2.10			
Nails				

Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Eyes				
Positive	1.95	2	2.000	.100
Negative	2.10			
Neutral	1.95			
Clothes				
Positive	1.95	2	2.000	.100
Negative	1.95			
Neutral	2.10			
Nose				
Positive	1.90	2	1.000	.050
Negative	2.05			
Neutral	2.05			
Ears				
Positive	1.95	2	2.000	.100
Negative	2.10			
Neutral	1.95			
Jewellery				
Positive	1.95	2	3.714	.186
Negative	2.20			
Neutral	1.85			
Mouth				
Positive	1.95	2	2.000	,100
Negative	2.10			
Neutral	1.95			
Arms				
Positive	1.75	2	5.556	.278
Negative	1.75			
Neutral	2.50			
Legs				
Positive	2.40	2	8.400	.420
Negative	2.10			
Neutral	1.50			
Trunk				
Positive	2.15	2	3.714	.186

Negative	2.05			
Neutral	1.80			
Sitting				
Positive	2.00	2	.000	.100
Negative	2.00			
Neutral	2.00			

Table L24.

NT/HC within-group differences on Repetitive Movements codes.

	Mean rank	**df**	**Chi-square**	**Kendall's W**
Hands				
Positive	2.00	2	.	.000
Negative	2.00			
Neutral	2.00			
Legs				
Positive	1.90	2	2.000	.100
Negative	2.00			
Neutral	2.10			
Whole Body/Trunk				
Positive	2.00	2		.000
Negative	2.00			
Neutral	2.00			

Appendix M. Study 3 example syntax

```
* Encoding: UTF-8.

*EXAMPLE: Pearson's correlations for EDE-Q and non-verbal behaviours .

DATASET ACTIVATE Autism and AN .
NONPAR CORR
  /VARIABLES=EDEQ_TOTAL overall_proportion_bodypos_facing overall_proportion_bodypos_44
    overall_proportion_bodypos_45_90 overall_proportion_bodypos_90
overall_proportion_legs_crossed
    overall_proportion_legs_uncrossed overall_proportion_trunk_upright
    overall_proportion_trunk_forwards overall_proportion_trunk_backwards
overall_proportion_trunk_other
    overall_proportion_gaze_on overall_proportion_gaze_down overall_proportion_gaze_away
    overall_proportion_hands_beats overall_proportion_hands_diectic
overall_proportion_hands_iconics
    overall_proportion_hands_head overall_proportion_hands_chin overall_proportion_hands_neck
    overall_proportion_hands_hair overall_proportion_hands_cheeks overall_proportion_hands_nails
    overall_proportion_hands_eyes overall_proportion_hands_clothes
overall_proportion_hands_nose
    overall_proportion_hands_ears overall_proportion_hands_jewellery
overall_proportion_hands_mouth
    overall_proportion_hands_arms overall_proportion_hands_legs overall_proportion_hands_trunk
    overall_proportion_hands_sitting overall_proprotion_RM_hands overall_proprotion_RM_legs
    overall_proprotion_RM_trunk
  /PRINT=SPEARMAN TWOTAIL NOSIG FULL
  /CI METHOD(FHP)  CILEVEL(95)
  /MISSING=PAIRWISE.

* Benjamini-Hochberg for EDE-Q and non-verbal behaviours . Different data set of only p-values .

sort cases by p (a).
compute i=$casenum.
sort cases by i (d).
compute q=.05.
compute m=max(i,lag(m)).
compute crit=q*i/m.
compute test=(p le crit).
compute test=max(test,lag(test)).
execute.
formats i m test(f8.0) q (f8.2) crit(f8.6).
value labels test 1 'Significant' 0 'Not Significant'.
```