Adolescence, autism and technology: How technology can impact the social lives and wellbeing of adolescents with an autism diagnosis

Anna Byrne-Smith BSc Hons MSc DClinPsy

SECTION A:

Technology-delivered social skills interventions for young people with autism: a systematic review

Word count: 7920

SECTION B:

Adolescence, autism and social media: Relationships between social media use, social capital and wellbeing among adolescents with autistic traits.

Word count: 7984

Overall word count: 15, 905

A thesis submitted in partial fulfilment of the requirements of Canterbury Christ Church University for the degree of Doctor of Clinical Psychology July 2021

SALOMONS INSTITUTE FOR APPLIED PSYCHOLOGY CANTERBURY CHRIST CHURCH UNIVERSITY

Acknowledgements

Sincerest thanks to my supervisor on this project Linda Hammond for the support and excellent advice on what has been a sometimes difficult journey. Additional thanks are owed to Sonia Fihosy and Fergal Jones for generously giving their time and guidance over the past year. Many thanks to all the participants who took part in this project. Final thanks to my parents and boyfriend for their encouragement.

Summary of the MRP

Section A

Section A is a narrative review of social skills interventions that have been used to enhance the social skills of adolescents with a diagnosis of autism. The review examined the types of interventions used as well as their efficacy, acceptability and generalisability. Exploration of the research revealed some limited evidence supporting the use of technology-delivered social skills interventions. Interventions offered little benefit over in-person interventions and limited generalisability. However, such interventions were positively received by young people which may improve intervention adherence. Clinical and research implications are provided.

Section B

Section B is a mixed-methods study examining the social media experiences of 222 adolescents with and without autistic traits. Participants' views on the advantages and disadvantages of using social media and its impact on their social life were collected. A number of hypotheses concerning social media's impact on social capital and wellbeing were tested, including the moderating role of autistic traits. Results show that social media use can have a positive impact on adolescents' social lives and improve online social capital. Its impact on wellbeing appeared to vary depending on autistic traits. Findings are discussed in terms of their implications for clinical practice. Limitations are considered and implications for future research are provided.

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Section A

Technology-delivered social skills interventions for young people with autism: a systematic review

Word count: 7814 (276)

A thesis submitted in partial fulfilment of the requirements of Canterbury Christ Church
University for the degree of Doctor of Clinical Psychology

July 2021

SALOMONS INSTITUTE

CANTERBURY CHRIST CHURCH

Abstract

Differences in social communication characteristic of autism can lead to social skills difficulties among young people with an autism diagnosis. Social skills interventions developed for use with this group include interventions delivered over technology platforms. Although the impact of these has been reviewed in the child and adult groups, there is no current review of such interventions in the adolescent age group. This review sought to assess the existing research examining the use of technology-delivered social skills interventions among adolescents with an autism diagnosis.

After critical appraisal, a narrative review of 18 papers was conducted. These described social skills interventions delivered over computer and robot platforms targeting a variety of social skills. The efficacy, acceptability and generalisability of these was examined.

Adolescents receiving technology-delivered social skills interventions reported high acceptability of such interventions. These offered social skills benefits in the short-term. However, they did not offer benefits above in-person delivery and showed limited long-term generalisability. Clinical implications for the potential use of such interventions are described. Research recommendations are made including a greater focus on the adolescent age group and on the impact of technology on intervention adherence.

Keywords: autism, adolescence, social skills, technology

Introduction

Technology use in the present day

‘Technologies’, described as ‘innovations developed to meet a human need, using both practical and theoretical knowledge following an organised process’ (Open University, 2019) have increased in both reach and capacity over the past century, with exponential increases in technological progress (Roser & Ritchie, 2013). Concurrently decreasing prices and increasing technological power have increased the accessibility of advanced technology and brought it in to the home, with 89% of adults in Great Britain using the internet daily or almost daily in 2020, compared to 35% in 2006 (Office for National Statistics, ONS, 2020).

Young people are particularly enthusiastic technology users with 83% of 12–15-year-olds owning a smart phone and 59% a tablet (Ofcom, 2019). Young people report feeling positively about technology, with 81% of 11–17-year-olds saying that it has helped them in all areas of their lives, although also raising concerns around issues such as cybersecurity and cyberbullying (Nominet, 2019). Reported levels of proficiency with technology are high in this age group, and young people surveyed have reported a willingness to adopt new technologies and excitement about the development of future technologies (Nominet, 2019).

Autism and technology

Young people with an autism diagnosis have been reported as being equally or more enthusiastic about technology use than their typically developing counterparts, describing unique benefits of using technology specific to their communication difficulties (Benford & Standen, 2009).

‘Autism’ can be conceptualised socially and medically, with the social model of autism arguing that autism is a socially constructed condition, formed through oppression and barriers to societal integration (Kapp, 2019). More generally, social models argue that disability is created through society failing to adapt to the needs of differently abled individuals (Kapp, 2013). In contrast, the medical model of autism proposes that autism is a neurodevelopmental condition affecting communication and behaviour. Around 70,000 people live with an autism diagnosis in the UK, with 1 in 100 children receiving a diagnosis (British Medical Association, 2021). Social communication is a key component of the diagnosis, with diagnostic criteria including early years ‘impairment’ in communication, attachment, or play, as well as later ‘impairment’ in social interaction and communication and increased restrictive repetitive and stereotyped behaviours (Lord et al, 2018; World Health Organisation, 1992). Social communication differences typically include difficulties with interpreting verbal and non-verbal communication and mentalising (The National Autistic Society, 2021). Individuals reportedly encounter problems ‘reading’ other people and responding appropriately in social situations (Nah & Poon, 2010). Given these communication difficulties it has been hypothesised that young people with autism may specifically benefit from technology use through the removal or reduction of sensory information and demands, leading to reduced stress and enhanced communication (Benford, 2008).

Reports from individuals with an autism diagnosis support this idea, suggesting that technology use aids social functioning in several ways. Young adults in the autistic community report that virtual platforms provide opportunities for supporting emotional awareness, promoting socialisation, and easing anxiety (Gallup & Serianni, 2017), and that the anonymity of a virtual environment makes socialising online feel more comfortable than in person (Gallup et al, 2016). Participating in multiplayer games has been shown to increase opportunities for engaging in reciprocal conversation, making requests, and interpreting and using gestures (Stone, Mills & Saggers, 2019). Further, young people playing prosocial video games exhibit more prosocial language and language initiation, and less social anxiety (Rolston, 2019). There is also evidence that participating in mainstream technologies, such as computer games, results in long-term improvements in social functioning in children and adolescents (Dickinson & Place, 2016). Interviews conducted with young people in one qualitative study revealed that these individuals felt more able to develop friendships through gameplaying with a joint purpose, and that they were able to use interaction skills developed online to better socialise in a face-to-face setting (Gallup et al, 2016).

Social skills interventions for people with autism

Medical definitions of autism refer to social communication difficulties as fundamental to the diagnosis, while social models counter that communication difficulties inherently reside within the interaction rather than the individual (Kapp, 2019). Social deficit narratives have therefore been criticised as pathologising, placing the responsibility for communication adaptation on individuals with autism rather than the neurotypical. Nevertheless, perceived social deficits in individuals with an ASD diagnosis can lead to poorer life outcomes including social isolation resulting from difficulties in forming friendships (Bauminger et al, 2003; Jobe & Williams White, 2007), reduced employment and wellbeing and criminality. Such outcomes can be ameliorated with intervention. For example, one long-term study of typically developing individuals reported a 50% increase in school completion, 16% increase in work participation and 30% decrease in acquisition of a criminal record in adulthood following preschool social skills training (Algan et al, 2014).

These findings have led to the development of interventions targeting social skills in individuals with autism. A broad definition of social skills characterises them as ‘the skills required to achieve social competence’ (McFall, 1982). After reviewing and distilling existing models, one paper identified four social skills dimensions that could be the focus areas of intervention: communication skills, emotion regulation skills, cognitive skills, and social problem-solving skills (Grover et al, 2020). Under this definition *communication skills* are deemed to be the skills required to influence the behaviours of another, *emotion regulation skills* as the skills required to regulate emotional experience, *cognitive skills* encompass an individual’s knowledge of and interpretation of social situations, and *problem-solving skills* are the skills required to identify social problems and generate solutions (Grover et al, 2020). Further details on these are presented in Table 1.

Studies of in-person social skills training groups targeting these social skills in autistic adolescents have yielded positive results. Such interventions have been shown to improve outcomes in social competence and ‘problem’ behaviours (Tse et al, 2007), with one systematic review revealing moderate effectiveness of social skills training on outcomes across 19 studies (Gates et al, 2017). Self-reported improvements were greater than those reported by parents or teachers, indicating that different stakeholders may have different perceptions of the effectiveness of such interventions (Gates et al, 2017). There is some, albeit limited, evidence that such improvements persist beyond the immediate short-term, with one study reporting improvements in social responsiveness, clinical severity and adaptive functioning for the three months following the intervention (Olsson et al, 2017).

Table 1: Social skills dimensions (Grover, Nangle, Buffie & Andrews, 2020).

Communication skills
Use of language (e.g. greetings, negotiating conflict, making requests)
Adjustment of language (e.g., adjusting the content based on the age, setting or relationship with the recipient),
Conversation skills (e.g., conversational turn taking, alerting to topic change and non-verbal communications like eye contact and facial expressions)
Emotion regulation skills
Situation selection and modification (e.g., choosing situations that will minimise negative and maximise positive emotional experiences and modifying them if necessary),
Attentional deployment (e.g., altering the focus of attention to moderate emotional state),
Cognitive change (e.g. altering cognitive appraisal of the situation)
Response modulation (directly moderating the emotion and its expression with, for instance, medication and masking)
Cognitive skills
Informational knowledge (applying prior knowledge of social situations to anticipate roles and expectations)
Informational processing (using social cues to make attributions and organise behaviour),
Perspective taking (identifying the internal states and beliefs of others and distinguishing them from your own)
Neuropsychological processing (e.g. focusing attention, processing social information, problem solving)
Social problem-solving skills
Problem definition and formulation (gathering and formulating relevant information)
Generation of alternatives (considering a range of possible responses)
Decision making (considering positive and negative consequences of each solution)
Solution implementation and verification (putting the solution into action and evaluating the outcome)

Existing literature on technology-delivered social skills interventions for people with autism

Technology-based versions of in-person social skills interventions have been proposed as an alternative to real-life interventions. Technology platforms offer the potential to minimise monetary and time costs for services and service-users, improving accessibility. The familiarity and acceptability of technology among young people may increase motivation to access interventions. Reported benefits specific to young people with autism, including facilitation and ease of communication, may also increase motivation and maximise intervention benefits.

Systematic reviews of technology-delivered social skills interventions offer some limited support of their use with individuals with an autism diagnosis. A review of children and adults with autism across a very wide age range of 4-52 years, found mixed results. While interventions had a positive impact on social competence, there were mixed or inconclusive results for the identification of facial and vocal emotion and identification of false beliefs. Reported results were small and not generalised to real-life situations (Ramdoss et al, 2012). Reviews examining the impact of social skills interventions in children reported more positive findings. One review examining computer- and robot-assisted training among children primarily aged 3-12 years found that most trials showed positive outcomes and some generalisability to real world situations (DiPietro et al, 2019). Another examining the efficacy of computer-based instruction (CBI), video modelling and role play in children and adolescents found that CBI met the criteria for evidence-based practice (McCoy et al, 2016).

Rationale for the review

Existing reviews examining the impact of technology-delivered social skills interventions have focused on outcomes for young children or across technologies and age groups. This partly reflects the existing literature, where preschool children have been the primary focus of interventions. There is currently no review of literature examining outcomes exclusively for older children and adolescents. This has been identified as a gap in the literature, where the need for a focus on this age group has been specifically highlighted (Ramdoss et al, 2012).

Adolescence is a distinct developmental phase characterised by rapid physical, socio-emotional, cognitive and neurological development (WHO, 2021). The World Health

Organisation defines adolescence as the period between 10 and 19 years of age (WHO, 2021), whilst neuroscientists define it as the period between 10 and 25 years of age, due to the continuation of significant brain development into the 20s (Arain et al, 2013). Brain development including increasing cortical development of white matter and reduction in grey matter correspond with changes in executive functioning, impulse control, goal orientation and emotional processing (Yurgelun-Todd, 2007). Qualitative differences in cognition and emotion between early childhood and adolescence have also been identified (Christie & Viner, 2005). Unlike in earlier developmental stages, adolescents are more able to conceptualise abstract as well as concrete concepts, enabling them to consider new possibilities in social relations (Gleitman et al, 2007).

Erikson spoke of the crisis of self-identity occurring during this period, where adolescents begin to develop a unique sense of their own identity, and place increasing emphasis on peer rather than family relationships (Erikson, 1968). Peer relationship intimacy levels typically increase with increasing adolescent age, surpassing parent-child intimacy levels (Hunter & Youniss, 1982). Interactions qualitatively change with age, with children engaging in more cooperative play with a greater number of peers over time (Parten, 1933). As adolescents are exposed to a variety of new social situations with novel social roles and expectations, a new set of social skills are developed (de Armas & Kelly, 1989). Young people with a diagnosis of autism face particular challenges in adolescence including building and navigating increasingly complex social relationships, facing stigma specific to their diagnosis and managing transitions including changes in education settings and the increase of responsibility (Cheak-Zamora et al, 2015). Identity development within cultural norms and expectations requires the additional integration of the autism diagnosis

(Mesa & Hamilton, 2021), as well as the development sexual and gender identities which can be challenging in this group (Hillier et al, 2019).

Given the distinct developmental features of this life stage it would be expected that adolescents' experiences of technology use and social interactions would be substantially different to those of both younger children and adults. In terms of reported usage, differences are predictably in evidence, with 1% of 3-4 year olds owning their own smartphone, compared with 83% of 12-15 year olds. While 52% of 3–4-year-olds go online for around 9 hours per week, 99% of 12–15-year-olds go online for around 20 hours per week (Organisation for Economic Cooperation and Development, 2019). For these reasons the study of social skill interventions with adolescents, as distinct from those involving younger children, is a necessary contribution to the existing literature.

Due to the paucity of existing literature in the adolescent age group, highlighted in previous reviews, this review will examine all stages of adolescence, including early adolescence (age 10-14), middle adolescence (ages 15-17) and late adolescence (ages 18-19) (Salmela-Aro, 2011), with findings for different age groups separated out in the results, where this is possible.

Review objective

This review aims to assess the use of technology-delivered social skills interventions with older children and adolescents with an autism diagnosis, as well as to assess the quality of existing literature. The aims of the review are sixfold:

1. To examine the types of **technology** used to deliver the interventions.

2. To examine which **social skills** are being targeted, and the types of **interventions** used.
3. To assess the acceptability of these technologies and interventions to young people.
4. To assess the impact of social skills interventions on social skills.
5. To assess the generalisability of any results to real-world situations.
6. To assess the quality of the literature.

Methods

Study design

This review has adopted a narrative approach, employing a systematic search and review of both the qualitative and quantitative literature in the area, in order to create a coherent narrative addressing the questions posed above.

Inclusion criteria

The review included both qualitative and quantitative experimental studies examining the impact of technology-delivered interventions on social skills in young people with a diagnosis of autism. For the purposes of this review, adolescence will be defined as age 10-19, in line with the WHO definition. Studies with participants with an average age in this range were included in the review. Average age has been used due to the large number of studies adopting broad age ranges, and because several studies do not give the precise age range of participants. Authors were contacted directly in order to elicit details on ages but did not respond. The inclusion criteria are listed in Table 2.

Table 2: Inclusion criteria

Inclusion Criteria
Published in English
Published in or after 2000
Participants aged between 10 and 19, or with an average age in this range
Participants with a diagnosis of autism, as per the definition
Research based on technology-delivered social skills intervention as per the definitions[1]
Quantitative or qualitative design

Literature search

A literature search of four databases, PsycINFO, Medline, ASSIA and Web of Science was conducted on the 12th February 2021. The search was pre-planned with search terms developed through assessing existing reviews. Key search terms were combined with Boolean operators 'OR' and 'AND'. The search terms are listed in Table 2. The date range of papers was limited to 01/01/2000 to the current day, as it was felt technology older than twenty years would be irrelevant to current technological advances. Reference lists of relevant papers were then searched by hand.

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[1] Informal use of technology without a structured intervention will not be included

Table 3: Search terms

Search Topic	**Specific terms used**
Population	adolescen* OR teen* OR young people OR child* OR girl OR boy OR youth OR young person OR school* OR student* OR university OR young adult AND Autis* OR ASC OR ASD OR Asperger* OR neurodevelopment* OR autism spectrum AND
Exposure	Tech* OR online OR computer* OR robot* OR software OR social media OR online social network* OR social networking site OR digital OR digital technolog* OR internet or mobile phone OR cell phone OR video game* OR virtual reality OR computer assisted intervention* OR computer based intervention* OR computer assisted technology AND
Outcome	Soci* OR social connection* OR social skills OR friend* OR social life OR relation* OR social capital OR loneliness OR turn taking OR eye contact OR empath* OR joint attention OR prosocial

Results

Literature search

The literature search yielded 368 papers. Of these, 122 were duplicates and were removed from the review. The abstracts of the remaining 246 papers were read individually. 54 papers were read in full, of which 9 were selected for inclusion in the review. Hand searching of references yielded another 9 papers which were included in the final study of 18 papers. The selection process is detailed in the PRISMA diagram in Figure 1.

Figure 1: PRISMA diagram

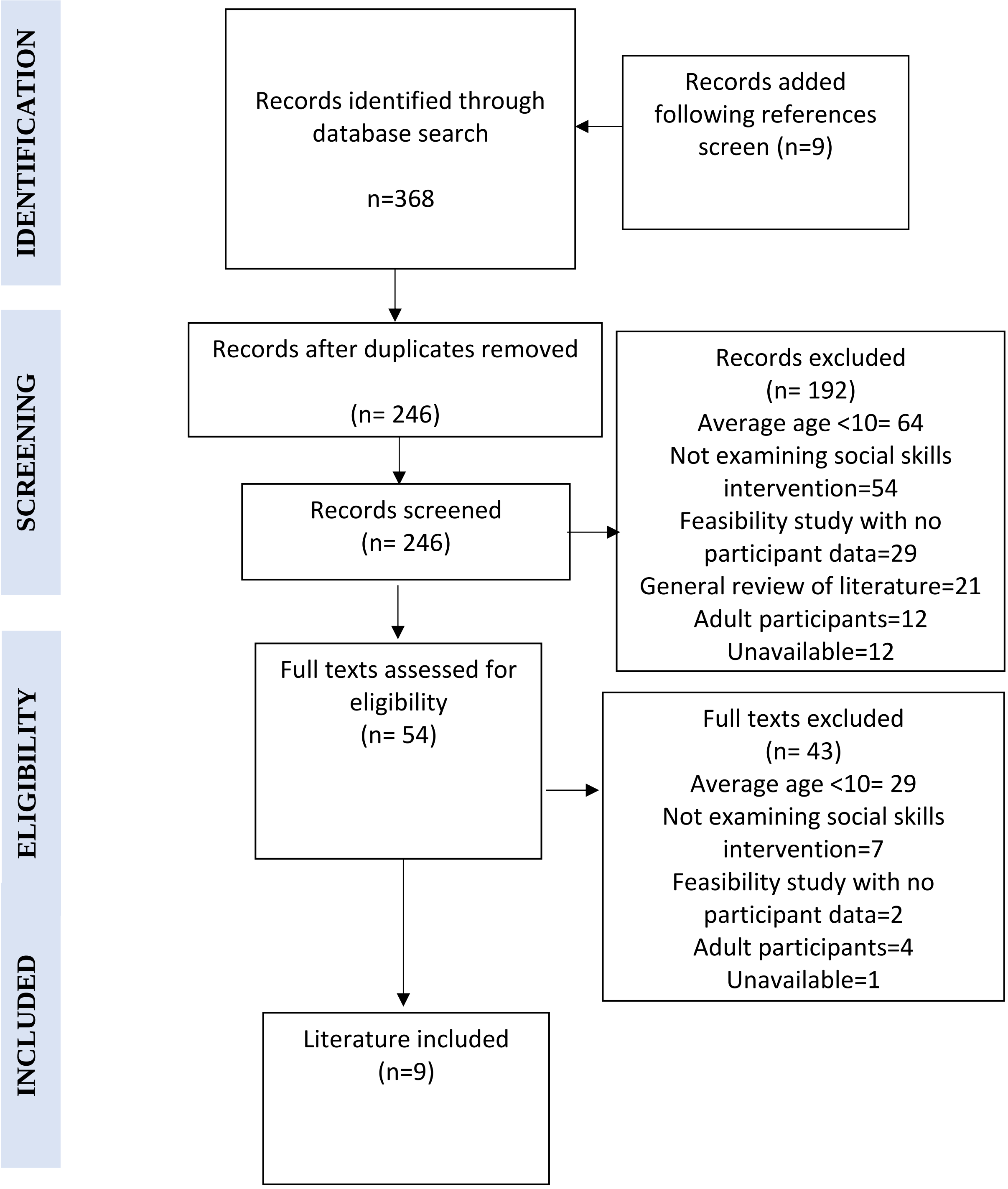

Table 4: Summary of papers

Author (year)	**Location**	**Sample size, age range (mean), % male**	**Study design, method of data collection and analysis**	**Research topic and aims**	**Technology platform used and timeframe**	**Outcome**
1. Chung et al (2016)	South Korea	N= 20; 13-18 years (mean= 16.05 years); 85% male	Quantitative; repeated measures ANCOVA	To find out whether social cognition (measured by assessing social communication, emotional word and facial expression recognition as well as brain activity) would improve with prosocial game-delivered CBT, and how this compares to offline CBT.	Prosocial online game CBT accessed via PC. 1 hour per day, 3 days a week for 6 weeks.	Improvements in social communication and emotion recognition were similar in the online to offline CBT groups. There were differences in brain activity between groups suggesting increased emotional arousal and facial recognition in the online group. Online group members had an improved social interaction score but lower social behaviour score than the offline group.
2. De Silva et al (2009)	Japan	N= 4; 10-11 years (mean not stated); % male not stated.	Qualitative; video analysis	To determine whether an assistive robot could improve eye contact and joint attention in children.	HOAP[2] robot . 3 robot interaction sessions.	Children made good eye contact with the robot and joint attention increased over time.
3. Didehbani et al (2016)	USA	N= 30; 7-16 years (mean= 11.4 years); 86.6% male	Quantitative; paired sample t-test.	To examine the effect of the intervention on affect recognition, social attribution, attention and executive function.	Virtual reality social cognition training accessed via PC. 2 sessions twice a week for 5 weeks.	Significant differences in pre- and post-measures for emotion recognition and social attribution were found.
4. Friedrich et al (2015)	USA	N= 13; 6-17 years (mean= 11.7 years); 92.3% male	Quantitative; repeated measures ANOVA.	To find out whether participants could moderate their brain mirror neuron activity during the task and whether there would be a reduction in symptomology.	Computer-based social mirroring game with neurofeedback training. 16 one-hour sessions 2-3 times a week for 6-10 weeks.	Participants learned to moderate brain activity and demonstrated improvements in emotional responsiveness, emotional recognition, spontaneous imitation and functional daily behaviour.

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[2] Humanoid for Open Architecture Platform (HOAM) robots are humanoid robots produced by Fujitsu.

5. Gwynette et al (2017)	USA	N= 6; 12-19 years (mean= 14.1 years); 100% male	Quantitative; paired t-test.	To see whether intervention resulted in changes to social skills as measured by questionnaires including the social responsiveness scale-2, social skills improvement system rating scale and project Rex Connect parent survey.	Facebook delivered online social skills group accessed via PC. 15 minutes minimum per day, 6 days a week for 8 weeks.	There were no statistically significant differences between pre- and post-intervention questionnaires about social skills. Participants indicated high satisfaction and acceptability of the intervention.
6. Hopkins et al (2011)	USA	N= 49; 6-15 years (mean= 10.17 years); 89.8% male	Quantitative; ANCOVA	To examine the impact of the technology on emotion and facial recognition, and social behaviours in the natural environment.	Computer-based social skills training programme. 12 10-25 minute sessions twice per week for 6 weeks.	Children with low functioning autism improved in emotion recognition and social interaction. Children with high functioning autism improved in emotion recognition, social interaction and social interaction in natural environments.
7. Ke & Im (2013)	USA	N= 4; 9-10 years (mean not stated but ¾ participants aged 10 years); 50% male	Qualitative; video coding and thematic analysis	To examine the impact of a virtual reality-based social skills intervention and its different components on the social interaction and communication performance.	Computer-based virtual reality social skills training on Second Life virtual reality platform. 6-9 one hour sessions over 2-3 weeks.	Improvements were observed in responding, initiation, greeting, positive conversation-ending and nonverbal communication identification. Parent- and self-reported improvements in social functioning were reported in both questionnaire (SSQ) and interview measures.
8. Ke, Moon & Sokolikj (2020)	USA	N= 7; 10-14 years (mean= 12.3 years); 85.7% male	Quantitative; video coding with paired t-test	To determine the effect of VR social skills training on the social skills performance of participants	Virtual reality intervention accessed on a home computer. 16-31 sessions of around 1-hour duration 1-2 times per week.	Pre- to post-intervention improvements were found in interaction initialisation, successful interaction negotiation positive self-identity expressions and cognitive flexibility. Parent- and self-reported SCQ and SSQ questionnaires revealed non-significant post-interventions reduction in reported autism traits and improvements in social and communication scores.
9. Mandasari et al (2011)	Malaysia	N= 3; 10-11 years (mean not stated); 100% male	Qualitative; observation and teacher interviews.	To determine whether social story interventions impact 5 target behaviours- initiate and sustain conversation, make requests in class and	Animated social stories delivered via desktop PC. 10-15 minute sessions 2-3 times per day for one week.	Improvements were observed in proactive requests and prosocial behaviours such as making requests, sharing food, remaining quiet at appropriate moments. All participants exhibited

				remain quiet in class and at lunchtime.		changes, although these varied between individuals.
10. Mitchell et al (2007)	U.K.	N= 6, 14-16 years (mean= 15.0), 50% male	Quantitative; video coding with paired t-test.	To discover whether a virtual environment is a good platform for teaching social functioning with regards to making decisions in social scenarios and whether there are learning benefits.	Virtual reality intervention using Visualiser software accessed on PC. Two 30-50-minute sessions carried out over 2 days.	Some participants improved in some tasks, with some of the greatest improvements in participants with the lowest IQ scores. Improvements occurred between assessments either side of the intervention, indicating that it was the intervention and not assessment practice that yielded benefits.
11. Moon & Ke (2019)	USA	N= 15; 10-14 years (mean not stated); 86.6% male	Mixed-methods; one way ANOVA and thematic analysis	To find out whether VR-based social skills interventions have good treatment integrity and promote social communication.	Virtual reality-based training on OpenSimulator accessed via PC. Multiple 1-hour sessions over 8-16 weeks.	Qualitative and quantitative assessment both demonstrated that participants exhibited high numbers of desired social behaviours in virtual environments. Some virtual scenarios were better received than others, for example tasks involving leadership were more challenging for participants.
12. Serret et al (2014)	France	N= 33; 6-17 years (mean= 11.4 years); 93.9% male	Quantitative; repeated measures ANOVA	To assess whether this computer game intervention could impact performance in emotion-recognition tasks.	JeStiMulE game accessed via PC. One hour twice per week for 4 weeks.	Participants' emotion recognition improved following intervention, particularly on the simpler emotions such as sadness, anger and happiness. This improvement not only applied to avatar faces but generalised to real human faces.
13. Silver & Oakes (2001)	UK	N= 22 (11 experimental, 11 control); 12-18 years (mean= 14.4); % male not stated	Quantitative; repeated measures ANOVA	To assess the impact of the 'emotion trainer' computer programme on the ability to recognise and predict emotions in others.	Emotion trainer computer programme accessed via PC. 10 daily sessions over 2-3 weeks.	Participants improved on measures of emotion recognition, with gains correlating significantly with the number of times the computer programme was used. The experimental group improved significantly more than that control group.
14. Stichter et al (2014)	USA	N= 11; 11-14 years (mean= 12.57); 100% male	Quantitative; questionnaire measures with paired t-tests.	To determine the impact of the virtual environment intervention on descriptive and performative assessment, it's fidelity to the in-person training equivalent and experienced social validity by participants.	Collaborative virtual reality iSocial social skills training accessed via PC. 5 units each lasting 2 weeks with a total of 31 31-45 minute lessons every other school day.	Significant pre- to post-intervention improvements were identified in parent-reported executive functioning and social responsiveness, particularly for social cognition, social motivation and social communication, with teachers noting non-significant improvements. The virtual intervention had high fidelity to the in-person intervention and parents teachers and participants all reported having a positive experience with the intervention.

15. Suzuki & Lee (2016)	Japan	N= 5; 12-16 years (mean= 13.4 years); 100% male	Qualitative; video analysis	To evaluate whether the robot elicited prosocial behaviours such as staying close and interacting.	NAO robot. Two trials consisting of different musical games.	Participants approached and stayed close to the robot. Some attributed theory of mind and demonstrated care towards the robot. However, participants did not follow instructions given by the robot.
16. Tanaka et al (2017)	Japan	N= 10; 7-19 years (mean= 11.8); 100% male.	Quantitative; coded observation with paired t-tests.	Whether computer mediated social skills training providing feedback on performance can result in improvements in conversational skills: pitch, conversation speed, amplitude, word length and smiling, as well as non-verbal skills.	Automated social skills training on PC. One 50-minute session with assigned homework tasks.	Conversational skills significantly improved between pre- and post-intervention. Non-verbal skills increased, including some not targeted by the intervention, such as eye gaze and narrative structure.
17. Zhao et al (2016)	USA	N= 12; (3 participants stated ASD), age range not stated (mean= 10.92 years- 11.7 in ASD participants), 83.3% male (ASD participants 100% male)	Quantitative; comparison, without statistical analysis	To assess usability and whether collaborative operation efficiency improved with game play.	Collaborative virtual environment on PC 8 games completed over the course of around 1 hour.	ASD participants performed better collaboratively in post-test than pre-test and talked more. Participants reported interest in the game.
18. Zhao et al (2018)	USA	N= 24; age range not stated (mean= 12.6 years); % male not stated.	Quantitative; Wilcoxon signed-rank test	To evaluate the acceptability and efficacy of a virtual communication enhancement system. To compare performance with and without communication enhancement.	Collaborative virtual environment ‘Hand-in-Hand’ accessed via PC. One session consisting of 8 games.	Participants demonstrated improvements in cooperation and communication after using the game and reported satisfaction with the intervention. Participants in the communication enhancement group, where the technology included communication prompts showed greater improvements.

Quality assessment

An evaluation of the studies was conducted by the author using the NIH Quality Tool for Before-After (pre-post) studies with no control group (National Heart Blood and Lung Institute, 2019) for those studies that fell within this description. This tool was selected as a large number of studies utilised a pre-post intervention design. There were a number of studies which included a control group or for which assessments were taking during rather than before or after intervention delivery. These were assessed using the Quality Assessment Tool (QATSDD) (Sirriyeh et al, 2012), as this tool encompasses both quantitative and qualitative studies. Overall analysis of study quality using the NIH and QATSSD quality assessment tools revealed that most studies were of a reasonably good quality. A summary of quality assessment using these frameworks is included below, with more detailed assessment provided in Appendices 1 and 2.

Table 5: Quality assessment summary using NIH before-after studies with no control group

Criteria	Quality assessment of papers												
	1	3	4	5	8	9	10	12	13	14	16	17	18
Aims/objectives clearly stated	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟨	🟩	🟨	🟨	🟩
Eligibility criteria prespecified and described	🟩	🟩	🟩	🟨	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟥
Participants representative of the clinical population	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Eligible participants enrolled in the study	🟩	🟩	🟩	🟨	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟥
Sufficiently large/justified sample size	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Intervention clearly described and consistently delivered	🟩	🟩	🟩	🟨	🟩	🟩	🟩	🟩	🟩	🟨	🟩	🟩	🟩
Outcome measures prespecified and consistently assessed	🟩	🟩	🟩	🟨	🟩	🟨	🟩	🟩	🟩	🟩	🟨	🟨	🟨
Assessors blinded to intervention	⬛	🟩	⬛	⬛	🟥	🟥	🟩	⬛	⬛	⬛	🟩	⬛	⬛
Loss to follow up under 20% and accounted for	🟩	🟩	🟩	🟩	🟨	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Statistical tests examining pre- to post-intervention with p values	🟩	🟩	🟩	🟨	🟩	⬛	🟩	🟩	🟩	🟩	🟩	🟥	🟩
Outcome measures performed multiple times before and after intervention	🟥	🟥	🟥	🟥	🟩	🟩	🟨	🟥	🟥	🟥	🟨	🟥	🟥
Group level analyses take account of individual-level data	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛	⬛

🟩	= Met criterion	🟨	= Partially met criterion	🟥	= Did not meet criterion	⬛	= N/A

Table 6: Quality assessment using Quality Assessment Tool (QATSSD)

Criteria	Quality assessment of papers					
	2	6	7	11	12	15
Explicit theoretical framework	🟩	🟩	🟩	🟩	🟩	🟪
Aims/objectives clearly stated	🟪	🟩	🟩	🟩	🟧	🟩
Clear description of research setting	🟩	🟩	🟩	🟩	🟩	🟩
Sample size considered	🟥	🟥	🟥	🟥	🟥	🟥
Sample representative of the target population and sufficiently sized	🟪	🟧	🟪	🟧	🟧	🟪
Description of procedure for data collection	🟪	🟩	🟩	🟩	🟩	🟧
Rationale for choice of data collection	🟥	🟩	🟩	🟩	🟥	🟥
Detailed recruitment data	🟪	🟧	🟪	🟪	🟧	🟥
Validity and reliability of outcome measures (quantitative)/ analytical process (qualitative)	🟥	🟩	🟧	🟥	🟪	🟥
Fit between stated research question and data collection (quantitative)/data collection tool (qualitative)	🟩	🟩	🟩	🟩	🟩	🟩
Fit between research question and method of analysis	🟧	🟩	🟧	🟩	🟩	🟧
Good justification for analytical method selected	🟥	🟥	🟪	🟧	🟪	🟥
Evidence of user involvement in design	🟥	🟥	🟥	🟥	🟥	🟥
Strengths and limitations critically discussed	🟥	🟧	🟪	🟧	🟩	🟥

🟩	= Met criterion	🟧	= Moderately met criterion	🟪	= Very sightly met criterion	🟥	= Did not meet criterion	⬛	= N/A

Methodological critique

Aims and objectives.

For the majority (13/18) of the studies, aims were clearly stated and predefined, and studies provided a clear and detailed summary of the relevant theory and literature. Two of the studies examined the efficacy of intervention as a secondary aim of the study, with the main aim of examining the feasibility of their intervention. However, these did conduct a sufficiently thorough assessment of the outcomes of intervention to be included in the review.

Recruitment and sampling.

The sample size of most studies was small, with only three studies including over 30 participants, and seven studies examining under 10 participants. A number of these studies used qualitative methods such as video analysis which might have justified such sample sizes. However, none of the studies provided prior justification of the sample size or provided a power calculation. Small sample sizes may have increased the likelihood of individual confounding variables. Confounding variables were not controlled for in the studies and were generally not considered, although some studies highlighted these in their discussion. One potential benefit of these generally small sample sizes is an increase in the detail of information gathered for each participant, with seven studies able to report individual level results and explore individual confounding factors.

The inclusion of clear and prespecified inclusion and exclusion criteria was variable across the studies. Some studies provided descriptive information about recruited participants rather than clearly indicating whether such demographic factors were prespecified prior to recruitment. The demographic data collected about participants was limited, with most studies collecting information about age and gender alone. The most frequent additional data collected was IQ, which was measured in seven studies, followed by diagnostic information about which category of autism diagnosis had been received which was collected in five studies. Information relating to specific abilities such as reading ability and vocabulary was collected in one and two studies respectively and one study collected information on handedness. Ethnicity information was collected in three studies, and no studies collected demographic data relating to socioeconomic background or any other demographic variables. This relative lack of demographic data collected in selected papers means that these variables could not be controlled for and their influence on outcomes was not assessed.

Five studies recruited participants across developmental age groups including, for instance, participants in middle childhood as well as participants in late childhood, early and middle adolescence, without separating the results of these different groups. This means that the results of individuals from very different developmental life stages were conflated in these studies. All studies recruited participants representative of the population, recruiting young people with an autism diagnosis. One study included typically developing peers but presented results for the autism group separately to other participants and was thus included in the review. Loss to follow-up across the studies was minimal, with participants in all studies completing both pre- and post- intervention outcome measures. The one study with a loss of participants included an additional follow-up after the post-intervention outcome measure, with loss occurring at this follow-up rather than at the initial post-intervention measurement point.

Methodology.

Studies universally pre-determined the interventions and outcome measures to be used with participants. The vast majority (16/18) of studies provided a detailed description of these, with just two studies providing a partial rather than complete description of the intervention to be used. Interventions and outcome measures were applied consistently across participants. Service-user involvement in the design of the studies was quite minimal. Although two studies included pilot studies and others collected user feedback, none explicitly described service user involvement in design.

In 16 of the 18 studies reviewed all participants received the intervention, with two studies including a control group. One study compared online delivery of the intervention with offline delivery. The pre-post nature of the majority (16/18) of studies provided a within-participant comparison of the effect of the intervention to a without-intervention state. The methods of assessment included observation, questionnaires, computer-based and physiological measures. Ten of the 18 studies involved an element of observer assessment. Of these, seven were pre-post intervention comparisons where the blinding of assessors to the pre- or post-intervention status of the material might have been beneficial. Assessors were blinded in only four of these. Most studies collected outcome measures twice, once pre- and once immediately post-intervention, with four of the 18 studies conducting more than two assessments of social skills. The studies might have benefitted from collecting outcome measures several times before and after the delivery of interventions in order to obtain average scores that may have been more representative of true performance and less open to compromise from temporal fluctuations in individual factors such as energy or attention. Only two studies provided longer-term follow-up over one and three months.

General critique.

The studies were conducted between 2001 and 2020 with ten of the 18 studies conducted since 2015. The relatively recent date of most included studies means that the technology used is likely to be relevant to current-day young people. The average age of participants across all studies was between 10 and 19 years old but the studies recruited participants across a wide range of ages. Five studies recruited participants across a questionably wide age range e.g. age 6-16, without differentiating results between different age groups. This makes the results of the studies very difficult to interpret given the notable differences between developmental groups detailed in the introduction. This is a significant limitation of the existing literature, as very few studies focused exclusively on the adolescent age group. 13 of the 15 studies reporting gender had a greater representation of male compared to female participants, with six having 100% male ASD participants. This reflects the target population as well as the likelihood of a gender-bias in diagnosis, with an existing 4:1 male to female ratio of autism diagnoses compared with a predicted true underlying ratio of 3:1 male to female (Loomes et al, 2017). While many included papers (10/18) were from the USA, studies were also conducted in Asia, Europe and Australia; thus, findings were helpfully gathered across a variety of cultural contexts. The inclusion of five papers from non-Western countries is positive for the generalisability of the results outside Western contexts.

Findings

The findings are laid out according to the aims of the review: to examine the types of technology, types of interventions used and social skills targeted, their impact on social skills, acceptability and generalisability.

Technology platforms used.

Technology platforms used were PC computers and robots, with 16 of the 18 studies using interventions accessed via a computer, whilst the other two used robots. Of the robot studies, one used NAO robots and one a HOAP robot. Robots were used to deliver structured social games and activities. Computer-based interventions included social computer games, avatar interactions over virtual reality platforms, animated social stories, and a Facebook social skills group. Computer games and virtual reality platforms were used most often in studies, with eight studies using virtual reality interactions and three using games. Virtual reality platforms included Second Life, OpenSimulator, Hand-in-Hand, iSocial and Visualiser. The iSocial virtual reality platform was multi-sensory including visual, auditory, and tactile stimulations. Most of the studies (11/18) included a human collaborator alongside the technology platform, to facilitate the intervention or technology use, provide guidance or interact virtually with participants.

Social skills targeted and interventions used.

Social skills were measured using questionnaire-based outcome measures, observation, or both. All studies assessed skills in participants themselves, with six studies including parent-reported measures in addition to participant-derived measures, and two studies including teacher as well as parent assessments.

Studies targeted social skills in three of the four identified social skills domains; *communication skills, cognitive skills, and social problem-solving skills* (Grover et al, 2020). The *emotion regulation* domain of social skills was not examined by any of the included studies, meaning that an important element of social skills was not covered by the literature. The most frequently targeted skills were *communication skills,* including reciprocal and social interaction, eye contact frequency and duration, conversation initiation, conversation perpetuation, interpersonal negotiation and cooperation, narrative skills and making requests. *Cognitive skills* targeted were informational processing including affect recognition, body language identification and social attribution, as well as cognitive flexibility. Other cognitive skills were neuropsychological processing skills including focused attention, with studies specifically examining joint attention. Two studies targeted *social problem solving*, including identification and information gathering and solution implementation. An additional outcome measured in one of the studies was positive self-identity expression.

Studies also looked at reductions in ASD ‘symptomology’, including repetitive, ritualised and stereotyped behaviours, communication and interaction difficulties, mainly assessed through standardised assessment tools such as the social communication questionnaire (SCQ) (Rutter et al, 2003), social responsiveness scale (SRS) (Constantino & Gruber, 2012), social skills questionnaire (SSQ) (Spence, 1995), Autism Treatment Evaluation Checklist (ATEC) (Rimland & Edelson, 1999) and Vineland Adaptive Behaviour Scale (Sparrow et al, 1984).

The majority of study authors devised their own social skills interventions. Others were adapted from existing in-person interventions. For example, one study adapted its iSocial intervention from an existing Social Competence Intervention (SCI-A), (Stichter et al, 2014), another adapted an existing group social skills intervention for online use (Gwynette et al, 2017), while a further study used a CBT intervention (Chung et al, 2016). When the fidelity of one technology-adapted intervention to the in-person version was assessed by independent raters, near 100% fidelity was found for content, process, behaviour management and verbal feedback (Stichter et al, 2014). Three interventions were collaborative, with participants able to engage with one another or a facilitator virtually.

Individualisation of interventions.

A variety of individualisations were made for the interventions included in the study. For instance, one study allowed participants to individualise their avatars and personalise them to look like themselves (Serret et al, 2014). Two studies assessed the needs of participants before selecting behaviours to be targeted, with one conducting classroom observations and interviews with teachers before deciding which behaviours to target and creating the intervention (Mandasari et al, 2011), and another including an instruction phase where participants’ target skills and goals were identified (Suzuki & Lee, 2016).

Other studies tailored the intervention according to the support needs of the participants. For example, one study identified a participant’s learning need with regards to reading ability and personalised his virtual environment to include more visual cues which helped him access the intervention (Moon & Ke, 2019), while others adapted the scaffolding provided by facilitators according to individual need (Ke & Im, 2013; Mitchell et al, 2007). One study provided a number of adaptations for individual learning needs, with participants able to select their response mode (non-verbal, concrete verbal or more abstract verbal responses), tactile stimulation level (according to sensory need), and game type (according to cognitive style) (Serret et al, 2014).

Some studies encouraged enhanced performance by individualising training or providing personal feedback, with two studies allowing participants to move at their own pace through the training phase (Serret et al, 2014; Zhao, Swanson et al, 2016). Performance feedback provided to participants included neurofeedback (Friedrich et al, 2015) and performance feedback, including opportunities to re-watch task performances, predicted intervention scores, comparison with a role-model (Serret et al, 2014) and positive comments (Silver & Oakes, 2001). One study offered in-game rewards for social interaction in order to enhance targeted skills (Zhao et al, 2018).

Acceptability of the technology and interventions.

Observation by assessors noted positive engagement with the technologies and interventions used, with a very low drop-out rate across all studies. Six studies included formal assessment of the acceptability of the technology among participants. Reports were positive, with young people expressing appreciation and satisfaction with the technology and reporting finding it easy to use. Appreciation of the intervention was so high in two studies that participants requested to continue using it after the conclusion of the study (Ke & Im, 2013; Ke et al, 2020). As well as appreciating the intervention, when questioned, participants had a good understanding of the object of the intervention, which corresponded to the intentions of the researchers (Zhao et al, 2016; Zhao et al, 2018). Other stakeholders also expressed satisfaction, with parents and teachers reporting that the intervention matched the social problems being experienced, and that the young people benefitted (Stichter et al, 2014).

Assessments with participants revealed some preferences among young people with regards to the technology and intervention used. A preference for individualised interventions was expressed, with participants requesting to customise virtual avatars and environments to be personalised to themselves (Ke & Im, 2013). Gaming elements of the interventions were particularly appreciated by participants, with flying tasks (Ke & Im, 2013) and in-game rewards (Zhao et al, 2016) mentioned as potentially motivational game elements. Gaming sites are the most visited websites by ASD individuals, and a gaming platform may increase motivation for intervention engagement (Kuo et al, 2014).

Effectiveness of technology-mediated interventions.

Technology-mediated social skills interventions appeared to be successful at improving targeted social skills in young people immediately post-intervention, with 17 studies reporting improvements in some or all targeted social skills. The one study that did not report improvements was unique in that it used a less structured intervention in the form of a Facebook social skills group with suggested topics and social skills advice. The less structured nature of this intervention may have contributed to the lack of improvement. Measures of 'symptomology' also indicated improvements, with reductions in questionnaire scores, such as the SCQ, SRS and Vineland adaptive behaviour scale (Chung et al, 2016; Friedrich et al, 2015; Ke et al, 2020). However, these were not significant in all cases (Ke & Im, 2013). When improvements in autistic participants were compared with typically developing peers, greater improvements were found in the ASD group (Tanaka et al, 2017). This might be as a result of greater social deficits in this group providing scope for greater evidence of improvement. Alternatively, the ASD group might have experienced increased enthusiasm for the technology platform.

Comparison with control groups suggested that improvements in social skills were the result of the intervention content itself, with the intervention group demonstrating a significant improvement compared to control groups taking part in an online drawing activity (Hopkins et al, 2011) or school lessons (Silver & Oakes, 2001). The mode of intervention delivery however did not appear to influence the outcome of the intervention. When online intervention delivery was compared to offline there were no significant differences in social skills improvement, although there were differences in the domains affected. Greater improvements in social interaction were observed in the online group and social behaviour in the offline group (as measured by the social communication questionnaire (Chung et al, 2016).

Participants improved more on some skills than others, with one study reporting greater improvements in facial than gestural emotion recognition, and on more simple than complex emotions, perhaps reflecting the underlying strengths and weaknesses of the ASD group (Serret et al, 2018). Tasks differed in their ability to elicit the desired behaviours. For instance, tasks with more pressure were less successful and creative tasks more successful at improving self-identity expression, (Ke et al, 2020), while in one study proactive tasks, such as interviewing, yielded fewer target behaviours (Moon & Ke, 2019). In general, participants appeared to respond well to creative tasks with minimal pressure and proactivity, lots of visual stimuli and a familiar context and objective.

Elements of the technology appeared to facilitate learning. One study found that observational learning helped with the acquisition of social skills (Ke & Im, 2013). Another reported that an enhanced communication version of the game with communication encouragement and prompts resulted in a better performance with more cooperation and communication as well as better participant feedback (Chung et al, 2016).

Individuation of responses.

Studies indicated that the effectiveness of the technology-delivered intervention might be highly individualised, with participants displaying variations in performance according to the task and the social skill targeted. Factors influencing performance were hypothesised to be interest levels and motivation towards tasks and individual responses to social stimuli (Ke et al, 2020). Temporal factors such as mood and comfort may also have played a part in responses. Personal motivation appeared important, with performance improving for more relevant and personally interesting tasks. For example, one study found that one participant thrived in tasks involving creative storytelling, while another who did not use the school cafeteria showed less engagement on a task recreating a cafeteria environment (Ke & Im, 2013). Participants were observed to show different trends over time with tasks, taking varying amounts of time to understand and improve, which might have been the result of individual ability or familiarity with the technology (Didehbani et al, 2016; Ke et al, 2020).

Effectiveness in different groups.

Age.

Comparison across ages was not possible as most included papers did not separate the results for different groups or control for age in their analyses. However, when comparing papers focussing on different age groups similar results were found, with all age groups benefitting from technology-delivered social skills interventions. This may partly have been the result of individualisations made by some authors which might have made interventions accessible to different age groups.

One paper compared the individual results of participants of different ages and commented that greater improvements appeared to have been made in younger participants (Tanaka et al, 2017). This may reflect learning processes, with older ages having had a longer period to learn social skills. In contrast, another paper found that improvements did not correlate with age, with no significant differences between participants aged 12-18 (Silver & Oakes, 2001).

High and low functioning ASD.

The majority of studies included participants with high functioning autism exclusively, with many studies specifying an IQ > 70 as one of the inclusion criteria or reporting patient demographics where all participants had an IQ above 70. Studies including low-functioning participants noted that such participants could access and benefit from suitable interventions. For instance, one study examined an intervention that was designed as appropriate for all levels of functioning, with no verbal instructions and both verbal and non-verbal response options. This study found that the intervention was accessible to most participants, with good adaptability, efficiency and effectiveness, and that participants with diverse intellectual profiles showed improvement in emotion recognition with this needs-specific adapted intervention (Serret et al, 2014).

Only one study directly recruited and compared participants with both low- (LFA) and high-functioning autism (HFA; defined as an IQ below and above 70 respectively), which found that both groups improved on social skills measures. However, the nature of the improvement differed somewhat between the groups. Observers noted that LFA participants exhibited fewer negative interactions, and HFA participants more positive interactions after the intervention. Improvements were also more generalised in HFA participants. For example, although both groups improved on measures of emotion recognition, low-functioning participants improved only on the emotion recognition of photographs, not of drawings, while HFA participants improved on both, and only the HFA group improved with regards to facial recognition (Hopkins et al, 2011).

A paper that examined the effect of a social skills intervention on participants with different verbal abilities found no corelation between verbal ability and skills improvement (Silver & Oakes, 2001). In contrast, another paper noted that of the three participants demonstrating the greatest improvements in social functioning, two were the participants with the lowest verbal IQ scores, with the authors noting that verbal IQ is often connected to social functioning (Mitchell et al, 2007). Its authors hypothesised that individuals with more impairment might have more to gain from such an intervention.

Comorbid ADHD.

When participants with comorbid ADHD were compared to those with only an ASD diagnosis, no significant differences were found in any of the areas investigated: affect recognition, social attribution, analogic reasoning or auditory attention (Didehbani et al, 2016).

Neurological findings.

Two studies included brain activity in their assessment of intervention outcomes and found neurological changes in response to intervention. One used an online CBT intervention and found increased brain activity in areas of the brain associated with emotional arousal. It was hypothesised that these associated brain areas indicated an increased ability to recognise emotions and consider associated environments in response to emotionally charged faces. Brain activity appeared to be impacted differently with different intervention delivery modes, with the offline group exhibiting increased brain activity in different parts of the brain to the online group. Neurological changes appeared to directly correlate to social skills acquisition; for instance, changes within the left fusiform gyrus positively correlated with changes in the correct response rate for emotion recognition, and negatively correlated with SCQ interaction scores in the online intervention group (Chung et al, 2016).

Another study looked at using neurofeedback training to modulate brain activity and found that a social mirroring game with neurofeedback could link and improve brain responses, behaviour, and emotional responses during social interactions. In this study participants were trained to moderate brain activity by regulating a type of brain rhythm called mu rhythm, associated with mirror neuron activation. Participants were able to learn to control mu rhythm, showing more mu suppression (and therefore mirror neurone activation) in post-intervention assessment than pre-intervention. This corresponded with improvements in emotion recognition, spontaneous imitation behaviour, and general adaptive behaviour. Other physiological factors appeared to play a role in facilitating cognitive social skills. For example, higher heart rate variability at rest corresponded with a higher percentage of correct responses and shorter reaction time in expression recognition, suggesting that the autonomic nervous system may play a part in social cognition (Friedrich et al, 2015).

Generalisability to real world settings.

A significant limitation of most studies was that they did not assess whether improvements in social skills generalised beyond the intervention itself, or after the end of the intervention. However, those that did assess the generalisability of increased social skills had promising results. For instance, three used questionnaire and interview-based assessment with parents who reported significant reductions in ASD behaviour outside of the intervention setting. These included better social responsiveness and better behavioural adaptation (Friedrich et al, 2015), increased voluntary engagement in daily social interaction (Ke et al, 2020), increased interest in communication with peers and demonstration of a wider variety of interests (Ke & Im, 2013).

Only two studies assessed whether improvements were maintained after the end of the intervention. In interviews one- and three-months after the conclusion of the intervention, participants and parents reported that the positive effects gained were maintained beyond the end of the intervention (Ke et al, 2020; Tanaka et al, 2017). Participants themselves believed that the skills learnt would generalise, reporting that they felt that their learning would help them to get along with others (Sticher et al, 2014).

Generalisability of skills was also noted within interventions. One study assessed social skills from a café-based intervention in both a café and bus environment and found that learning from the café scenario generalised to the bus scenario (Mitchell et al, 2007), while in another study improvements in avatar facial expression recognition generalised to recognition of real-life faces in photographs (Serret et al, 2014). Participants in some studies showed improvements in skills not targeted in the intervention, such as eye contact and narrative structure (Tanaka et al, 2017) and volume of social conversation (Zhao et al, 2016).

Although all studies used interventions that were formalised to a greater or lesser extent, some interventions used pre-existing and commonly used platforms or games. These have the potential for use in interventions that could be more easily integrated into everyday life, such as a pre-existing locally popular game platforms (Chung et al, 2016) and Facebook (Gwynette et al, 2017), which is used by around 140 million 13-17-year-olds worldwide (Statistica, 2021). Some studies focussed on their virtual platforms being naturalistic and as relevant to real-life as possible with common social scenarios (Ke & Im, 2013; Ke et al, 2020).

Discussion

This review assessed the use of technology-delivered social skills interventions in adolescents, in terms of the types of technology and interventions used, their acceptability to young people, and their impact on social skills both in the experimental setting and the real world. The review found that a wide variety of technologies and interventions were used, with author-developed virtual reality interventions the most common. Social skills targeted were primarily communication and cognitive skills, and the studies found that interventions had a beneficial impact on targeted social skills. The limited evidence on generalisability suggested that improvements in social skills generalised beyond the skills targeted, and beyond the intervention, although the longevity of these effects was not established. Improvements in social skills after intervention were noted across age groups and among groups with low-functioning as well as high-functioning autism, as well as co-morbid ADHD. Improvements corresponded with neurological changes including increased activity in brain areas linked to emotional arousal and mirror neuron activation, as well as changes in the autonomic nervous system.

This review adds to the current literature, where there has been an identified need for a review focusing on adolescents exclusively. The findings of this review accord with previous reviews in different age groups, where technology-delivered social skills training was found to be moderately impactful on social skills acquisition.

Clinical implications

The findings of this review suggest that technology is a potential medium for delivering social skills interventions. The technology was well-liked by participants which may increase motivation for intervention participation. Other elements of the technology might also provide benefits such as offering flexibility in terms of creating different virtual environments and social scenarios. Virtual reality platforms in particular allow participants a naturalistic environment in which to try out skills and make mistakes without real-world consequences.

In terms of skills acquisition however, technology-delivered intervention did not appear to offer benefits above in-person delivery. In addition, included papers assessed a relatively narrow range of social skills, with some papers focusing on very specific skills such as emotion recognition, joint attention or eye contact. The domain of emotion regulation was not studied by any papers, meaning that a central aspect of social skills was not included. It is likely that all four described domains integrate and operate together. The included literature therefore does not assess how interventions impact upon the acquisition of the full complexity of social skills as they are expressed in the real world.

If technology platforms are utilised for intervention delivery, a tailored individualised approach is indicated by the literature. Many papers highlighted the individualised needs and responses of participants. Participants themselves also reported a desire to personalise the interventions. Technology offers possibilities in this area, with the potential to personalise interventions at a relatively low monetary and time cost.

Technology-delivered intervention has the possibility to improve access to treatment, with the potential of delivering interventions to disparate locations and pooling resources across services (Stichter et al, 2014). Cost savings on facilities and staffing could also increase the numbers of young people offered access to the intervention. Although many included studies involved a human facilitator, there was some evidence that the need for assistance was reduced after participants had adapted to the task (De Silva et al, 2009). Although it is possible that lack of facilitation could result in a lack of engagement or of inappropriate behaviour, this was not observed in the included studies. Authors instead reported high participant motivation without incidents of inappropriate behaviour or cyberbullying (Gwynette et al, 2017). Potential barriers to accessibility with this delivery are the requirement for access to sufficiently high specification computers or robots. Accessibility for participants of all ability levels also requires interfaces to be suitably user-friendly.

Research implications

This review highlights the need for further research in this area. There is a particular need for more research focusing specifically on the adolescent age group, without including younger children. Although there was some individualisation of intervention which might have facilitated engagement across age groups, this was not the case for all studies. In addition, different developmental groups are likely to respond differently to interventions. Future research should offer a more complete assessment of social skills, spanning and integrating the four described domains. In particular, a focus on the emotion regulation domain of social skills would be a beneficial addition to the current literature. Research assessing the generalisability of social skills acquisition both outside the intervention and in the long-term would be an important area of development. The current literature offers extremely limited evidence of how skills might generalise to real-world settings. Future research would benefit from focusing on this as well as the longevity of any effects over the months following intervention delivery.

Other avenues for exploration include examining which interventions and technology platforms are more successful at facilitating positive change. The inclusion of control groups in future research would increase confidence in the findings about the efficacy of social skills interventions. Examining the hypothesis that enthusiasm for technology has the potential to increase motivation and improve intervention uptake would be a valuable contribution in determining whether technology-delivered intervention offers benefits beyond in-person intervention.

Future research could also build on the findings of the current review. For instance, studies could contribute to existing findings around intervention efficacy in different groups. This could include continuing to explore the suitability and efficacy of interventions among participants with LFA and co-morbid conditions. Controlling for demographic variables such as ethnic and socioeconomic background would give insight as to whether such factors impact access and response to social skills interventions. Other potentially confounding variables such as access to additional interventions should also be considered in future research. Other review findings that would benefit from further exploration are physiological findings with regards to the role of brain and autonomic nervous system in social skills acquisition.

Limitations of the review

The primary limitation of the review was the disparate age ranges of participants, in particular the conflation of different developmental age groups in some included papers. Other limitations include incomplete access to all available literature due to paywall constraints. Half of included papers came from hand-search of references, indicating that search terms did not cover all possible iterations of concepts.

Limitations of the literature

Large age ranges were a limitation of the literature, with papers spanning age groups utilised the same intervention for all participants. This 'one-size-fits-all' approach to intervention is likely to be inappropriate given the different needs and interests of different age groups. Of the five papers examining participants across different age groups, only one adapted then intervention according to individual needs. Children's' access to and interest in technology types changes with age (Chaudron et al, 2018). With 78% of 17-year-olds owning their own laptop or computer compared to 5% of children aged six (YouGov, 2019), it is likely that older teenagers would be more competent with the technology used in the studies. Older adolescents are also more cognitively competent than younger children with greater ability to think abstractly and have different social interests (La Guardia & Ryan, 2002). The lack of separation of age groups in the included studies offers a serious limitation to the conclusions that can be drawn from the aggregated findings.

Research design limitations include the absence of a control group in most of the studies and the lack of control of potentially confounding variables. It is therefore unclear if observed improvements were down to the intervention itself or to other factors such as attention, stimulation or participation in alternative interventions. One study reported that

9/13 participants were involved in interventions including ABA, CBT, occupational therapy, speech and language therapy and music therapy (Friedrich et al, 2015). In another, participants were receiving intense behavioural intervention at school (De Silva et al, 2009). Involvement in other therapeutic interventions is likely to have impacted upon the outcomes of the intervention for participants and might have confounded results.

Generalisability of results was limited due to the lack of real-world assessment of social skills acquired following the intervention. Most studies assessed social skills immediately after the completion of the intervention and used questionnaire or test performance measures. These short-term assessments are unlikely to capture generalisability to real-world settings. Generalisability is also compromised due to the absence of studies of the emotion regulation domain of social skills, and of studies assessing skills across all four domains.

The studies offered a limited assessment of intervention efficacy across different groups. Study participants were primarily high-functioning and male. Nine studies specifically excluded participants on the basis of ability, and six had exclusively male participants. Review findings may therefore be less relevant to low-functioning and female young people, who are likely to respond differently to intervention. For example, autistic girls exhibit differences to boys in compensatory and ‘masking’ behaviours in social situations (Dean et al, 2017), as well as exhibiting different technology preferences (Mascheroni & Ólafsson, 2014; Anderson & Jiang 2018). The lack of additional demographic data related to variables such as ethnicity and socioeconomic background means that it is unclear if interventions are equally effective across ethnic and socioeconomic groups.

Conclusions

The findings of this review offer limited support of the use of technology in delivering social-skill interventions to young people with a diagnosis of autism. The lack of separation of age groups in the studies reduced the extent to which conclusions could be drawn specifically about the adolescent age group. However, young people assessed appeared to improve in the measured social skills in the short-term. Although the mode of delivery did not appear superior to in-person delivery, young people reported appreciating and feeling motivated by the technology used. It is therefore possible that this method of delivery might improve intervention uptake and adherence. Other potential benefits include intervention flexibility and personalisation. Future research should focus on assessing these potential benefits as well as the generalisability of results to real-world settings and across time. A focus on all social skills domains including emotion regulation will be necessary to fully assess the impact of interventions upon social skills. Crucially, future research should focus on the adolescent group specifically, without conflating results from participants of different ages. If technology is utilised to deliver social skills intervention, an individualised intervention is indicated by both research authors and participants.

References

Algan, Y., Beasley, E., Tremblay, R.E. & Vitaro, F. (2014). *The long term impact of social skills training at school entry: A randomized controlled trial.* Paris: Sciences Po.

Anderson, M. & Jiang, J. (2018). Teens, social media & technology 2018. *Pew Research Center, 31*, 1673-1689.

Arain, M., Haque, M., Johal, L., Mathur, P., Nel, W., Rais, A., Sandhu, R. & Sharma, S. (2013). Maturation of the adolescent brain. *Neuropsychiatric disease and treatment, 9*, 449. DOI: 10.2147/NDT.S39776

Bauminger, N., Shulman, C. & Agam, G. (2003). Peer interaction and loneliness in high-functioning children with autism. *Journal of Autism and Developmental Disorders, 33*, 489–507. DOI: 10.1023/A:1025827427901.

Benford, P. (2008). *The use of Internet-based communication by people with autism* (Doctoral dissertation, University of Nottingham, United Kingdom). Retrieved from: https://lemosandcrane.co.uk/resources/University%20of%20Nottingham%20-%20The%20use%20of%20internet-based%20communication%20by%20people%20with%20autism.pdf

Benford, P. & Standen, P. (2009). The internet: a comfortable communication medium for people with Asperger syndrome (AS) and high functioning autism (HFA)? *Journal of Assistive Technologies, 3* (2), 44-53. https://doi.org/10.1108/17549450200900015

British Medical Association (2021). *Autism spectrum disorder*. Retrieved from: https://www.bma.org.uk/what-we-do/population-health/child-health/autism-spectrum-disorder#:~:text=It%20is%20estimated%20that%20around,diagnosis%20of%20autism%20spectrum%20disorder.

Chaudron, S., R. Di Gioia and M. Gemo (2018), Young Children (0-8) and Digital Technology, a Qualitative Study Across Europe. *Publications Office of the European Union*. https://doi.org/10.2760/294383

Cheak-Zamora, N. C., Teti, M., & First, J. (2015). ‘Transitions are Scary for our Kids, and They're Scary for us’: Family Member and Youth Perspectives on the Challenges of Transitioning to Adulthood with Autism. *Journal of Applied Research in Intellectual Disabilities, 28(*6), 548-560. DOI: https://doi.org/10.1111/jar.12150

Christie, D. & Viner, R. (2005). ABC of adolescence: Adolescent development. *British Medical Journal, 330*, 301–304 http://doi.org/10.1136/bmj.330.7486.301

Chung, E. Y. (2019). Robotic intervention program for enhancement of social engagement among children with autism spectrum disorder. *Journal of Developmental and Physical Disabilities, 31*(4), 419-434. doi:10.1007/s10882-018-9651-8

Chung, U., Han, D. H., Shin, Y. J., & Renshaw, P. F. (2016). A prosocial online game for social cognition training in adolescents with high-functioning autism: An fMRI study. *Neuropsychiatric Disease and Treatment, 12*, 651-660. DOI:10.2147/NDT.S94669

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

Dean, M., Harwood, R. & Kasari, C. (2017). The art of camouflage: Gender differences in the social behaviors of girls and boys with autism spectrum disorder. *Autism, 21*(6), 678-689. DOI: 10.1177/1362361316671845 de Armas, A. & Kelly, J.A. (1989). Social Relationships in Adolescence: Skill Development and Training. In J. Worell, J. & F. Danner (Eds), *The Adolescent as Decision-Maker*, (83-109), Academic Press. https://doi.org/10.1016/B978-0-08-088582-7.50010-7.

De Silva, P.R.S., Tadano, K., Saito, A., Lambacher, S. G. & Higashi, M. (2009). The development of an assistive robot for improving the joint attention of autistic children. *IEEE 11th International Conference on Rehabilitation Robotics, 1*, 694-700. DOI: 10.1109/ICORR.2009.5209583.

Didehbani, N., Allen, T., Kandalaft, M., Krawczyk, D., & Chapman, S. (2016). Virtual reality social cognition training for children with high functioning autism. *Computers in Human Behavior, 62*, 703-711. DOI: 10.1016/j.chb.2016.04.033

Dickinson, K. & Place, M. (2016). The impact of a computer-based activity prram on the social functioning of children with autistic spectrum disorder. *Games for health journal, 5*(3), 209-215. https://doi.org/10.1089/g4h.2015.0063

DiPietro, J., Kelemen, A., Liang, Y. & Sik-Lanyi, C. (2019). Computer- and robot-assisted therapies to aid social and intellectual functioning of children with autism spectrum disorder. *Medicina-Lithuania, 55*(8), 440. DOI: 10.3390/medicina55080440

Erikson, E.H. (1968). *Childhood and society*. New York: Norton.

Friedrich, E.V., Sivanathan, A., Lim, T., Suttie, N., Louchart, S., Pillen, S. & Pineda, J. A. (2015). An effective neurofeedback intervention to improve social interactions in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 45*(12), 4084-4100. DOI: 10.1007/s10803-015-2523-5

Gallup, J. & Serianni, B. (2017). Developing Friendships and an Awareness of Emotions Using Video Games: Perceptions of Four Young Adults with Autism. *Education and Training in Autism and Developmental Disabilities, 52*(2), 120-131. DOI: 10.2307/26420384

Gallup, J., Serianni, B., Duff, C. & Gallup, A. (2016). An exploration of friendships and socialization for adolescents with autism engaged in massively multiplayer online role-playing games (MMORPG). *Education and Training in Autism and Developmental Disabilities*, 51(3), 223-237. Retrieved from: https://www.jstor.org/stable/24827520

Gates, J.A., Kang, E. & Lerner, M.D. (2017). Efficacy of group social skills interventions for youth with autism spectrum disorder: a systematic review and meta-analysis. Clinical Psychology Review, 52, 164-181. http://dx.doi.org/10.1016/j.cpr.2017.01.006

Gleitman, H., Reisberg, D., & Gross, J. J. (2007). In Durbin J. (Ed.), *Psychology* (7th ed.). New York: W.W. Norton.

Grover, R. L., Nangle, D. W., Buffie, M., & Andrews, L. A. (2020). Defining social skills. In Nangle, D.W., Erdley, C.A. & Schwartz-Mette, R.A. *Social Skills Across the Life Span* (pp. 3-24). Academic Press. https://doi.org/10.1016/B978-0-12-817752-5.00001-9

Gwynette, M.F., Morriss, D., Warren, N., Truelove, J., Warthen, J., Ross, C.P., Mood, G., Snook C.A. & Borckardt, J. (2017). Social Skills Training for Adolescents with Autism Spectrum Disorder Using Facebook (Project Rex Connect): A Survey Study. *JMIR Mental Health, 4*(1). DOI: 10.2196/mental.6605

Hillier, A., Gallop, N., Mendes, E., Tellez, D., Buckingham, A., Nizami, A & O'Toole, D. (2020) LGBTQ + and autism spectrum disorder: Experiences and challenges. *International Journal of Transgender Health, 21*(1), 98-110, DOI: 10.1080/15532739.2019.1594484

Hopkins, I. M., Gower, M. W., Perez, T. A., Smith, D. S., Amthor, F. R., Casey Wimsatt, F. & Biasini, F.J. (2011). Avatar assistant: Improving social skills in students with an ASD through a computer-based intervention. *Journal of Autism and Developmental Disorders, 41*(11), 1543-1555. DOI: http://dx.doi.org/10.1007/s10803-011-1179-z

Hunter, F. T., & Youniss, J. (1982). Changes in functions of three relations during adolescence. *Developmental Psychology, 18*(6), 806. DOI: https://doi.org/10.1037/0012-1649.18.6.806

Jobe, L.E. & Williams White, S. (2007). Loneliness, social relationships, and a broader autism phenotype in college students. *Personality and Individual Differences, 42*(8) 1479-1489. DOI: 10.1016/j.paid.2006.10.021

Jordan, K., King, M., Hellersteth, S., Wiren, A. & Mulligan, H. (2013). Feasibility of using a humanoid robot for enhancing attention and social skills in adolescents with autism spectrum disorder. *International Journal of Rehabilitation Research, 36*(3), 221-227. DOI: 10.1097/MRR.0b013e32835d0b43

Kandalaft, M.R., Didehbani, N., Krawczyk, D.C., Allen, T.T. & Chapman, S.B. (2013). Virtual reality social cognition training for young adults with high-functioning autism. *Journal of Autism and Developmental Disorders, 43*(1), 34-44. DOI: http://dx.doi.org/10.1007/s10803-012-1544-6

Kapp, S. K. (2013). Interactions between theoretical models and practical stakeholders: the basis for an integrative, collaborative approach to disabilities. In Autistic Self Advocacy Network, & Daniel Jordan Fiddle Foundation (Eds.), *Empowering leadership: A systems change guide for Autistic College students and those with other disabilities* (pp. 104-113). The Autism Press.

Kapp, S. (2019). How social deficit models exacerbate the medical model: Autism as case in point. *Autism Policy & Practice, 2*(1), 3-28.

Ke, F. & Im, T. (2013) Virtual-Reality-Based Social Interaction Training for Children with High-Functioning Autism. *The Journal of Educational Research, 106*(6), 441-461, DOI: 10.1080/00220671.2013.832999

Ke, F., Moon, J., & Sokolikj, Z. Virtual reality-based social skills training for children with autism spectrum disorder. *Journal of Special Education Technology*. DOI: https://doi.org/10.1177/0162643420945603

Kuo, M.H., Orsmond, G.I., Coster, W.J., Cohn, E.S. (2014) Media use among adolescents with autism spectrum disorder. *Autism, 18*(8), 914-923. DOI: 10.1177/1362361313497832

La Guardia, J., & Ryan, R. (2002). What adolescents need. In F. Pajares & T. Urdan (Eds.) *Academic motivation of adolescents* (pp. 193-218). Connecticut: Information Age Publishing.

Lord, C., Elsabbagh, M., Baird, G., & Veenstra-Vanderweele, J. (2018). Autism spectrum disorder. *The Lancet, 392(10146)*, 508-520. DOI: https://doi.org/10.1016/S0140-6736(18)31129-2

Loomes, R., Hull, L., Mandy, W.P.L. (2017). What Is the Male-to-Female Ratio in Autism Spectrum Disorder? A Systematic Review and Meta-Analysis*. Journal of the American Academy of Child and Adolescent Psychiatry. 56*(6), 466-474. DOI:10.1016/j.jaac.2017.03.013.

Mandasari, V., Lu, M. V., & Theng, L. B. (2011). 2D animated Social Story for assisting social skills learning of children with autism spectrum disorder. In Theng, L (Ed.), *Assistive and Augmentive Communication for the Disabled: Intelligent technologies for communication, learning and teaching* (pp. 1–24). New York: Information Science Reference. DOI: 10.4018/978-1-60960-541-4.ch001

Mascheroni, G. and K. Ólafsson (2014). *Net Children Go Mobile: Risks and Opportunities.* Milan: Educatt. Retrieved from: http://netchildrengomobile.eu.

McCoy, A., Holloway, J., Healy, O., Rispoli, M. & Neely, L.(2016). A Systematic Review and Evaluation of Video Modeling, Role-Play and Computer-Based Instruction as Social Skills Interventions for Children and Adolescents with High-Functioning Autism. *Review Journal of Autism and Developmental Disorders, 3*, 48–67. DOI: https://doi.org/10.1007/s40489-015-0065-6

McFall, R. M. (1982). A review and reformulation of the concept of social skills. *Behavioral Assessment, 4*(1), 1–33. DOI: https://doi.org/10.1007/BF01321377

Mesa, S., & Hamilton, L. G. (2021). “We are different, that’sa fact, but they treat us like we’re different-er”: Understandings of autism and adolescent identity development. Advances in Autism.

Mitchell, P., Parsons, S. & Leonard, A. (2007). Using Virtual Environments for Teaching Social Understanding to 6 Adolescents with Autistic Spectrum Disorders. *Journal of Autism and Developmental Disorders, 37*, 589–600. DOI: https://doi.org/10.1007/s10803-006-0189-8

Moon, J., & Ke, F. (2019). Exploring the treatment integrity of virtual reality-based social skills training for children with high-functioning autism. *Interactive Learning Environments,* 1-5. DOI: https://doi.org/10.1080/10494820.2019.1613665

Nah, Y-H & Poon, K.K. (2011) The perception of social situations by children with autism spectrum disorders. *Autism, 15*(2), 185-203. DOI:10.1177/1362361309353616

National Heart Lung and Blood Institute (2019). *Quality assessment tools*. Retrieved from: https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools

Nominet (2019). *Today’s youth, tomorrow’s internet: A Nominet Digital Futures Report*. Retrieved from: https://media.nominet.uk/wp-content/uploads/2019/06/DFI-Youth-Report.pdf?_ga=2.168117601.1744853183.1616921316-1592815427.1616921316 (28/03)

OECD (2019). *What do we know about children and technology*. Retrieved from: https://www.oecd.org/education/ceri/Booklet-21st-century-children.pdf

Ofcom (2019). *Children and parents: Media use and attitudes report 2019*. Retrieved from: https://www.ofcom.org.uk/__data/assets/pdf_file/0023/190616/children-media-use-attitudes-2019-report.pdf

Office of National Statistics (2020). *Internet access- households and individuals, Great Britain: 2020*. Retrieved from: https://www.ons.gov.uk/peoplepopulationandcommunity/householdcharacteristics/homeinternetandsocialmediausage/bulletins/internetaccesshouseholdsandindividuals/2020

Olsson, N.C., Flygare, O., Coco, C., Görling, A., Råde, A., Chen, Q., Lindstedt, K., Berggren, S., Serlachius, E., Jonsson, U., Tammimies, K., Kjellin, L. & Bölte, S. (2017). Social skills training for children and adolescents with autism spectrum disorder: a randomized controlled trial. *Journal of the American Academy of Child & Adolescent Psychiatry, 56*(7), 585-592. DOI: https://doi.org/10.1016/j.jaac.2017.05.001

Parten, M. B. (1933). Social play among preschool children. *The Journal of Abnormal and Social Psychology, 28*(2), 136. DOI: https://doi.org/10.1037/h0073939

Ramdoss, S., Machalicek, W., Rispoli, M., & Lang, R. (2012). Computer based interventions to improve social and emotional skills in individuals with autism spectrum disorders: A systematic review. *Developmental Neurorehabilitation, 15*(2), 119-135. https://doi.org/10.3109/17518423.2011.651655

Rimland, B. & Edelson, M. (1999). *The Autism Treatment Evaluation Checklist (ATEC).* San Diego: Autism Research Institute.

Rolston, B. (2019). *Video Games as Prosocial Playgrounds for Adolescents with ASD* (Doctoral dissertation, Minot State University, United States of America). Retrieved from https://search.proquest.com/dissertations-theses/video-games-as-prosocial-playgrounds-adolescents/docview/2285295957/se-2?accountid=9869

Roser, M. and Ritchie, H. (2013). *Technological Progress*. Retrieved from: 'https://ourworldindata.org/technological-progress'

Rutter M, Bailey A & Lord C (2003). *The Social Communication Questionnaire*. Los Angeles: Western Psychological Services

Salmela-Aro, K. (2011). Stages of Adolescence. In B. B. Brown, & M. J. Prinstein (Eds.), *Encyclopedia of Adolescence* (pp. 360-368). Academic press. DOI: https://doi.org/10.1016/B978-0-12-373951-3.00043-0.

Serret, S., Hun, S., Iakimova, G., Lozada, J., Anastassova, M., Santos, A., Vesperini, S. & Askenazy, F. (2014). Facing the challenge of teaching emotions to individuals with low-and high-functioning autism using a new serious game: a pilot study. *Molecular autism, 5*(1), 1-17. DOI: https://doi.org/10.1186/2040-2392-5-37

Silver M, Oakes P. (2001). Evaluation of a New Computer Intervention to Teach People with Autism or Asperger Syndrome to Recognize and Predict Emotions in Others. *Autism, 5*(3), 299-316. DOI: 10.1177/1362361301005003007

Sparrow, S.S., Balla, D.A., Cicchetti, D.V. (1984). *Vineland Adaptive Behavior Scales*. Minneapolis: American Guidance Services.

Spence, S. H. (1995). *Social skills training: Enhancing social competence with children and adolescents*. Windsor: NFERNELSON.

Statistica (2021). *Distribution of Facebook users worldwide as of January 2021, by age and gender*. Retrieved from: https://www.statista.com/statistics/376128/facebook-global-user-age-distribution/

Stone, B. G., Mills, K. A. & Saggers, B. (2019). Online multiplayer games for the social interactions of children with autism spectrum disorder : A resource for inclusive education. *International Journal of Inclusive Education, 23*(2), 209-228. DOI: http://dx.doi.org/10.1080/13603116.2018.1426051

Suzuki, R., & Lee, J. (2016). Robot-play therapy for improving prosocial behaviours in children with autism spectrum disorders. *2016 International Symposium on Micro-Nano Mechatronics and Human Science (MHS)*, 1-5, DOI: 10.1109/MHS.2016.7824238

Tanaka, H., Negoro, H., Iwasaka, H., & Nakamura, S. (2017). Embodied conversational agents for multimodal automated social skills training in people with autism spectrum disorders. *PloS one, 12(*8). DOI: https://doi.org/10.1371/journal.pone.0182151

The National Autistic Society (2021). *What is autism?* Retrieved from: https://www.autism.org.uk/advice-and-guidance/what-is-autism on 04/02/2021

The Open University (2019). *What is technology?* Retrieved from: https://www.open.edu/openlearn/science-maths-technology/engineering-and-technology/technology/what-technology on 09/02/2021

Tse, J., Strulovitch, J., Tagalakis, V., Meng, L. & Fombonne, E. (2007). Social skills training for adolescents with Asperger syndrome and high-functioning autism. *Journal of autism and developmental disorders, 37*(10), 1960-1968. DOI: 10.1007/s10803-006-0343-3

World Health Organization. (1992). *International classification of diseases: Diagnostic criteria for research (10th edition).* Geneva: Switzerland.

World Health Organization (WHO). (1993). *The ICD-10 classification of mental and behavioural disorders*. World Health Organization.

World Health Organisation (2021). *Adolescent Health*. Retrieved from: https://www.who.int/health-topics/adolescent-health#tab=tab_1

Yang, Y. J. D., Allen, T., Abdullahi, S. M., Pelphrey, K. A., Volkmar, F. R., & Chapman, S. B. (2017). Brain responses to biological motion predict treatment outcome in young adults with autism receiving virtual reality social cognition training: Preliminary findings. *Behaviour Research and Therapy, 93*, 55-66. DOI: 10.1016/j.brat.2017.03.014

YouGov (2019). *How many children have their own tech?* Retrieved from: https://docs.cdn.yougov.com/kp1bpgx43s/YouGov%20-%20Kids%20and%20tech%20Results.pdf

Yurgelun-Todd, D. (2007). Emotional and cognitive changes during adolescence. *Current opinion in neurobiology, 17*(2), 251-257. https://doi.org/10.1016/j.conb.2007.03.009

Zhao, H., Swanson, A., Weitlauf, A., Warren, Z., & Sarkar, N. (2016). A novel collaborative virtual reality game for children with ASD to foster social interaction. In M. Antona & C. Stephanidis (Eds.) *Universal Access in Human-Computer Interaction. Users and Context Diversity* (vol. 9739, pp. 276-288). DOI: https://doi.org/10.1007/978-3-319-40238-3_27

Zhao, H., Swanson, A.R., Weitlauf, A.S., Warren, Z.E., & Sarkar, N. (2018). Hand-in-hand: A communication-enhancement collaborative virtual reality system for promoting social interaction in children with autism spectrum disorders. *IEEE Transactions on Human-Machine Systems, 48*(2), 136-148. DOI:10.1109/THMS.2018.2791562

Section B

Adolescence, autism and social media: Relationships between social media use, social capital and wellbeing among adolescents with autistic traits

Word count: 7937

A thesis submitted in partial fulfilment of the requirements of Canterbury Christ Church University for the degree of Doctor of Clinical Psychology

July 2021

SALOMONS INSTITUTE

CANTERBURY CHRIST CHURCH

Abstract

Social media has risen to increasing prominence in the lives of adolescents. Although its effects on social connections and wellbeing have been studied in the neurotypical population, minimal research has focused on the experiences of adolescents with autistic traits. From the limited literature in this area, autistic individuals appear to use social media differently to neurotypical peers, experiencing unique benefits including the removal of autism-specific communication barriers.

This paper examines the relationships between social media use, social connection making and wellbeing in a group of 222 autistic and neurotypical adolescents. Both quantitative and qualitative data was collected to examine several hypotheses relating to these relationships. The role of autistic traits was examined as a possible moderating factor in all hypotheses.

Adolescents reported a generally positive impact of social media on their social life. Social media use resulted in increases in online social capital, particularly among adolescents with autistic traits. Social capital in turn positively impacted wellbeing. Overall, social media use did not impact wellbeing, but this varied with autistic traits. Participants without autistic traits exhibited increases in wellbeing with social media use while those with more autistic traits demonstrated decreases in wellbeing. Implications for future research and clinical practice are discussed.

Keywords: Social media, autism, adolescence, social life, wellbeing, social capital, social connections

Introduction

Social media in the 21st century

'Social media' can be defined as web-based platforms sharing features including a focus on user-generated content. They allow the creation of user-specific personal profiles that are employed to develop social networks (Obar & Wildman, 2015). Popular examples include Facebook, Instagram, TikTok and Twitter. Social media was first developed in the late 20th century and has since increased in both scope and usage; around 55% (4.33 billion) of the world population are social media users (Datareportal, 2021). It has been predicted that users spend around 15% of their waking lives using social media (Datareportal, 2021).

Social media and social connection

One of the primary uses of social media is to form or sustain social relationships (Whiting & Williams, 2013), with users most likely to use social media to maintain existing ties, rather than to initiate new ties (Ellison et al, 2011). Social media use is associated with stronger friendships (Valkenburg & Peter, 2007), with research indicating that social media use increases the depth of existing relationships rather than activating latent ties or creating connections with strangers (Bauernschuster et al, 2014; Ellison et al., 2007; Pénard & Poussing, 2010). Social media participation is positively associated with the frequency of face-to-face meetings with friends and acquaintances (Sabatini & Sarracino, 2014).

One of the ways that such social advantages have been conceptualised is as 'social capital', which describes a form of capital embedded in the relationships between individuals (Ellison et al, 2011). Two basic forms of social capital have been described: bonding and bridging (Putnam, 2000). Bonding social capital comprises the capital inherent in close social ties which might result in emotional, financial, or physical support. Bridging social capital derives from connection with casual acquaintances and can result in benefits including access to novel information and a broadening of world views.

Existing research suggests that Internet and social media use are related to social capital both on and offline (Skoric et al, 2016). The intensity of social media use has been shown to predict bridging social capital a year later, particularly for lower self-esteem individuals (Steinfield et al, 2008). The relationship between social media use and social capital appears bidirectional, with individuals possessing greater existing social capital more likely to use the Internet to foster social relationships (Pénard & Poussing, 2010). The different ways in which users interact with social media may affect the relationship between social media use and social capital. Specifically, different types of connection strategies used online, either to initiate relationships, information seek about acquaintances or maintain existing relationships can impact social capital differently, with information-seeking associated with the greatest improvements in social capital (Ellison et al, 2011).

Table 7: Types of social capital

	Type of capital	
Setting	Bonding *Close social ties resulting in emotional, financial and physical support.*	Bridging *Connection with acquaintances which can increase access to information and opportunities.*
Online	***Online bonding social capital*** Close social ties online	***Online bridging social capital*** Loose social ties online
Offline	***Offline bonding social capital*** Close social ties offline	***Offline bridging social capital*** Loose social ties offline

Social media and wellbeing

Given its reported impact on relationships, it might be expected that social media use would affect personal wellbeing. Wellbeing is a concept that encompasses a sense of life-satisfaction and happiness (hedonic wellbeing), as well as personal meaning and self-realisation (eudaimonic wellbeing) (Ryan & Deci, 2001). A growing number of studies have examined this relationship, with mixed results (Keles et al, 2020). Some research suggests that social media use has a positive relationship or no relationship with wellbeing (Orben & Przybylski, 2019). Other authors have found that greater use is associated with lower wellbeing and higher risk of depression (Twenge & Campbell, 2019). The direction of this relationship however is unclear, with depressive symptoms, stress and loneliness resulting in greater social media use (Cataldo et al, 2021).

It is possible that personal user-related factors moderate the relationship between social media use and wellbeing. For instance, there is evidence that attachment style and personality type influence the degree to which social media negatively impacts upon mental health (Young et al, 2020; Kircaburun et al, 2020). Gender also has an impact, with females more likely to exhibit problematic social media use (Kircaburun et al, 2020).

The different ways in which users interact with social media has also been proposed as an important factor, with more and less adaptive ways of using these platforms. Passive use (when users observe others' activities without engagement), is associated with lower levels of subjective wellbeing than active participation, such as posting an update (Verduyn, et al 2017). Some users demonstrate 'problematic use' of social media, with uncontrolled and compulsive behaviours. Problematic use is associated with choice of platform and motives for using social media. Individuals reporting motives such as meeting new people, presenting a more popular self and passing time/entertainment were more likely to report problematic social media use. With regards to platform choice, Instagram, Snapchat and Facebook users reported more problematic use than Twitter, YouTube WhatsApp and Google users (Kircaburun et al, 2020).

Autism and social media

The medical model of autism describes it as a ‘lifelong neurodevelopmental condition’ affecting communication and behaviours. This is disputed by proponents of social conceptions of autism, who advocate embracing and supporting rather than pathologising neurodiversity (Chapman, 2019). Medical diagnosis is based upon the identification of reported social interaction difficulties, persistent rigid and repetitive behaviours, resistance to change and restricted interests, often accompanied by sensory sensitivities (National Institute for Health and Care Excellence, 2016). It is estimated that 1 in every 160 children worldwide has autistic spectrum disorder (ASD) (World Health Organisation, 2019).

The use of social media among individuals with an autism diagnosis has been little studied. The limited available research indicates that adults with an autism diagnosis engage with social media, doing so primarily to connect with others, as well as for entertainment and work purposes (Mazurek, 2013). Studies examining computer-mediated communication (CMC) (encompassing email and text message as well as social media) suggest that individuals with autism are enthusiastic about such technology. There is evidence that these individuals use the internet qualitatively differently from others, with different perceived benefits (Gillespie-Lynch et al, 2014). Particular reported benefits for adults with an autism diagnosis include control over time and pacing, self-expression and self-presentation, opportunities to meet like-minded others and management of social cues (e.g. clarity of written text, lack of non-verbal cues and lack of small talk) (Benford & Standon, 2009; Benford, 2008; Van der Aa et al, 2016). This reportedly reduces stress and sensory overstimulation and aids communication (Benford, 2008).

Social media and social connection among individuals with an ASD diagnosis

Individuals with an autism diagnosis tend to be more isolated than others (Bauminger et al, 2003; Jobe & Williams White, 2007), with fewer reciprocal relationships and poorer friendship quality (Kasari et al, 2011; Calder et al, 2013; Locke et al, 2010). It has been hypothesised that the stated benefits of CMC may assist these individuals in connecting with others. Research supports this, with autistic adults using CMC reporting higher levels of online social life satisfaction (van der Aa, 2016).

Studies of online communication among individuals with autism have not examined social capital as a measurement of connection. However, it is possible that the facilitation of communication online may impact upon this. The acquisition of social capital depends upon effective communication (Wellman, 2011), with communication being described as the ‘currency of social capital’ (Gonzales, 2015). Reduction of spatial, temporal and autism-specific communication barriers alongside increased reach and control of information flow may result in increased social capital for autistic social media users (Resnick, 2001).

Social media use and wellbeing among individuals with an ASD diagnosis

As with the general population, there is mixed evidence as to whether and how social media use impacts upon the wellbeing of users with an autism diagnosis. One study examining CMC with adults found that its use corresponded with decreased life satisfaction (van der Aa et al, 2016). By contrast, adults using one social media site (Facebook), reported higher happiness than those who did not. However, this effect was not found for an alternative site (Twitter) (Ward et al, 2018). It is possible these findings reflect the ways that individuals are using these sites, with Facebook being used more to connect with friends and family.

Adolescence, autism and social media

Adolescents are some of the most prolific users of social media, with 96% of 16-24-year-olds in the UK using social media (Office of National Statistics, 2017). Adolescence is a distinct developmental stage lasting from approximately age 10 to 19 (World Health Organisation, 2021). It is characterised by rapid physical, social and cognitive development, and a move towards personal independence (Christie & Viner, 2005). Adolescents begin to develop their identity and peer relationships during this period (Jenkins, 2014).

Adolescents use social media to develop and maintain friendships (Anderson & Jiang, 2018) and report that social media helps them to understand and connect with their friends (Borca et al, 2015). In line with the adult literature, research in this group suggests mixed findings on the impact of social media on wellbeing, (Best et al, 2014) with results varying from individual to individual (Beyens et al, 2020).

Data for adolescents with a diagnosis of autism is less comprehensive, with few studies examining social media use and its impacts in this group. Studies of social connection-making found that adolescents with diagnosed ASD have more positive, secure and high-quality friendships with greater use of social networks (Kuo et al, 2014; van Schalkwyk et al, 2017). This relationship was moderated by anxiety in one study, with a weaker relationship between social media use and friendship in more anxious participants (van Schalkwyk et al, 2017).

The impact of social media on wellbeing in this group has been little studied. One study found that adolescents with autistic traits are more likely to display disordered social media use including persistence, escape and withdrawal. These participants were then more likely to display higher levels of depressive symptoms (Şahin & Usta, 2020). Individuals with reduced social skills abilities appear to use social media to avoid negative emotions which in turn reduces subjective wellbeing (Şahin & Usta, 2020).

Study aims

This study examines social media use in adolescents with and without autistic traits. It examines the ways social media is used in building connections, and how its use impacts social capital and wellbeing. There has been very little research examining the use of social media exclusive of other forms of CMC in the autistic group. Existing research has been conducted with adults, with a paucity of research among adolescents with autistic traits. The experiences and challenges of adolescents using social media is likely to differ from those of adults using CMC. The more visual and time-contingent environment of social media among adolescents may result in difficulties obtaining reported CMC benefits such as control over pacing, self-expression and social cues.

This study will build on previous research undertaken by van der Aa, Pollman, Platt and van der Gaag (2016) which examined CMC use, social relationships, and wellbeing in adults with a diagnosis of autism. This study found that individuals with an autism diagnosis appreciated different elements of CMC, were more likely to make friends online and were satisfied with their online social lives compared to a comparison group. Measures of life satisfaction however were lower with increased CMC use. The current study examines associations between the same three factors (usage, social relationships and wellbeing), while also examining the potentially mediating role of social relationships between social media use and wellbeing. It utilises some of the same measures as the van der Aa et al study, including reported advantages of social media while changing others, examining social capital instead of the strength of one social relationship. Rather than examining all forms of computer mediated communication, the current study examines social media exclusively. The focus while also examining focuses on a different age group, examining participants in late adolescence, when social media use is typically high.

Hypotheses

Hypothesis 1: Young people with autistic traits will see different advantages and disadvantages of social media use for making connections to young people without autistic traits.

Hypothesis 2: Participants with and without autistic traits will report differently about the effect social media has on their social life.

Hypothesis 3: Individuals with and without autistic traits will differ in their preference for connection strategies (to initiate, social information seek or maintain connections), with individuals with autistic traits using initiating strategies relatively more and maintenance strategies less than those without autistic traits.

Hypothesis 4: There will be a relationship between social media use and bridging social capital (making connections between social groups) both on and offline, and this will vary between individuals with and without autistic traits.

Hypothesis 5: There will be a relationship between social media use and bonding social capital (developing strong ties) both on and offline, and this will vary between individuals with and without autistic traits.

Hypothesis 6: There will be a relationship between social media use and wellbeing for participants and this will vary between individuals with and without autistic traits.

Hypothesis 7: There will be a relationship between social capital and wellbeing, and this will vary between individuals with and without autistic traits.

Hypothesis 8: Any relationship between social media use and wellbeing will be mediated by social capital and this will vary between individuals with and without autistic traits.

Method

Design

A non-experimental, survey-based, cross-sectional design was used for this study. An online survey was created based on existing measures and questions drawn from previous studies. This can be accessed at www.socialmediasurvey.co.uk. The survey was piloted on a group of three young people aged 16-17 recruited from a secondary school, who were asked to provide feedback on the suitability and acceptability of the survey. The feedback was incorporated into the design of the survey, which was then advertised on social media platforms, autism groups and a participant-recruitment website.

Descriptive information about the ways that participants used social media was collected, including the perceived advantages and disadvantages of using these platforms. Participants were asked whether they had received an autism diagnosis. They were also asked to complete the autism quotient (AQ) questionnaire to determine levels of autistic traits. Both ASD diagnosis and AQ score were used in the statistical analyses to examine differences between participants according to both stated diagnosis and autistic traits. The relationship between social media use and social capital, as well as that between social media and wellbeing were examined, with stated diagnosis and AQ scores as moderating variables. Finally, a moderated mediation was used to examine whether the relationship between social media use and wellbeing was mediated by social capital and whether this was moderated by autistic traits.

Sample size

Using graphs created by Miles and Shevlin (2001), a minimum sample size for regression analyses was calculated at 80. This was for an anticipated medium effect size with a power of .8 and factoring in 3 predictors. MacKinnon, Fairchild and Fritz's (2007) paper was used for examining power calculations for a moderated mediation analysis. This recommended a sample of 71, assuming medium effects for both relationships, with a power of .8. Medium effect sizes were assumed because this was considered sufficient to be clinically meaningful given the limited amount of research in the area. Therefore, a minimum sample of 80 participants was sought, with an aim to recruit as many participants as possible.

Participants

Participants were recruited using several recruitment strategies. Adverts were placed on the Facebook, Facebook messenger and Instagram platforms. These were targeted at young people with an interest in online autism groups such as Autism Speaks and Autism Awareness. In addition, participants were recruited through advertisement by the Cambridge Autism Research Database (CARD) and Autistica Network. These organisations provided details of the study in emails going out to their members, including young people with autism and their parents. These emails included a link to the survey. Finally, targeted recruitment took place on the participant recruitment website ‘Prolific’, where potential participants were screened for age and autism diagnosis.

222 participants were recruited with these methods. Participants were aged 16-19, both male and female and with an understanding of English. 70.3% of the total sample were female and 32.9% had a diagnosis of autism. The average age was 17.0 years. Participants were predominantly White British (72.1%) and living with caregivers (90.1%). 84.2% had an education level at GCSE level or higher. Participant demographic information is included in Table 8.

Table 8: Demographic information

Variable	Frequency
Autism Diagnosis (n, %)[3]	
Diagnosis	73 (32.9%)
No diagnosis	149 (67.1%)
Gender (n, %)	

Variable	Frequency
Ethnicity (n, %)	
White British	160 (72.1%)
White Irish	1 (0.5%)
White other	19 (8.6%)

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[3] Participant numbers according to stated ASD diagnosis, not AQ score

Total		Black African	9 (4.1%)
Female	156 (70.3%)	Black Caribbean	1 (0.5%)
Male	52 (23.4%)	Black other	1 (0.5%)
Prefer not to say	14 (6.3%)	Indian	2 (0.9%)
ASD group		Pakistani	3 (1.4%)
Female	35 (47.9%)	Bangladeshi	3 (1.4%)
Male	33 (45.2%)	Chinese	3 (1.4%)
Prefer not to say	5 (6.8%)	Asian other	3 (1.4%)
No diagnosis group		White and black Caribbean	3 (1.4%)
Female	121 (81.2%)	White and Asian	3 (1.4%)
Male	19 (12.8%)	Other mixed	6 (2.7%)
Prefer not to say	9 (6.0%)	Other	3 (1.4%)
Age (mean, sd)	17.0 (1.049)	Prefer not to say	2 (0.9%)
Living situation (n, %)		**Highest education**	
At home with caregiver	200 (90.1%)	GCSE or equivalent	107 (48.2%)
Living at university	14 (6.3%)	A-Level or equivalent	76 (34.2%)
Living independently	7 (3.2%)	Undergraduate degree	4 (1.8%)
Current employment		Some secondary education	28 (12.6%)
School/college	148 (67.2%)	Other/not sure	7 (3.2%)
Higher education	58 (26.3%)	**Relationship status**	
Employment	6 (2.8%)	Single	163 (73.4%)
Unemployed	10 (4.5%)	In a relationship	59 (26.6%)

Measures

Autism Quotient.

The Autism Quotient-10 (Allison et al, 2012) is a 10-point self-report scale capturing autistic traits. It was adapted from the full Autism Quotient (AQ) and validated with a group of 4176 individuals with and without an autism diagnosis, including 637 adolescents. Researchers determined a scoring cut-off point of 6 for indication of autistic traits. For the adult version of the scale (age ≥16), this cut-off showed sensitivity of 0.88, specificity of 0.91 and positive predictive value of 0.85 for detecting individuals with an ASD diagnosis. The scale is NICE recommended (NICE, 2016) for use in screening adults suspected to have autistic traits. The AQ-10 has 10 items rated on a 4-point Likert scale from ‘definitely disagree’ to ‘definitely agree’.

Warwick-Edinburgh Wellbeing Scale.

The Warwick-Edinburgh wellbeing scale (WEMWBS; University of Warwick, 2006) is a self-report scale for people aged 13 and above, designed to capture eudemonic (happiness) and hedonic (meaning and self-realisation) elements of wellbeing. The scale has good reliability and validity, with a test-retest reliability of 0.83 and Cronbach's alpha of 0.89 (Tennant et al, 2007), and has been used by NHS direct as a screening tool for mental ill-health (University of Warwick, 2020). The WEMWBS invites users to rate statements of their feelings over the preceding 2 weeks on a 5-point scale from 'none of the time' to 'all of the time' e.g. 'I have been feeling useful'. This yields a total score ranging from 14-70, with higher scores representing higher mental wellbeing.

Social media intensity scale.

The Facebook intensity scale (Ellison et al, 2007) was adapted into the 'social media intensity scale' by substituting 'Facebook' for 'social media' in measure questions. This measure was developed to assess individual investment in social media beyond the degree of usage. Questions were measured on a 5-point Likert scale (strongly disagree-strongly agree), rating statements such as 'I am proud to tell people I'm on social media'. The 6-point version of the scale was used, without free text components (Shankleman, 2020). The Facebook intensity scale has yet to be systematically validated. However, studies have consistently shown the scale to be reliable (Cronbach's α >.70), including instances where it has been adapted to be made relevant to more general social media use (Salehan & Negahban, 2013).

Social media advantages and disadvantages.

Questions about the advantages and disadvantages of social media were taken from van der Aa et al (2016). Three areas of advantage were identified by participants with autism in this study: ‘time independence’, ‘no co-presence’ and ‘ease to express self’. The three questions with the highest factor loading from each category were included in this study; all had strong factor loading with a minimum of .518. Participants were asked to rate each statement on a 100-point scale from ‘disadvantage’ to ‘advantage’; for instance, ‘online I don’t have to react instantly’. The three categories of advantages were shown to have good internal consistency (time independence α= .89, no co-presence α= .87, relative ease to express oneself α= .76), with a significant difference found on ratings of these between individuals with and without an autism diagnosis, $p < .001$. In addition to these pre-set questions, participants were asked to describe perceived advantages and disadvantages in a free-text box.

Social connection strategies.

Questions about social connection strategies used online were adapted from those developed by Ellison et al (2007 & 2011) with university students. Factor analysis by these authors revealed three dimensions representing different connection strategies: initiating contact with others, information seeking about acquaintances and maintaining close ties. Items relating to social information seeking and maintaining ties were found to have good internal consistency (Cronbach’s alpha = .70). One question pertaining to each strategy was chosen based on comprehensiveness and relevance to adolescents. The word ‘Facebook’ was replaced with ‘social media’ and one item was adapted to make more relevant to adolescents (I use social media to keep in touch with family and friends). Two further pre-set questions were asked relating to the perceived impact of social media on participants’ social life: ‘social media has a positive impact on my social life’ and ‘social media helps me find people with similar interests’. All pre-set questions were rated on a 100-point slider from ‘strongly disagree’ to ‘strongly agree’. In addition, a free text box was included where participants were asked ‘what impact does social media have on your social life?’.

Internet social capital scale.

The Internet social capital scale (Williams, 2006) was used to evaluate social capital on- and offline. Factor analysis revealed two social capital domains: bridging and bonding social capital. Participants were asked to rate their agreement with 20 statements pertaining to both social capital domains for both online and offline relationships on a 5-point Likert scale (strongly disagree to strongly agree). For the purposes of the study the wording of some questions was amended to make it more accessible to British young people e.g. the word ‘dollar’ was replaced with ‘pound’. In validation with 884 volunteers (aged 14-68), the scale demonstrated good reliability (α= ≥.841 for all four domains) and reasonable goodness of fit (goodness of fit index= .88 online, .90 offline). The scale demonstrated good construct validity, with correlations between social capital domains and measures of similar constructs, as well as with behaviours such as meeting new people, going out and having offline contacts.

Procedure

Participants wishing to participate were taken via hyperlink to the online survey. Participants were first presented with an information sheet before being asked if they would like to take part in the survey. They were offered the opportunity to receive the results of the study via email and to participate in a prize draw for a £50 voucher. Participants were not offered individual feedback or the results of their completed questionnaires. After indicating that they would like to take part in the study, participants were taken to a separate consent page. After giving consent, participants completed the demographic and self-report questions as described. At the end of the study, participants were presented with a debrief page offering the contact details of relevant mental health organisations and the research team. Participants were encouraged to contact the researcher with any questions or concerns.

Ethical issues

Ethical approval for the study was granted by the ethics committee at the Salomons Institute for Applied Psychology, Canterbury Christ Church University. Ethical issues around anonymity and participant wellbeing were carefully considered, particularly in light of the young age of participants and the sensitivity of some of the questions and questionnaires used. In line with guidelines from Berman (2016), participants were advised before commencing the survey that questions about their wellbeing might be upsetting. They were advised to consider not taking part if this was likely. Participants were advised that they could pause the survey and resume it at a later point if necessary. They were also reminded that they could discontinue at any point. At the end of the study, signposting for Mind and YoungMinds was provided, as well as contact details for the research team. Collected data was anonymised by removing any email addresses and instead identifying participants only by a random string of numbers and letters.

Statistical analysis

This study used a mixed-method approach, collecting both qualitative and quantitative data. Qualitative data was analysed using content analysis. This followed the conventional approach, without using preconceived categories (Hsieh & Shannon, 2005).

The results of open-ended questions were read through multiple times, allowing ideas to emerge through immersion in the data (Kondracki & Wellman, 2002). Codes were identified by highlighting key words in the data that captured key concepts. Codes were then organised by the author into categories consisting of codes with interrelated concepts (Patton, 2001). The frequency of reporting of these categories was than assessed statistically.

Statistical analysis was conducted using SPSS software. Datasets were initially analysed for test assumptions including violations of normality and homogeneity of variance. Where these were violated, group sizes were equalised by the random removal of 'no diagnosis' participants in order to increase robustness of the tests to assumption violation (Field, 2017). In some instances, non-parametric alternatives were utilised. Hypotheses were assessed for both the variable of stated ASD diagnosis as well as total AQ score where possible. Where multiple tests were undertaken, the Bonferroni correction for multiple comparisons was used.

Chi-squared tests were used to assess free-text box content in hypotheses 1 and 2. Pre-set questions were analysed using MANOVA, Mann-Whitney U and independent t-test. Hypothesis 3 was tested using 2-way ANOVA. Hypotheses 4-8 were tested using the PROCESS bootstrapping macro for SPSS (Hayes, 2017). Hypotheses 4-7 were assessed using model 1, a moderation model (see Figure 2), while hypothesis 8 was analysed using model 59, a moderated mediation model (see Figure 3).

Figure 2: Hayes (2017) PROCESS macro model 1

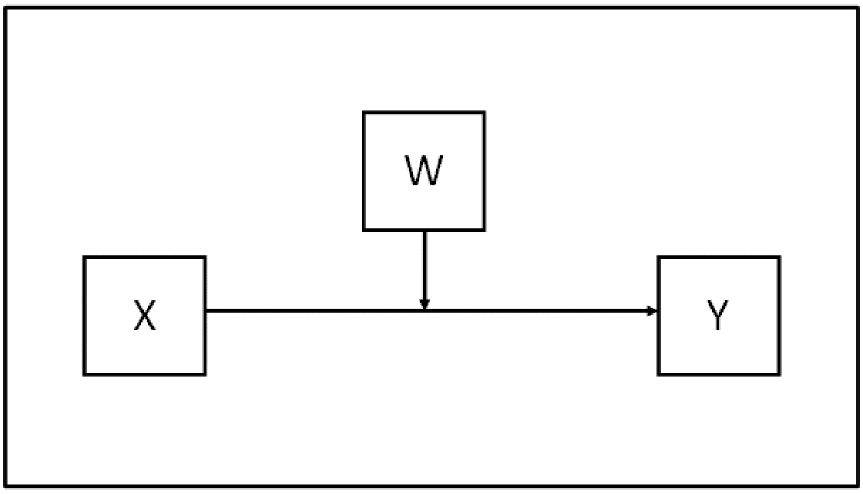
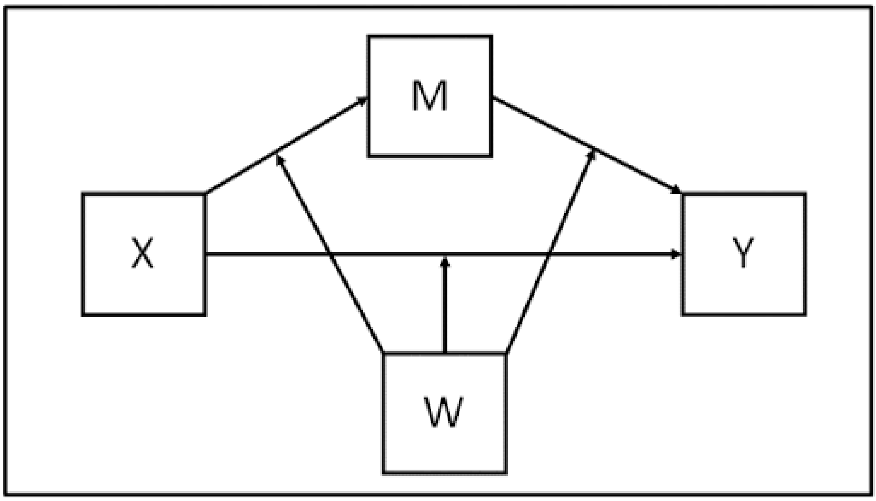


Figure 3: Hayes PROCESS macro model 59



Results

Hypothesis 1

Free text boxes were used to gather exploratory data about the advantages and disadvantages perceived by the young people. This was then assessed using content analysis. Content analysis of free text boxes about social media *advantages* revealed 18 initial categories of social media advantages. These were distilled into 9 themes which are detailed in Table 9. A tree diagram detailing this process in included in Appendix 8.

Table 9: Reported advantages of social media

Theme	Description	Example quotes
1. Social life	This describes maintaining existing connections such as staying in touch with friends and family, receiving updates and being able to make real-life social plans.	'I can connect with friends and family that I'm not able to see often and catch up with them' 'I can talk to my closest friends online and send them posts or photos'
2. Information seeking	Participants described using social media to keep in touch with world news and facilitate learning. Other types of information seeking included updates on celebrities, local businesses and important social issues.	'Increased awareness and general knowledge' 'Enhances the learning experience' 'Getting news from around the world quickly'
3. Entertainment	Participants used social media to provide entertainment or pass time. This included watching videos, playing videos, and viewing entertaining memes.	'Playing games and watching videos' 'Something to escape to, enjoyment'
4. Content creation	Young people described using social media platforms to create content in order to promote their lifestyle, influence others and keep a record of their life.	'I grow my platform and get to work with small business' 'Post updates about your life' 'Building up a following for your brand'
5. Connection seeking	Participants reported using social media to make connections with unknown others, find likeminded individuals and an online community.	'It has helped me connect with all kinds of people and as such my world view is not as ignorant' 'It's easier to find communities that share the same interests as you, helping you to feel less isolated'
6. Wellbeing	Young people described using social media to improve wellbeing through viewing motivational and inspirational content and finding support for their mental health.	'It gives me a place to manage my mental health, as I can create private accounts with no followers to talk about my issues easily' 'People can support each other in this hard time'
7. Identity	Participants reported advantages of developing their self-identity and building self-esteem through developing interests, debating and sharing opinions.	'It has helped me massively with discovering parts of my identity (LGBTQ+) and accept them' 'Being able to express yourself'
8. Autonomy	Participants described enjoying the autonomous aspects of social media such as accessing desired materials quickly and having control over when	'I like being able to consume media that I can enjoy whenever I want'

	and how they used social media platforms.	‘People are able to post as little or as much as possible’
9. Conversation management	Conversation management included reported reduction in stress and increased ease of conversation without face-to-face interaction, as well as increased ability to determine other’s intentions.	‘Can ignore people if you feel annoyed’ ‘Easier to start conversation’ ‘Being able to put across my thoughts more accurately in literate form’

As can be seen in Table 10, the most commonly reported advantage in both groups was ‘social life’, followed by ‘information seeking’ and ‘new connections’. The least commonly reported advantage was ‘conversation management’ in the no diagnosis group, and ‘identity development’ in the autism diagnosis group.

Pearson’s Chi-square analysis was performed to compare rates of reporting for each advantage in the ‘ASD’ and ‘no diagnosis’ groups. This revealed significant differences between groups in the advantages: ‘entertainment’ and ‘conversation management’. The ASD group were more likely to report conversation management and less likely to report entertainment as advantages of social media. ‘Content creation’ and ‘autonomy’ neared significance, with ‘no diagnosis’ participants reporting content creation more and autonomy less as advantages of social media. Bonferroni correction was used to correct for multiple comparisons. Of the significant comparisons, only ‘entertainment’ survived Bonferroni correction at *p*= .0056.

Table 10: Chi-squared analysis of social media advantages

Advantages	**N reported (% of group)**		**χ2**	**P value**
Social life	ASD	52 (71.2%)	.393	.531
	No diagnosis	112 (75.2%)		
Information seeking	ASD	27 (37.0%)	1.278	.258
	No diagnosis	67 (45.0%)		
Entertainment	ASD	7 (9.6%)	8.204	.004*

	No diagnosis	39 (26.2%)		
Content creation	ASD	5 (6.8%)	3.698	.054
	No diagnosis	24 (16.1%)		
New connections	ASD	23 (31.5%)	.009	.924
	No diagnosis	46 (30.9%)		
Wellbeing	ASD	11 (15.1%)	2.184	.139
	No diagnosis	35 (23.6%)		
Identity development	ASD	5 (3.4%)	1.390	.238
	No diagnosis	5 (6.8%)		
Autonomy	ASD	18 (24.7%)	3.775	.052
	No diagnosis	21 (14.1%)		
Conversation management	ASD	8 (11.0%)	6.560	.010*
	No diagnosis	4 (2.7%)		

Content analysis of disadvantages revealed 20 categories that were distilled into 10 themes detailed in Table 11. A tree diagram of the categories is included in Appendix 9.

Table 11: Reported disadvantages of social media

Theme	**Description**	**Example quotes**
Mental health	Young people reported negative impacts on mental health as a disadvantage of social media, including heightened depression and anxiety and lowered self-esteem.	‘It can have a bad effect on your mental health’ ‘If you’re not doing so well mentally it can be draining’
Time consumption	Participants reported finding social media addictive and that it took up too much of their time. This resulted in them missing real-world activities.	‘I often get absorbed in it and spend too much time on it’ ‘Takes you away from real life. You may feel less motivated to get up and actually do things’
Unwanted content	Participants spoke about viewing or receiving unwanted social media content. This included triggering or	‘Can be cyberbullying and people can be nasty’

	upsetting material, cyberbullying and trolling.	'Sometimes content can be triggering or upsetting'
Negative comparison	Young people talked about negatively comparing themselves to others online. This included comparing personal appearance, activities and experiencing FOMO (fear of missing out).	'I compare my boring life to other interesting ones' 'You can find yourself comparing yourself and saying negative things about your own body when seeing those thin models'
Online safety	Young people were concerned about safety features including stalking, identity theft and sexual misconduct online. The lack of online policing and anonymity of perpetrators were concerns for participants.	'Identity theft could occur, hacking into accounts, talking to strangers' 'I see… harassment, sexting and stalking as disadvantages'
Misleading	Participants reported disliking the misleading nature of online content. This included 'fake news' and 'catfishing': misleading representations of world news and individuals.	'Being exposed to false news' 'Unreliability of the source when news is spoken about' 'Not always true what you see'
Peer pressure	Young people felt pressure to participate in social media and to obtain likes and comments. They also reported feeling pressure to follow popular trends and fashions.	'Very high pressure on body image and popularity' 'Pressured to use it' 'Puts pressure to get as many likes/comments/followers'
Cancel culture	Participants reported 'cancel culture', when individuals are ostracised from online communities, as a disadvantage of social media.	'Cancel culture is a horrible part of social media….To cancel someone ignores the possibility of personal growth that could come with approaching…with empathy and educating them'
Polarised views	Participants reported that social media could heighten the polarisation of views. They reported computer algorithms tailoring content and creating echo chambers of opinion.	'Radical ideas from both ends of the political spectrum' 'Social media platforms incentivise division and controversy'
Conversation management	Some participants reported that conversation management was more difficult online. Reported problems were understanding the tone of conversations and the escalation of arguments.	'Sometimes I get sort of confused about whether or not someone is joking or being mean because it's difficult to tell tone'

The most commonly reported disadvantages for both groups were the impact on mental health and time consumption, followed by unwanted content and negative comparison. Pearson's Chi-Squared for each disadvantage revealed significant differences between groups in the ‘negative comparisons’ and ‘conversation management’ categories. The ASD group were less likely to report ‘negative comparisons’ as a disadvantage and more likely to report ‘conversation management’. Bonferroni correction at *p*= .005 was used to correct for multiple comparisons. No factors survived Bonferroni correction.

Table 12: Chi-squared analysis of social media disadvantages

Disadvantages	**N reported (% of group)**		**χ2**	**P value**
Mental health	ASD	32 (43.8%)	.169	.681
	No diagnosis	61 (40.9%)		
Time consumption	ASD	32 (43.8%)	.121	.728
	No diagnosis	69 (46.3%)		
Unwanted content	ASD	25 (34.2%)	.235	.627
	No diagnosis	56 (37.6%)		
Negative comparison	ASD	15 (20.5%)	4.389	.036*
	No diagnosis	51 (34.2%)		
Online safety	ASD	29 (19.5%)	1.124	.289
	No diagnosis	10 (13.7%)		
Misleading	ASD	11 (15.1%)	.005	.943
	No diagnosis	23 (15.4%)		
Peer pressure	ASD	9 (12.3%)	.040	.841
	No diagnosis	17 (11.4%)		
Cancel culture	ASD	0 (0.0%)	1.996	.158
	No diagnosis	4 (2.7%)		
Polarised views	ASD	2 (2.7%)	.483	.487
	No diagnosis	7 (4.7%)		
Conversation management	ASD	4 (5.5%)	5.145	.023*
	No diagnosis	1 (0.07%)		

Pre-set questions were also used to examine perceived advantages and disadvantages and assessed using MANOVA. Participants were asked to rate each statement in terms of how much of a disadvantage/advantage it was on a scale of 0-100. Cases from the ‘no diagnosis’ group were randomly removed to equalise the groups due to a violation of the assumption of equality of covariance. This sample MANOVA revealed a statistically significant difference depending on ASD diagnosis, *F*(9, 133)= 2.141, *p*=.030, Pillai’s trace= .127, partial n^2=.127.

Analysis with individual ANOVAs revealed that ASD diagnosis had a statistically significant effect on the three questions relating to ‘no co-presence’. Only the most significant of these (‘online I don’t have to pay attention to others’ facial expressions’) survived the Bonferroni correction, with a significance level <.0056.

Table 13: MANOVA analysis of pre-set advantages

Advantages	**Mean (sd)**		**F (9, 133)**	**P value**	**Partial n^2**
Online I don’t have to react instantly	ASD	79.575 (19.226)	2.522	.114	.018
	No diagnosis	74.257 (20.810)			
Online I can have a conversation in a quiet environment	ASD	83.863 (15.594)	2.530	.114	.018
	No diagnosis	79.286 (18.732)			
Online I can communicate while being alone	ASD	81.055 (20.437)	.590	.444	.004
	No diagnosis	83.571 (18.655)			
Online I don’t have to watch my facial expression	ASD	78.192 (29.366)	5.109	.025*	.035
	No diagnosis	67.186 (28.834)			
Online I don’t have to make eye contact	ASD	81.699 (25.309)	5.696	.018*	.039
	No diagnosis	70.729 (29.568)			
Online I don’t have to pay attention to the other’s facial expression	ASD	66.767 (32.589)	10.627	.001*	.070
	No diagnosis	49.786 (29.550)			
Through my online experience I can have a real-life conversation more easily	ASD	63.301 (29.075)	2.307	.131	.016
	No diagnosis	55.843 (29.639)			
Online I can talk in a more personal way with others	ASD	67.507 (25.358)	.325	.569	.002
	No diagnosis	64.914 (28.489)			
Online I can more easily bring up a difficult subject	ASD	74.014 (25.358)	.101	.751	.001
	No diagnosis	72.586 (28.375)			

Hypothesis 2

Participants were asked about the impact of social media on their social life via a free text box- ‘what impact does social media have on your social life?’ Participants reported both positive and negative impacts of social media on their social life. These were grouped through content analysis into themes (see Appendix 10).

Table 14: Reported impact of social media on social life

Theme	**Description**	**Example quotes**
New connections	Participants reported that social media use enhanced their social life by helping them to meet new people and make new friends.	‘I have made new friends and met new people’ ‘I am able to meet new people and find out about them before meeting up’
Maintaining connections	Participants reported social media helping them to maintain existing relationships.	‘Helps me stay in contact with people I can’t see/don’t live near, especially during lockdown’
Contacting acquaintances	Some participants were able to use social media to connect with acquaintances who they wouldn’t otherwise feel able to contact.	‘It allowed me to make friends that I know in real life but wouldn’t have been confident to talk to otherwise’
Conversation facilitation	Young people reported that social media use helped them to have conversations more easily and to develop conversation topics.	‘I talk more on social media than real life’ ‘It improves it by helping me get better at talking to new people’
Facilitating real-life meeting	Young people spoke about using social media to arrange real-life meetings with others.	‘Social media makes it easier to arrange to meet up with people and to contact everyone involved without having to exchange numbers’
Increase confidence	Participants reported that social media improved their social life by increasing their confidence in themselves.	‘It’s helped me as a person to grow out of my shell and come out of my comfort zone’
Able to socialise alone	Some young people felt that social media improved their social life by enabling them to interact with others without having to leave their home or meet in-person.	‘I get to meet people without having to actually meet them’ ‘It has allowed me to make close friends without leaving the house, doing which is doubly difficult for me as an autistic person… embracing queerness’

Reduce in-person contact	Participants reported that social media reduced their in-person contact	'The more I've spent on it the more isolated I become from my friends and family because I like being alone'
Cause arguments	Participants reported that social media could result in arguments with friends.	'If I don't like my friends post they get upset and think I don't like them'
Reduces real-life conversation proficiency	Some participants felt that social media use resulted in decreases in their ability to communicate in-person.	'I pushed away a lot of people because I'm really scared to make conversations with people I don't know. I guess it's because I've spend more time on the internet than socialazing. Meeting new people makes me really uncomfortable right now...'

Seven positive factors were reported. Chi-square analysis for each of these revealed no significant differences between the groups in terms of how often they reported these. Although it did not meet statistical significance, the greatest difference between groups was in the 'facilitation of real-life meeting' category, which was reported less by the ASD group.

Table 15: Chi-squared analysis of positive impacts on social life

Positive factors	**N reported (% of group)**		**χ2**	**P value**
New connections	ASD	18 (24.7%)	.122	.727
	No diagnosis	40 (26.8%)		
Maintaining connections	ASD	21 (28.8%)	.103	.748
	No diagnosis	46 (30.9%)		
Contacting acquaintances	ASD	2 (2.7%)	.483	.487
	No diagnosis	7 (4.7%)		
Conversation facilitation	ASD	7 (9.6%)	1.984	.159
	No diagnosis	7 (4.7%)		
Facilitating real-life meeting	ASD	1 (1.4%)	2.968	.085
	No diagnosis	10 (6.7%)		
Increase confidence	ASD	1 (1.4%)	1.133	.287

	No diagnosis	6 (4.0%)		
Able to socialise alone	ASD	5 (6.8%)	2.185	.139
	No diagnosis	4 (2.7%)		

Participants reported three negative ways in which social media impacted their social life. Chi-squared analysis revealed that there were no significant differences in how likely participants with and without an autism diagnosis were to report these factors.

Table 16: Chi-squared analysis of negative impacts on social life

Negative factors	**N reported (% of group)**		**χ2**	**P value**
Reduce in-person contact	ASD	9 (6.0%)	2.484	.115
	No diagnosis	1 (1.4%)		
Cause arguments	ASD	1 (1.4%)	.385	.535
	No diagnosis	4 (2.7%)		
Reduces real-life conversation proficiency	ASD	2 (2.7%)	.117	.732
	No diagnosis	3 (2.0%)		

Pre-set questions were also used to explore the impact of social media on social life. Tests were performed to assess whether young people with and without diagnosed autism reported differently about the impact of social media on their social life. Where data met parametric test assumptions an independent samples t-test was used and when it did not a Mann Whitney U test was used. There was no significant difference between the groups.

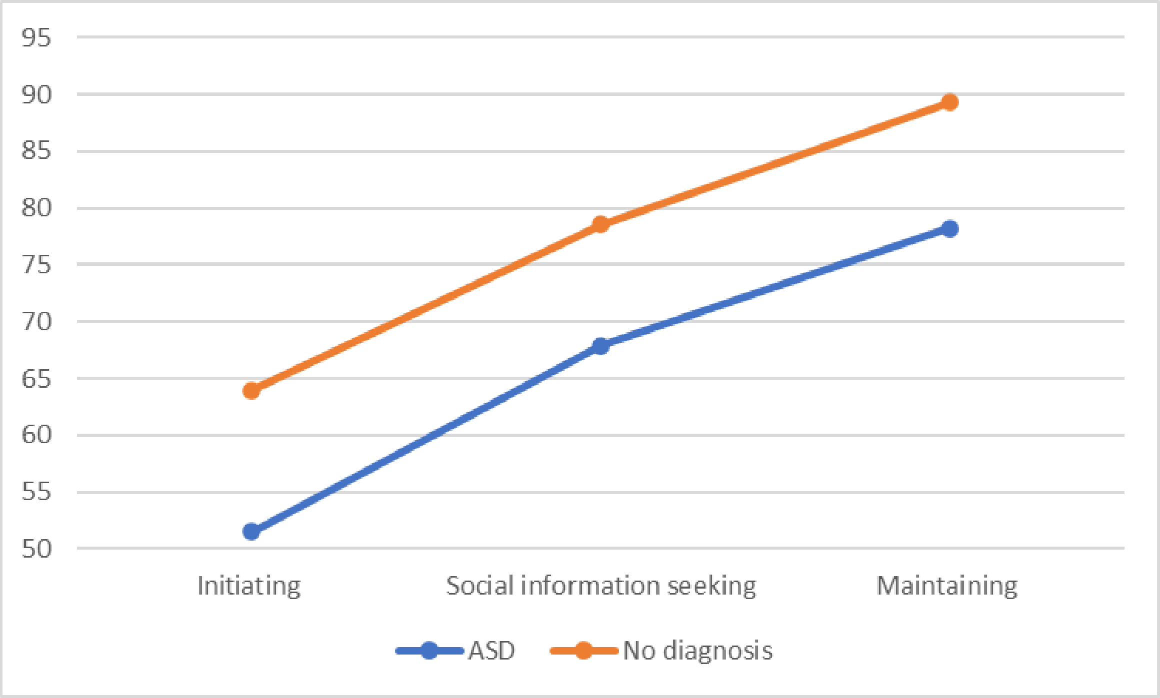
Table 17: Analysis of pre-set questions about impacts on social life

Question	**Mean (sd)**		**t/U**	**P value**
Social media has a positive impact on my social life	ASD	65.000 (27.568)	t= .473	.637
	No diagnosis	67.178 (23.063)		
Social media helps me find people with similar interests	ASD	71.931 (15.239)	U= 5019.500	.481
	No diagnosis	71.739 (24.221)		

Hypothesis 3

A 2-way ANOVA was used to analyse differences in connection strategies (initiating, social information seeking and maintaining connections) between groups. Due to violations of assumptions of normality and homogeneity of variance, data was randomly removed to equalise group sizes. Results obtained with data removed were the same, so the original results are reported. There was a statistically significant difference in the strategies used, *F*(1,217) = 59.065, *p*= <.001. Both groups used social media most to maintain connections and least to initiate connections. The 'no diagnosis' group used these strategies more often than the ASD group. However, there was no difference in preference for strategies used, *F*(1,217) = .048, *p*= .953.

Figure 4: Graph showing social connection strategies of ASD and no diagnosis groups.



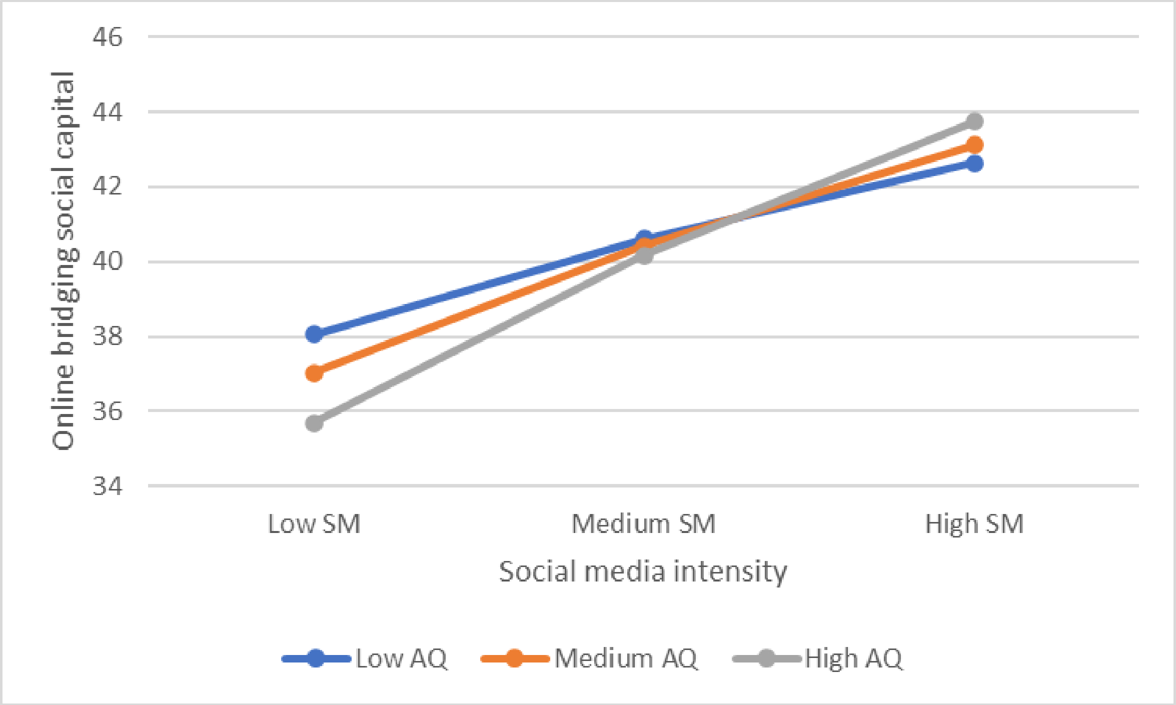
Hypothesis 4

Moderation analysis using Hayes PROCESS macro, model 1, was used to examine the relationship between social media use and bridging social capital on- and offline. Social media intensity predicted online bridging social capital. This relationship was moderated by AQ score such that individuals with lower AQ scored showed greater social capital gains with social media use. However, this relationship does not survive Bonferroni correction at *p*= .0125. Social media intensity did not predict offline bridging social capital.

Table 18: PROCESS analysis of social media and bridging social capital

Interaction	**F (3, 218)**	**P value**	**R^2**
Social media and online bridging social capital moderated by ASD diagnosis			
Total model	21.8556	<.001*	.231
Social media intensity		<.001*	
ASD diagnosis		.105	
Interaction		.190	
Social media and online bridging social capital moderated by AQ score			
Total model	22.738	<.001*	.238
Social media intensity		.094	
AQ score		.015*	
Interaction		.023*	
Social media and offline bridging social capital moderated by ASD diagnosis			
Total model	2.380	.071	.032
Social media intensity		.362	
ASD diagnosis		.400	
Interaction		.642	
Social media and offline bridging social capital moderated by AQ score			
Total model	2.585	.054	.034
Social media intensity		.471	
AQ score		.467	
Interaction		.777	

Figure 5: Graph showing the relationship between social media use and online bridging social capital for different AQ scores



Hypothesis 5

PROCESS macro model 1 was used to examine the relationship between social media use and bonding social capital. This revealed a significant relationship between social media use and online bonding social capital, but this was not moderated by ASD diagnosis or AQ score. There was no significant relationship between social media use and offline bonding social capital.

Table 19: PROCESS analysis of social media use and bonding social capital

Interaction	**F (3, 218)**	**P value**	**R²**
Social media and online bonding social capital moderated by ASD diagnosis			
Total model	13.319	<.001*	.155
Social media intensity		<.001*	
ASD diagnosis		.362	
Interaction		.373	
Social media and online bonding social capital moderated by AQ score			
Total model	13.043	<.001*	.152
Social media intensity		.010*	
AQ score		.755	
Interaction		.728	
Social media and offline bonding social capital moderated by ASD diagnosis			
Total model	.872	.457	.012
Social media intensity		.185	
ASD diagnosis		.746	
Interaction		.665	
Social media and offline bonding social capital moderated by ASD diagnosis			
Total model	1.225	.301	.017
Social media intensity		.166	
AQ score		.608	
Interaction		.451	

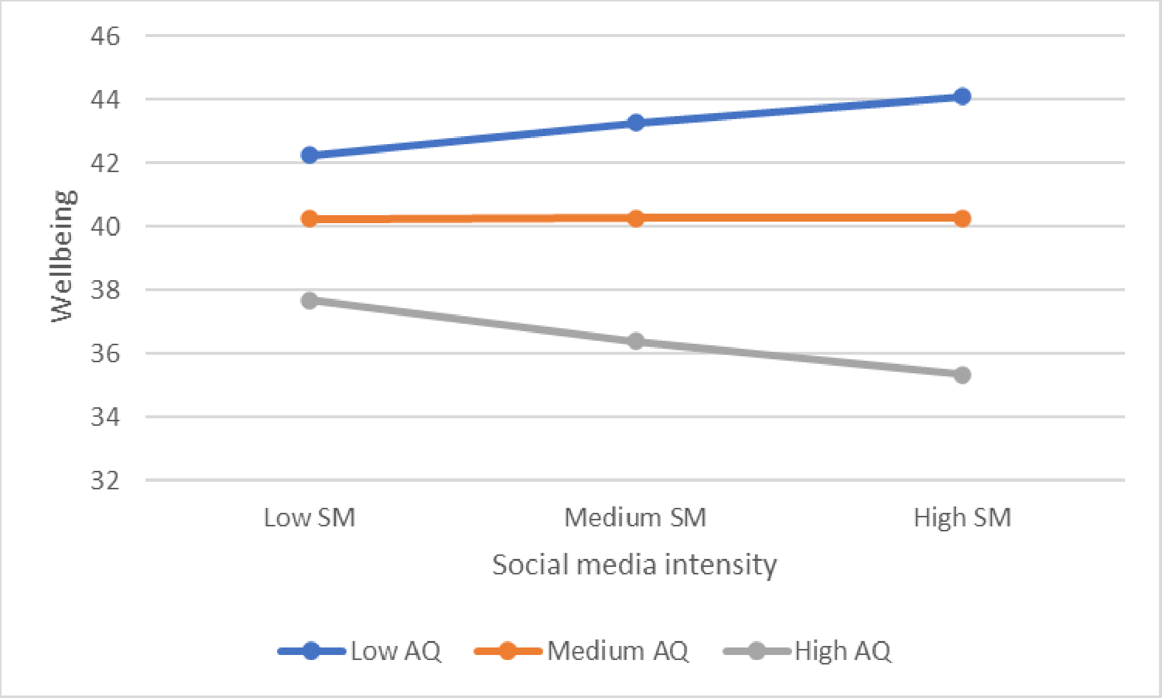
Hypothesis 6

PROCESS macro (model 1) was used to assess the relationship between social media use and wellbeing and whether this was moderated by ASD diagnosis or AQ score. Social media intensity and ASD/AQ score did not predict wellbeing. There was a near significant interaction of social media use and wellbeing mediated by AQ scores. For participants with lower AQ scores there was a positive correlation between social media intensity and wellbeing. As AQ scores increased there was a negative correlation between social media use and wellbeing.

Table 20: PROCESS analysis of social media use and wellbeing

Interaction	**F (3, 218)**	**P value**	**R²**
Social media and wellbeing moderated by ASD diagnosis			
Total model	.515	.672	.007
Social media intensity		.616	
ASD diagnosis		.262	
Interaction		.232	
Social media and wellbeing moderated by AQ score			
Total model	8.459	<.001*	.104
Social media intensity		.117	
AQ score		.507	
Interaction		.069	

Figure 6: Relationship between social media intensity and wellbeing with AQ score



Hypothesis 7

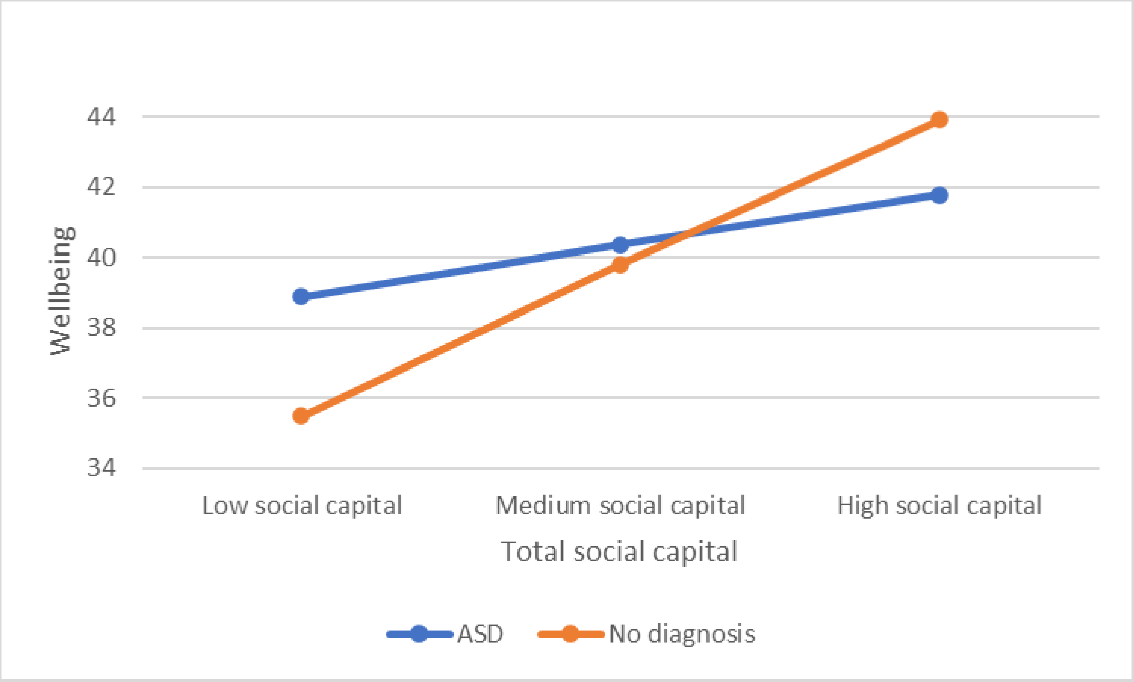
Analysis using the PROCESS macro, model 1, examined the relationship between social capital and wellbeing. This revealed a relationship between total social capital and wellbeing, which was moderated by ASD diagnosis but not AQ score. After controlling for multiple comparisons with Bonferroni correction (*p*= .005) this effect was no longer significant. When total social capital was broken down into its four domains, online bridging, offline bridging and offline bonding social capital predicted wellbeing. ASD diagnosis/AQ score did not moderate any of these relationships.

Table 21: PROCESS analysis of social capital and wellbeing

Interaction	**F (3, 218)**	**P value**	**R²**
Total social capital and wellbeing moderated by ASD diagnosis			
Total model	12.000	<.001*	.142
Total social capital		<.001*	
ASD diagnosis		.023*	
Interaction		.029*	
Total social capital and wellbeing moderated by AQ score			
Total model	18.486	<.001*	.203
Total social capital		<.001*	
AQ score		.647	
Interaction		.262	
Online bridging social capital and wellbeing moderated by ASD diagnosis			
Total model	3.641	.014*	.012
Online bridging social capital		.001*	
ASD diagnosis		.052	
Interaction		.066	
Online bridging social capital and wellbeing moderated by AQ score			
Total model	10.019	<.001*	.121
Online bridging social capital		.082	
AQ score		.960	
Interaction		.471	
Offline bridging social capital and wellbeing moderated by ASD diagnosis			
Total model	13.422	<.001*	.156
Offline bridging social capital		<.001*	
AQ score		.297	
Interaction		.365	
Offline bridging social capital and wellbeing moderated by AQ score			
Total model	19.994	<.001*	.216
Offline bridging social capital		.016*	
AQ score		.340	
Interaction		.934	

Online bonding social capital and wellbeing moderated by ASD diagnosis			
Total model	1.128	.338	.124
Online bonding social capital		.082	
AQ score		.142	
Interaction		.128	
Online bonding social capital and wellbeing moderated by AQ score			
Total model		<.001*	
Online bonding social capital		.046*	
AQ score		.701	
Interaction		.095	
Offline bonding social capital and wellbeing moderated by ASD diagnosis			
Total model	12.130	<.001*	.143
Offline bonding social capital		<.001*	
AQ score		.168	
Interaction		.171	
Offline bonding social capital and wellbeing moderated by AQ score			
Total model	20.135	<.001*	.217
Offline bonding social capital		.073	
AQ score		.086	
Interaction		.366	

Figure 7: Graph showing the relationship between social capital and wellbeing with ASD diagnosis



Hypothesis 8

The PROCESS macro, model 59, was used to examine the relationship between social media use and wellbeing. This revealed a significant effect of the total model. In line with findings from other hypotheses, social capital, ASD diagnosis and the interaction of social media use and AQ score had a significant impact on wellbeing. Social capital however did not significantly impact wellbeing.

Table 22: PROCESS analysis of social media use and wellbeing mediated by social capital

Interaction	**F (5, 216)**	**P value**	**R^2**
Social media and wellbeing mediated by social capital and moderated by ASD diagnosis			
Total model	8.627	<.001*	.167
Social media intensity		.117	
Social capital		<.001*	
ASD		.030*	
Interaction social media x ASD		.550	
Interaction social capital x ASD		.094	
Social media and wellbeing mediated by social capital and moderated by AQ score			
Total model	13.469	<.001*	.238
Social media intensity		.544	
Social capital		.006*	
AQ score		.408	
Interaction social media x AQ		.048*	
Interaction social capital x AQ		.846	

Discussion

This discussion offers a review of the findings of this study, and of their clinical and research implications. The findings will also be considered within the particular societal context in which this research has taken place.

Advantages of social media use

Teens in this study reported a number of advantages and disadvantages associated with using social media. Some of the most commonly cited advantages related to social connections; both for maintaining existing connections and making new connections. These were important for both autistic participants and their neurotypical counterparts. In addition, participants felt that social media was beneficial for identity development, creating and consuming content and for entertainment purposes. The ability for autonomy and conversation management on social media were also reported as advantages. Some felt that their wellbeing was positively impacted through positive and inspirational content. Reported advantages accorded with previous research, where adolescents with and without autism reported benefits including developing and maintaining friendships, identity exploration and self-presentation (Uhls et al, 2017; Mandy & Hull, 2019).

There were some differences between participants with and without a diagnosis of autism. Participants with a diagnosis of autism were more likely to report ‘conversation management’ and ‘autonomy’ as advantages of social media. These findings accord with current literature examining CMC, where control of the online environment and management of social cues have been reported as advantages among autistic adults (Benford & Standen, 2009). Participants with an autism diagnosis were less likely than their peers to report ‘entertainment’ and ‘content creation’ as advantages of social media. This was an unexpected finding. Previous research has found that adolescents with autism use media, including social media, for entertainment purposes, including videos and games (Kuo et al, 2014; Shane & Albert, 2008; Sallafranque-St-Louis & Normand, 2017). A tendency towards rigid and stereotyped interests inherent in autism diagnosis might have impacted upon this (World Health Organisation, 1992). It is possible that the ‘ASD group’ participants in this study were using more specific sites related to their particular interests for entertainment purposes, rather than gaining more generic entertainment from social media sites.

Pre-set questions relating to communication over social media platforms found some differences in perceived advantages. Of the three areas identified by van der Aa et al (2016), (time independence, no co-presence and ease to express self), questions related to ‘no co-presence’ were reported as significantly more advantageous by participants with an autism diagnosis. Questions related to the other domains (time independence and expressing self), were not reported as significantly more advantageous by one group than the other. This is reflected in the data from free-text boxes where participants from both groups reported advantages related to identity development and self-expression, and that socialising alone benefitted their social life. These findings were different to those found in adults, where the autistic group found all three categories more advantageous than the comparison group (van der Aa et al, 2016). These differences might be generational. Young people have been exposed to social media over much of their lives and might therefore perceive more benefits in being able to express themselves online while in a quiet solitary environment. The findings might also relate to the unique context of this study, which took place during a national COVID-19 lockdown. The resulting enforced isolation may have altered how neurotypical teens perceived isolated online socialising. In the context of enforced physical isolation from friends, socialising without contact might have been perceived as more beneficial.

Disadvantages of social media use

Reported disadvantages included negative impacts on mental health, unwanted content, negative comparison to others and time consumption. Some participants reported disliking the polarisation of views, peer pressure and cancel culture online. Others reported that information was misleading and that they feared for their online safety. Conversation management was another reported disadvantage. Again, these self-reported disadvantages support existing research which reported impacts on mental health, inappropriate content and cyberbullying as negative aspects of social media use (Uhls et al, 2017).

Participants with and without an autism diagnosis were equally likely to report most of these disadvantages. However, participants with autism were more likely to report conversation management as a disadvantage and less likely to report negative comparisons with others as a disadvantage. Previous research has also found that autistic adults saw online methods of communicating as both a help and a hindrance. For example, adults using CMC reported feeling that they could communicate on a more equal basis online but also that they feared losing control of their interactions (Benford, 2008). Differences in reported negative comparisons may relate to differences in mentalisation. Social comparison requires sophisticated mental state understanding of oneself and others. Individuals with autism experience greater difficulties with mental state attribution, action comprehension, perspective taking and identification with others, which might make negative comparisons with others less likely (Shamay-Tsoory, 2008; Marsh & Hamilton, 2011). Differences in the gender distributions in the groups might also have impacted these findings. 81% of participants in the 'no diagnosis' were female compared to 48% of the ASD group. Girls are substantially more likely to report difficulties with body confidence and to experience reductions in confidence related to social media use (Royal Society for Public Health, 2017).

Social media use and social connections

Overall, participants reported that social media had a positive impact on their social life and helped them to find like-minded others with similar interests. This was equally true for participants with and without an autism diagnosis. When asked to narratively describe the impact of social media on their social life, participants reported both positive and negative impacts. Positive impacts were more commonly reported, including offering increased contact with friends, strangers and acquaintances. Participants reported that socialising was improved by conversation management, increased confidence and being able to socialise alone. Negative impacts on social life were reductions in real-life contact, conversation proficiency and escalation of arguments. There were no differences in the reported impacts of social media on social life between the autism and no-diagnosis group, although the ‘diagnosis’ group appeared less likely to use social media to facilitate real-life meetings.

In terms of the connection strategies used online, participants reported using social media most often to maintain close ties, then to seek information about acquaintances, and finally to create new ties. This echoed previous research in neurotypical young adults where the same preferences were observed (Ellison et al, 2011). The ‘no-diagnosis’ group was more likely than the ‘ASD’ group to use all three strategies than the autism group. However, contrary to the stated hypothesis, there was no difference in strategy preference. It had been hypothesised that the ASD group would exhibit a greater preference for initiating new relationships. Young people with an autism diagnosis are likely to have a limited number of true friends online and to use social media to contact new like-minded individuals if offline social contact is low (Benford, 2008; Sallafranque-St-Louis & Normand, 2017). However, individuals with autism have also reported using social media to maintain contact with friends (Sallafranque-St-Louis & Normand, 2017), hence these findings accord with some aspects of the existing research.

Social media use predicted increased online social capital for both close and distant ties. However, this benefit of social media use did not extend to offline relationships. Again, this finding may have been impacted by COVID-19 reducing the potential for offline contact. In terms of utilising more distant connections, the impact of social media differed according to AQ score. Participants with autistic traits experienced greater bridging social capital gains with social media use. While these participants exhibited lower social capital with low social media investment, this increased steeply with social media investment. This finding may reflect the removal of communication barriers online that may offer greater communication benefits for participants with autistic traits (Benford & Standon, 2009; Benford, 2008; Van der Aa et al, 2016). It might also relate to the tendency towards specific interests in this group, who might benefit from connecting with others who share common interests.

Social media use and wellbeing

Social media intensity did not predict wellbeing in either group, and there was no mediating effect of social capital on the relationship between social media and wellbeing. However, there was a near significant interaction between social media use and AQ score with regards to wellbeing. Participants with autistic traits demonstrated decreased wellbeing with greater social media use, which differed from participants without ASD traits who demonstrated increased wellbeing scores. This may be due to observed differences in engagement with social media. Adolescents with autistic traits and depression have been observed to demonstrate more persistence, escape and withdrawal when using social media (Şahin & Usta, 2020). It is possible that the general autistic population exhibit the same patterns of social media use which impacts their wellbeing.

Social capital predicted wellbeing in individuals with and without an ASD diagnosis. This differed between groups, with participants reporting a diagnosis of autism not demonstrating increases in wellbeing to the same extent as 'no-diagnosis' participants. This may relate to differences in sensitivity to validation from others. It is possible that individuals with autism may be less attuned to differences in social capital, as demonstrated by the relatively less reported 'social comparison' disadvantage in this group. Neurotypical individuals using social media are more likely to derive their self-worth from friendship quality, which in turn impacts their wellbeing (Shankleman, 2020). It is possible that this relationship operates differently among young people with autistic traits.

Clinical implications

Social media use appears to provide some benefits for teenagers if reported negative factors are mitigated. This group would therefore benefit from guidance and support on how to use social media in ways that support and enable their wellbeing. This is particularly true for adolescents with autistic traits, who appear to be more vulnerable to the negative aspects of social media. Participants with high autistic traits showed decreases in wellbeing with social media use while those with low autistic traits showed wellbeing increases. Staff and parents in close and regular contact with young people may wish to consider the presence of autistic traits as a possible risk factor for susceptibility to negative social media impacts. This observation may be particularly pertinent in educational and residential settings for those working with young people with an autism diagnosis.

Unlike neurotypical participants, wellbeing in this group did not appear to be strongly connected to social factors such as social capital or comparisons with others. This may be unsurprising given the nature of the social challenges faced by individuals with an autism diagnosis. For users with autistic traits therefore, positive use of social media may relate more to the management of aspects such as viewing unwanted content, cyberbullying and online safety. With young people accessing social media from a young age, it may be beneficial to introduce support and guidance early, when young people are more likely to accept this. This could include problem solving online dilemmas, support to manage bullying or how to use social media safely. Young people could also be encouraged to utilise online social opportunities to build confidence and social facility through connecting to others with shared interests and undertaking shared online activities. Social media companies could play a role in reducing negative factors by providing greater controls on content and access on their platforms. Companies should consider the diversity of users and how negative factors could impact groups differently.

One potential benefit of social media highlighted in this study was its potential for supporting social connections with others. Social media use appeared to have a positive impact on adolescents' social lives. This was particularly true for participants with autistic traits with regards to making new connections online. However, these benefits were mostly confined to online relationships and did not appear to extend to real-life settings. While online social contact provides an important opportunity to build relationships, arguably social contact offline requires a differing set of skills that may not be developed online

(Reich, 2017). Young people may benefit from support to optimise the social capital gained from online contact and facilitate its generalisation to offline contexts. The acquisition of key skills for offline socialising such as adaptability and prosocial behaviours could be facilitated through intervention (Reich, 2017). This might be particularly important for young people with autistic traits who report greater loneliness and difficulties connecting with others (Bauminger et al, 2003) and who were less likely to use social media to facilitate real-life meetings. For this group, an approach focusing on individual interests could be used to promote the development of offline relationships. For instance, young people meeting like-minded others online could be supported to arrange an in-person meeting, or to use interests developed online to meet peers in in-person settings.

Research implications

The findings of this study offer several potential avenues for future research and investigation. The impact of social media use on the wellbeing of young people with autistic traits should be investigated further. Future research could examine whether young people with autistic traits are more negatively impacted by social media use and why. This could include examining the specific ways that young people use social media and whether those with autistic traits are using it in ways that more deleteriously impact wellbeing. Qualitative research could helpfully be used to examine social media use in this group in more depth.

The use of social media to make connections with others could also be examined further. Young people with autistic traits appeared to use social media to connect with others less than their peers, and their wellbeing appeared less contingent on social factors. This difference from neurotypical peers could be investigated further in terms of the nature of these relationships. Qualitative research could explore whether teenagers with autistic traits perceive connection making online as important and how they feel that it impacts their wellbeing.

Online communication appeared to benefit this group beyond their peers in terms of developing an outward-looking, community-minded perspective and making new connections. Future research could examine this relationship and potential contributing factors. It is possible that the reduction of communication barriers enables young people with autistic traits to access different communities online. Alternatively, a greater likelihood of social isolation and rigid interests in this group might motivate these young people to seek accepting online communities where they are more able to express themselves. Future research could be extended to other age groups to determine whether younger adolescents exhibited the same responses.

Limitations

This study had several limitations. There was an unequal number of participants reporting a diagnosis compared to those who did not, with many more participants without a stated ASD diagnosis. This meant that sometimes data had to be removed for the viable comparison of the two groups. There was a sizeable imbalance of gender in the group of young people without a diagnosis of autism. The overrepresentation of girls in this group could potentially have resulted in a greater tendency towards body image and social comparison concerns in this group. In addition, the survey was targeted at the U.K. population, with the majority of study participants from a White background. Findings therefore may not generalise to other groups. The context of the study may also have compromised its generalisability. The survey took place during a pandemic with a national lockdown in place, severely constraining all social contact. This significantly affected the social and educational lives and wellbeing of all young people and may have reduced any observed differences between participants with and without autistic traits.

This study used Internet-collected self-report measures in a cross-sectional design. This offered a limited perspective on social media use and wellbeing which may change over time. Future research could examine these factors over longer periods of time and collect the views of other stakeholders including parents and teachers. Experiential or descriptive measures relating to social life and wellbeing could offer a more realistic perspective of the impact of social media use in the real world.

Conclusions

This study found that adolescents with and without autistic traits experienced both advantages and disadvantages of using social media. Young people felt that social media use had a beneficial impact on their social life, and experienced benefits to online relationships with social media use. This was particularly true for young people with autistic traits when developing new connections. Although social media use did not impact wellbeing in the overall group, this appeared to vary according to the extent of autistic traits. Participants with autistic traits may benefit from the use of social media to develop new connections but might require support to achieve this safely online. Clinicians, teachers and parents should consider the impact of autistic traits on the experiences of adolescents accessing social media. Future studies might benefit from further exploring how young people with autistic traits use social media and how this impacts their wellbeing.

References

Allison, C., Auyeung, B. & Baron-Cohen, S. (2012). Toward brief “red flags” for autism screening: the short autism spectrum quotient and the short quantitative checklist in 1,000 cases and 3,000 controls. *Journal of the American Academy of Child & Adolescent Psychiatry, 51*(2), 202-212. DOI: https://doi.org/10.1016/j.jaac.2011.11.003

Anderson, M. & Jiang, J. (2018). *Teens, Social Media & Technology*. Pew Research Center.

Bauminger, N., Shulman, C. & Agam, G. (2003). Peer interaction and loneliness in high-functioning children with autism*. Journal of Autism and Developmental Disorders, 33*, 489–507. DOI: 10.1023/A:1025827427901.

Bauernschuster, S., Falck, O., & Woessmann, L. (2014). Surfing alone? The Internet and social capital: Evidence from an unforeseeable technological mistake. *Journal of Public Economics, 117*, 73-89. DOI: https://doi.org/10.1016/j.jpubeco.2014.05.007

Benford, P. (2008). *The use of Internet-based communication by people with autism* (Doctoral dissertation, University of Nottingham, United Kingdom). Retrieved from: https://lemosandcrane.co.uk/resources/University%20of%20Nottingham%20-%20The%20use%20of%20internet-based%20communication%20by%20people%20with%20autism.pdf

Benford, P. & Standen, P. (2009). The internet: a comfortable communication medium for people with Asperger syndrome (AS) and high functioning autism (HFA)? *Journal of Assistive Technologies, 3* (2), 44-53. https://doi.org/10.1108/17549450200900015

Berman, G. (2016) *Ethical considerations for research with children*. London: Global Kids Online. Retrieved from: www.globalkidsonline.net/ethics

Best, P., Manktelow, R. & Taylor, B. (2014). Online communication, social media and adolescent wellbeing: A systematic narrative review. *Children and Youth Services Review, 41*, 27-36. DOI: https://doi.org/10.1016/j.childyouth.2014.03.001

Beyens, I., Pouwels, J.L., van Driel, I.I., Keijsers, L. & Valkenburg, P.M. (2020). The effect of social media on well-being differs from adolescent to adolescent. *Scientific Reports, 10*, 10763. DOI: https://doi.org/10.1038/s41598-020-67727-7

Borca G., Bina, M., Keller, PS., Gilbert, L.R. & Begotti, T. (2015). Internet use and developmental tasks: adolescents' point of view. *Computers in Human Behaviour, 52*, 49–58 DOI: https://doi.org/10.1016/j.chb.2015.05.029

Brown, Z., & Tiggemann, M. (2016). Attractive celebrity and peer images on Instagram: effect on women's mood and body image. *Body Image, 19*, 37-43. DOI:10.1016/j.bodyim.2016.08.007

Burke, M., Kraut, R., & Williams, D. (2010). Social use of computer-mediated communication by adults on the autism spectrum. *Proceedings of the 2010 ACM conference on Computer supported cooperative work*, 425-434. DOI: https://doi.org/10.1145/1718918.1718991

Calder, Lynsey; Hill, Vivian; Pellicano, Elizabeth (2013):.Autism 'Sometimes I want to play by myself': Understanding what friendship means to children with Autism in mainstream primary schoolsVol. 17, Iss. 3, 296-316. DOI:10.1177/1362361312467866

Cataldo, I., Lepri, B., Neoh, M. J. Y., & Esposito, G. (2021). Social media usage and development of psychiatric disorders in childhood and adolescence: A review. *Frontiers in Psychiatry, 11*, 1332. https://doi.org/10.3389/fpsyt.2020.508595

Christie, D. & Viner, R. (2005). ABC of adolescence: Adolescent development. *British Medical Journal, 330*, 301–304. DOI: http://doi.org/10.1136/bmj.330.7486.301

Datareportal (2021). Global social media stats. Retrieved from: https://datareportal.com/social-media-users

Ellison, N.B., Steinfield, C. & Lampe, C. (2007). The benefits of Facebook "friends:" Social capital and college students use of online social network sites. *Journal of Computer Mediated Communication, 12*, 1143-1168. DOI: https://doi.org/10.1111/j.1083-6101.2007.00367.x

Ellison, N.B., Steinfield, C., & Lampe, C. (2011). Connection strategies: Social capital implications of Facebook-enabled communication practices. *New Media & Society, 13*(6), 873-892. DOI: https://doi.org/10.1177/1461444810385389

Field, Andy (2017) *Discovering statistics using IBM SPSS statistics*, *5th edition*. London: SAGE Publications.

Gillespie-Lynch, K. Kapp, S.K. , Shane-Simpson, C., Smith, D.S. & Hutman, T. (2014). Intersections between the autism spectrum and the internet: perceived benefits and preferred functions of computer-mediated communication. *Intellectual and Developmental Disabilities, 52*(6), 456-469. DOI: 10.1352/1934-9556-52.6.456

Global State of Digital (2019). *Digital around the world in 2019*. Retrieved from https://p.widencdn.net/kqy7ii/Digital2019-Report-en

Hayes, A.F. (2017). *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach*. New York: Guilford Publications.

Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative health research, 15*(9), 1277-1288. DOI: 10.1177/1049732305276687

Jenkins, R. (2014). *Social identity*. London: Routledge.

Jobe, L.E. Williams White, S. (2007). Loneliness, social relationships, and a broader autism phenotype in college students. *Personality and Individual Differences, 42*(8) 1479-1489. DOI: 10.1016/j.paid.2006.10.021

Kasari, C., Locke, J., Gulsrud, A. & Rotheram-Fuller, E. (2011). Social Networks and Friendships at School: Comparing Children With and Without ASD. *Journal of Autism and Developmental Disorders, 41*(5), 533-544. DOI:10.1007/s10803-010-1076-x

Keles, B., McCrae, N., & Grealish, A. (2020). A systematic review: the influence of social media on depression, anxiety and psychological distress in adolescents. *International Journal of Adolescence and Youth, 25*(1), 79-93. DOI: /10.1080/02673843.2019.1590851

Kircaburun, K., Alhabash, S., Tosuntaş, Ş.B. & Griffiths, M.D. (2020). Uses and Gratifications of Problematic Social Media Use Among University Students: a Simultaneous Examination of the Big Five of Personality Traits, Social Media Platforms, and Social Media Use Motives. *International Journal of Mental Health and Addiction, 18*, 525–547 DOI: https://doi.org/10.1007/s11469-018-9940-6

Kondracki, N. L., & Wellman, N. S. (2002). Content analysis: Review of methods and their applications innutrition education. *Journal of Nutrition Education and Behavior, 34*, 224-230. DOI: https://doi.org/10.1016/S1499-4046(06)60097-3

Kuo, M. H., Orsmond, G. I., Coster, W. J., & Cohn, E. S. (2014). Media use among adolescents with autism spectrum disorder. *Autism, 18*(8), 914–923. DOI: https://doi.org/10.1177/1362361313497832

Lin, N. (1999). Building a Network Theory of Social Capital. International Network for Social Network Analysis. *Connections, 22*(1). DOI: 10.4324/9781315129457-1

Locke, J., Ishijima, E.H., Kasari, C. & London, N., (2010). Loneliness, friendship quality and the social networks of adolescents with high-functioning autism in an inclusive school setting. *Journal of Research in Special Educational Needs*, *10*(2), 74-81. DOI:10.1111/j.1471-3802.2010.01148.x

MacIsaac, S., Kelly, J. & Gray, S. (2018). 'She has like 4000 followers!': the celebrification of self within school social networks. *Journal of Youth Studies, 21*(6), 816–835. DOI: https://doi.org/10.1080/13676261.2017.1420764

MacKinnon, D.P., Fairchild, A.J. & Fritz, M.S. (2007). Mediation analysis. *Annual Review of Psychology, 58*, 593-614. DOI: https://doi.org/10.1146/annurev.psych.58.110405.085542

Mandy, W. & Hull, L. (2019). *Autistic Adolescents' use of social media*. Retrieved from: mackinnhttps://www.ucl.ac.uk/grand-challenges/sites/grand-challenges/files/mandy_hull.pdf

Marsh, L. E., & Hamilton, A. F. D. C. (2011). Dissociation of mirroring and mentalising systems in autism. *Neuroimage, 56*(3), 1511-1519. DOI: https://doi.org/10.1016/j.neuroimage.2011.02.003

Mazurek, M.O. (2013). Social media use among adults with autism spectrum disorders. *Computers in Human Behavior, 29*, 1709–1714. DOI: https://doi.org/10.1016/j.chb.2013.02.004

Miles, J., & Shevlin, M. (2001). *Applying regression and correlation: A guide for students and researchers*. London: Sage.

Nadkarni, A., Hofmann, S. G. (2012). Why do people use Facebook? *Personality and Individual Differences, 52*(3), 243–249. DOI: https://doi.org/10.1016/j.paid.2011.11.007

National Autistic Society (2020). *Autism.* Retrieved from: https://www.autism.org.uk/about/what-is/asd.aspx

National Institute of Health and Care Excellence (2016). *Autism spectrum disorder in adults: diagnosis and management.* Retrieved from: https://www.nice.org.uk/guidance/cg142/chapter/Introduction

Obar, J. A., & Wildman, S. S. (2015). Social media definition and the governance challenge-an introduction to the special issue. Social media definition and the governance challenge: An introduction to the special issue. *Telecommunications policy, 39*(9), 745-750. DOI: /10.2139/ssrn.2663153

ONS (2017). *Social networking by age group, 2011 to 2017*. Retrieved from: https://www.ons.gov.uk/peoplepopulationandcommunity/householdcharacteristics/homeinternetandsocialmediausage/adhocs/007401socialnetworkingbyagegroup2011to2017

Orben, A., & Przybylski, A. K. (2019). The association between adolescent well-being and digital technology use. *Nature Human Behaviour, 3*(2), 173-182. DOI: https://doi.org/10.1038/s41562-018-0506-1

Patton, M. Q. (2002). *Qualitative research and evaluation methods*. Thousand Oaks: Sage

Pempek, T. A., Yermolayeva, Y. A., & Calvert, S. L. (2009). College students' social networking experiences on Facebook. *Journal of Applied Developmental Psychology, 30*(3), 227–238. DOI: https://doi.org/10.1016/j.appdev.2008.12.010

Pénard, T., Poussing, N. (2010). Internet Use and Social Capital: The Strength of Virtual Ties. *Journal of Economic Issues 44(3)*, 569-595. DOI: https://doi.org/10.2753/JEI0021-3624440301

Posserud, M. B., Breivik, K., Gillberg, C., & Lundervold, A. J. (2013). ASSERT–The Autism Symptom Self-Report for adolescents and adults: Bifactor analysis and validation in a large adolescent population. *Research in Developmental Disabilities, 34*(12), 4495-4503. DOI: https://doi.org/10.1016/j.ridd.2013.09.032

Putnam, R.D. (2000) *Bowling Alone: The Collapse and Revival of American Community*. New York: Simon and Schuster

Reich, S. M. (2017). Connecting offline social competence to online peer interactions. *Psychology of Popular Media Culture, 6(*4), 291. DOI: https://doi.org/10.1037/ppm0000111

Royal Society for Public Health (2017). *#Status of mind*. Retrieved from: https://www.rsph.org.uk/static/uploaded/d125b27c-0b62-41c5-a2c0155a8887cd01.pdf

Ryan, R. M., & Deci, E. L. (2001). On happiness and human potentials: A review of research on hedonic and Eudaimonic well-being. *Annual Review of Psychology, 52*, 141–166. DOI: https://doi.org/10.1146/annurev.psych.52.1.141

Sabatini, F., Sarracino, F. (2014). *Will Facebook save or destroy social capital? An empirical investigation into the effect of online interactions on trust and networks.* Mannheim: Leibniz Institute for the Social Sciences.

Şahin, B., & Usta, M. B. (2020). Use of social media and autistic traits in adolescents diagnosed with major depressive disorder. *Anadolu Psikiyatri Dergisi, 21*(6), 641-648. DOI: 10.5455/apd.94769

Salehan, M. & Negahban, A. (2013). Social networking on smartphones: When mobile phones become addictive. *Computers in Human Behavior, 29*, 2632-2639. DOI: https://doi.org/10.1016/j.chb.2013.07.003

Sallafranque-St-Louis, F. & Normand, C.L. (2017). From solitude to solicitation: How people with intellectual disability or autism spectrum disorder use the internet. *Cyberpsychology: Journal of Psychosocial Research on Cyberspace, 11*(1). DOI: https://doi.org/10.5817/CP2017-1-7

Shamay-Tsoory, S.G. (2008). Recognition of ‘Fortune of Others’ Emotions in Asperger Syndrome and High Functioning Autism. Journal of Autism and Developmental Disorders 38, 1451–1461. https://doi.org/10.1007/s10803-007-0515-9

Shane, H.C. and Albert, P.D. (2008). Electronic screen media for persons with autism spectrum disorders: results of a survey. *Journal of Autism and Developmental Disorders, 38*, 1499–1508. DOI: https://doi.org/10.1007/s10803-007-0527-5

Shankleman, M. (2020). *Adolescent Social Media Use and Well-Being* (Doctoral dissertation, Canterbury Christ Church University, United Kingdom). Retrieved from: https://www.proquest.com/openview/c49dddbc3f68a0c71d55565340b50d70/1?pq-origsite=gscholar&cbl=44156

Singleton, A., Abeles, P., & Smith, I. C. (2016). Online social networking and psychological experiences: The perceptions of young people with mental health difficulties. *Computers in Human Behavior, 61,* 394-403. DOI: https://doi.org/10.1016/j.chb.2016.03.011

Skoric, M.M., Zhu, Q., Goh, D. & Pang, N. (2016). Social media and citizen engagement: a meta-analytic review. *New Media and Society, 18*(9), 1817-1839. DOI: 10.1177/1461444815616221

Steinfield, C., Ellison, N.B. & Lampe, C. (2008). Social capital, self-esteem, and use of online social network sites: A longitudinal analysis. Journal of applied developmental psychology, 29(6), 434-445. https://doi.org/10.1016/j.appdev.2008.07.002

Tennant, R., Hiller, L., Fishwick, R., Platt, S., Joseph, S., Weich, S., Parkinson, J., Secker., J. & Stewart-Brown, S. (2007). The Warwick-Edinburgh mental well-being scale (WEMWBS): development and UK validation. *Health and Quality of life Outcomes, 5*, 63. DOI: https://doi.org/10.1186/1477-7525-5-63

Twenge, J.M. (2020). Why increases in adolescent depression may be linked to the technological environment. *Current Opinion in Psychology, 32*, 89-94. DOI: https://doi.org/10.1016/j.copsyc.2019.06.036

Twenge, J.M., Joiner, T.E., Rogers, M.L. & Martin, G.N. (2018). Increases in depressive symptoms, suicide-related outcomes, and suicide rates among US adolescents after 2010 and links to increased new media screen time. *Clinical Psychological Science, 6*, 3-17. DOI: https://doi.org/10.1177/2167702617723376

Uhls, Y.T., Ellison, N.B. & Subrahmanyam, K. (2017). Benefits and costs of social media in adolescence. *Pediatrics, 140*(2), 67-70. DOI: https://doi.org/10.1542/peds.2016-1758E

University of Warwick (2020). *Collect, score, analyse and interpret WEMWBS*. Retrieved from: https://warwick.ac.uk/fac/sci/med/research/platform/wemwbs/using/howto/

Valkenburg, P. M., & Peter, J. (2007). Preadolescents' and adolescents' online communication and their closeness to friends. *Developmental Psychology, 43*(2), 267–277. DOI: https://doi.org/10.1037/0012-1649.43.2.267

Van Den Eijnden, R., Koning, I., Doornwaard, S., Van Gurp, F. & Ter Bogt, T. (2018). The impact of heavy and disordered use of games and social media on adolescents’ psychological, social, and school functioning. *Journal of behavioral addictions, 7*(3), 697-706. DOI: https://doi.org/10.1556/2006.7.2018.65.

van der Aa, C., Pollmann, M. M., Plaat, A., & van der Gaag, R. J. (2016). Computer-mediated communication in adults with high-functioning autism spectrum disorders and controls. *Research in Autism Spectrum Disorders, 23*, 15-27. DOI: /10.1016/j.rasd.2015.11.007

van Schalkwyk, G.I., Marin, C.E., Ortiz, M. Rolison, M. Qayyum, Z. McPartland, J.C. Lebowitz, E.R., Volkmar, F.R. & Silverman, W.K. (2017). Social Media Use, Friendship Quality, and the Moderating Role of Anxiety in Adolescents with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders, 47*, 2805–2813. DOI: https://doi.org/10.1007/s10803-017-3201-6

Verduyn, P., Ybarra, O., Résibois, M., Jonides, J. & Kross, E. (2017). Do Social Network Sites Enhance or Undermine Subjective Well-Being? A Critical Review. *Social Issues and Policy Review, 11*(1), 274–302. DOI: https://doi.org/10.1111/sipr.12033

Ward, D.M., Dill-Shackleford, K.E. & Mazurek, M.O. (2018). Social media use and happiness in adults with autism spectrum disorder. *Cyberpsychology, Behavior, and Social Networking, 21*(3), 205-209. DOI: 0.1089/cyber.2017.0331

Williams, D. (2006) On and off the ’Net: Scales for Social Capital in an Online Era. Journal of Computer-Mediated Communication, 11(2), 593–628. DOI: /10.1111/j.1083-6101.2006.00029.x

Wellman, B. (2001). Computer networks as social networks. *Science, 293*(5537), 2031-2034. DOI: 10.1126/science.1065547

Whiting, A. & Williams, D. (2013). Why people use social media: a uses and gratifications approach. *Qualitative Market Research, 16*(4), 362-369. DOI: https://doi.org/10.1108/QMR-06-2013-0041

World Health Organization. (1992). *International classification of diseases: Diagnostic criteria for research (10th edition)*. Geneva, Switzerland: World Health Organisation.

World Health Organisation (2019). *Autism Spectrum Disorders*. Retrieved from: https://www.who.int/news-room/fact-sheets/detail/autism-spectrum-disorders

World Health Organisation (2021). *Adolescent Health*. Retrieved from: https://www.who.int/health-topics/adolescent-health#tab=tab_1

Yang, C. (2016). Instagram use, loneliness, and social comparison orientation: interact and browse on social media, but don’t compare. *Cyberpsychology, Behavior, and Social Networking, 19*, 703-708. DOI: 10.1089/cyber.2016.0201

Young, L., Kolubinski, D. C. & Frings, D. (2020). Attachment style moderates the relationship between social media use and user mental health and wellbeing. *Heliyon, 6*(6). DOI: https://doi.org/10.1016/j.heliyon.2020.e04056.

Appendix 1: NIH Quality Assessment tool

Quality Assessment Tool for Before-After (Pre-Post) Studies With No Control Group

Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the study question or objective clearly stated?			
2. Were eligibility/selection criteria for the study population prespecified and clearly described?			
3. Were the participants in the study representative of those who would be eligible for the test/service/intervention in the general or clinical population of interest?			
4. Were all eligible participants that met the prespecified entry criteria enrolled?			
5. Was the sample size sufficiently large to provide confidence in the findings?			
6. Was the test/service/intervention clearly described and delivered consistently across the study population?			

Criteria	Yes	No	Other (CD, NR, NA)*
7. Were the outcome measures prespecified, clearly defined, valid, reliable, and assessed consistently across all study participants?			
8. Were the people assessing the outcomes blinded to the participants' exposures/interventions?			
9. Was the loss to follow-up after baseline 20% or less? Were those lost to follow-up accounted for in the analysis?			
10. Did the statistical methods examine changes in outcome measures from before to after the intervention? Were statistical tests done that provided p values for the pre-to-post changes?			
11. Were outcome measures of interest taken multiple times before the intervention and multiple times after the intervention (i.e., did they use an interrupted time-series design)?			
12. If the intervention was conducted at a group level (e.g., a whole hospital, a community, etc.) did the statistical analysis take into account the use of individual-level data to determine effects at the group level?			

Appendix 2: QATSSD quality assessment tool

Criteria	0 = Not at all	1 = Very slightly	2 = Moderately	3 = Complete
Explicit theoretical framework	No mention at all.	Reference to broad theoretical basis.	Reference to a specific theoretical basis.	Explicit statement of theoretical framework and/or constructs applied to the research.
Statement of aims/objectives in main body of report	No mention at all.	General reference to aim/objective at some point in the report including abstract.	Reference to broad aims/objectives in main body of report.	Explicit statement of aims/objectives in main body of report.
Clear description of research setting	No mention at all.	General description of research area and background, e.g. 'in primary care'.	General description of research problem in the target population, e.g. 'among GPs in primary care'.	Specific description of the research problem and target population in the context of the study, e.g. nurses and doctors from GP practices in the east midlands.
Evidence of sample size considered in terms of analysis	No mention at all.	Basic explanation for choice of sample size. Evidence that size of the sample has been considered in study design.	Evidence of consideration of sample size in terms of saturation/information redundancy or to fit generic analytical requirements.	Explicit statement of data being gathered until information redundancy/saturation was reached or to fit exact calculations for analytical requirements.
Representative sample of target	No statement	Sample is limited but represents some of the	Sample is somewhat diverse but not entirely representative, e.g.	Sample includes individuals to represent a cross section of the target population,

Criteria	0 = Not at all	1 = Very slightly	2 = Moderately	3 = Complete
group of a reasonable size	of target group.	target group or representative but very small.	inclusive of all age groups, experience but only one workplace. Requires discussion of target population to determine what sample is required to be representative.	considering factors such as experience, age and workplace.
Description of procedure for data collection	No mention at all.	Very basic and brief outline of data collection procedure, e.g. ‘using a questionnaire distributed to staff’.	States each stage of data collection procedure but with limited detail, or states some stages in details but omits others.	Detailed description of each stage of the data collection procedure, including when, where and how data were gathered.
Rationale for choice of data collection tool(s)	No mention at all.	Very limited explanation for choice of data collection tool(s).	Basic explanation of rationale for choice of data collection tool(s), e.g. based on use in a prior similar study.	Detailed explanation of rationale for choice of data collection tool(s), e.g. relevance to the study aims and assessments of tool quality either statistically, e.g. for reliability & validity, or relevant qualitative assessment.
Detailed recruitment data	No mention at all.	Minimal recruitment data, e.g. no. of questionnaire	Some recruitment information but not complete account of the recruitment process, e.g. recruitment figures but no	Complete data regarding no. approached, no. recruited, attrition data where relevant, method of recruitment.

Criteria	0 = Not at all	1 = Very slightly	2 = Moderately	3 = Complete
		sent and no. returned.	information on strategy used.	
Statistical assessment of reliability and validity of measurement tool(s) (Quantitative only)	No mention at all.	Reliability and validity of measurement tool(s) discussed, but not statistically assessed.	Some attempt to assess reliability and validity of measurement tool(s) but insufficient, e.g. attempt to establish test–retest reliability is unsuccessful but no action is taken.	Suitable and thorough statistical assessment of reliability and validity of measurement tool(s) with reference to the quality of evidence as a result of the measures used.
Fit between stated research question and method of data collection (Quantitative)	No research question stated.	Method of data collection can only address some aspects of the research question.	Method of data collection can address the research question but there is a more suitable alternative that could have been used or used in addition.	Method of data collection selected is the most suitable approach to attempt answer the research question
Fit between stated research question and format and content of data collection tool e.g. interview schedule (Qualitative)	No research question stated.	Structure and/or content only suitable to address the research question in some aspects or superficially.	Structure & content allows for data to be gathered broadly addressing the stated research question(s) but could benefit from greater detail.	Structure & content allows for detailed data to be gathered around all relevant issues required to address the stated research question(s).
Fit between research question and method of analysis	No mention at all.	Method of analysis can only address the research question	Method of analysis can address the research question but there is a more suitable alternative that could have been used or	Method of analysis selected is the most suitable approach to attempt answer the research question in detail, e.g. for qualitative IPA preferable for experiences

Criteria	0 = Not at all	1 = Very slightly	2 = Moderately	3 = Complete
		basically or broadly.	used in addition to offer greater detail.	vs. content analysis to elicit frequency of occurrence of events, etc.
Good justification for analytical method selected	No mention at all.	Basic explanation for choice of analytical method	Fairly detailed explanation of choice of analytical method.	Detailed explanation for choice of analytical method based on nature of research question(s).
Assessment of reliability of analytical process (Qualitative only)	No mention at all.	More than one researcher involved in the analytical process but no further reliability assessment.	Limited attempt to assess reliability, e.g. reliance on one method.	Use of a range of methods to assess reliability, e.g. triangulation, multiple researchers, varying research backgrounds.
Evidence of user involvement in design	No mention at all.	Use of pilot study but no involvement in planning stages of study design.	Pilot study with feedback from users informing changes to the design.	Explicit consultation with steering group or statement or formal consultation with users in planning of study design.
Strengths and limitations critically discussed	No mention at all.	Very limited mention of strengths and limitations with omissions of many key issues.	Discussion of some of the key strengths and weaknesses of the study but not complete.	Discussion of strengths and limitations of all aspects of study including design, measures, procedure, sample & analysis.

Appendix 3: Papers assessed with NIH pre-post assessment tool

Quality assessment criteria	**Example**	1. Chung et al (2016)	3. Didehbani et al (2016)	4. Friedrich et al (2015)	5. Gwynette et al (2017)
Aims	Aims and research questions clearly described	Yes Stated hypothesis that CBT using prosocial game would improve social cognition.	Yes. Primary aim to assess feasibility of intervention, and to measure changes in affect recognition, social attribution and executive functioning.	Yes. The aim was to examine improvements in neurofeedback training for the reduction of ASD symptoms.	Yes. Stated hypotheses that Facebook delivered social skills training would be feasible and potentially improve clinical outcomes.
Eligibility	Eligibility criteria clearly described so that study could be repeated	Yes Participants aged 13-16, diagnosed with ASD, IQ >70, ADOS score 4-7. Exclusion of comorbid psychiatric or physical illness, head trauma, IQ <70 or substance abuse history.	Yes. Participants aged 7-16, with a diagnosis of Asperger's or PDD-NOS. Exclusions of individuals with a history of neurologic disorders, an acute psychiatric condition or Axis I psychopathology (except ADHD).	Yes. 6-17 years old, who had not taken part in neurofeedback training previously and had a diagnosis of ASD verified within a year of training, could understand the task and were compliant.	Partly. Participant demographics including age range, diagnosis of ASD and an IQ in the average range described, but it is not made clear if these are eligibility criteria.
Participant representativeness	Study participants representative of the population to which the intervention will be applied	Yes. All participants had a diagnosis of ASD, and were reassessed with an ADOS assessment.	Yes. All participants had a diagnosis of Aperger's or PDD-NOS and diagnosis was confirmed with and ADOS assessment.	Yes. All participants had a diagnosis of ASD verified within the previous year.	Yes. All participants had a diagnosis of ASD and were recruited from an autism program at a medical university.
Participant enrolment	Eligibility criteria pre-determined, applied to all participants and all eligible participants enrolled	Yes. Inclusion criteria appears prespecified and specific and all available participants took part, unless excluded.	Yes. It appears that inclusion and exclusion criteria were prespecified and available participants recruited.	Yes. Eligibility appears predetermined Recruitment procedures not described.	Partly. It is unclear if eligibility criteria are predetermined. All participants fall within described demographics and available participants recruited.

Sample size	Rationale for sample size and power calculation presented	No. 20 participants. No rationale for sample size given.	No. 30 participants. No rationale for sample size given.	No. 13 participants. No rationale for sample size given.	No. 6 participants. No rationale for sample size given.
Intervention delivery	Intervention clearly described and delivered consistently to participants with high adherence	Yes. Online platform as well as the content of CBT sessions described. Physical environment of intervention delivery described.	Yes. The intervention procedure was clearly described.	Yes. A description of the computer game used in the game is provided.	Partly. A description of the Facebook group is given but without in-depth information about the content of group discussions or guidance. Apparently consistent delivery and high adherence.
Outcome measures	Outcome measures described, reliable and validated	Yes. All outcome measures described and their consistency or reliability stated.	Yes. Outcome measures were clearly described in detail and validity and reliability information provided.	Yes. Description of outcome measures and physiological measurements provided. Reputable and much used outcome measures utilised.	Partly. Questionnaires listed, including well-known relevant outcome measures as well as programme-specific measures. Reliability and validity not described.
Assessor blinding	Assessors don't know whether participants received the intervention	N/A. Questionnaire-based and objective outcomes measures used.	Yes. Assessors blinded for assessment involving rater scoring.	N/A. Physiological and questionnaire outcome measures used.	N/A Questionnaire use did not require blinding of assessors.
Loss to follow-up	Minimal loss to follow-up from baseline assessment (80% follow-up)	Yes. Only one participant dropped out due to lack of interest.	Yes. No loss to follow-up.	Yes. Two out of the original 15 participants dropped out.	Yes. No loss to follow-up.
Statistical testing	Formal statistical tests with statistical significance reported	Yes. Statistical tests reported with significance levels.	Yes. Statistical tests reported with significance.	Yes. Statistical tests reported with significance.	Partly. Statistical tests used but results with significance not reported.
Repeated assessment	Outcome measures measured more than once before and after the study period	No. Outcome measures were assessed once at baseline and once after intervention completion.	No. Outcome measures completed once before commencement and once after completion of the intervention.	No. One measurement was taken before the intervention and one afterwards.	No. Oucome measures collected once before and once after intervention.

Individual-level outcomes	For group-level interventions, analysis tales into account individual-level data	N/A Intervention delivered at an individual level.	N/A Intervention delivered at individual level.	N/A Intervention delivered at an individual level.	N/A Intervention delivered at an individual level.

Quality assessment criteria	**Example**	8. Ke, Moon & Sokolikj (2020)	9. Mandasari et al (2011)	10. Mitchell et al (2007)	13. Serret et al (2014)
Aims	Aims and research questions clearly described	Yes Stated aim to discover what effect participating in virtual reality based social skills training has on social skills performance.	No. No aims or hypotheses are presented, although the authors mention evaluating the appropriateness and efficacy of the intervention.	Yes. To discover whether a virtual environment is appropriate for social skills teaching among young people with ASD and if there are learning benefits.	Yes. The aim of the study was to assess the adaptability, effectiveness and efficiency of the technology. The stated hypothesis was that the intervention would result in emotion recognition improvement.
Eligibility	Eligibility criteria clearly described so that study could be repeated	Yes Participants aged 10-14 with a diagnosis of autism, the ability to read, write and speak and with a reasonable level of education,	Yes. Criteria described are a diagnosis of autism, difficult behaviours with impaired communication, able to operate a computer and with reasonable intellectual and language abilities.	Yes. Participants aged 14-16 with a formal diagnosis of autism, without co-morbid diagnosis.	Yes. Participants aged 6-17 with a diagnosis of autism, able to discriminate primary and secondary colours and with prior experience of using a computer.
Participant representativeness	Study participants representative of the population to which the intervention will be applied	Yes. All participants had a diagnosis of ASD and were recruited from an autism centre.	Yes. All participants had a diagnosis of ASD.	Yes. All participants had a diagnosis of ASD.	Yes. All participants had a diagnosis of autism.
Participant enrolment	Eligibility criteria pre-determined, applied to all participants and all eligible participants enrolled	Yes. Inclusion criteria appears prespecified and it appears that all available participants were enrolled in the study.	Yes. Inclusion criteria appears prespecified and it appears that available participants took part.	Yes. Inclusion and exclusion criteria pre-specified and applied to all participants.	Yes. Eligibility criteria pre-defined and applied to all participants. Only participants unable to use the technology were excluded.
Sample size	Rationale for sample size and power calculation presented	No. 7 participants. No rationale for sample size given.	No. 3 participants. No rationale for sample size given.	No. 6 participants. No rationale for sample size given.	No. 33 participants. No rationale for sample size given.

Intervention delivery	Intervention clearly described and delivered consistently to participants with high adherence	Yes. The virtual reality platform was described and illustrations provided.	Yes. The social stories animation platform and delivery environment were described.	Yes. Each stage of the intervention was described in detail.	Yes. A detailed description of the game was given, with all participants receiving the intervention.
Outcome measures	Outcome measures described, reliable and validated	Yes. Video coding described, as well as the questionnaire measure which was a standard social communication assessment with reported internal consistency.	Partly. Target behaviours to be observed described as well in the observation schedule, but with no description of coding practices.	Yes. The video coding process was described in detail, including justification for the particular method and reference to how this would yield accurate data.	Yes. Outcome assessment described and pilot study to determine reliability was used and described.
Assessor blinding	Assessors don't know whether participants received the intervention	No. No description of assessor blinding.	No. No description of assessor blinding.	Yes. Assessors were blinded to the nature of the study, participants' ASD diagnosis and the time-points of the data.	N/A Assessment was carried out using a computer programme.
Loss to follow-up	Minimal loss to follow-up from baseline assessment (80% follow-up)	Partly. All 7 participants completed the intervention and post-intervention assessment. Four completed follow-up assessment.	Yes. No loss to follow-up.	Yes. One participant of the original 7 lost to follow-up, with a description of the circumstances.	Yes. 3 of the original 36 participants dropped out with loss to follow-up explained.
Statistical testing	Formal statistical tests with statistical significance reported	Yes. Statistical tests reported with significance levels.	N/A. Qualitative observations were used.	Yes. Statistical tests with significance reported.	Yes. Statistical tests with significance reported.
Repeated assessment	Outcome measures measured more than once before and after the study period	Yes. Outcome measures were assessed at several time points before, during and after intervention delivery.	Yes. Outcome measures were assessed every day for a week pre-intervention, for one week during the intervention and for two weeks after the intervention.	Partly. Assessments were taken twice either before or after the intervention, to establish if improvements were due to the intervention or practice effects.	No. Assessment carried out once before and once after the intervention.

Individual-level outcomes	For group-level interventions, analysis tales into account individual-level data	N/A Intervention delivered at an individual level.	N/A Intervention delivered at an individual level.	N/A Intervention was delivered at an individual level.	N/A Intervention delivered at an individual level.

Quality assessment criteria	**Example**	14. Strichter et al (2014)	16. Tanaka et al (2017)	17. Zhao et al (2016)	18. Zhao et al (2018)
Aims	Aims and research questions clearly described	Yes. Stated aims were to examine the intervention's utility with regards to its impact on social competence, fidelity to the offline intervention and experienced validity of the intervention by participants.	Partly. The learning summary is detailed as well as a broad description of what was being examined, without explicitly stating aims.	Partly. A summary of the paper of provided in terms of it presenting the design and evaluating the efficacy of a technology system but aims are not explicitly laid out.	Yes. The stated study aim is to assess the technology with regards to its ability to foster collaboration.
Eligibility	Eligibility criteria clearly described so that study could be repeated	Yes. Participants aged 11-14 with a diagnosis of ASD, IQ >75 and access to neurotypical peers for some of the day.	Yes. Participants aged 7-19 with a diagnosis of autism of PDD-NOS, an IQ >70.	No. Eligibility criteria are not described.	No. Eligibility criteria are not described.
Participant representativeness	Study participants representative of the population to which the intervention will be applied	Yes. All participants had a diagnosis of autism which was re-confirmed with an ADOS or ADI assessment.	Yes. All participants had a diagnosis of autism.	Yes. 3 of the 12 participants had a diagnosis of autism which was confirmed using the social communication questionnaire (SCQ). The results of these individuals were stated separately from the typically developing participants.	Yes. 12 of the 24 participants had a diagnosis of autism. The results of these individuals were stated separately from the typically developing participants.
Participant enrolment	Eligibility criteria pre-determined, applied to all participants and all eligible participants enrolled	Yes Eligibility criteria were pre-defined and recruitment process described with eligible participants recruited.	Yes. Eligibility appears pre-defined and applied to all participants. Only participants who did not complete intervention procedure were excluded.	No. There do not appear to be eligibility criteria and recruitment method is not stated so it is known if all eligible participants were enrolled.	No. There do not appear to be eligibility criteria and recruitment method is not stated so it is known if all eligible participants were enrolled.

Sample size	Rationale for sample size and power calculation presented	10 participants. No rationale for sample size given.	No. 10 participants. No rationale for sample size given.	No. 12 participants. No rationale for sample size given.	No. 24 participants. No rationale for sample size given.
Intervention delivery	Intervention clearly described and delivered consistently to participants with high adherence	Partly. An overall description of the intervention was given but without specific session-by-session details. Interventions appear to have been delivered consistently.	Yes. A description of the intervention provided and applied to all participants.	Yes. A detailed description of the game was provided.	Yes. A detailed description of the game and testing procedure was provided.
Outcome measures	Outcome measures described, reliable and validated	Yes. Well-known and reputable outcome measures used with validity and reliability described.	Partly. Assessment by video coding was described with the credentials of the coder. However information on the reliability of this method was not provided.	Partly. Outcome measures collected automatically by the computer described. Reliability and validity not discussed.	Partly. A description of the game performance measures used to assess outcomes were described but without consideration of reliability or validity.
Assessor blinding	Assessors don't know whether participants received the intervention	N/A Standardised questionnaire-based outcome measures were used with no need for assessor blinding.	Yes. The assessor coding the videos was unaware of the timepoint of videos and watched pre- post- and follow-up videos in a random order.	N/A Assessment was carried out using a computer programme.	N/A Standardised game performance measures were used with no need for assessor blinding.
Loss to follow-up	Minimal loss to follow-up from baseline assessment (80% follow-up)	Yes. No loss to follow-up.	Yes. 2 of the original 12 participants were removed with justification.	Yes. No loss to follow-up.	Yes. No loss to follow-up.
Statistical testing	Formal statistical tests with statistical significance reported	Yes. Statistical tests reported with significance.	Yes. Statical tests with significance provided.	No. Pre-post comparisons made without statistical testing.	Yes. Statical tests with significance provided.
Repeated assessment	Outcome measures measured more than once	No. Assessments carried out once 2 weeks prior and once	Partly. Follow-up scores were taken once 3 months post-	No.	No.

	before and after the study period	2 weeks post intervention delivery.	intervention, although only 3 of 10 participants returned for follow-up.	Assessments carried out once pre- and once post-intervention.	Assessments carried out once pre- and once post-intervention.
Individual-level outcomes	For group-level interventions, analysis tales into account individual-level data	N/A Intervention delivered at an individual level.	N/A Intervention delivered at an individual level.	N/A Intervention delivered at an individual level.	N/A Intervention delivered at an individual level.

Appendix 4: Papers assessed using the QATSSD

Quality assessment criteria	2. De Silva et al (2009)	6. Hopkins et al (2011)	7. Ke & Im (2013)
Explicit theoretical framework	Completely. The theoretical basis of the study is described in the introduction.	Completely, The introduction details the theoretical underpinnings of the study.	Completely. Theoretical basis of the study and current literature detailed in the introduction.
Aims/objectives clearly stated	Very slightly. Aims alluded to in terms of assessing the usability and efficacy of a robot intervention but are not explicitly stated.	Completely. The aims of the study are explicitly stated; to examine the impact of the intervention on emotion and facial recognition and on social behaviours in the natural environment.	Completely. Aims and hypotheses stated. To examine the treatment integrity of the intervention and of the different social skills scenarios in the intervention.
Clear description of research setting	Completely. The research problem and target population were clearly described.	Completely Description of the research problem and target population included with recruitment process.	Completely. Description of the research problem and target population. Recruitment location and intervention location described.
Evidence of sample size considered in terms of analysis	Not at all. 5 participants. No rationale for sample size given.	Not at all. 49 participants. No rationale for sample size given.	Not at all. 4 participants. No rationale for sample size given.
Representative sample of target group of a reasonable size	Very slightly. The sample is representative but small at 3 participants.	Moderately. The sample is of a reasonable size and representative of the target population. Some demographic factors are considered.	Very slightly. The sample is representative but very small, with only 4 participants.
Description of procedure for data collection	Very slightly. A brief description of data collection in terms of measuring the frequency and duration of joint attention is provided.	Completely. A description of the intervention and outcome measure administration was provided in detail.	Completely. A full description of data collection including descriptions of the adult coders and a detailed account of the procedure was provided.

Rationale for choice of data collection	Not at all. There is no mention of the rationale for data collection through observation.	Completely. Data collection tools described including their relevance to the study and validity and reliability information.	Completely. Rationale for across-subjects research design was provided, with description and justification of quantitative outcome measures and descriptions of qualitative measures.
Detailed recruitment data	Very slightly. Site of recruitment and final recruitment numbers described but no detailed description of recruitment.	Moderately. Recruitment figures and rationale for exclusions included but without a detailed account of recruitment strategy.	Very slightly. Description of recruitment site and final figures provided but not of the recruitment process.
Assessment of validity and reliability of outcome measures (quantitative)/analytical process (qualitative)	Not at all. No description of validity or reliability of the analytical process.	Completely. Validity and reliability information included for all measures.	Moderately. Information about the validity and reliability of quantitative outcome measures was provided but not qualitative.
Fit between stated research question and method of data collection (quantitative)/data collection tool (qualitative)	Completely. Data collection through observation appropriate for apparent aim of assessing intervention. .	Completely. A wide variety of appropriate outcome measures were used to capture different elements of the research questions.	Completely. The selected data collection methods both quantitative and qualitative are suitable for the aim of the study.
Fit between research question and method of analysis	Moderately. The chosen method of assessing video data is suitable but a more detailed assessment including quantitate analysis of qualitative data would have yielded more detailed information.	Completely. The quantitative method of analysis and selected measures were appropriate for answering the stated research questions.	Moderately. The qualitative assessment of and comparison of outcome measures over time is appropriate but could have benefitted from quantitative analysis including statistical significance.
Good justification for analytical method selected	Not at all. No justification of analytical method was provided.	Not at all. No justification of analytical method was provided.	Very slightly. A basic justification of method of analysis was provided in terms of a thematic analysis' ability to explore the relevant information.
Evidence of user involvement in design	Not at all. No mention of service user involvement in study design.	Not at all. No mention of service user involvement in study design.	Not at all. No mention of service user involvement in study design.

Strengths and limitations critically discussed	Not at all. No discussion of strengths and limitations.	Moderately. The limitations of the study were explicitly described, but did not include all aspects of the study.	Very slightly. A description of the limitations with regards to the technology platform was provided, but not other aspects of the study.

Quality assessment criteria	11. Moon & Ke (2019)	12. Silver & Oakes (2001)	15. Suzuki & Lee (2016)
Explicit theoretical framework	Completely. Literature review included.	Completely. The introduction details previous research and the theoretical basis of the study.	Very slightly. Current literature in the area is referred to but not described in detail.
Aims/objectives clearly stated	Completely. Aims and hypotheses stated. To examine the treatment integrity of the intervention and of the different social skills scenarios in the intervention.	Moderately. The study describes evaluating the computer program ‘emotion trainer’, designed to enhance emotion recognition and prediction, but does not lay this out as an explicit aim. .	Completely. Stated hypothesis are that children will touch the correct body part of the robot, approach and greet the robot and stay in close proximity.
Clear description of research setting	Completely. Description of research problem and target population.	Completely. Description of the research problem and target population as well as recruitment site.	Completely. A description of the target population and the setting of the study was provided.
Evidence of sample size considered in terms of analysis	Not at all. 15 participants. No rationale for sample size given.	Not at all. 22 participants. No rationale for sample size given.	Not at all. 5 participants. No rationale for sample size given.
Representative sample of target group of a reasonable size	Moderately. Sample is representative but not very large.	Moderately. The sample is of a reasonable size and representative of the target population. Experimental and control groups matched on demographic factors.	Very slightly. The sample is representative but small.
Description of procedure for data collection	Completely. Intervention, intervention platform and intervention delivery described in	Completely. A description of the program was provided in detail, with all participants	Moderately. The method of data collection in terms of observations was detailed but

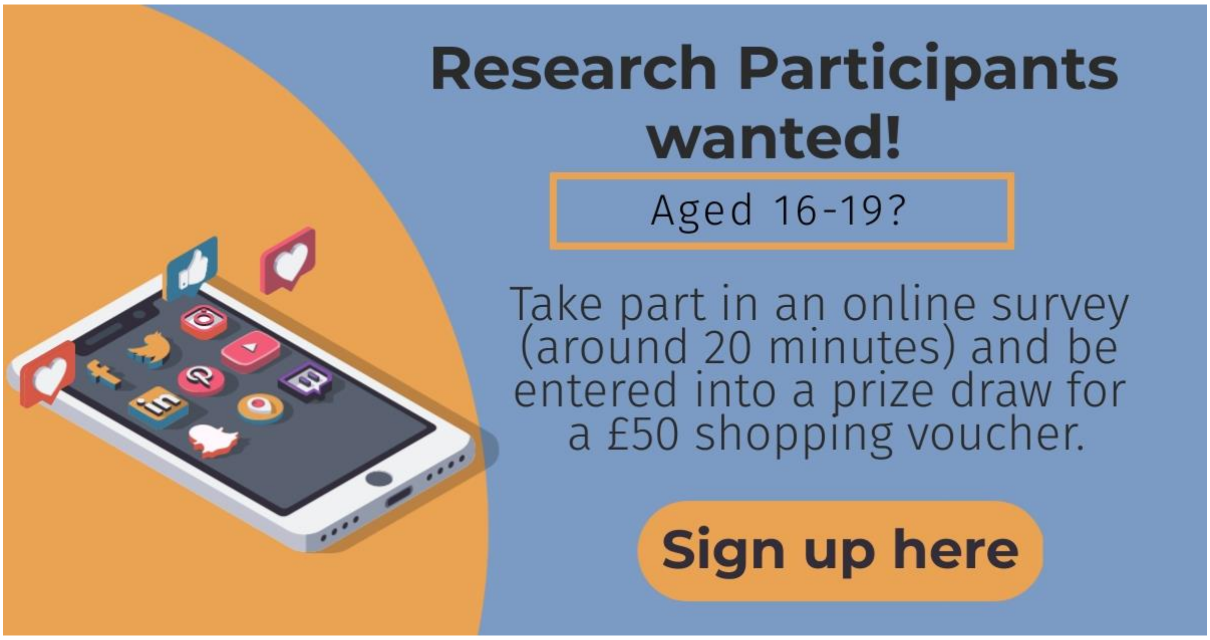
	detail, as well as target behaviours for identification.	in the experimental group receiving the same intervention.	without full information including the physical environment.
Rationale for choice of data collection	Completely. Description of a rationale for using treatment integrity outcome measure described.	Not at all. There is no rationale for the choice of data collection provided.	Not at all. No justification for choice of data collection is provided.
Detailed recruitment data	Very slightly. Description of final recruitment figures but not of process.	Moderately. Description of recruitment site and of reasons for exclusions, drop-outs provided.	Not at all. No description of recruitment strategy provided.
Assessment of validity and reliability of outcome measures (quantitative)/analytical process (qualitative)	Not at all. No description of validity or reliability of outcome measures.	Very slightly. Descriptions of outcome measures were provided, with inter-rater reliability provided for one measure.	Not at all. There is no consideration of the validity and relaiability of assessment strategy used.
Fit between stated research question and method of data collection (quantitative)/data collection tool (qualitative)	Completely. Method of data collection through video very suitable to the aim of assessing treatment integrity.	Completely. A variety of outcome measures were used including intervention errors and emotion recognition, which are appropriate to the research aim.	Completely. Data collection through observation fits with the research questions relating to interaction with the robot.
Fit between research question and method of analysis	Completely. Method of analysis suitable to answering the stated research question. Mixed method design allows for additional verification of quantitative findings.	Completely. The quantitative method of pre-post analysis using ANOVA was appropriate for evaluating the effect of the intervention on emotion recognition.	Moderately. Qualitative descripions with some quantitative figures are provided. Further quantitative analysis of findings could have provided a more detailed analysis.
Good justification for analytical method selected	Completely. Chosen assessment tool was justified in terms of its ability to answer the research questions.	Very slightly. The use of ANOVA is described in terms of fitting the data but there is no justification of a quantitative approach.	Not at all. No justification of analytical method was provided.
Evidence of user involvement in design	Not at all. No mention of service user involvement, although previous studies are referred to.	Not at all. No mention of service user involvement in study design.	Not at all. No mention of service user involvement in study design.
Strengths and limitations critically discussed	Moderately.	Completely. Both strengths and limitations of the study discussed.	Not at all. No discussion of study strengths and limitations.

	Discussion of strengths and limitations for some but not all aspects of the study.		

Appendix 5: Ethical approval information

This has been removed from the electronic copy.

Appendix 6: Social media advert



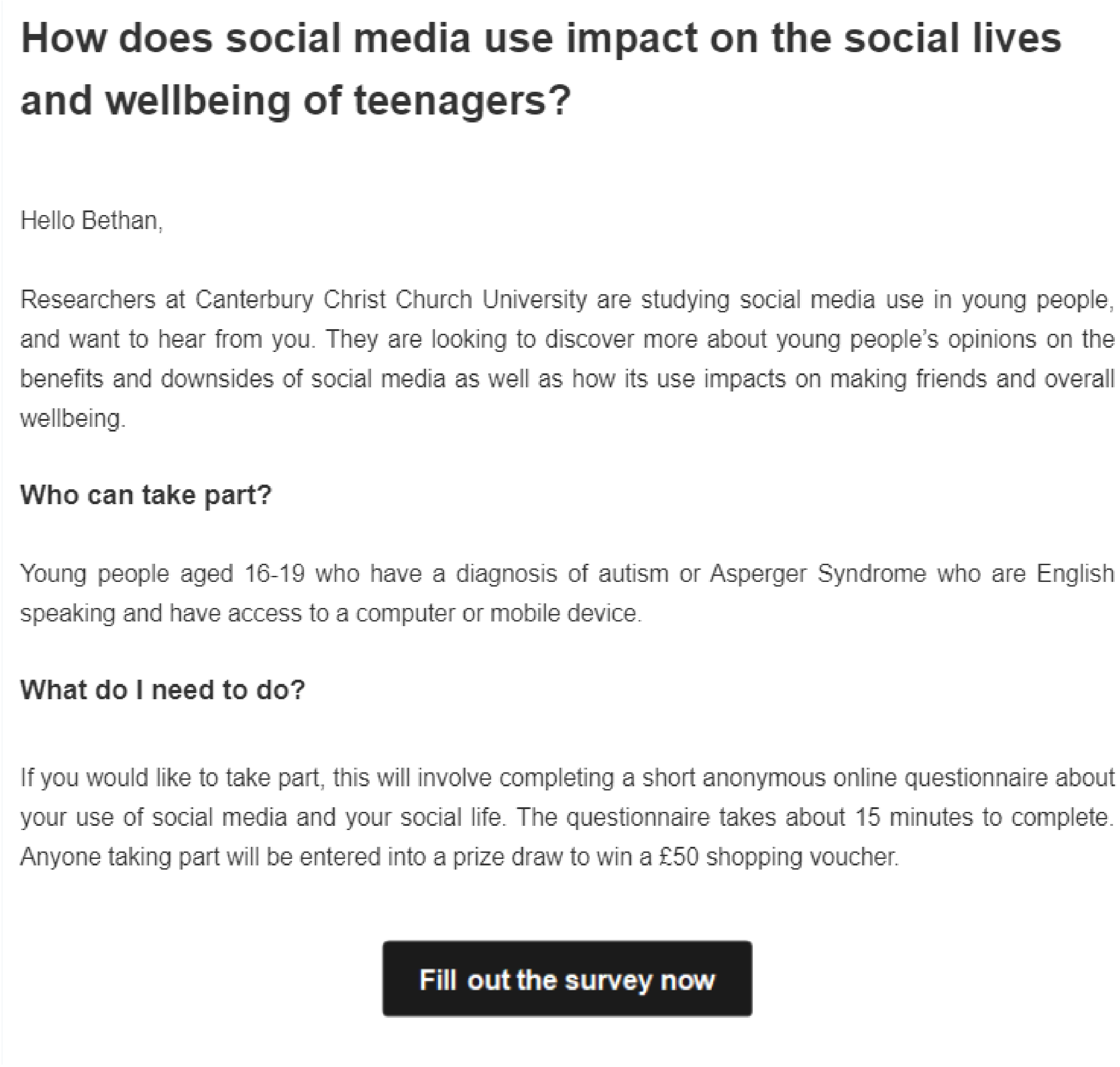
Research Participants wanted!

Aged 16-19?

Take part in an online survey (around 20 minutes) and be entered into a prize draw for a £50 shopping voucher.

Sign up here

Appendix 7: Email sent to Autistica members



How does social media use impact on the social lives and wellbeing of teenagers?

Hello Bethan,

Researchers at Canterbury Christ Church University are studying social media use in young people, and want to hear from you. They are looking to discover more about young people's opinions on the benefits and downsides of social media as well as how its use impacts on making friends and overall wellbeing.

Who can take part?

Young people aged 16-19 who have a diagnosis of autism or Asperger Syndrome who are English speaking and have access to a computer or mobile device.

What do I need to do?

If you would like to take part, this will involve completing a short anonymous online questionnaire about your use of social media and your social life. The questionnaire takes about 15 minutes to complete. Anyone taking part will be entered into a prize draw to win a £50 shopping voucher.

Appendix 8: Email sent to Cambridge Autism Research Database

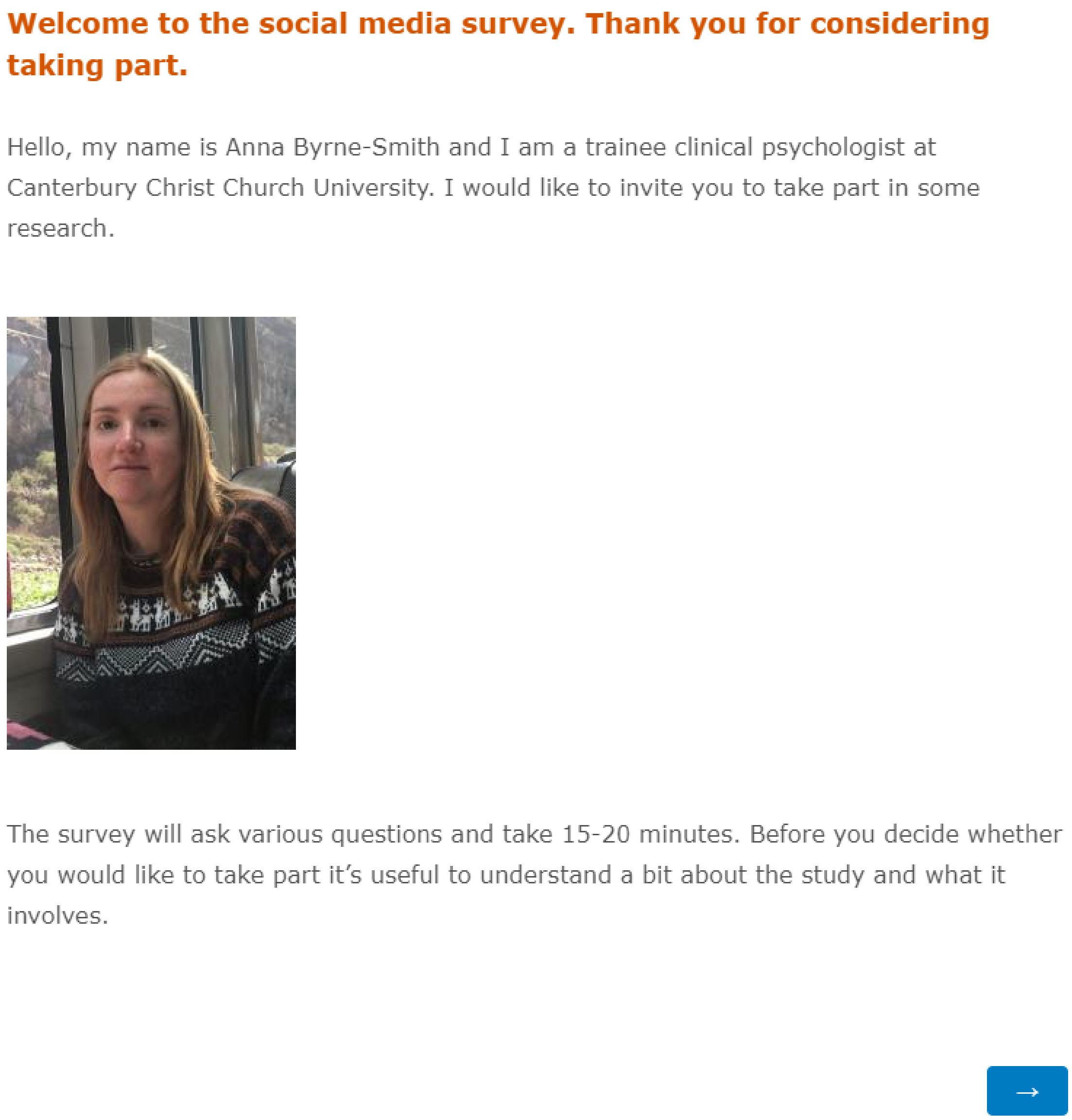
How does social media use impact on the social lives and wellbeing of teenagers?

My name is Anna Byrne-Smith, a trainee psychologist at Canterbury Christ Church University. I am looking for young people aged 16-19 to take part in my research study looking into social media use in young people. I am hoping to discover more about young people's opinions on the benefits and downsides of social media as well as how its use impacts on making friends and overall wellbeing.

I am looking for young people aged 16-19 with a diagnosis of autism or Asperger Syndrome who are English speaking and have access to a computer or mobile device to take part in the study. It involves completing a short online survey about social media use, social life and wellbeing. The survey is completely anonymous, and all participants will be entered into a prize draw for a £50 shopping voucher. The survey should take about 15 minutes to complete and can be accessed here: www.socialmediasurvey.co.uk

If you have any further questions about the study or would like to find out more you can contact me at anna.byrne-smith1282@canterbury.ac.uk or leave me telephone message on the number 01227 927070.

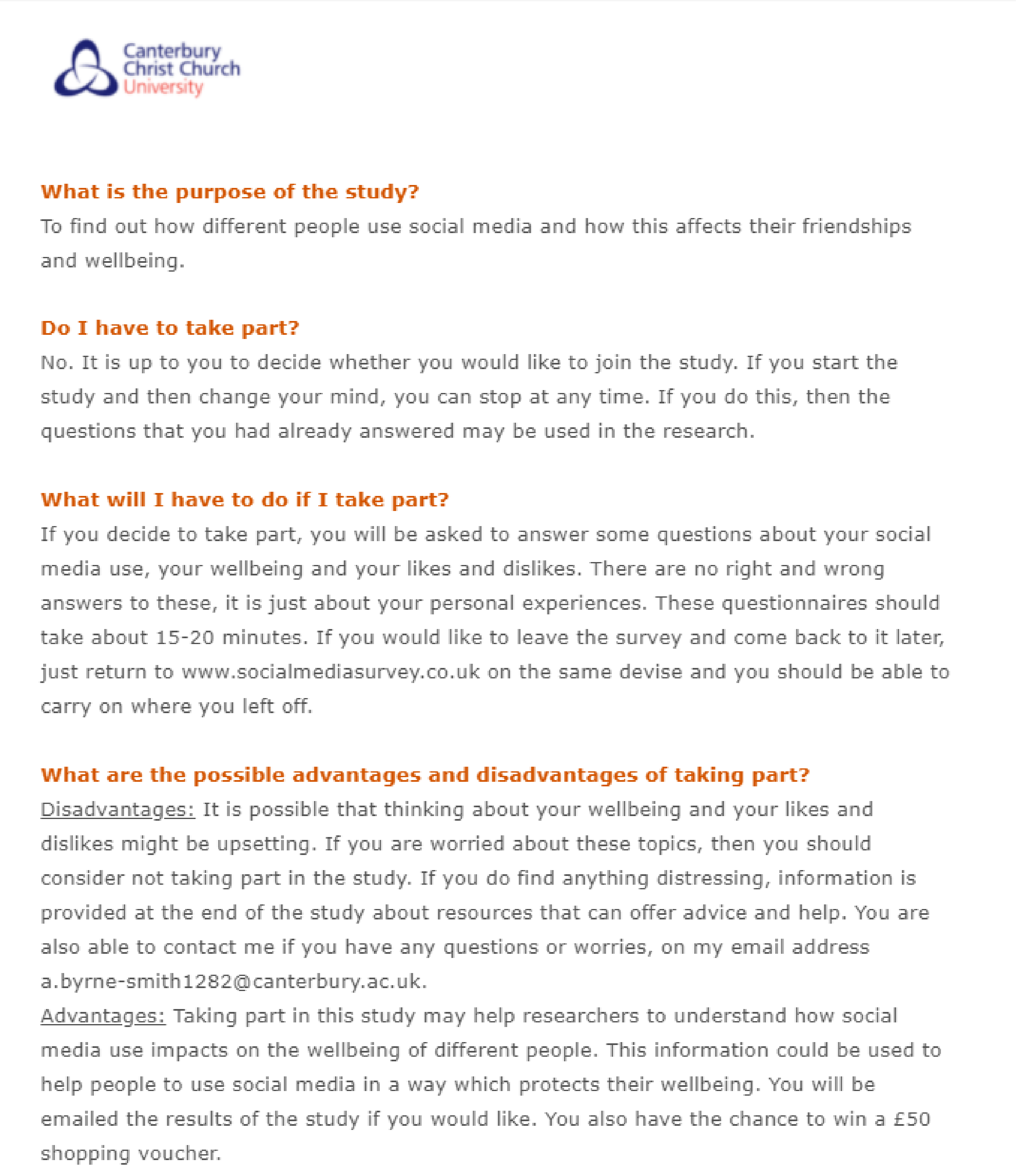
Appendix 6: Participant information and consent form



Welcome to the social media survey. Thank you for considering taking part.

Hello, my name is Anna Byrne-Smith and I am a trainee clinical psychologist at Canterbury Christ Church University. I would like to invite you to take part in some research.

The survey will ask various questions and take 15-20 minutes. Before you decide whether you would like to take part it’s useful to understand a bit about the study and what it involves.



Canterbury
Christ Church
University

What is the purpose of the study?

To find out how different people use social media and how this affects their friendships and wellbeing.

Do I have to take part?

No. It is up to you to decide whether you would like to join the study. If you start the study and then change your mind, you can stop at any time. If you do this, then the questions that you had already answered may be used in the research.

What will I have to do if I take part?

If you decide to take part, you will be asked to answer some questions about your social media use, your wellbeing and your likes and dislikes. There are no right and wrong answers to these, it is just about your personal experiences. These questionnaires should take about 15-20 minutes. If you would like to leave the survey and come back to it later, just return to www.socialmediasurvey.co.uk on the same devise and you should be able to carry on where you left off.

What are the possible advantages and disadvantages of taking part?

Disadvantages: It is possible that thinking about your wellbeing and your likes and dislikes might be upsetting. If you are worried about these topics, then you should consider not taking part in the study. If you do find anything distressing, information is provided at the end of the study about resources that can offer advice and help. You are also able to contact me if you have any questions or worries, on my email address a.byrne-smith1282@canterbury.ac.uk.

Advantages: Taking part in this study may help researchers to understand how social media use impacts on the wellbeing of different people. This information could be used to help people to use social media in a way which protects their wellbeing. You will be emailed the results of the study if you would like. You also have the chance to win a £50 shopping voucher.

Will the information from or about me that is collected during the study be kept confidential?

Yes. All information about you will be kept on a password-protected device and not shared with anyone else. Your answers to the survey will be kept anonymous and will be used in this study, and possibly in future studies around this subject. Your information will be kept securely for a maximum of 10 years and will then be destroyed. If you decide to give your email address for participation in the voucher prize draw or to hear about the results of the study, it will be kept separately to your survey answers and only be used for this purpose. It will not be used to contact you about further studies or for any other purpose than to contact you about the voucher and/or study results. Email addresses will be kept securely on a password protected device, separate to the survey data and email information will be destroyed once contact about the voucher/results has been made.

What if there is a problem?

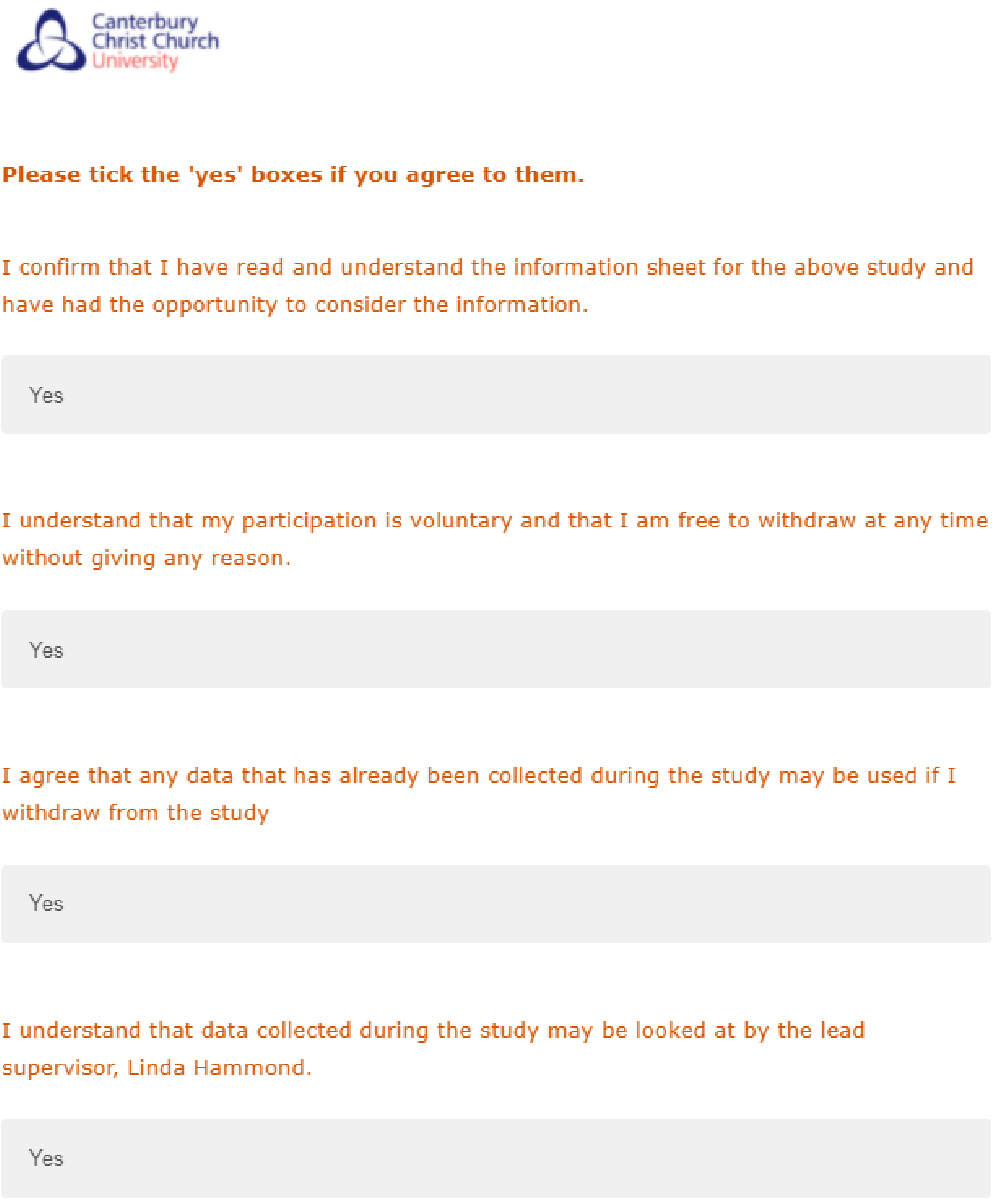
If you have a concern about any aspect of this study, you can contact me by leaving a message on the 24-hour voicemail phone number 01227 927070. Please leave a contact number and say that the message is for me, Anna Byrne-Smith, and I will get back to you as soon as possible. You can also contact my research supervisor Ms Linda Hammond at linda.hammond@canterbury.ac.uk. If you are unhappy with any part of the survey, please get in touch and let me know. If you are still unhappy, you can contact Dr Fergal Jones, Research Director at the Salomons Institute for Applied Psychology at fergal.jones@canterbury.ac.uk

What will happen to the results of the research study?

The results of the study may be published in a journal. You will be given the opportunity to receive information on the results of the study if you would like this.

Who is sponsoring and funding and who has approved the research?

This research is being supported by Canterbury Christ Church University. The ethics panel of the University has reviewed the study and given its approval for the study to go ahead.



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Christ Church
University

Please tick the 'yes' boxes if you agree to them.

I confirm that I have read and understand the information sheet for the above study and have had the opportunity to consider the information.

Yes

I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason.

Yes

I agree that any data that has already been collected during the study may be used if I withdraw from the study

Yes

I understand that data collected during the study may be looked at by the lead supervisor, Linda Hammond.

Yes

I understand that data collected during the study may be looked at by the lead supervisor, Linda Hammond.

Yes

I agree for my anonymous data to be used in further research studies.

Yes

I agree that written text may be used as anonymous quotations in the study.

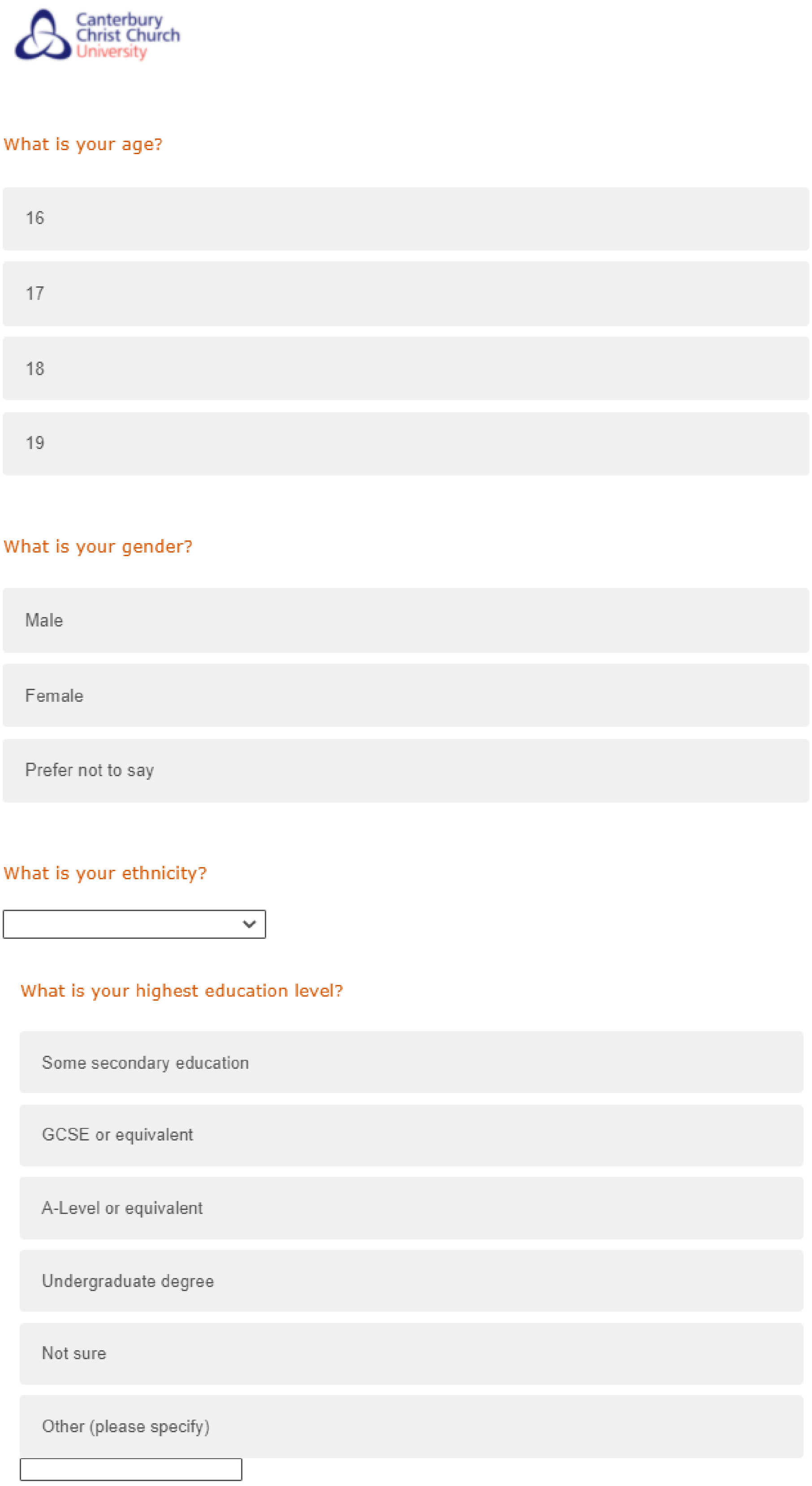
Yes

I have read and understood the information about the study and:

I would like to take part in this study

I would not like to take part in this study

Appendix 7: Survey



Canterbury Christ Church University

What is your age?

16

17

18

19

What is your gender?

Male

Female

Prefer not to say

What is your ethnicity?

What is your highest education level?

Some secondary education

GCSE or equivalent

A-Level or equivalent

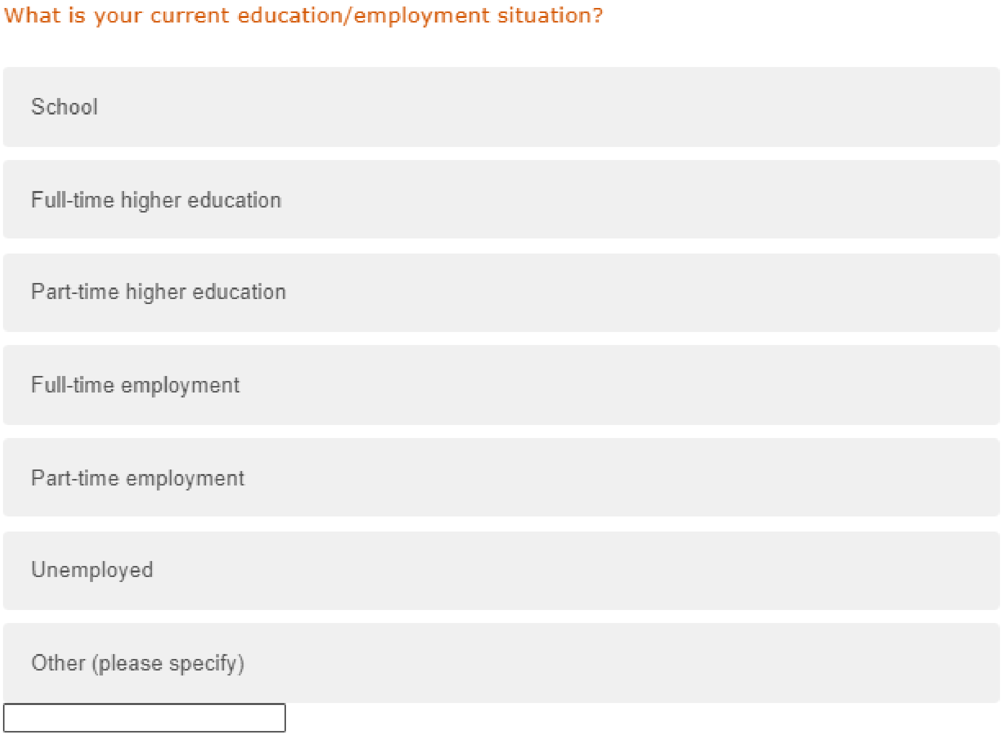
Undergraduate degree

Not sure

Other (please specify)

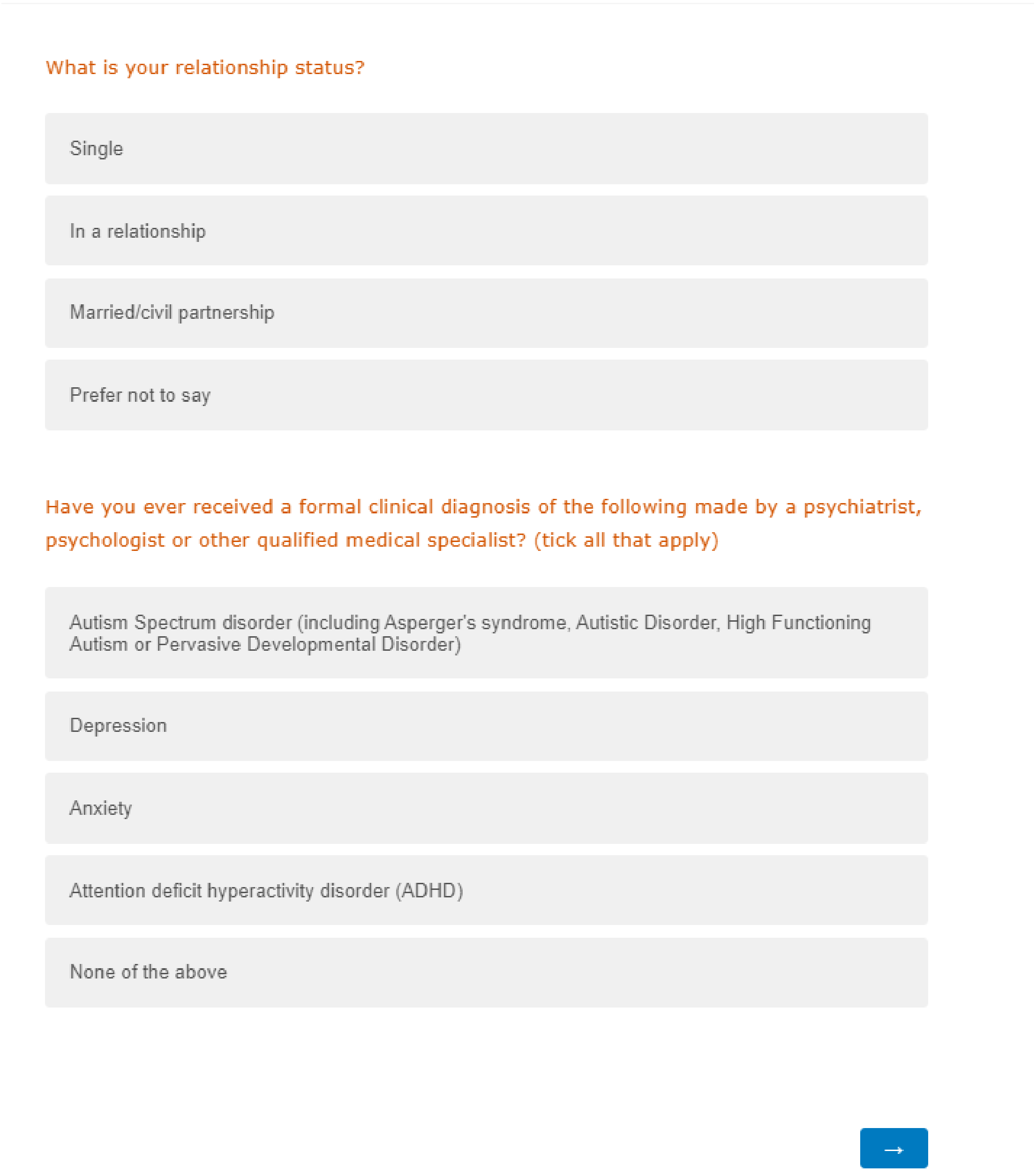
What is your current living situation?

- Living at home with parents, guardians or carers
- Living at university/other educational institution
- Live independently in rented or owned accommodation
- Other (please specify)



What is your current education/employment situation?

- School
- Full-time higher education
- Part-time higher education
- Full-time employment
- Part-time employment
- Unemployed
- Other (please specify)

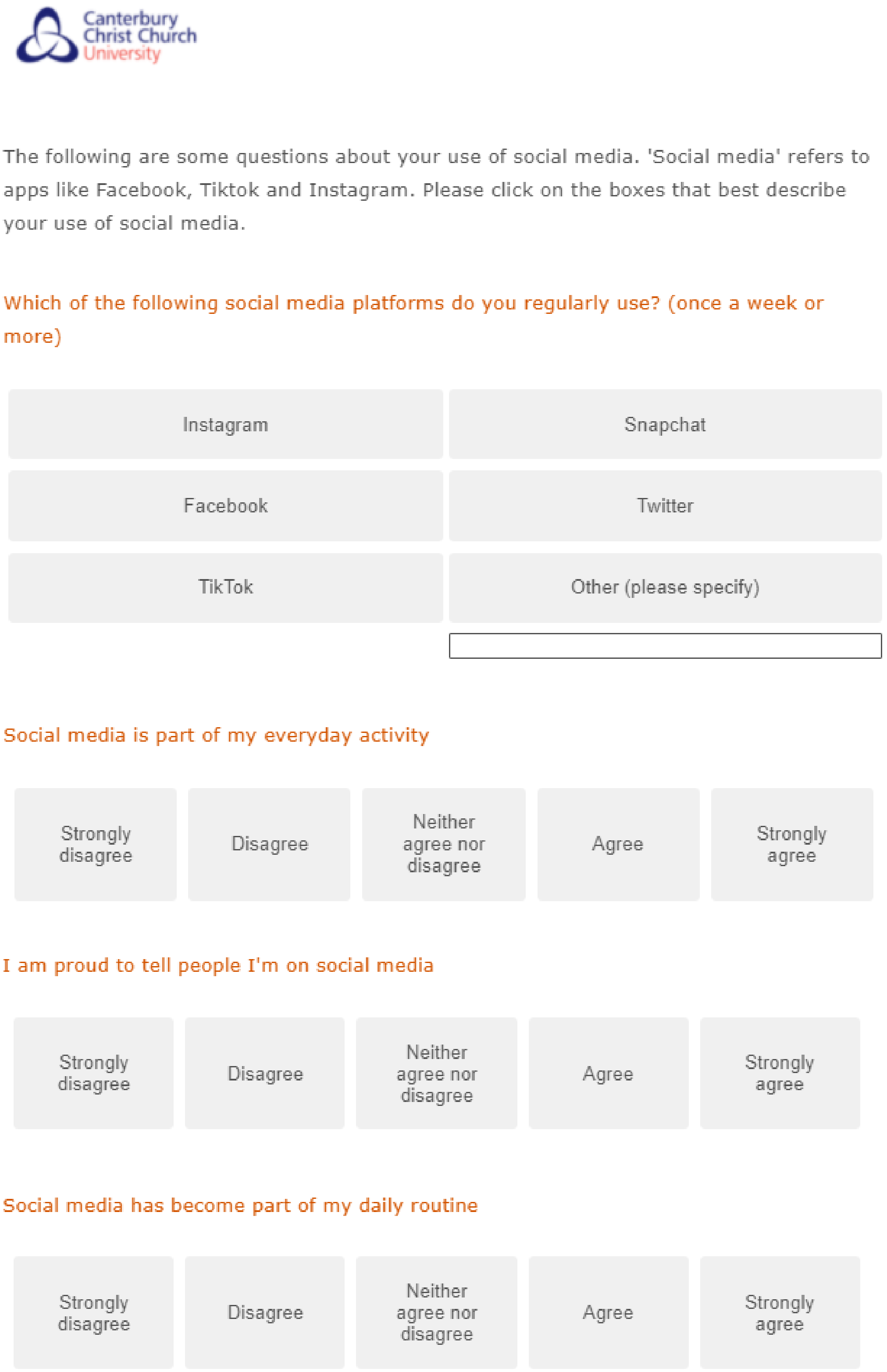


What is your relationship status?

- Single
- In a relationship
- Married/civil partnership
- Prefer not to say

Have you ever received a formal clinical diagnosis of the following made by a psychiatrist, psychologist or other qualified medical specialist? (tick all that apply)

- Autism Spectrum disorder (including Asperger's syndrome, Autistic Disorder, High Functioning Autism or Pervasive Developmental Disorder)
- Depression
- Anxiety
- Attention deficit hyperactivity disorder (ADHD)
- None of the above



The following are some questions about your use of social media. 'Social media' refers to apps like Facebook, Tiktok and Instagram. Please click on the boxes that best describe your use of social media.

Which of the following social media platforms do you regularly use? (once a week or more)

Instagram	Snapchat
Facebook	Twitter
TikTok	Other (please specify)

Social media is part of my everyday activity

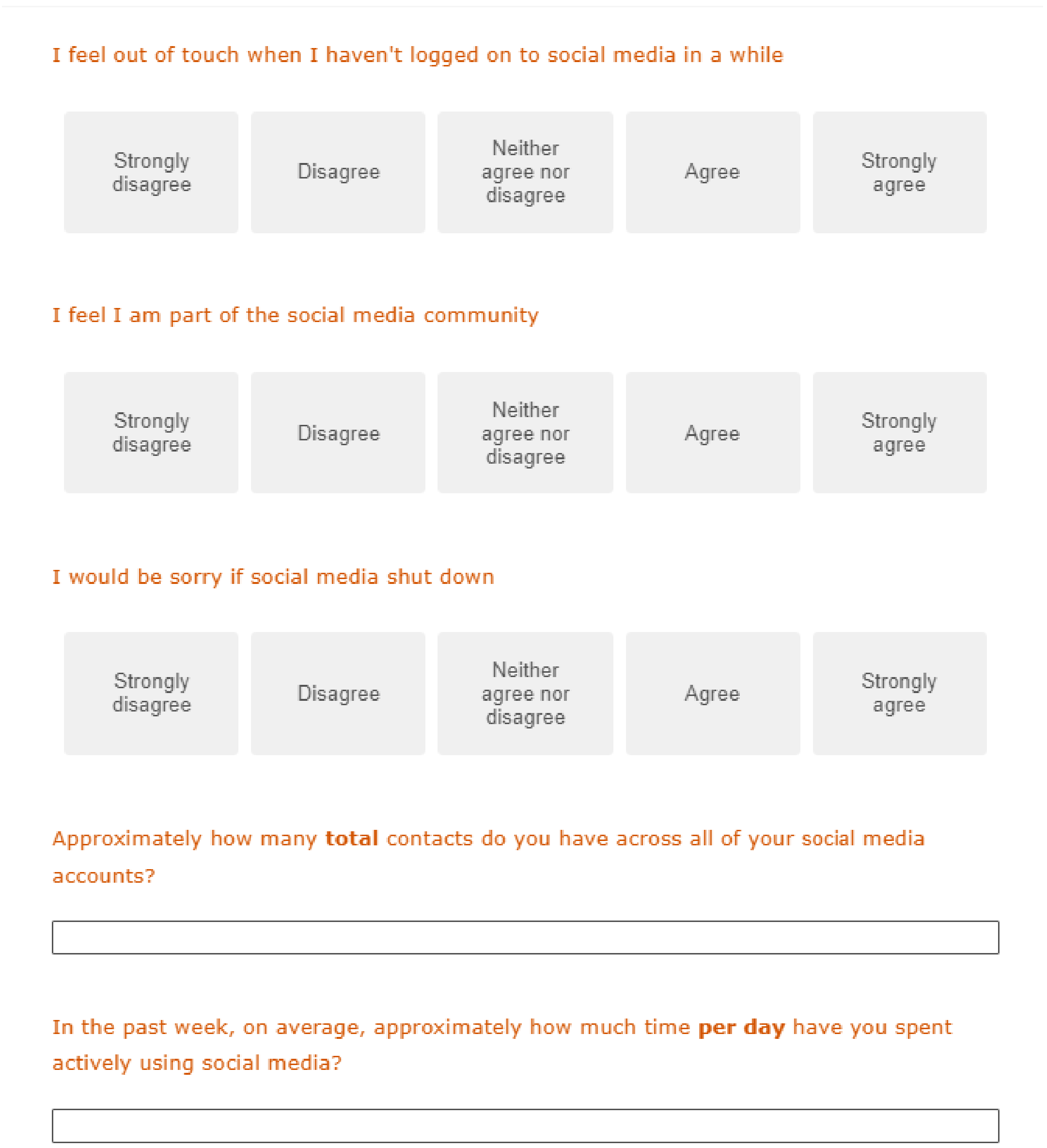
Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

I am proud to tell people I'm on social media

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

Social media has become part of my daily routine

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree



I feel out of touch when I haven't logged on to social media in a while

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

I feel I am part of the social media community

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

I would be sorry if social media shut down

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

Approximately how many **total** contacts do you have across all of your social media accounts?

In the past week, on average, approximately how much time **per day** have you spent actively using social media?

How has Covid-19 impacted your social media use?

I use social media more than before

I use social media less than before

I use social media about the same as before

What do you see as the advantages of using social media?

What do you see as the disadvantages of using social media?

Canterbury Christ Church University

The following are some questions about how you feel about social media. Please move the slider to show how much you find each of these an **advantage** or **disadvantage** of using social media.

Disadvantage 0
Neither an advantage or disadvantage
Advantage 100

Online I don’t have to react instantly

Online I can have a conversation in a quiet environment

Online I can communicate while being alone

Online I don't have to watch my facial expression

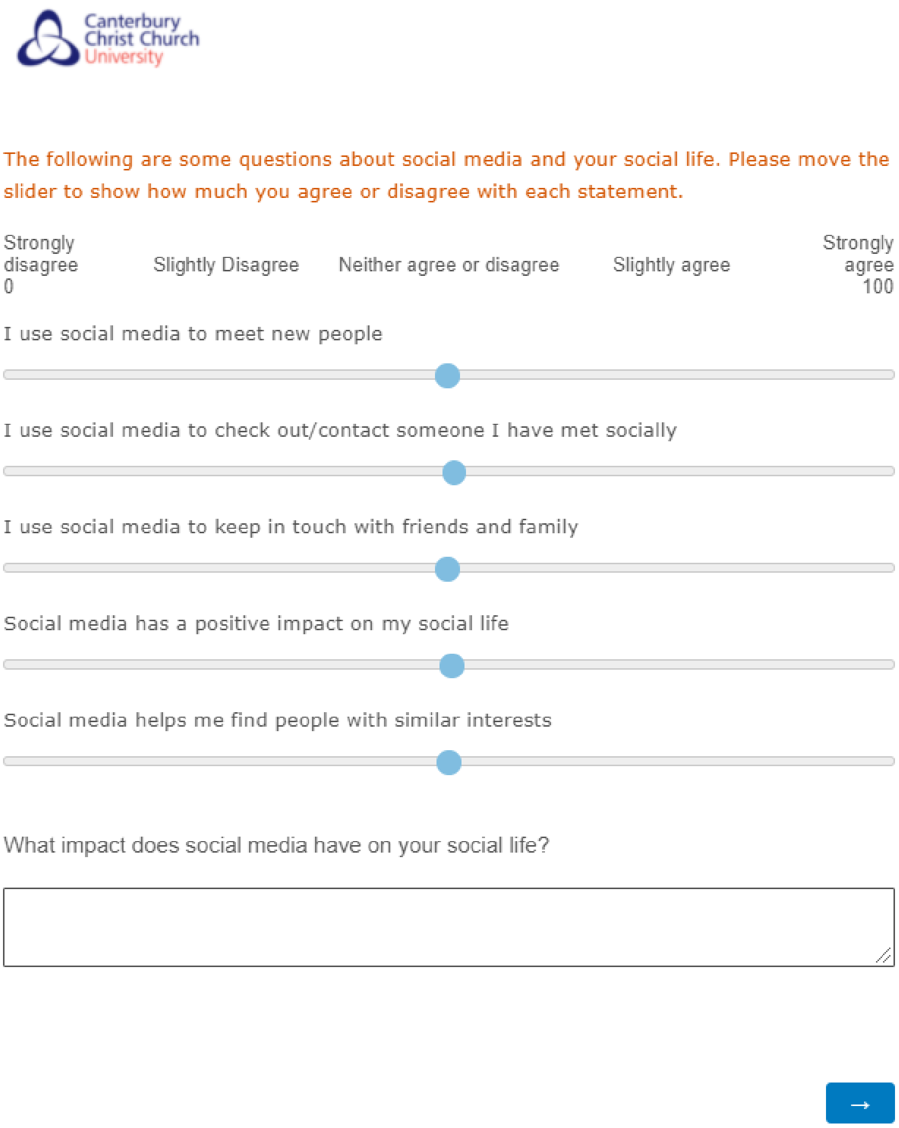
Online I don't have to make eye contact

Online I don't have to pay attention to the other's facial expression

Through my online experience I can have a real-life conversation more easily

Online I can talk in a more personal way with others

Online I can more easily bring up a difficult subject



Canterbury Christ Church University

The following are some questions about social media and your social life. Please move the slider to show how much you agree or disagree with each statement.

Strongly disagree 0	Slightly Disagree	Neither agree or disagree	Slightly agree	Strongly agree 100

I use social media to meet new people

I use social media to check out/contact someone I have met socially

I use social media to keep in touch with friends and family

Social media has a positive impact on my social life

Social media helps me find people with similar interests

What impact does social media have on your social life?

These are some questions about your relationships with other people, **both offline and online**. Tick the box that best matches how you feel about each statement.

There are several people online/offline I trust to help solve my problems

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○

There is no one online/offline that I feel comfortable talking to about intimate personal problems.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○

When I feel lonely, there are several people online/offline I can talk to.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○

If I needed an emergency loan of £50, I know someone online/offline I can turn to.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○

The people I interact with online/offline would put their reputation on the line for me.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○

The people I interact with online/offline would be good job references for me.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○

The people I interact with online/offline would share their last pound with me.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○

I do not know people online/offline well enough to get them to do anything important.

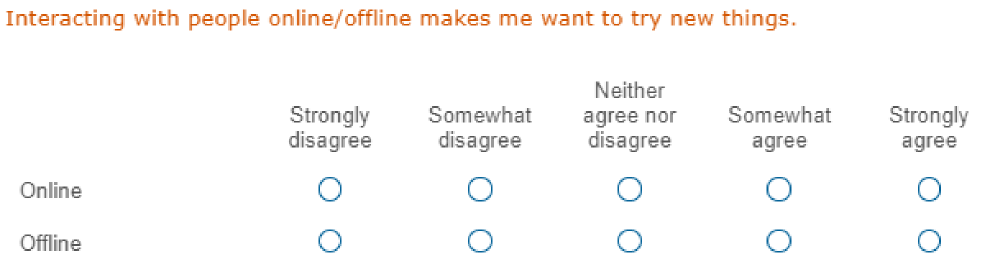
	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○

The people I interact with online/offline would help me fight an injustice.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○

Interacting with people online/offline makes me interested in things that happen outside of my town.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○

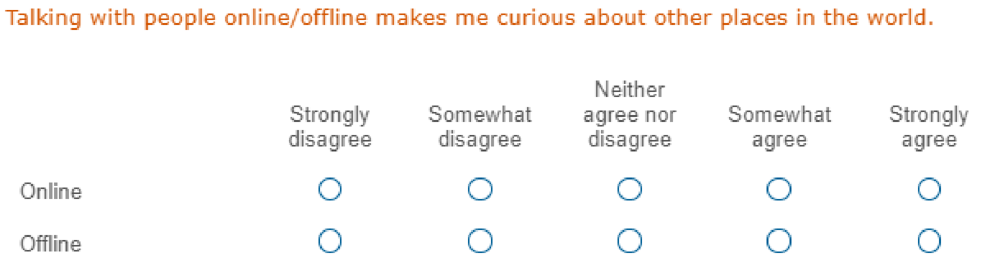


Interacting with people online/offline makes me want to try new things.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○

Interacting with people online/offline makes me interested in what people unlike me are thinking.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○

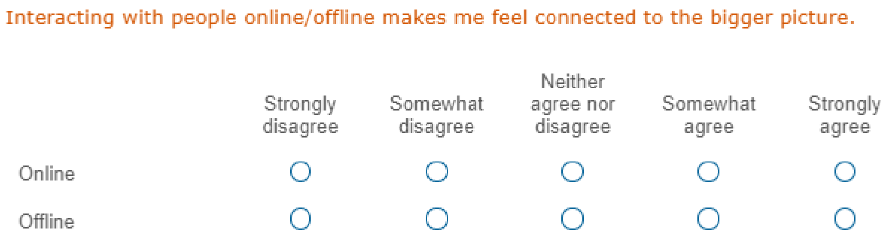


Talking with people online/offline makes me curious about other places in the world.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○

Interacting with people online/offline makes me feel like part of a larger community.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○



Interacting with people online/offline makes me feel connected to the bigger picture.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○

Interacting with people online/offline reminds me that everyone in the world is connected.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○

I am willing to spend time to support general online/offline community activities.

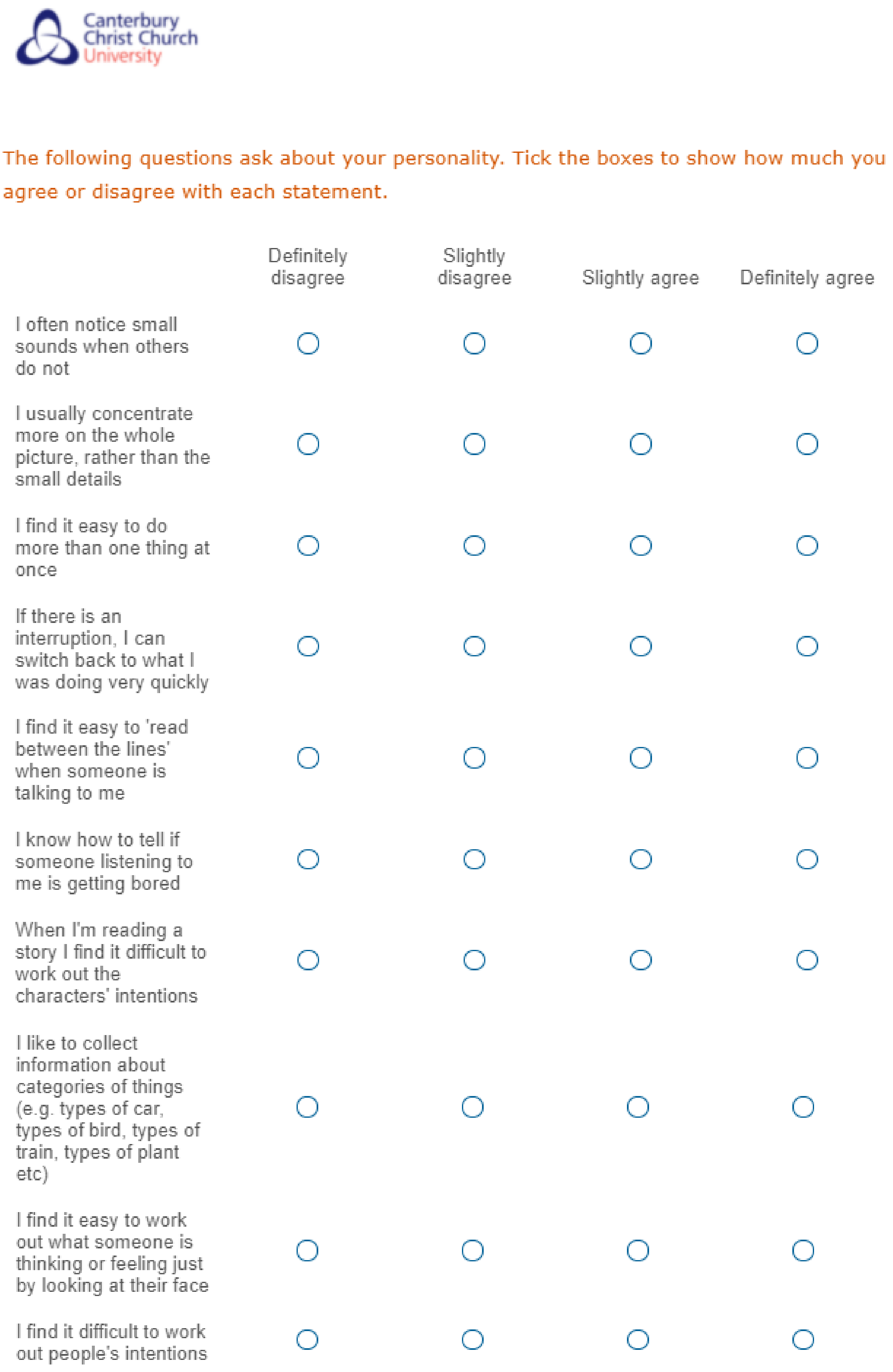
	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○

Interacting with people online/offline gives me new people to talk to.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○

Online/Offline, I come in contact with new people all the time.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Online	○	○	○	○	○
Offline	○	○	○	○	○



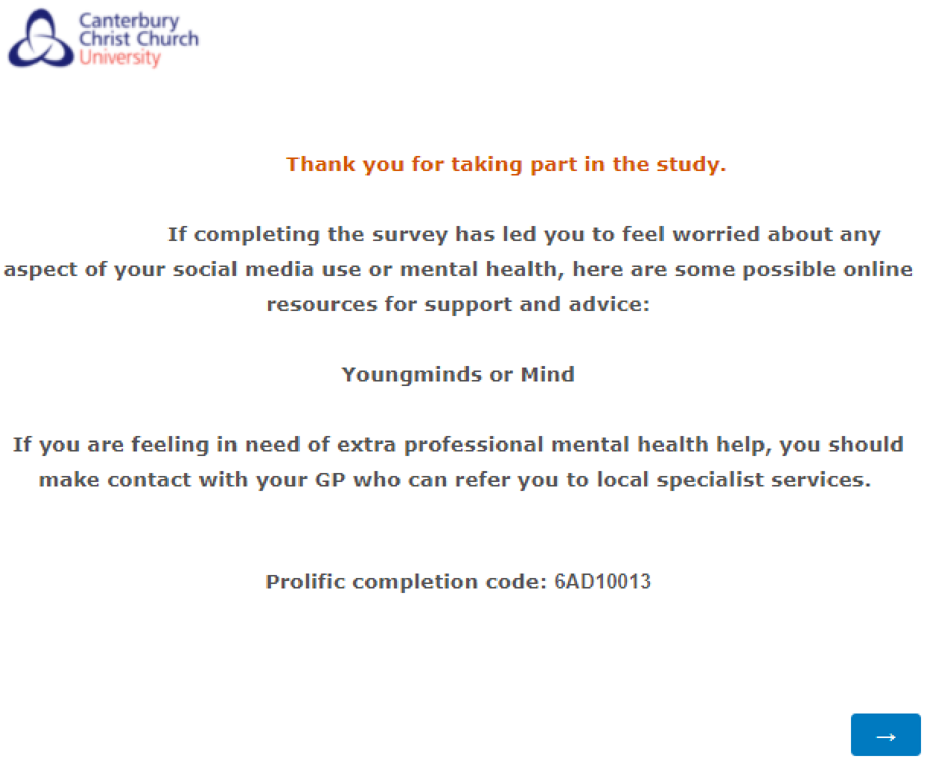
The following questions ask about your personality. Tick the boxes to show how much you agree or disagree with each statement.

	Definitely disagree	Slightly disagree	Slightly agree	Definitely agree
I often notice small sounds when others do not	○	○	○	○
I usually concentrate more on the whole picture, rather than the small details	○	○	○	○
I find it easy to do more than one thing at once	○	○	○	○
If there is an interruption, I can switch back to what I was doing very quickly	○	○	○	○
I find it easy to 'read between the lines' when someone is talking to me	○	○	○	○
I know how to tell if someone listening to me is getting bored	○	○	○	○
When I'm reading a story I find it difficult to work out the characters' intentions	○	○	○	○
I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant etc)	○	○	○	○
I find it easy to work out what someone is thinking or feeling just by looking at their face	○	○	○	○
I find it difficult to work out people's intentions	○	○	○	○

Canterbury
Christ Church
University

Below are some statements about feelings and thoughts. Please tick the box that best describes your experience of each over the last **2 weeks.**

	None of the time	Rarely	Some of the time	Often	All of the time
I've been feeling optimistic about the future	○	○	○	○	○
I've been feeling useful	○	○	○	○	○
I've been feeling relaxed	○	○	○	○	○
I've been feeling interested in other people	○	○	○	○	○
I've had energy to spare	○	○	○	○	○
I've been dealing with problems well	○	○	○	○	○
I've been thinking clearly	○	○	○	○	○
I've been feeling good about myself	○	○	○	○	○
I've been feeling close to other people	○	○	○	○	○
I've been feeling confident	○	○	○	○	○
I've been able to make up my own mind about things	○	○	○	○	○
I've been feeling loved	○	○	○	○	○
I've been interested in new things	○	○	○	○	○
I've been feeling cheerful	○	○	○	○	○



Thank you for taking part in the study.

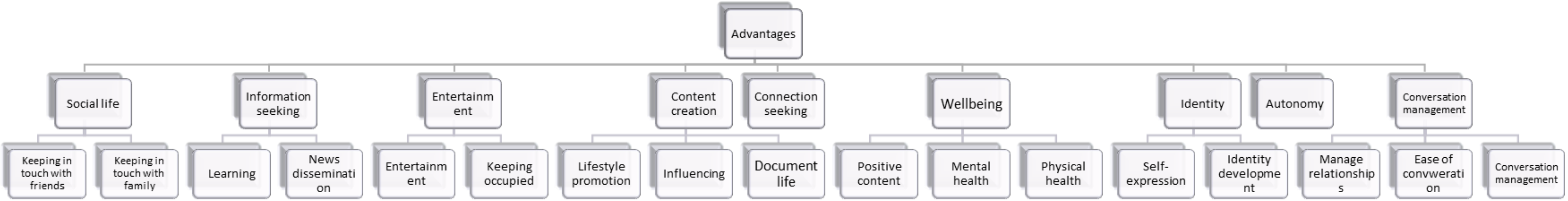
If completing the survey has led you to feel worried about any aspect of your social media use or mental health, here are some possible online resources for support and advice:

Youngminds or Mind

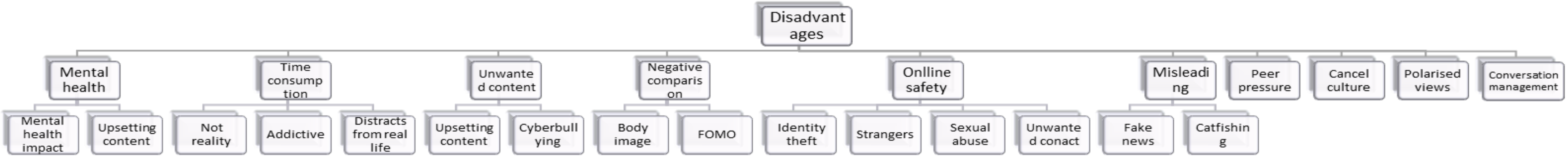
If you are feeling in need of extra professional mental health help, you should make contact with your GP who can refer you to local specialist services.

Prolific completion code: 6AD10013

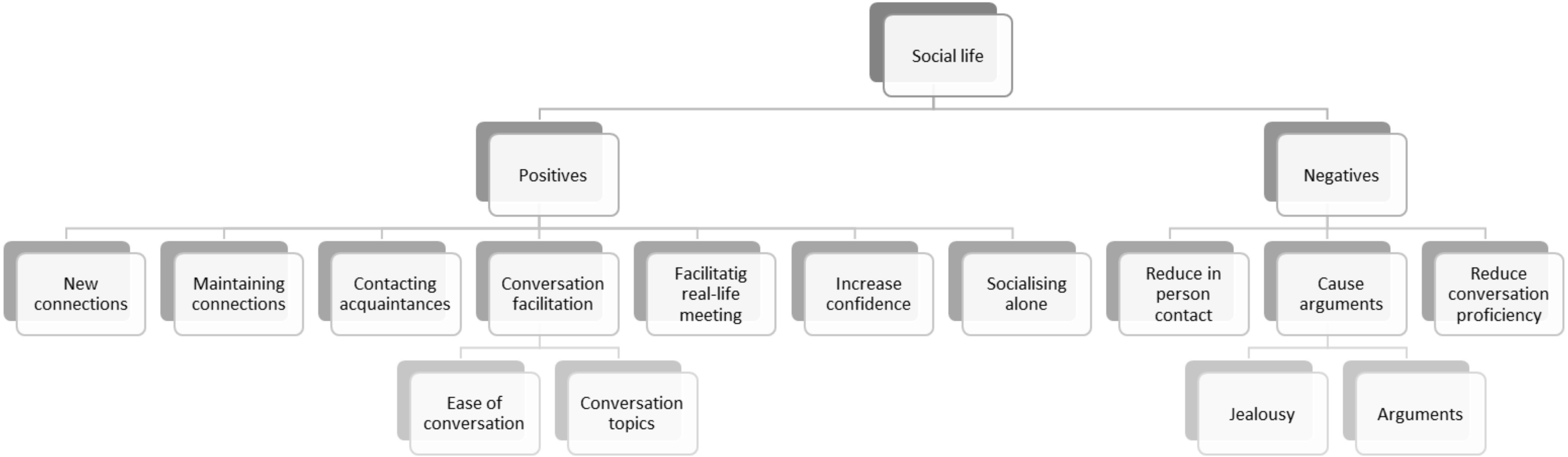
Appendix 8: Content analysis tree diagram- social media advantages



Appendix 9: Content analysis tree diagram- social media disadvantages



Appendix 10: Content analysis tree diagram- social life



Appendix 11: End of study report for participants

Dear participant,

You recently took part in my study, the Social Media Survey. Thank you very much for taking part. I am writing to you with an update on the findings of the study.

The study looked at what young people saw as the advantages/disadvantages of using social media, and social media's impact on young people's social lives and wellbeing. This was compared for young people with and without autistic traits to see if there were any differences.

The study found that young people saw several advantages as well as disadvantages to using social media. Overall participants felt that social media had a positive impact on their social life, particularly in terms of socialising online. The impact on wellbeing was different depending on autistic traits. Participants with autistic traits had lower wellbeing if they used social media more. Participants without autistic traits had higher wellbeing if they used social media more. It is possible that this was due to different ways of using social media.

Thanks again for taking part in the research. Your participation was very helpful.

Many thanks,

Anna Byrne-Smith

Trainee Clinical Psychologist
Canterbury Christ Church University

Appendix 12: Letter to ethics panel

Monday 5th July 2021

Dear Salomon's Ethics Committee,

_Re: MRP project *Adolescence, autism and social media: Relationships between social media use, social capital and wellbeing among adolescents with autistic traits.*

I am writing to send a short summary of findings and details of dissemination regarding the above study.

The study's abstract is as follows:

'Social media has risen to increasing prominence in the lives of adolescents. Although its effects on social connections and wellbeing have been studied in the neurotypical population, little research has focused on the experiences of adolescents with autistic traits. From the limited literature in this area, autistic individuals appear to use social media differently to neurotypical peers, experiencing unique benefits including the removal of autism-specific communication barriers.

This paper examines the relationships between social media use, social connection making and wellbeing in a group of 222 autistic and neurotypical adolescents. Both quantitative and qualitative data was used to examine several hypotheses relating to these relationships. The role of autistic traits was examined as a possible moderating factor in all hypotheses.

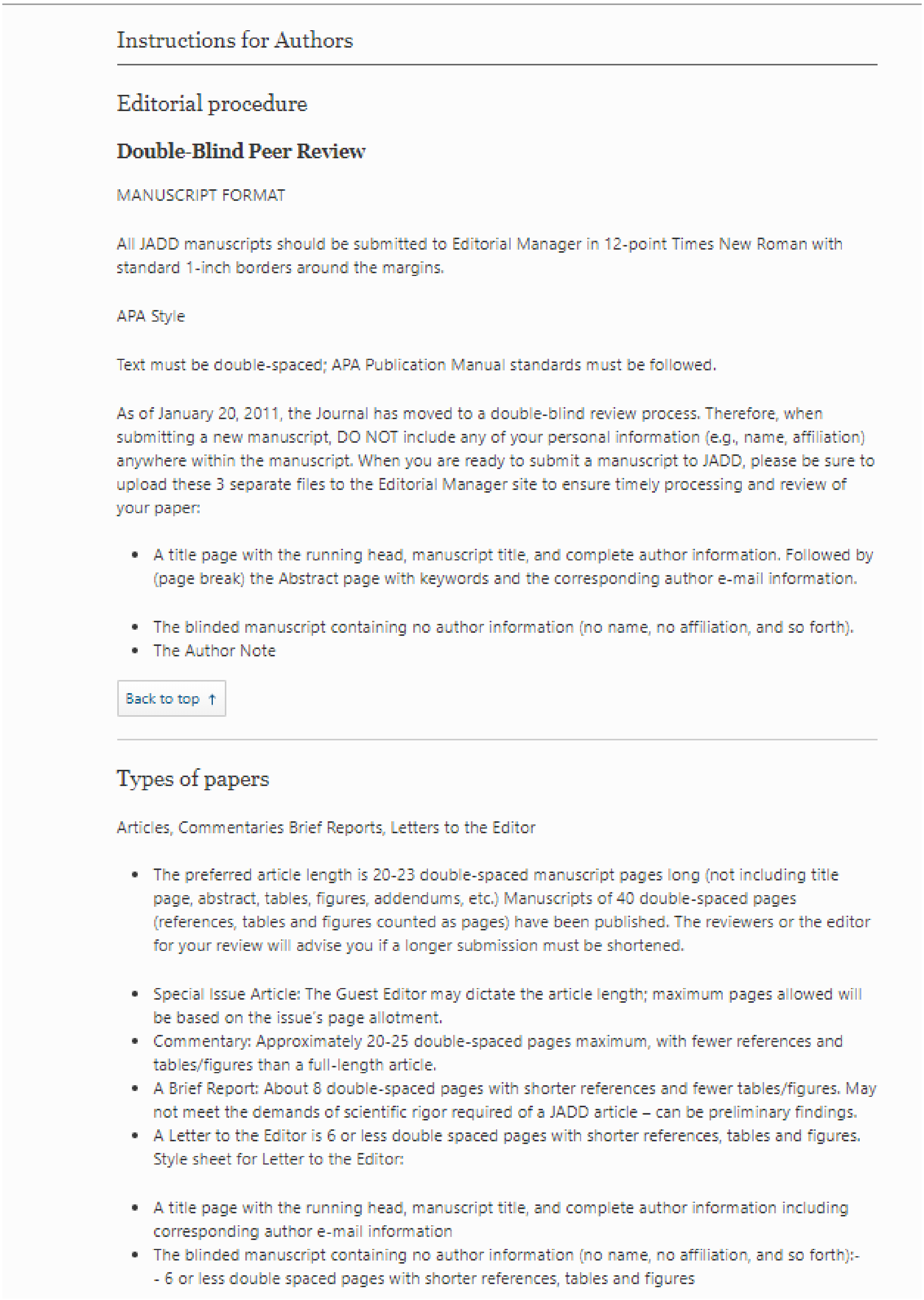
Adolescents reported a generally positive impact of social media on their social life. Social media use resulted in increases in online social capital, particularly among adolescents with autistic traits. Social capital in turn positively impacted wellbeing. Overall, social media use did not impact wellbeing, but this varied with autistic traits. Participants without autistic traits exhibited increases in wellbeing with social media use while those with more autistic traits demonstrated decreases in wellbeing. Implications for future research and clinical practice are discussed.'

I plan to share a summary of findings to all participants who requested ongoing communication about the study via email. We also hope to publish the findings in a peer reviewed journal such as 'Autism' or 'Journal of Autism and Developmental Disorders'.

Kind regards,

Anna Byrne-Smith
Trainee Clinical Psychologist

Appendix 13: Author guidelines for journal submission: Journal of Autism and Developmental Disorders



Instructions for Authors

Editorial procedure

Double-Blind Peer Review

MANUSCRIPT FORMAT

All JADD manuscripts should be submitted to Editorial Manager in 12-point Times New Roman with standard 1-inch borders around the margins.

APA Style

Text must be double-spaced; APA Publication Manual standards must be followed.

As of January 20, 2011, the Journal has moved to a double-blind review process. Therefore, when submitting a new manuscript, DO NOT include any of your personal information (e.g., name, affiliation) anywhere within the manuscript. When you are ready to submit a manuscript to JADD, please be sure to upload these 3 separate files to the Editorial Manager site to ensure timely processing and review of your paper:

- A title page with the running head, manuscript title, and complete author information. Followed by (page break) the Abstract page with keywords and the corresponding author e-mail information.

- The blinded manuscript containing no author information (no name, no affiliation, and so forth).
- The Author Note

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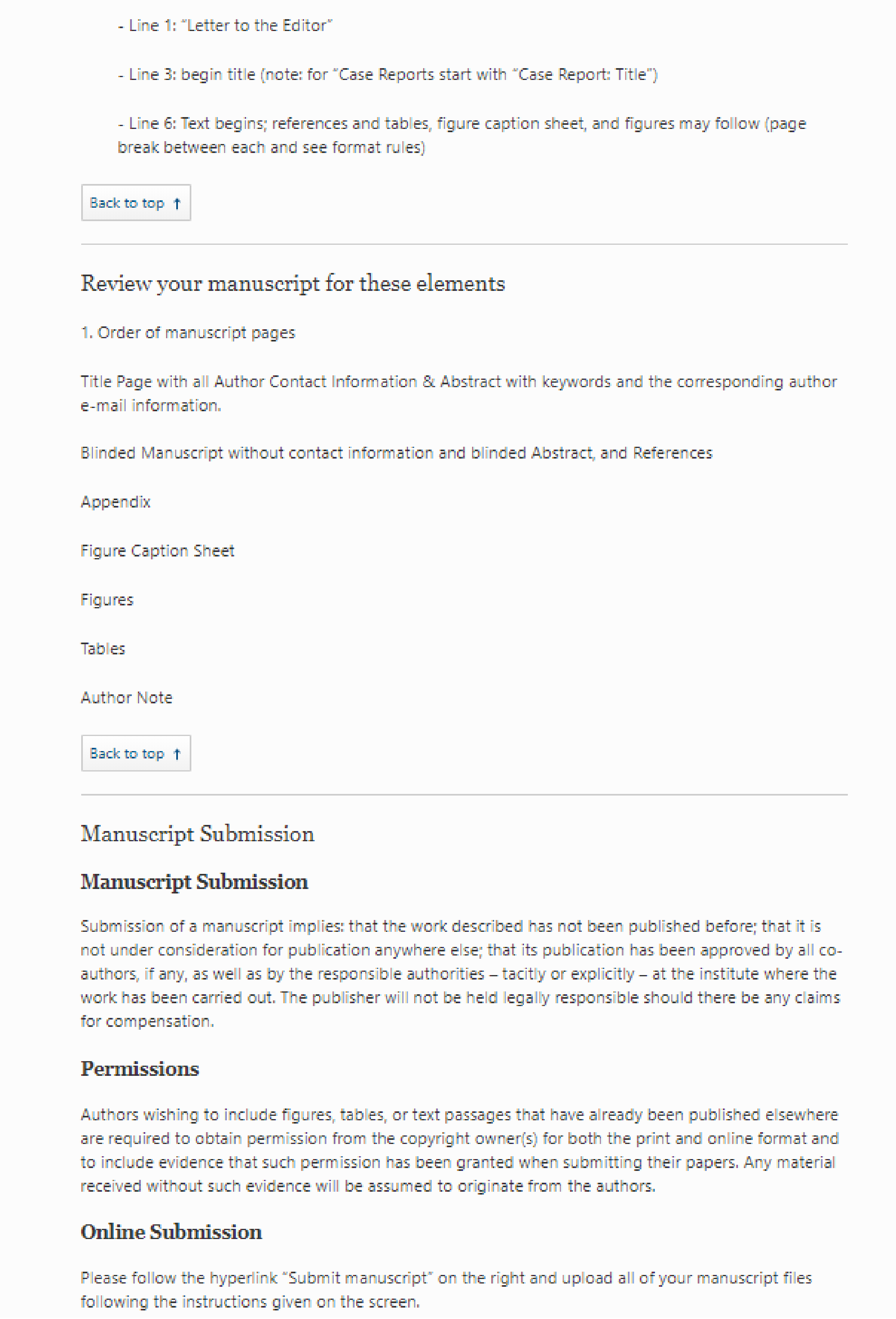
Types of papers

Articles, Commentaries Brief Reports, Letters to the Editor

- The preferred article length is 20-23 double-spaced manuscript pages long (not including title page, abstract, tables, figures, addendums, etc.) Manuscripts of 40 double-spaced pages (references, tables and figures counted as pages) have been published. The reviewers or the editor for your review will advise you if a longer submission must be shortened.

- Special Issue Article: The Guest Editor may dictate the article length; maximum pages allowed will be based on the issue's page allotment.
- Commentary: Approximately 20-25 double-spaced pages maximum, with fewer references and tables/figures than a full-length article.
- A Brief Report: About 8 double-spaced pages with shorter references and fewer tables/figures. May not meet the demands of scientific rigor required of a JADD article – can be preliminary findings.
- A Letter to the Editor is 6 or less double spaced pages with shorter references, tables and figures. Style sheet for Letter to the Editor:

- A title page with the running head, manuscript title, and complete author information including corresponding author e-mail information
- The blinded manuscript containing no author information (no name, no affiliation, and so forth):- - 6 or less double spaced pages with shorter references, tables and figures



- Line 1: “Letter to the Editor”

- Line 3: begin title (note: for “Case Reports start with “Case Report: Title”)

- Line 6: Text begins; references and tables, figure caption sheet, and figures may follow (page break between each and see format rules)

Review your manuscript for these elements

1. Order of manuscript pages

Title Page with all Author Contact Information & Abstract with keywords and the corresponding author e-mail information.

Blinded Manuscript without contact information and blinded Abstract, and References

Appendix

Figure Caption Sheet

Figures

Tables

Author Note

Manuscript Submission

Manuscript Submission

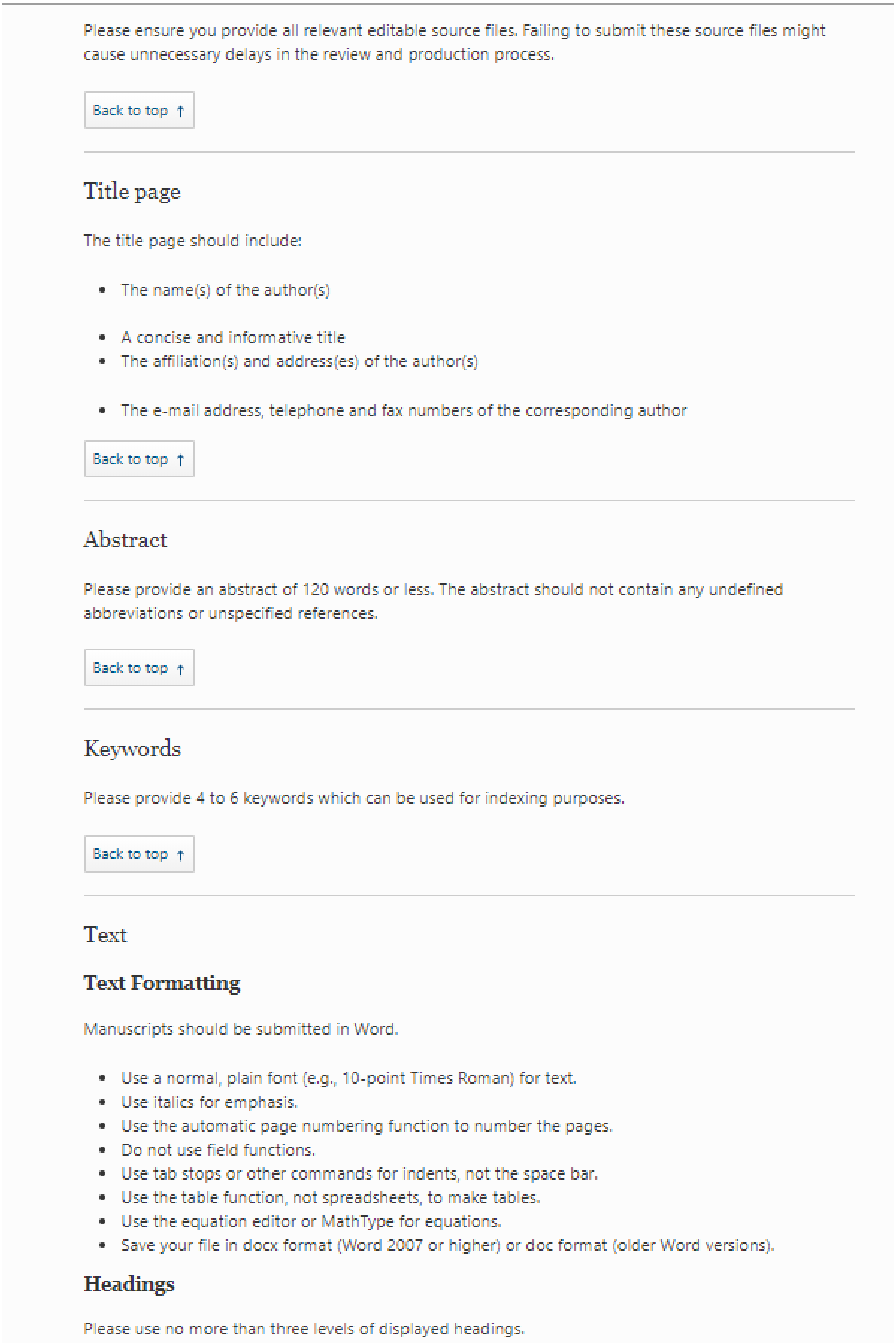
Submission of a manuscript implies: that the work described has not been published before; that it is not under consideration for publication anywhere else; that its publication has been approved by all co-authors, if any, as well as by the responsible authorities – tacitly or explicitly – at the institute where the work has been carried out. The publisher will not be held legally responsible should there be any claims for compensation.

Permissions

Authors wishing to include figures, tables, or text passages that have already been published elsewhere are required to obtain permission from the copyright owner(s) for both the print and online format and to include evidence that such permission has been granted when submitting their papers. Any material received without such evidence will be assumed to originate from the authors.

Online Submission

Please follow the hyperlink “Submit manuscript” on the right and upload all of your manuscript files following the instructions given on the screen.



Please ensure you provide all relevant editable source files. Failing to submit these source files might cause unnecessary delays in the review and production process.

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Title page

The title page should include:

- The name(s) of the author(s)
- A concise and informative title
- The affiliation(s) and address(es) of the author(s)
- The e-mail address, telephone and fax numbers of the corresponding author

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Abstract

Please provide an abstract of 120 words or less. The abstract should not contain any undefined abbreviations or unspecified references.

Back to top ↑

Keywords

Please provide 4 to 6 keywords which can be used for indexing purposes.

Back to top ↑

Text

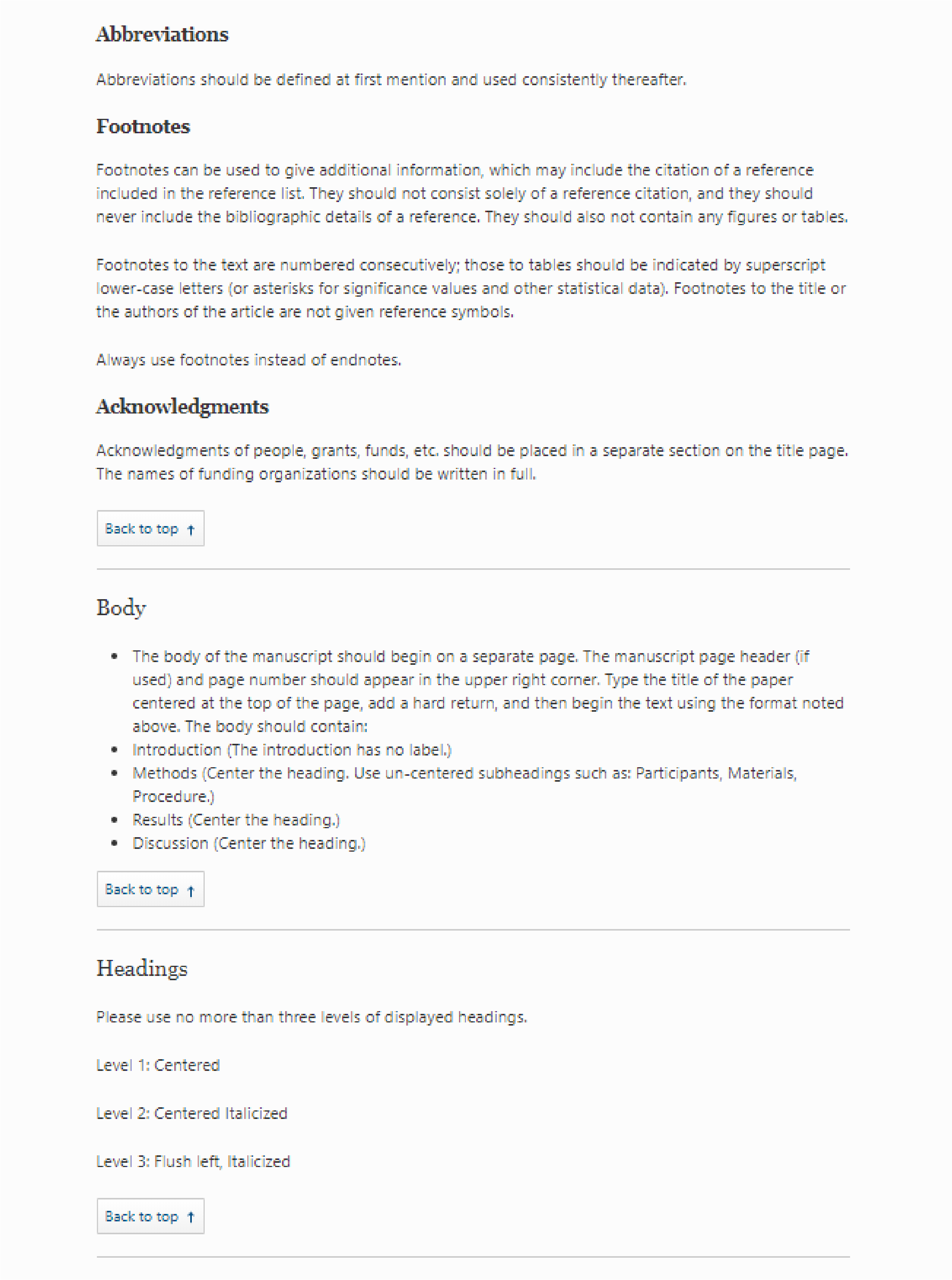
Text Formatting

Manuscripts should be submitted in Word.

- Use a normal, plain font (e.g., 10-point Times Roman) for text.
- Use italics for emphasis.
- Use the automatic page numbering function to number the pages.
- Do not use field functions.
- Use tab stops or other commands for indents, not the space bar.
- Use the table function, not spreadsheets, to make tables.
- Use the equation editor or MathType for equations.
- Save your file in docx format (Word 2007 or higher) or doc format (older Word versions).

Headings

Please use no more than three levels of displayed headings.



Abbreviations

Abbreviations should be defined at first mention and used consistently thereafter.

Footnotes

Footnotes can be used to give additional information, which may include the citation of a reference included in the reference list. They should not consist solely of a reference citation, and they should never include the bibliographic details of a reference. They should also not contain any figures or tables.

Footnotes to the text are numbered consecutively; those to tables should be indicated by superscript lower-case letters (or asterisks for significance values and other statistical data). Footnotes to the title or the authors of the article are not given reference symbols.

Always use footnotes instead of endnotes.

Acknowledgments

Acknowledgments of people, grants, funds, etc. should be placed in a separate section on the title page. The names of funding organizations should be written in full.

Body

- The body of the manuscript should begin on a separate page. The manuscript page header (if used) and page number should appear in the upper right corner. Type the title of the paper centered at the top of the page, add a hard return, and then begin the text using the format noted above. The body should contain:
- Introduction (The introduction has no label.)
- Methods (Center the heading. Use un-centered subheadings such as: Participants, Materials, Procedure.)
- Results (Center the heading.)
- Discussion (Center the heading.)

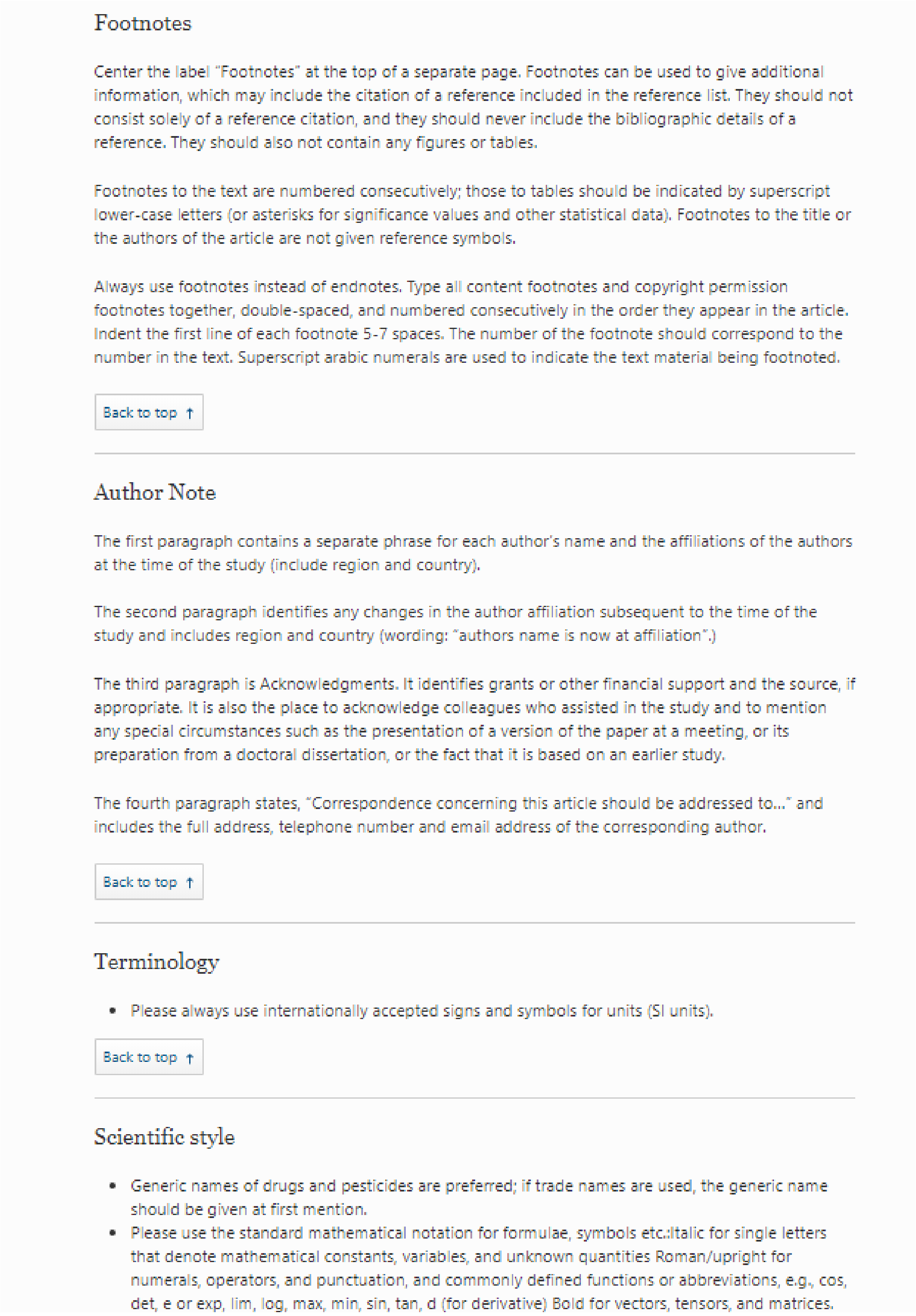
Headings

Please use no more than three levels of displayed headings.

Level 1: Centered

Level 2: Centered Italicized

Level 3: Flush left, Italicized



Footnotes

Center the label "Footnotes" at the top of a separate page. Footnotes can be used to give additional information, which may include the citation of a reference included in the reference list. They should not consist solely of a reference citation, and they should never include the bibliographic details of a reference. They should also not contain any figures or tables.

Footnotes to the text are numbered consecutively; those to tables should be indicated by superscript lower-case letters (or asterisks for significance values and other statistical data). Footnotes to the title or the authors of the article are not given reference symbols.

Always use footnotes instead of endnotes. Type all content footnotes and copyright permission footnotes together, double-spaced, and numbered consecutively in the order they appear in the article. Indent the first line of each footnote 5-7 spaces. The number of the footnote should correspond to the number in the text. Superscript arabic numerals are used to indicate the text material being footnoted.

Author Note

The first paragraph contains a separate phrase for each author's name and the affiliations of the authors at the time of the study (include region and country).

The second paragraph identifies any changes in the author affiliation subsequent to the time of the study and includes region and country (wording: "authors name is now at affiliation".)

The third paragraph is Acknowledgments. It identifies grants or other financial support and the source, if appropriate. It is also the place to acknowledge colleagues who assisted in the study and to mention any special circumstances such as the presentation of a version of the paper at a meeting, or its preparation from a doctoral dissertation, or the fact that it is based on an earlier study.

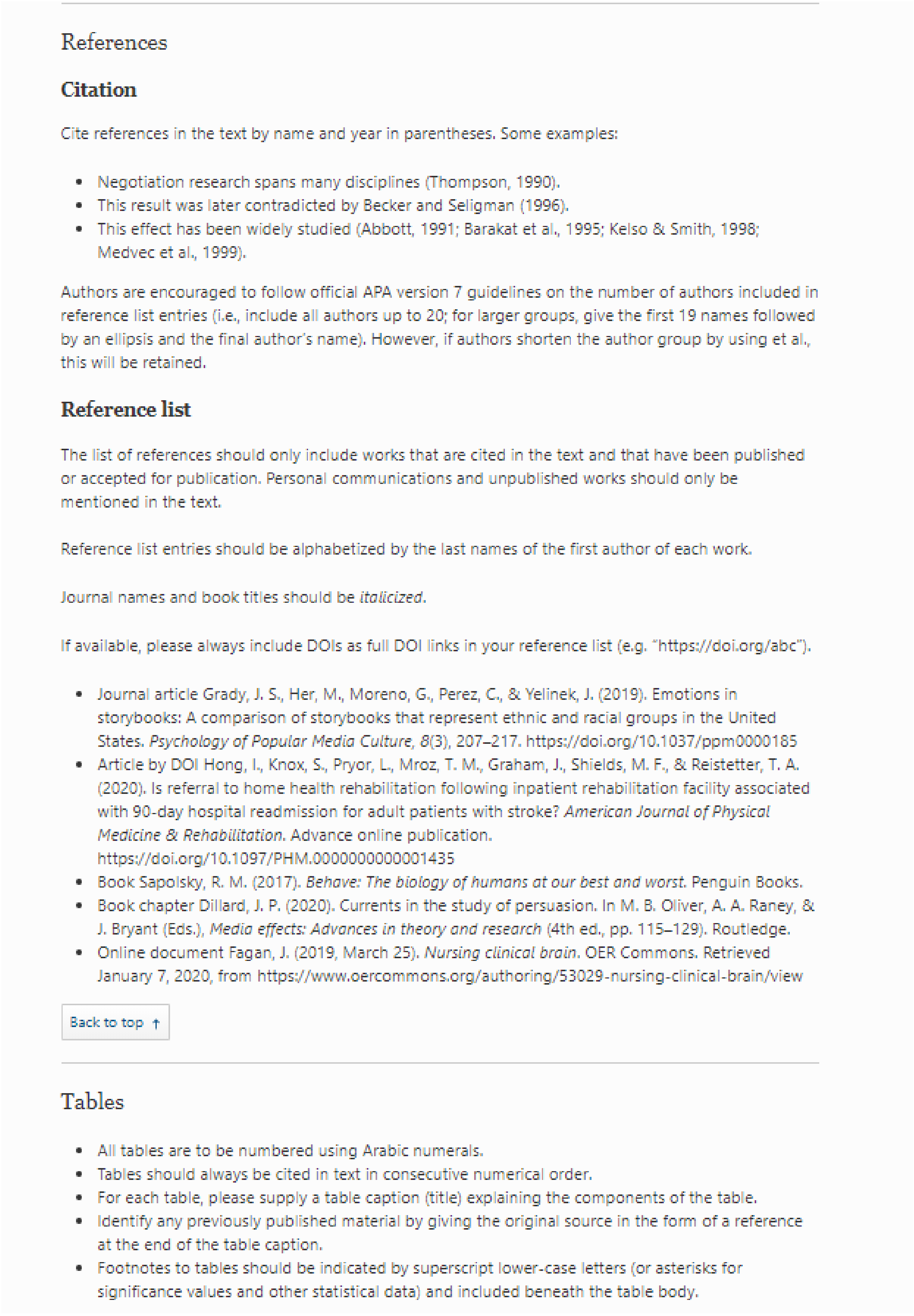
The fourth paragraph states, "Correspondence concerning this article should be addressed to..." and includes the full address, telephone number and email address of the corresponding author.

Terminology

- Please always use internationally accepted signs and symbols for units (SI units).

Scientific style

- Generic names of drugs and pesticides are preferred; if trade names are used, the generic name should be given at first mention.
- Please use the standard mathematical notation for formulae, symbols etc.:Italic for single letters that denote mathematical constants, variables, and unknown quantities Roman/upright for numerals, operators, and punctuation, and commonly defined functions or abbreviations, e.g., cos, det, e or exp, lim, log, max, min, sin, tan, d (for derivative) Bold for vectors, tensors, and matrices.



References

Citation

Cite references in the text by name and year in parentheses. Some examples:

- Negotiation research spans many disciplines (Thompson, 1990).
- This result was later contradicted by Becker and Seligman (1996).
- This effect has been widely studied (Abbott, 1991; Barakat et al., 1995; Kelso & Smith, 1998; Medvec et al., 1999).

Authors are encouraged to follow official APA version 7 guidelines on the number of authors included in reference list entries (i.e., include all authors up to 20; for larger groups, give the first 19 names followed by an ellipsis and the final author's name). However, if authors shorten the author group by using et al., this will be retained.

Reference list

The list of references should only include works that are cited in the text and that have been published or accepted for publication. Personal communications and unpublished works should only be mentioned in the text.

Reference list entries should be alphabetized by the last names of the first author of each work.

Journal names and book titles should be *italicized*.

If available, please always include DOIs as full DOI links in your reference list (e.g. "https://doi.org/abc").

- Journal article Grady, J. S., Her, M., Moreno, G., Perez, C., & Yelinek, J. (2019). Emotions in storybooks: A comparison of storybooks that represent ethnic and racial groups in the United States. *Psychology of Popular Media Culture, 8*(3), 207–217. https://doi.org/10.1037/ppm0000185
- Article by DOI Hong, I., Knox, S., Pryor, L., Mroz, T. M., Graham, J., Shields, M. F., & Reistetter, T. A. (2020). Is referral to home health rehabilitation following inpatient rehabilitation facility associated with 90-day hospital readmission for adult patients with stroke? *American Journal of Physical Medicine & Rehabilitation.* Advance online publication. https://doi.org/10.1097/PHM.0000000000001435
- Book Sapolsky, R. M. (2017). *Behave: The biology of humans at our best and worst.* Penguin Books.
- Book chapter Dillard, J. P. (2020). Currents in the study of persuasion. In M. B. Oliver, A. A. Raney, & J. Bryant (Eds.), *Media effects: Advances in theory and research* (4th ed., pp. 115–129). Routledge.
- Online document Fagan, J. (2019, March 25). *Nursing clinical brain.* OER Commons. Retrieved January 7, 2020, from https://www.oercommons.org/authoring/53029-nursing-clinical-brain/view

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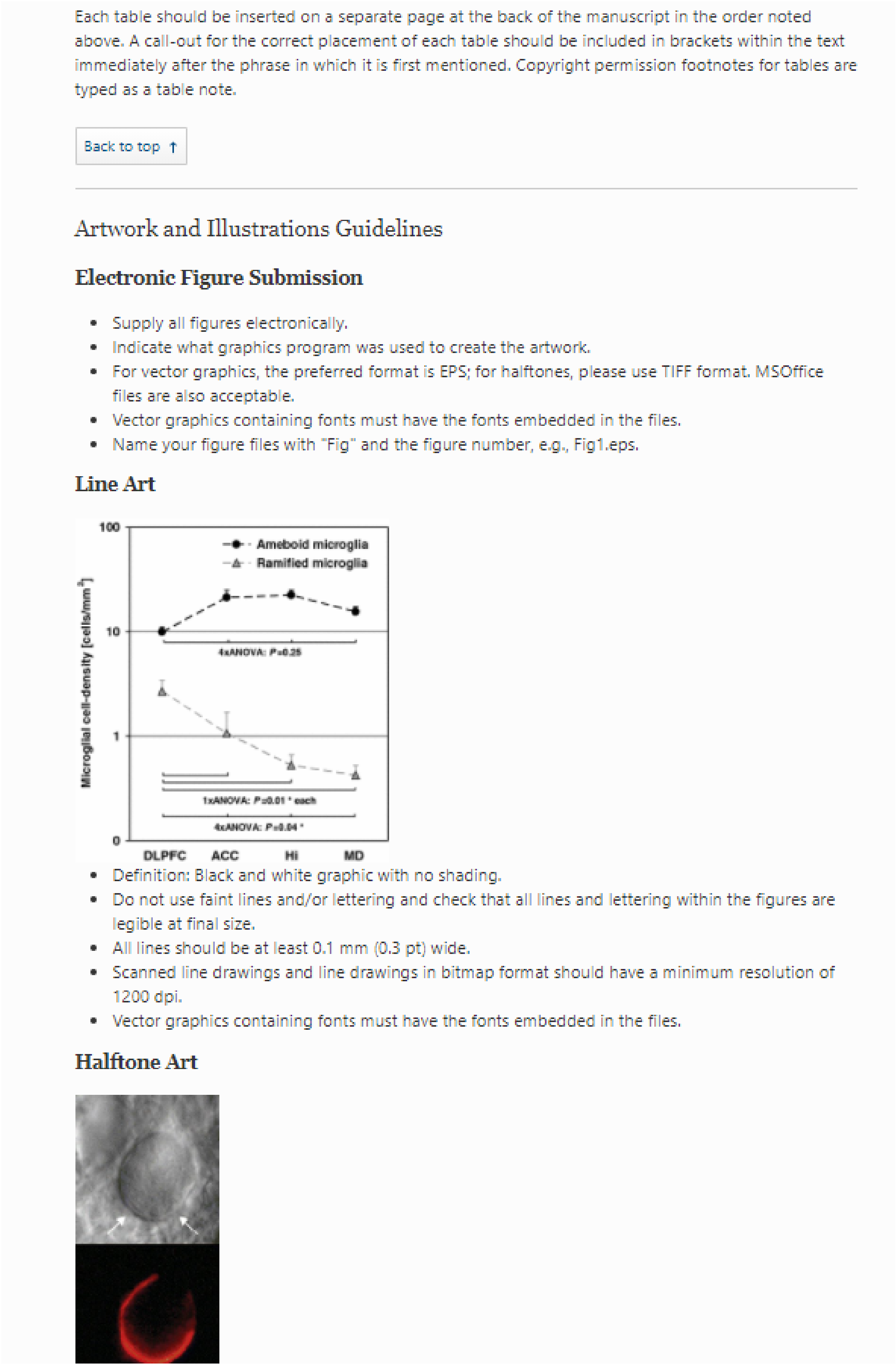
Tables

- All tables are to be numbered using Arabic numerals.
- Tables should always be cited in text in consecutive numerical order.
- For each table, please supply a table caption (title) explaining the components of the table.
- Identify any previously published material by giving the original source in the form of a reference at the end of the table caption.
- Footnotes to tables should be indicated by superscript lower-case letters (or asterisks for significance values and other statistical data) and included beneath the table body.



Each table should be inserted on a separate page at the back of the manuscript in the order noted above. A call-out for the correct placement of each table should be included in brackets within the text immediately after the phrase in which it is first mentioned. Copyright permission footnotes for tables are typed as a table note.

Artwork and Illustrations Guidelines

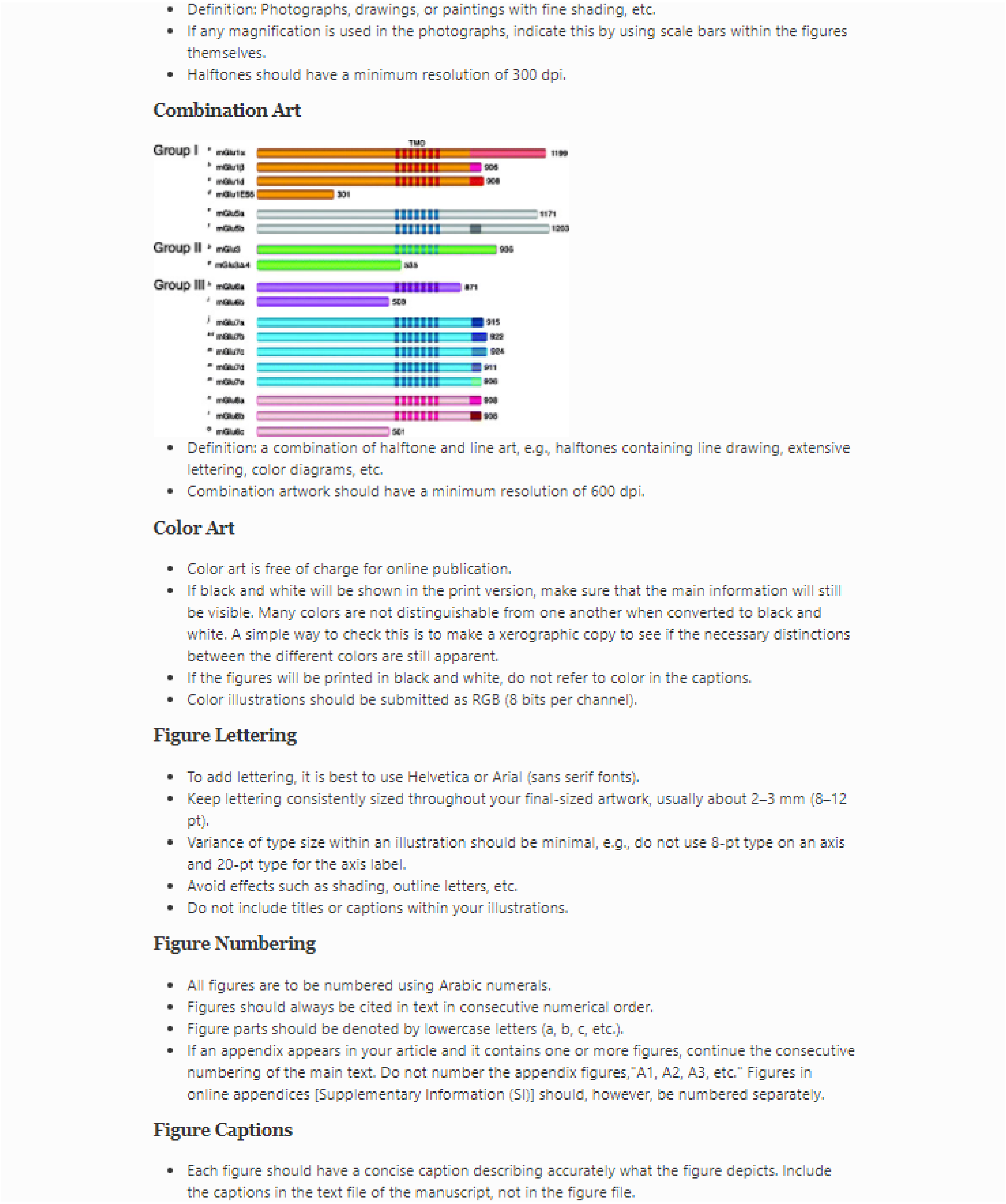
Electronic Figure Submission

- Supply all figures electronically.
- Indicate what graphics program was used to create the artwork.
- For vector graphics, the preferred format is EPS; for halftones, please use TIFF format. MSOffice files are also acceptable.
- Vector graphics containing fonts must have the fonts embedded in the files.
- Name your figure files with "Fig" and the figure number, e.g., Fig1.eps.

Line Art

- Definition: Black and white graphic with no shading.
- Do not use faint lines and/or lettering and check that all lines and lettering within the figures are legible at final size.
- All lines should be at least 0.1 mm (0.3 pt) wide.
- Scanned line drawings and line drawings in bitmap format should have a minimum resolution of 1200 dpi.
- Vector graphics containing fonts must have the fonts embedded in the files.

Halftone Art



- Definition: Photographs, drawings, or paintings with fine shading, etc.
- If any magnification is used in the photographs, indicate this by using scale bars within the figures themselves.
- Halftones should have a minimum resolution of 300 dpi.

Combination Art

- Definition: a combination of halftone and line art, e.g., halftones containing line drawing, extensive lettering, color diagrams, etc.
- Combination artwork should have a minimum resolution of 600 dpi.

Color Art

- Color art is free of charge for online publication.
- If black and white will be shown in the print version, make sure that the main information will still be visible. Many colors are not distinguishable from one another when converted to black and white. A simple way to check this is to make a xerographic copy to see if the necessary distinctions between the different colors are still apparent.
- If the figures will be printed in black and white, do not refer to color in the captions.
- Color illustrations should be submitted as RGB (8 bits per channel).

Figure Lettering

- To add lettering, it is best to use Helvetica or Arial (sans serif fonts).
- Keep lettering consistently sized throughout your final-sized artwork, usually about 2–3 mm (8–12 pt).
- Variance of type size within an illustration should be minimal, e.g., do not use 8-pt type on an axis and 20-pt type for the axis label.
- Avoid effects such as shading, outline letters, etc.
- Do not include titles or captions within your illustrations.

Figure Numbering

- All figures are to be numbered using Arabic numerals.
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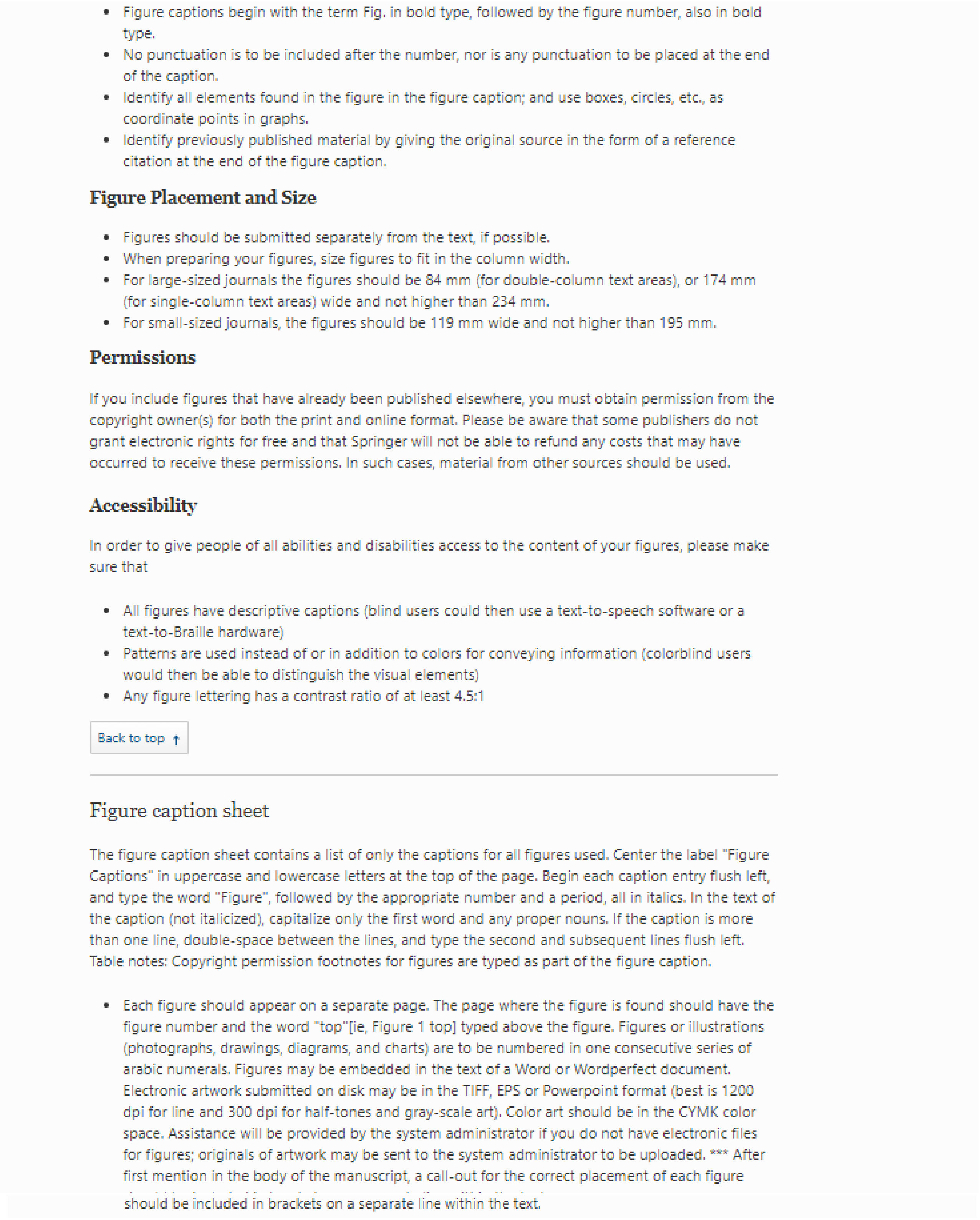

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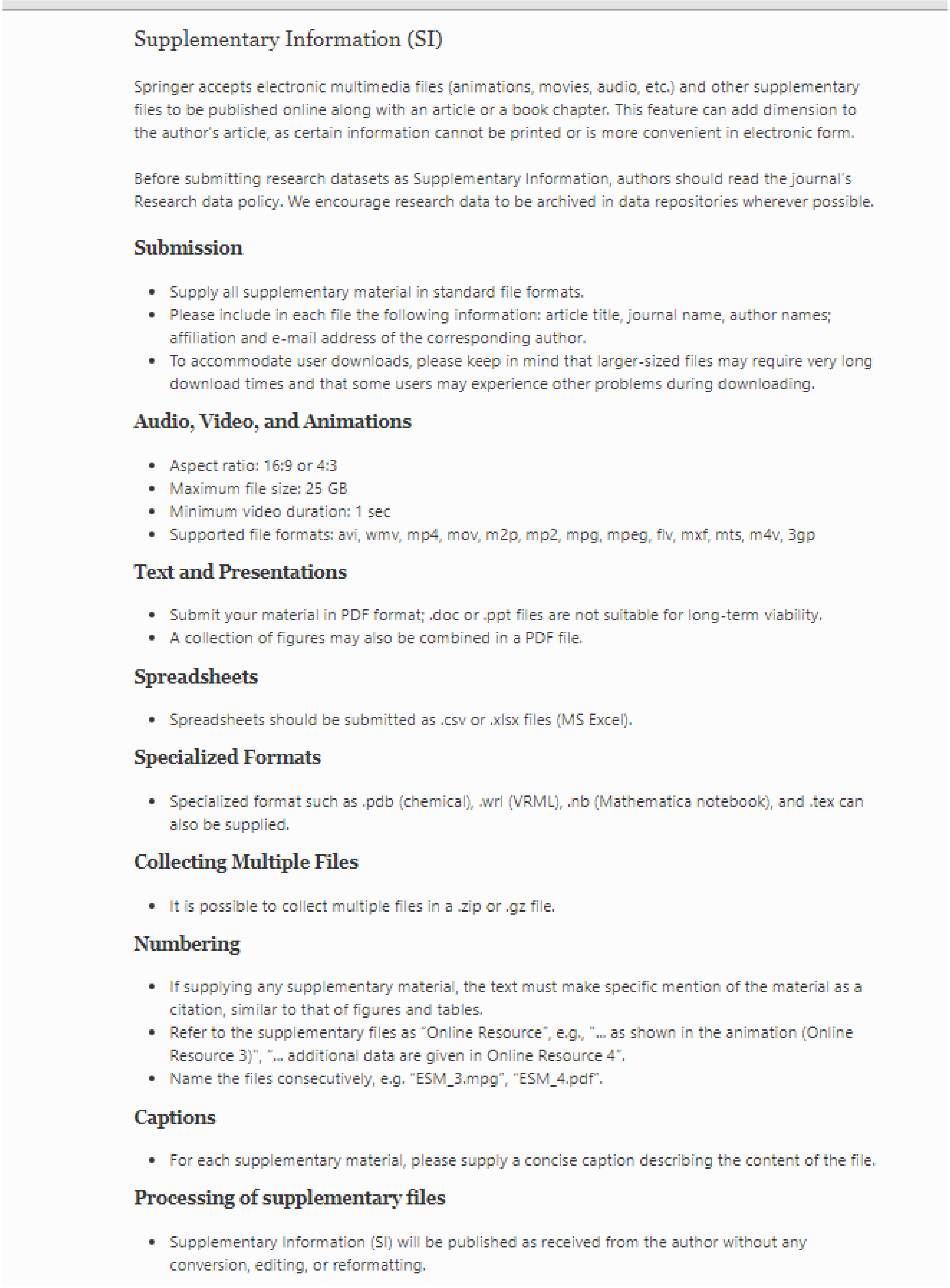

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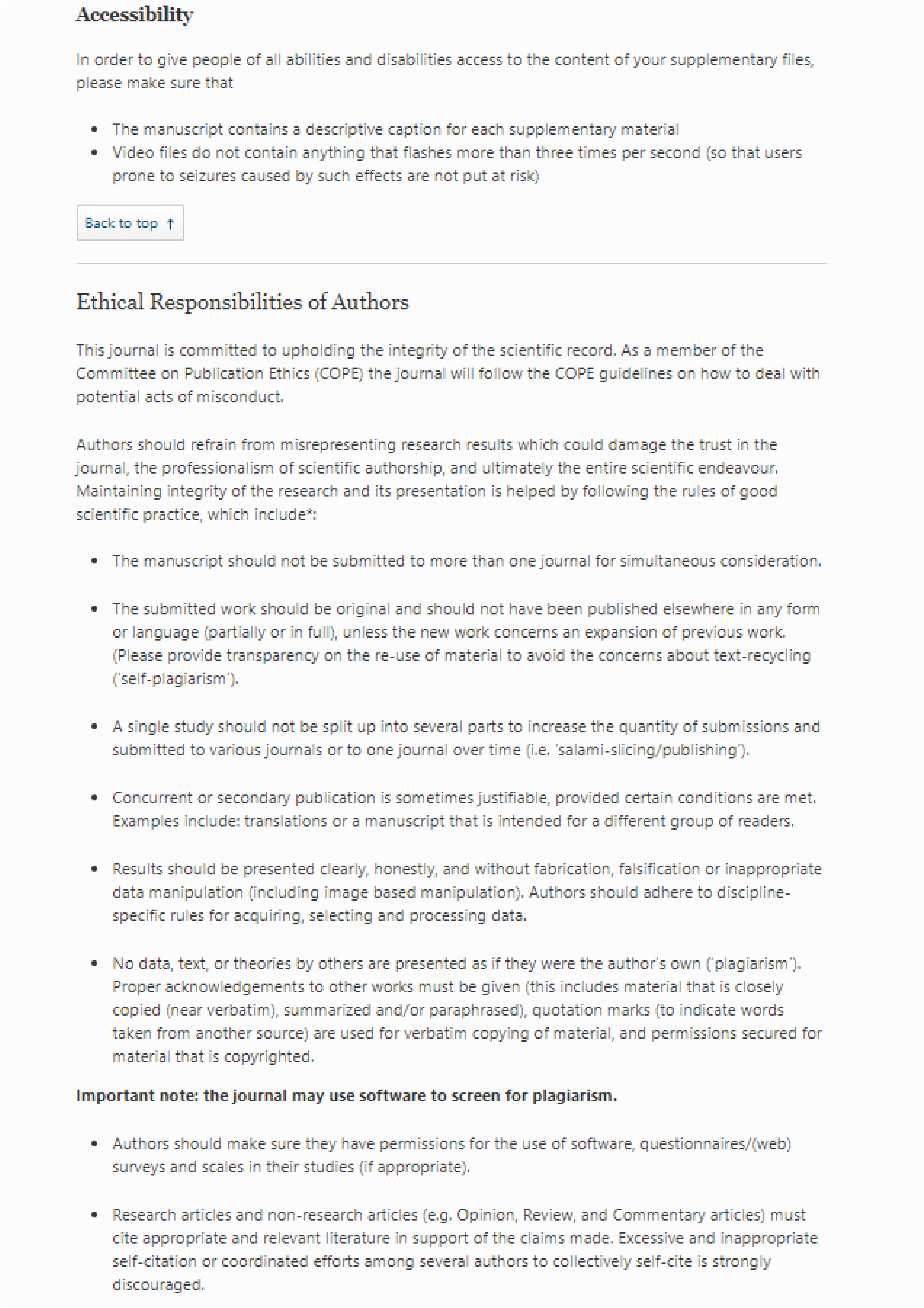

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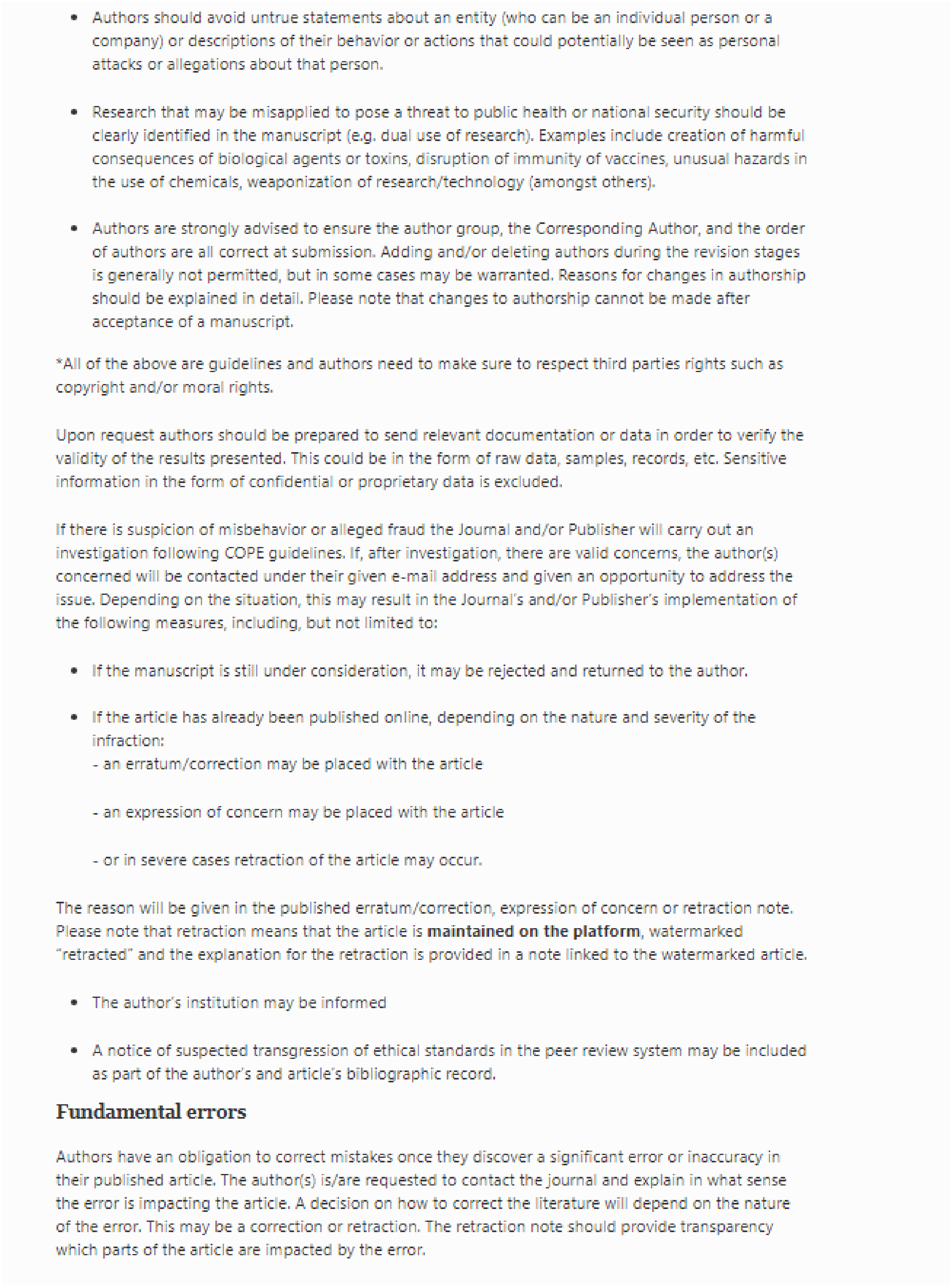

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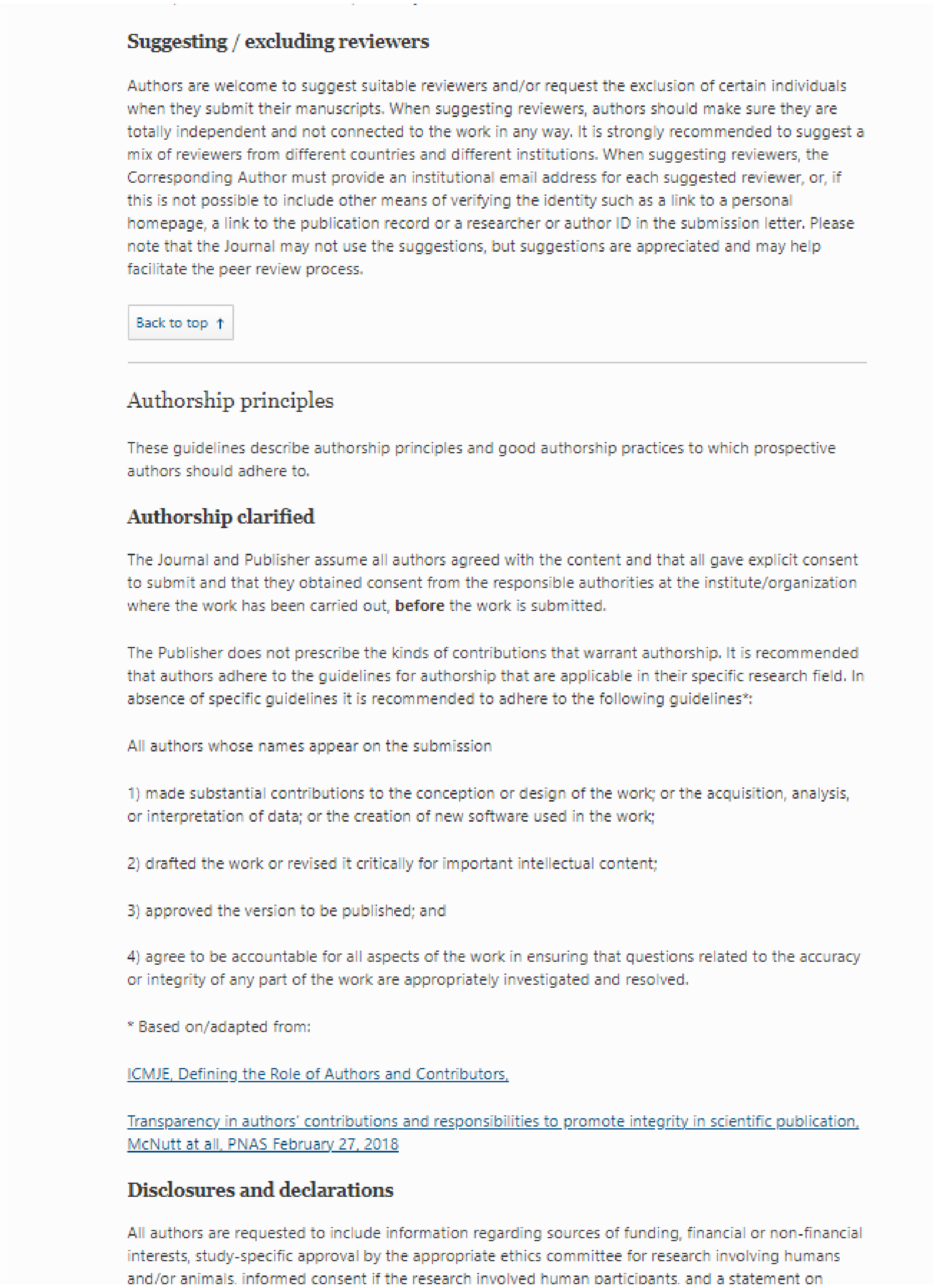

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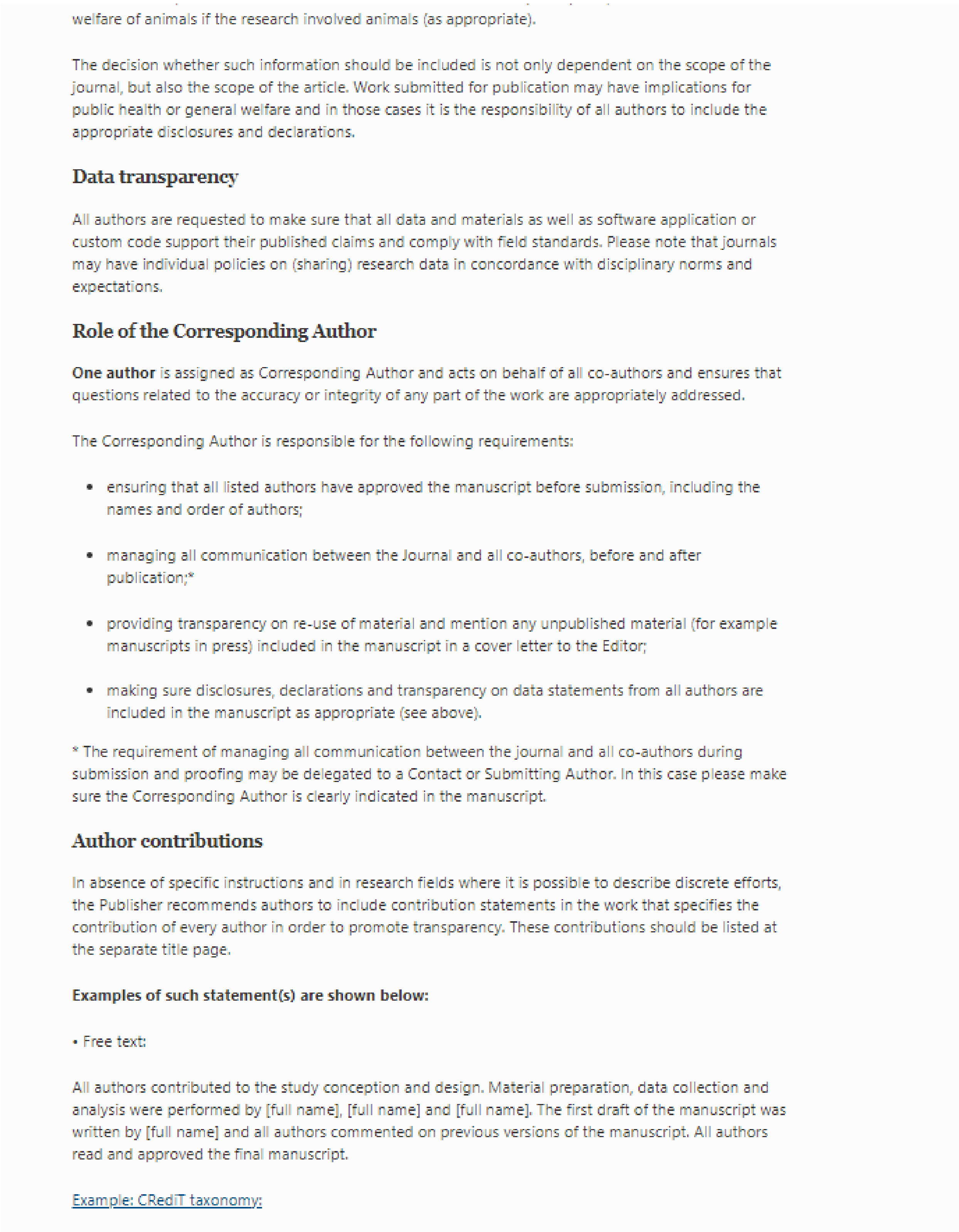

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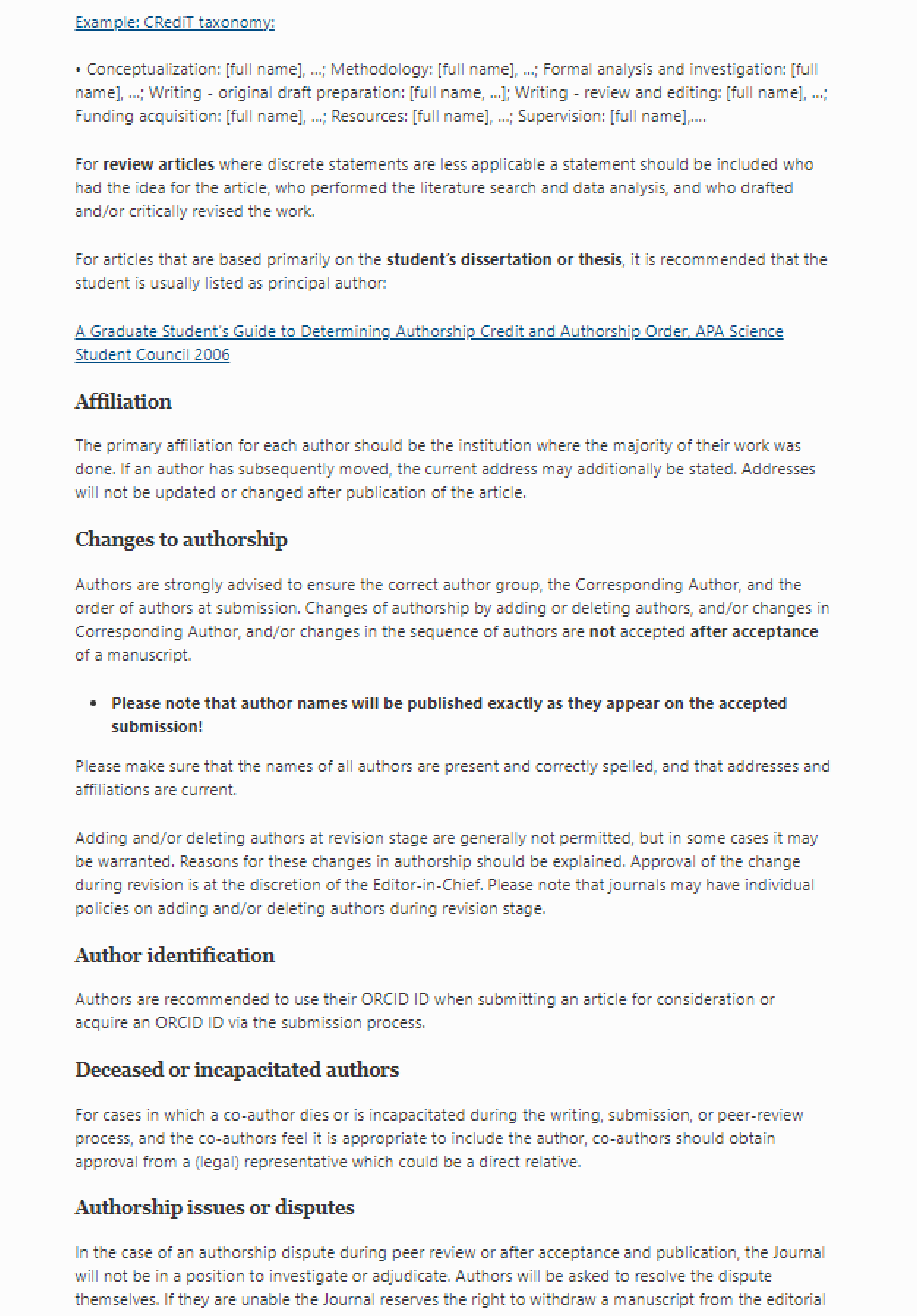

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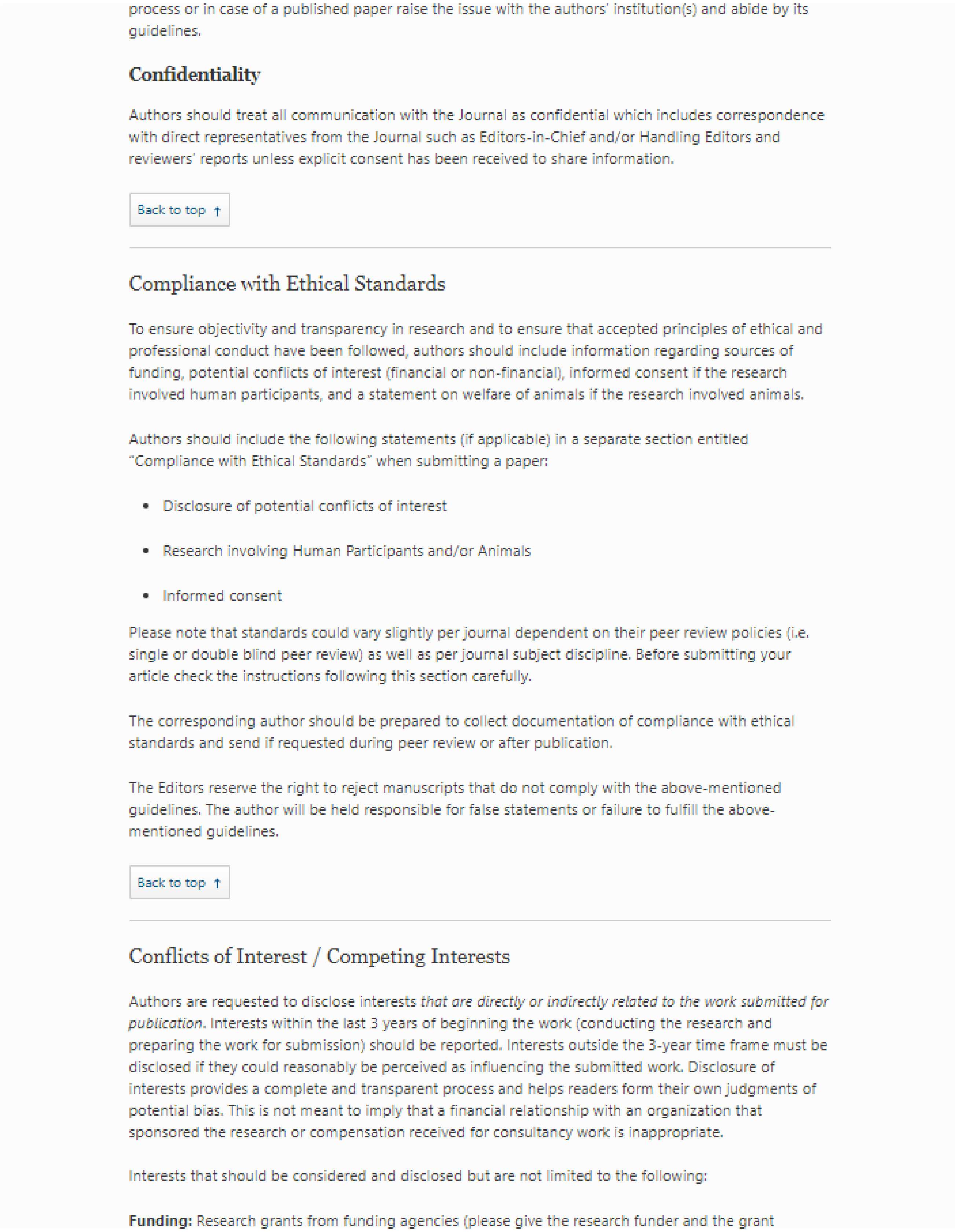

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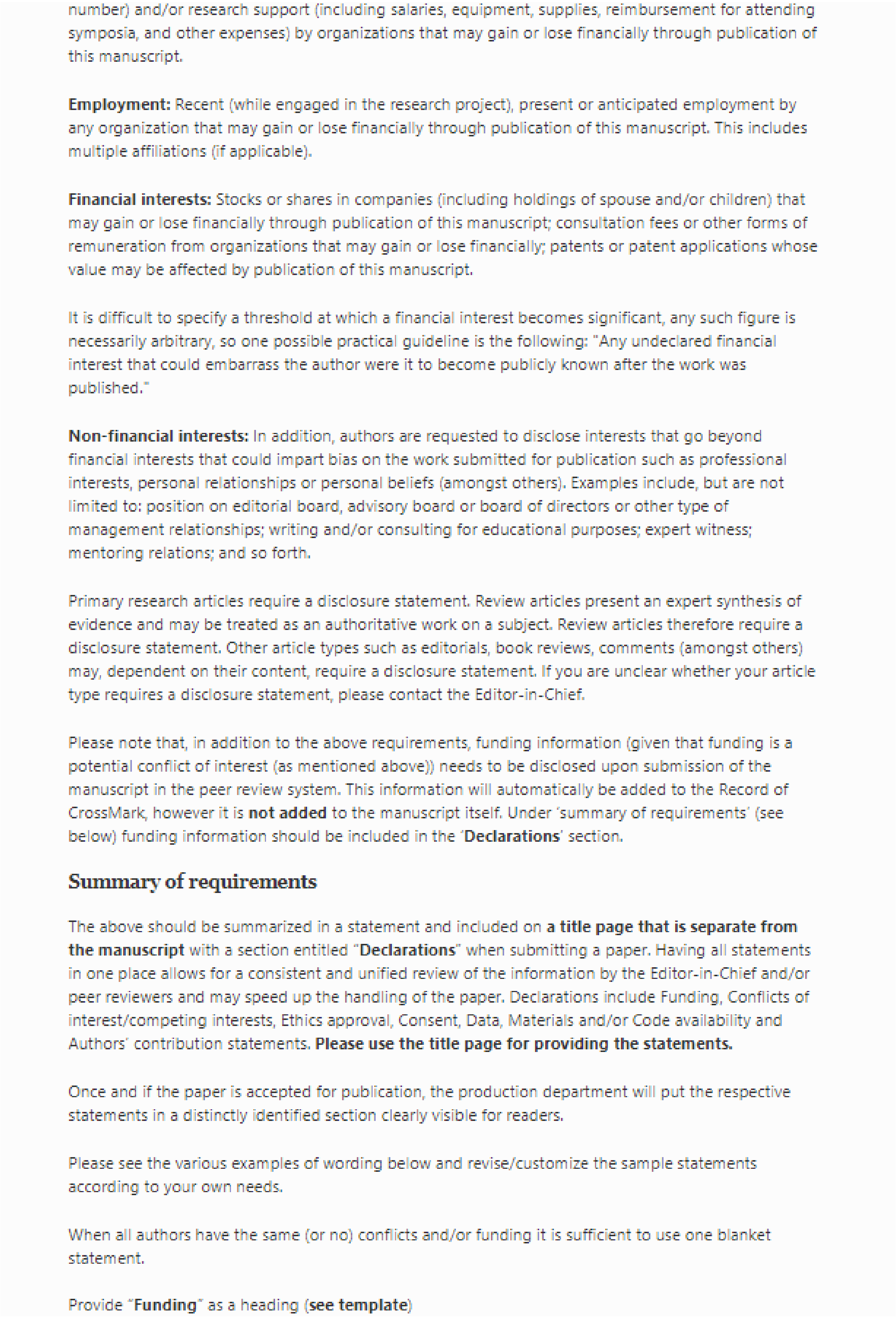

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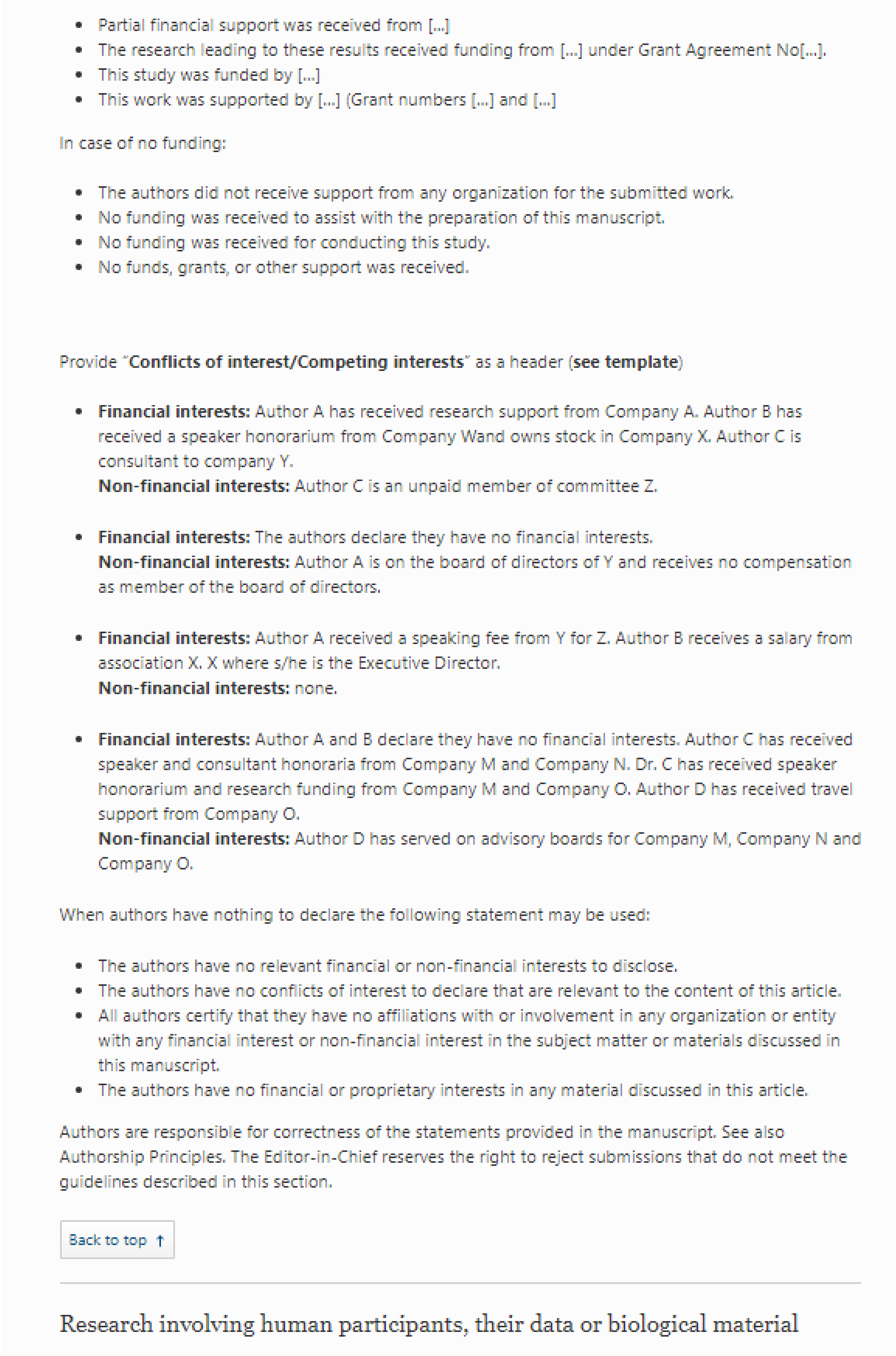

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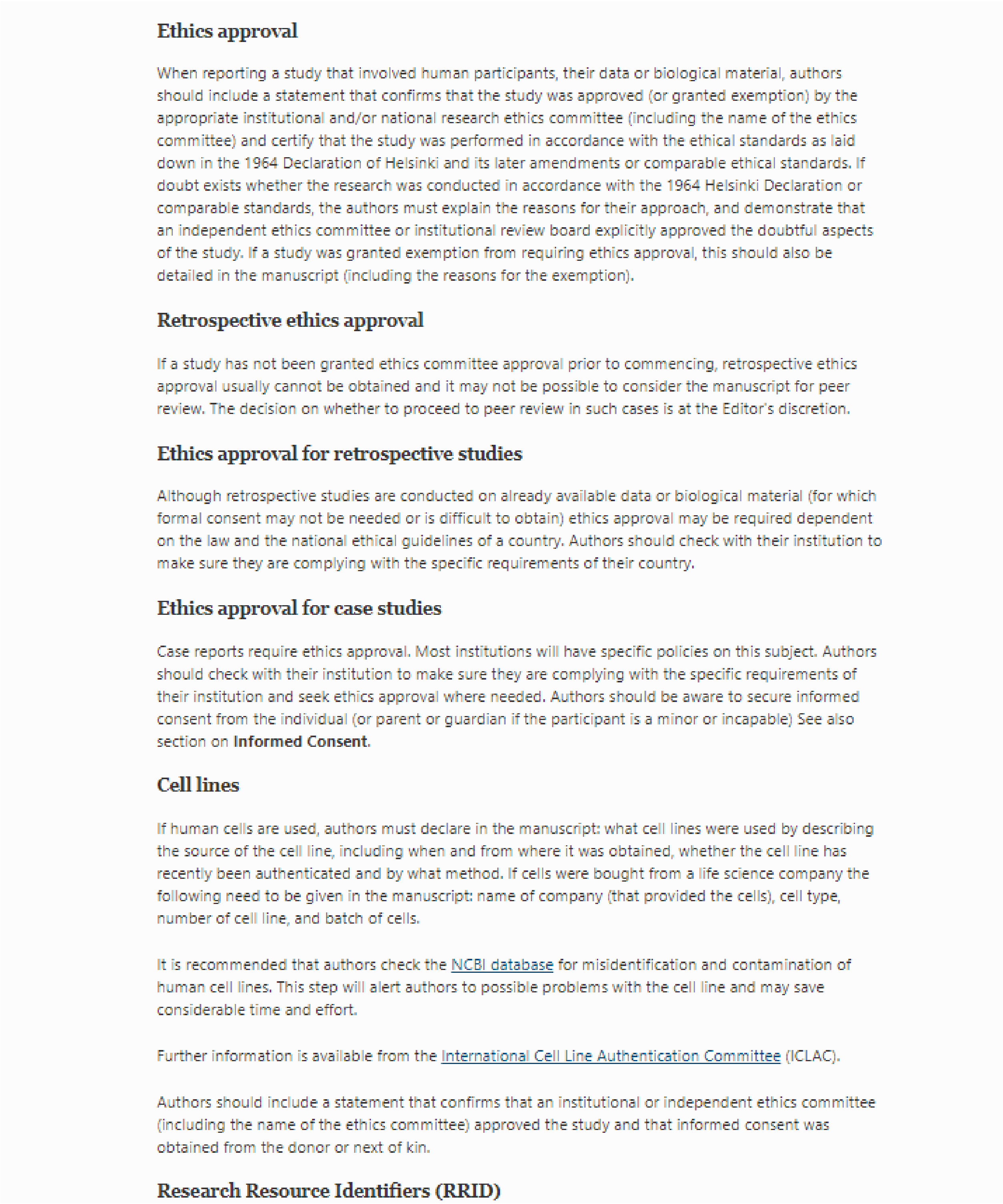

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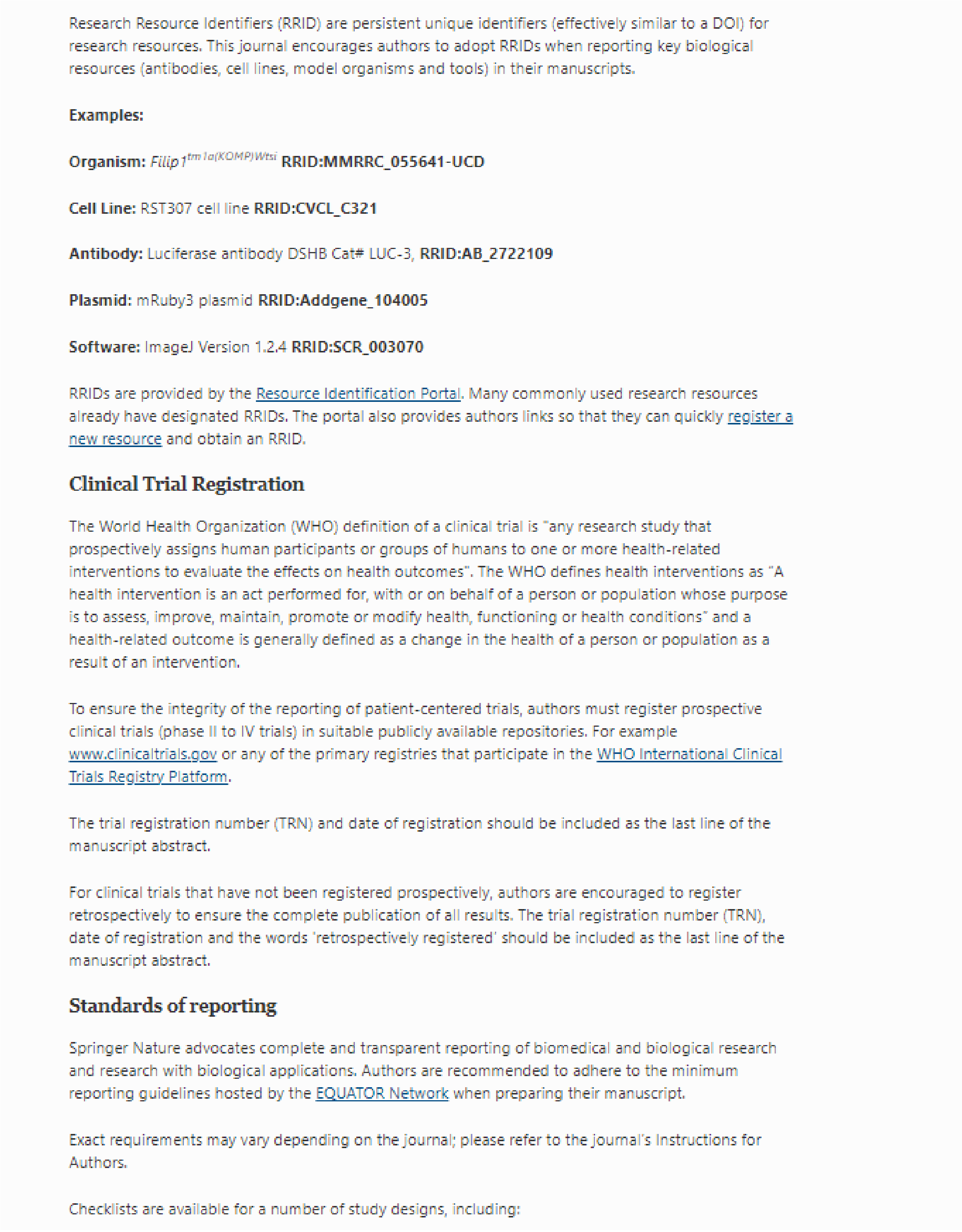

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Organism: *Filip1*$^{tm1a(KOMP)Wtsi}$ **RRID:MMRRC_055641-UCD**

Cell Line: RST307 cell line **RRID:CVCL_C321**

Antibody: Luciferase antibody DSHB Cat# LUC-3, **RRID:AB_2722109**

Plasmid: mRuby3 plasmid **RRID:Addgene_104005**

Software: ImageJ Version 1.2.4 **RRID:SCR_003070**

RRIDs are provided by the Resource Identification Portal. Many commonly used research resources already have designated RRIDs. The portal also provides authors links so that they can quickly register a new resource and obtain an RRID.

Clinical Trial Registration

The World Health Organization (WHO) definition of a clinical trial is "any research study that prospectively assigns human participants or groups of humans to one or more health-related interventions to evaluate the effects on health outcomes". The WHO defines health interventions as "A health intervention is an act performed for, with or on behalf of a person or population whose purpose is to assess, improve, maintain, promote or modify health, functioning or health conditions" and a health-related outcome is generally defined as a change in the health of a person or population as a result of an intervention.

To ensure the integrity of the reporting of patient-centered trials, authors must register prospective clinical trials (phase II to IV trials) in suitable publicly available repositories. For example www.clinicaltrials.gov or any of the primary registries that participate in the WHO International Clinical Trials Registry Platform.

The trial registration number (TRN) and date of registration should be included as the last line of the manuscript abstract.

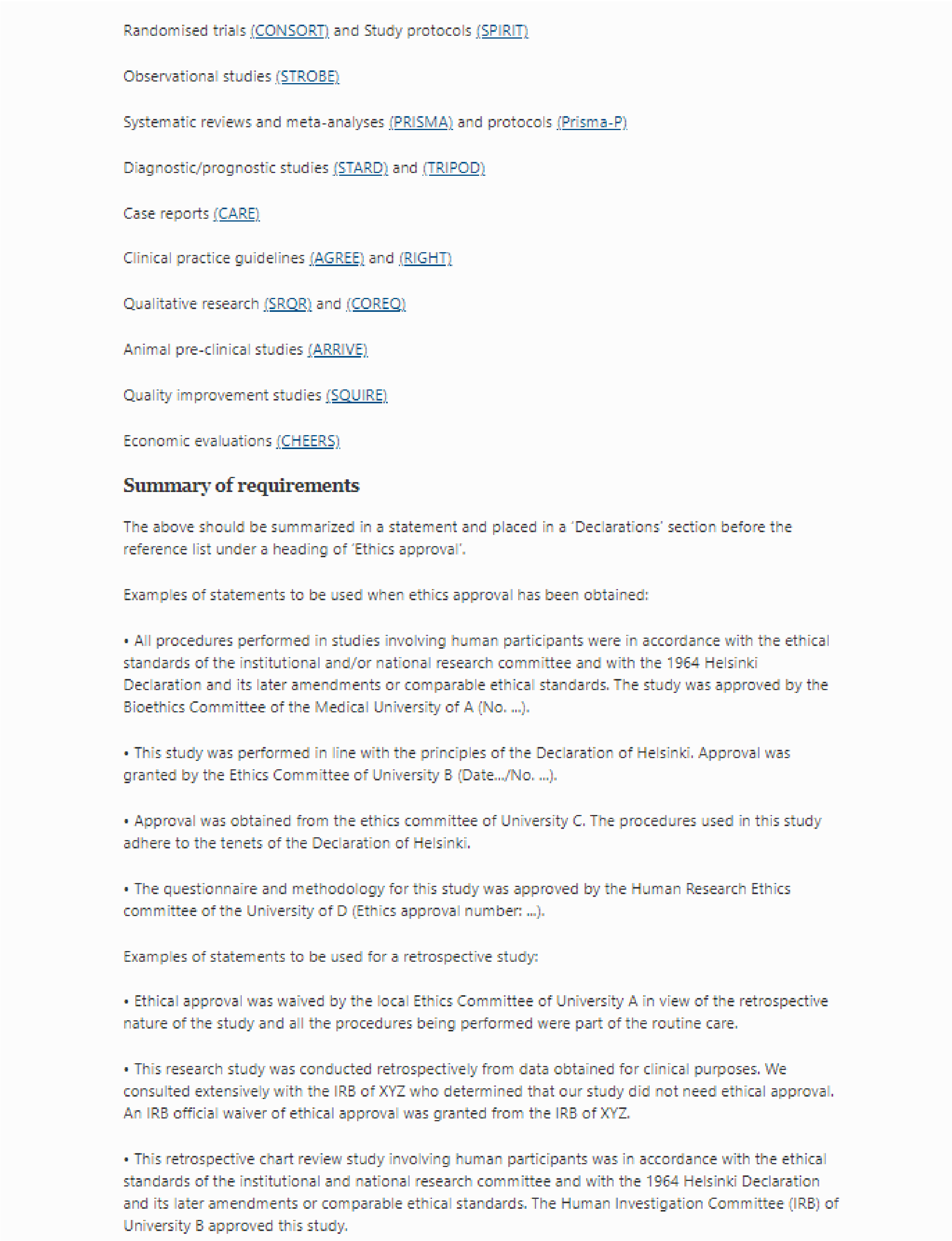
For clinical trials that have not been registered prospectively, authors are encouraged to register retrospectively to ensure the complete publication of all results. The trial registration number (TRN), date of registration and the words 'retrospectively registered' should be included as the last line of the manuscript abstract.

Standards of reporting

Springer Nature advocates complete and transparent reporting of biomedical and biological research and research with biological applications. Authors are recommended to adhere to the minimum reporting guidelines hosted by the EQUATOR Network when preparing their manuscript.

Exact requirements may vary depending on the journal; please refer to the journal's Instructions for Authors.

Checklists are available for a number of study designs, including:



Randomised trials (CONSORT) and Study protocols (SPIRIT)

Observational studies (STROBE)

Systematic reviews and meta-analyses (PRISMA) and protocols (Prisma-P)

Diagnostic/prognostic studies (STARD) and (TRIPOD)

Case reports (CARE)

Clinical practice guidelines (AGREE) and (RIGHT)

Qualitative research (SRQR) and (COREQ)

Animal pre-clinical studies (ARRIVE)

Quality improvement studies (SQUIRE)

Economic evaluations (CHEERS)

Summary of requirements

The above should be summarized in a statement and placed in a 'Declarations' section before the reference list under a heading of 'Ethics approval'.

Examples of statements to be used when ethics approval has been obtained:

- All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Bioethics Committee of the Medical University of A (No. ...).

- This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of University B (Date.../No. ...).

- Approval was obtained from the ethics committee of University C. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

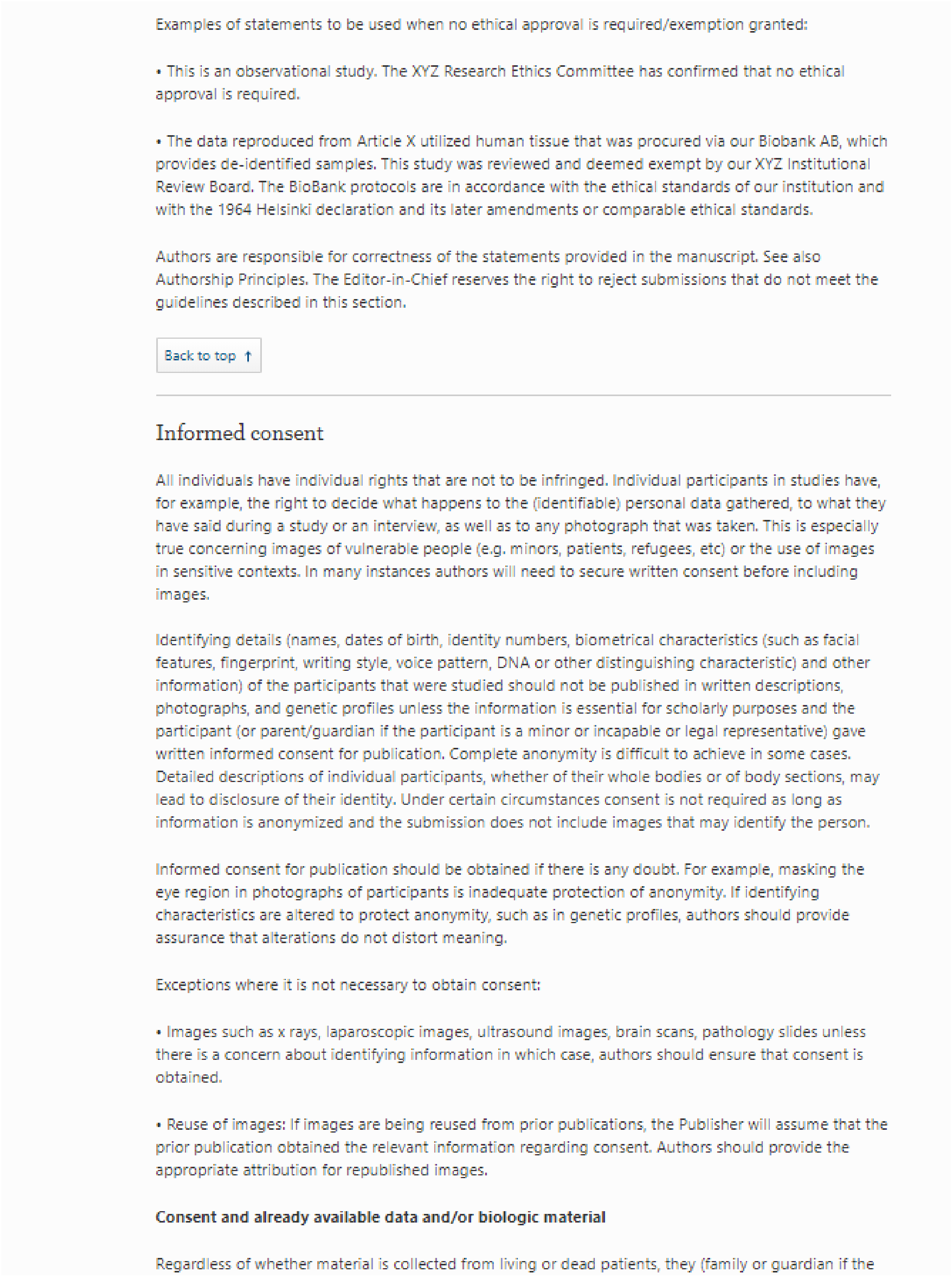
- The questionnaire and methodology for this study was approved by the Human Research Ethics committee of the University of D (Ethics approval number: ...).

Examples of statements to be used for a retrospective study:

- Ethical approval was waived by the local Ethics Committee of University A in view of the retrospective nature of the study and all the procedures being performed were part of the routine care.

- This research study was conducted retrospectively from data obtained for clinical purposes. We consulted extensively with the IRB of XYZ who determined that our study did not need ethical approval. An IRB official waiver of ethical approval was granted from the IRB of XYZ.

- This retrospective chart review study involving human participants was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The Human Investigation Committee (IRB) of University B approved this study.



Examples of statements to be used when no ethical approval is required/exemption granted:

- This is an observational study. The XYZ Research Ethics Committee has confirmed that no ethical approval is required.

- The data reproduced from Article X utilized human tissue that was procured via our Biobank AB, which provides de-identified samples. This study was reviewed and deemed exempt by our XYZ Institutional Review Board. The BioBank protocols are in accordance with the ethical standards of our institution and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Authors are responsible for correctness of the statements provided in the manuscript. See also Authorship Principles. The Editor-in-Chief reserves the right to reject submissions that do not meet the guidelines described in this section.

Informed consent

All individuals have individual rights that are not to be infringed. Individual participants in studies have, for example, the right to decide what happens to the (identifiable) personal data gathered, to what they have said during a study or an interview, as well as to any photograph that was taken. This is especially true concerning images of vulnerable people (e.g. minors, patients, refugees, etc) or the use of images in sensitive contexts. In many instances authors will need to secure written consent before including images.

Identifying details (names, dates of birth, identity numbers, biometrical characteristics (such as facial features, fingerprint, writing style, voice pattern, DNA or other distinguishing characteristic) and other information) of the participants that were studied should not be published in written descriptions, photographs, and genetic profiles unless the information is essential for scholarly purposes and the participant (or parent/guardian if the participant is a minor or incapable or legal representative) gave written informed consent for publication. Complete anonymity is difficult to achieve in some cases. Detailed descriptions of individual participants, whether of their whole bodies or of body sections, may lead to disclosure of their identity. Under certain circumstances consent is not required as long as information is anonymized and the submission does not include images that may identify the person.

Informed consent for publication should be obtained if there is any doubt. For example, masking the eye region in photographs of participants is inadequate protection of anonymity. If identifying characteristics are altered to protect anonymity, such as in genetic profiles, authors should provide assurance that alterations do not distort meaning.

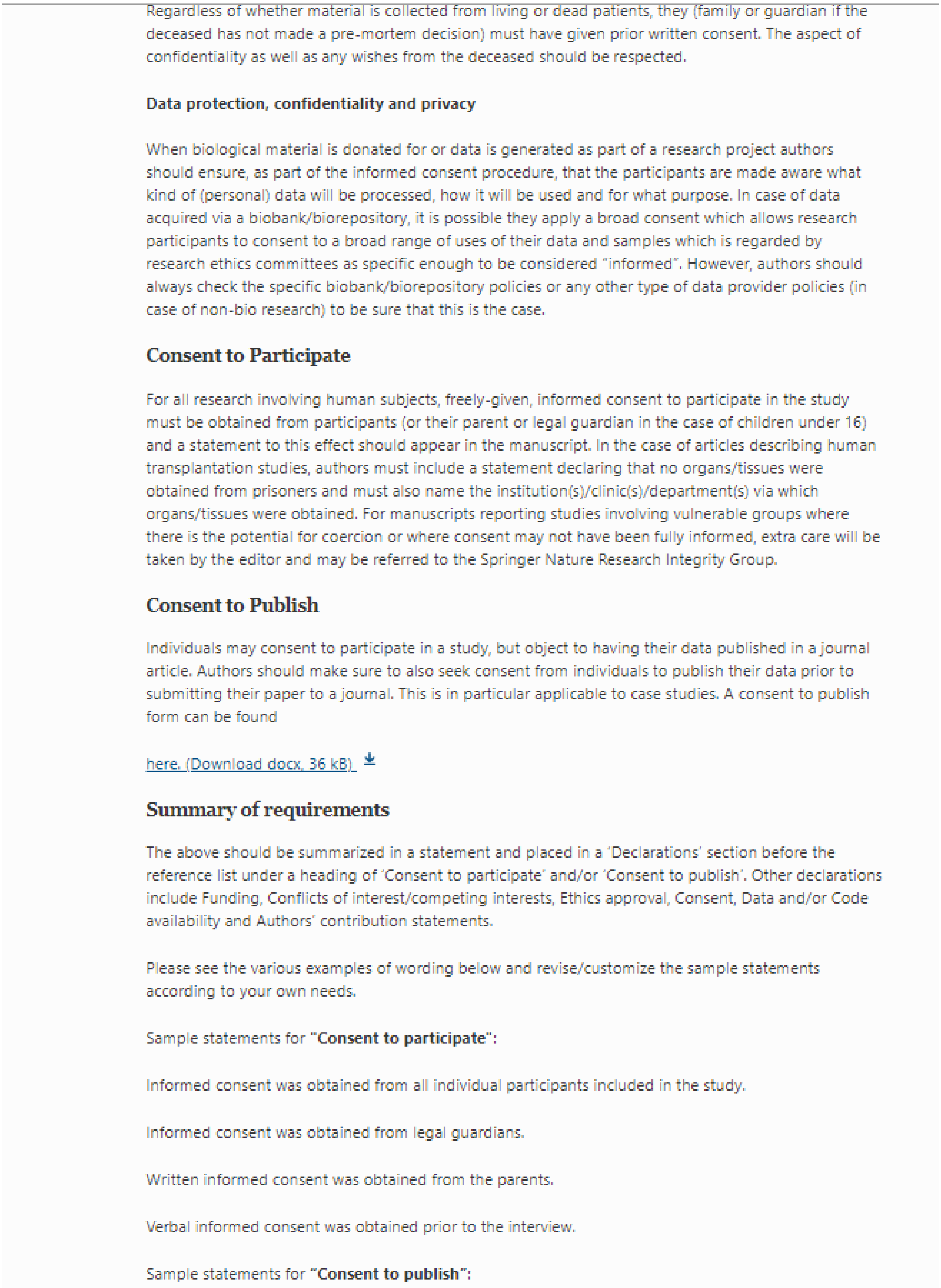
Exceptions where it is not necessary to obtain consent:

- Images such as x rays, laparoscopic images, ultrasound images, brain scans, pathology slides unless there is a concern about identifying information in which case, authors should ensure that consent is obtained.

- Reuse of images: If images are being reused from prior publications, the Publisher will assume that the prior publication obtained the relevant information regarding consent. Authors should provide the appropriate attribution for republished images.

Consent and already available data and/or biologic material

Regardless of whether material is collected from living or dead patients, they (family or guardian if the



Regardless of whether material is collected from living or dead patients, they (family or guardian if the deceased has not made a pre-mortem decision) must have given prior written consent. The aspect of confidentiality as well as any wishes from the deceased should be respected.

Data protection, confidentiality and privacy

When biological material is donated for or data is generated as part of a research project authors should ensure, as part of the informed consent procedure, that the participants are made aware what kind of (personal) data will be processed, how it will be used and for what purpose. In case of data acquired via a biobank/biorepository, it is possible they apply a broad consent which allows research participants to consent to a broad range of uses of their data and samples which is regarded by research ethics committees as specific enough to be considered "informed". However, authors should always check the specific biobank/biorepository policies or any other type of data provider policies (in case of non-bio research) to be sure that this is the case.

Consent to Participate

For all research involving human subjects, freely-given, informed consent to participate in the study must be obtained from participants (or their parent or legal guardian in the case of children under 16) and a statement to this effect should appear in the manuscript. In the case of articles describing human transplantation studies, authors must include a statement declaring that no organs/tissues were obtained from prisoners and must also name the institution(s)/clinic(s)/department(s) via which organs/tissues were obtained. For manuscripts reporting studies involving vulnerable groups where there is the potential for coercion or where consent may not have been fully informed, extra care will be taken by the editor and may be referred to the Springer Nature Research Integrity Group.

Consent to Publish

Individuals may consent to participate in a study, but object to having their data published in a journal article. Authors should make sure to also seek consent from individuals to publish their data prior to submitting their paper to a journal. This is in particular applicable to case studies. A consent to publish form can be found

here. (Download docx, 36 kB)

Summary of requirements

The above should be summarized in a statement and placed in a 'Declarations' section before the reference list under a heading of 'Consent to participate' and/or 'Consent to publish'. Other declarations include Funding, Conflicts of interest/competing interests, Ethics approval, Consent, Data and/or Code availability and Authors' contribution statements.

Please see the various examples of wording below and revise/customize the sample statements according to your own needs.

Sample statements for "**Consent to participate**":

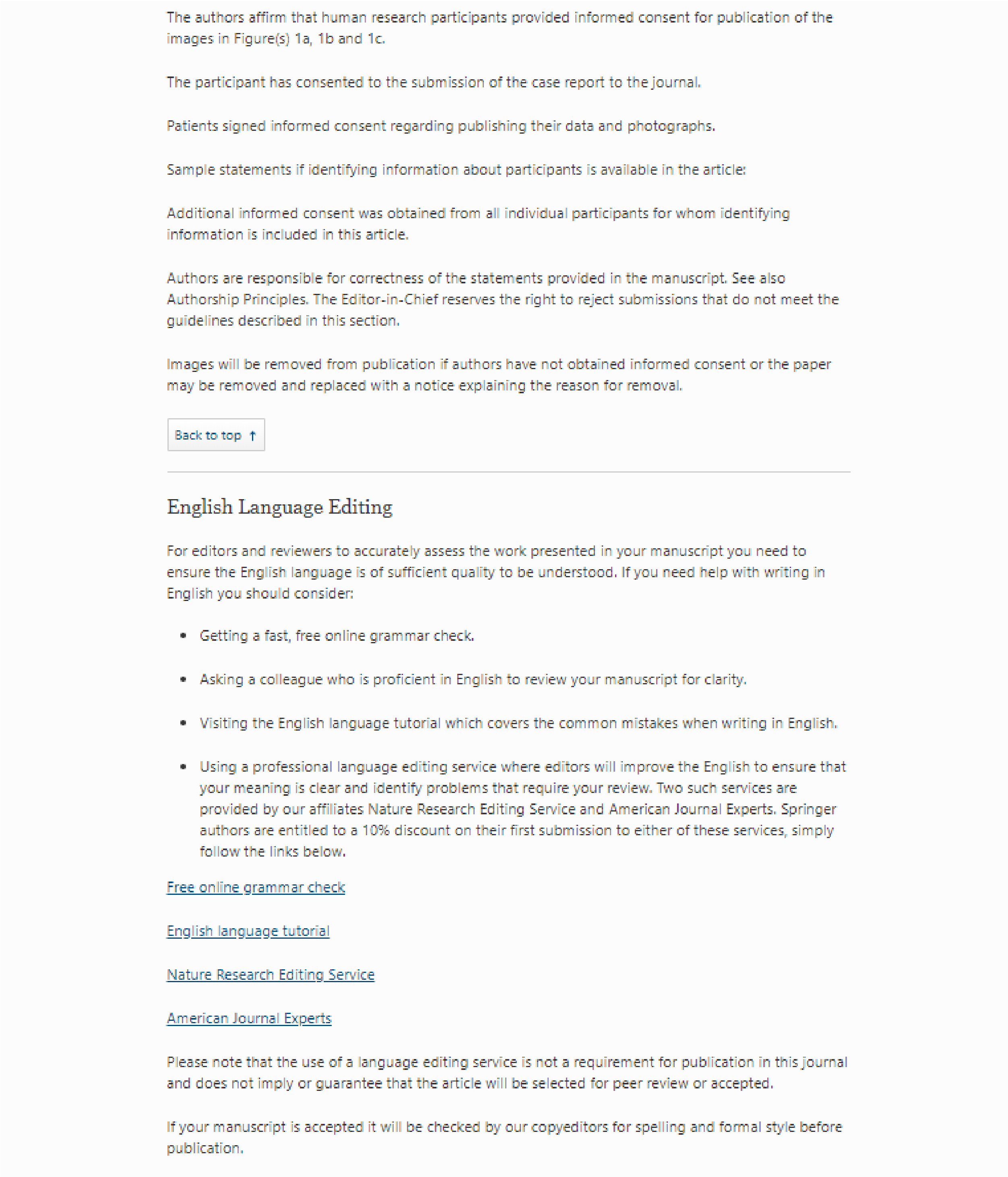
Informed consent was obtained from all individual participants included in the study.

Informed consent was obtained from legal guardians.

Written informed consent was obtained from the parents.

Verbal informed consent was obtained prior to the interview.

Sample statements for "**Consent to publish**":



The authors affirm that human research participants provided informed consent for publication of the images in Figure(s) 1a, 1b and 1c.

The participant has consented to the submission of the case report to the journal.

Patients signed informed consent regarding publishing their data and photographs.

Sample statements if identifying information about participants is available in the article:

Additional informed consent was obtained from all individual participants for whom identifying information is included in this article.

Authors are responsible for correctness of the statements provided in the manuscript. See also Authorship Principles. The Editor-in-Chief reserves the right to reject submissions that do not meet the guidelines described in this section.

Images will be removed from publication if authors have not obtained informed consent or the paper may be removed and replaced with a notice explaining the reason for removal.

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