RESEARCH PAPER

Music Evoked Nostalgia and Wellbeing in Autistic and Non-Autistic Young Adults

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Abstract

Nostalgia is known to boost state wellbeing and authenticity for people in the general population. However, little research has explored nostalgia's benefits outside of the general population. This study had two: (1) to explore music evoked nostalgia and its effects on mood, state wellbeing and authenticity in autistic individuals, a group of people who tend to experience reduced wellbeing, compared to non-autistic individuals and (2) to examine the influence of dispositional rumination and reflection on any benefits gained from nostalgic recollection. 146 autistic (69 diagnosed and 77 who self-identified as autistic) and 174 non-autistic people aged 18–25 took part in an online survey. Participants completed scales measuring autistic traits, rumination and reflection. They also reported their mood *before*, and their mood, state wellbeing and authenticity *after* a nostalgia manipulation, in which they either listened to and reflected on a nostalgic or a non-nostalgic song. Music evoked nostalgia (versus control) boosted state wellbeing and authenticity in autistic as well as non-autistic individuals. Results also indicated that people who were prone to reflection versus rumination were more likely to reap wellbeing benefits of engaging in nostalgia. This study is the first to show that music evoked nostalgia boosts state wellbeing and authenticity in autistic as well as in non-autistic individuals. Findings suggest that, depending on individual tendencies towards rumination and/or reflection, nostalgia could be viewed as a positive activity that autistic people could use to support wellbeing, aiding their day to day living in the non-autistic social world.

Keywords Authenticity · Autism · Nostalgia · Reflection · Rumination · Wellbeing

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Nostalgia, a *'sentimental longing or wistful affection for the past'* (Sedikides et al., 2016), is regarded as an emotion (Hepper et al., 2012; van Tilburg et al., 2018), and moreover, a complex, self-relevant and social emotion (Sedikides & Wildschut, 2023). A large body of experimental work shows that engaging in nostalgia boosts wellbeing for people in the general population (Juhl & Biskas, 2022; Kelley et al., 2022; Leunissen et al., 2021; Umar Ismail et al., 2020). However, little research has explored whether and how nostalgia boosts the wellbeing of autistic people, a group of people who experience lower wellbeing (Van Heijst & Geurts, 2015). The main aim of this study was to explore if nostalgia boosts mood, state wellbeing (positive affect, social connectedness and self-regard[1]) and feelings of authenticity in autistic as well as non-autistic adults, with a view to exploring whether nostalgic memories could be used as part of positive activities (activities that people undertake independently in their daily lives, such as writing a gratitude journal) to support the wellbeing of autistic people.

The focus of this study is music-evoked nostalgia. Nostalgic music is defined as any form of musical content (including instrumental, song or lyrics) which evokes feelings of nostalgia. Music serves as an important reminder of meaningful past experiences (Barrett et al., 2010) and therefore is a powerful source of nostalgia (Sedikides et al., 2022). Music evoked nostalgia has been shown to promote psychological benefits at state level for people in the general population, such as increased happiness, feelings of social connectedness and self-esteem. For example, one qualitative study showed that music evoked nostalgia can provide comfort and solace, through reminders of moments of happiness with close others (Saarikallio, 2011). In another study, participants who read nostalgic (versus control) song lyrics reported increased positive affect (Cheung et al., 2013). Participants who read nostalgic (versus control) song lyrics reported higher social connectedness (Cheung et al., 2013; Routledge et al., 2011; Stephan et al., 2015). Lastly, participants who listened to a nostalgic (versus control) song reported higher self-esteem (Cheung et al., 2013).

However, to the authors' knowledge, no studies have explored *music evoked* nostalgia and its effects on state or felt authenticity *'the sense or feeling that one is currently in alignment with one's true or genuine self; that one is being their real self'* (Sedikides et al., 2017, p. 3). This study operationalises state authenticity using the first component (self-alienation) of the Wood et al. (2008) authenticity scale. According to Wood et al., self-alienation involves feeling out of touch with *one's true self* or *the real me* (p.386). Authenticity is associated with a number of psychological benefits, such as increased subjective happiness, self-esteem, life satisfaction and resilience (Goldman & Kernis, 2002; Rivera et al., 2019; Wood et al., 2008). Music may be an appropriate avenue for exploring nostalgia's effect on authenticity since it serves as a resource for understanding of one's self-identity (Saarikallio, 2011). Studies using other forms of nostalgia induction (not music) in the general population have shown that nostalgia increases feelings of authenticity. For example, in one study, nostalgic (compared to both positive and ordinary) events evoked higher feelings of authenticity (Stephan et al., 2012). Similarly, participants who rated their

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[1] We measure self-regard in our study but view this as closely related to self-esteem and therefore the two terms are used interchangeably throughout.

memories as more nostalgic also rated themselves as more authentic and participants who reflected on a nostalgic (versus an ordinary) memory rated their past selves as more authentic (Baldwin et al., 2015). Baldwin et al. suggested that nostalgia provides individuals with a window into 'who they really are' (p.136).

In addition to the focus on music evoked nostalgia as a support for wellbeing, the focus of this study is on autistic people. Compared to non-autistic people, autistic individuals experience social, communicative, cognitive, sensory (Pearson & Rose, 2021) and emotion processing differences (Livingston et al., 2022). For a diagnosis of autism, individuals need to show 'impairments' in two areas: 1) social communication/interaction and 2) restricted, repetitive behaviours and interests (American Psychiatric Association, 2013). Although many autistic people have a diagnosis of autism, due to the barriers to getting a diagnosis (Cage & McManemy, 2021; Huang et al., 2020), increasingly there are many who self-identify as autistic (Lewis, 2017). Therefore, in this study, we were interested in the experiences of both those with a diagnosis of autism, and those who self-identify as autistic.

Given that nostalgia has been shown to boost wellbeing in the general population, there is a need to explore whether the same is true for more 'vulnerable' groups of individuals, such as autistic people. There are also strong reasons for research to explore ways to boost our chosen areas of wellbeing (positive affect, social connectedness, self-regard) and authenticity in autistic people. First, autistic compared to non-autistic people tend to experience increased mood disorders (Barlattani et al., 2023) and reduced wellbeing in general (Van Heijst & Geurts, 2015). Second, autistic people often have greater difficulties in achieving goals in relation to employment and social relationships and, as a consequence, tend to experience lower self-esteem (Nguyen et al., 2020). Third, relates to social connectedness. One of the diagnostic criteria for autism in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) (American Psychiatric Association, 2013) is 'impairments' in social communication/interaction. Indeed, a large amount of research still highlights deficits in social abilities in autistic people (Davis & Crompton, 2021). However, a recent concept has reframed our understanding of communication and interaction between both autistic and non-autistic individuals – the *double empathy problem* (DEP) (Milton et al., 2022; Milton, 2012a). According to the DEP, the non-autistic way of being and communicating is the dominant way of being and is therefore expected in society. However, autistic people experience the world differently to non-autistic people, including different communication styles, which makes it difficult for *both* autistic and non-autistic groups to understand each other – '*a two-way street*' (Milton, 2012a). Nevertheless, as autistic people live in a predominantly non-autistic social world, this makes social communication/interaction difficult for them, resulting in struggles with social connection, and often leading to minimising their autistic way of being (Hull et al., 2019) or attempting to pass as non-autistic in social situations (Perry et al., 2022). Lastly, relating back to the previous point about autistic people changing their way of being, is the concept of *masking*, which may impact on authenticity in autistic people. Here we use the term *masking* as this is often used in autistic communities (Sedgewick et al., 2022) but other terms exist, such as *camouflaging* or *compensation*. Masking is the use of *'strategies and behaviours to adapt to, and cope within, the everyday social world'* (Cook et al., 2021, p. 4). Masking has detrimental

consequences – it stops people getting in touch with who they really are (Hull et al., 2017). In short, masking limits authenticity and is related to reduced wellbeing (Cook et al., 2021).

Only two studies have explored nostalgia and wellbeing in autistic people, and therefore very little is known about nostalgic experiences in this group. One quantitative study explored how autistic (compared to non-autistic) young adults experienced nostalgia (Bennett et al., 2024a). Bennett et al. (2024a) reported both similarities and differences in proneness to nostalgia between autistic and non-autistic individuals, depending on the measure used. For example, using the *Southampton Nostalgia Scale* (SNS) (Sedikides et al., 2015b), results showed that autistic and non-autistic participants valued and experienced nostalgia to a similar extent. However, using the *Nostalgia Inventory* (NI*)* (Batcho, 1995), results suggested that autistic people *missed* typical aspects (friends, school, holidays) from their past much less compared to non-autistic people. Due to the lack of work in this area, reasons for lower proneness to nostalgia are unknown. The authors suggested that lower proneness to nostalgia amongst autistic individuals could be because this measure (NI) fails to capture aspects that are missed which are relevant to autistic people. An alternative explanation put forward by Bennett et al. (2024a) relates to different autistic life experiences, that is, that autistic people may not miss typical aspects from when they were younger due to more adverse memories (Bottema-Beutel et al., 2020; Kerns et al., 2017). One area that Bennett et al. (2024a) did not address with regards to proneness to nostalgia relates to autistic people's relationship with time. Scholars have suggested atypical time experience in autism. Scholars have suggested that the passage of time is '*faded out*', i.e. that it is hardly felt (Vogel et al., 2019, p. 29; Vogel & Vogeley, 2021). The past is experienced as separate memories – although meaningful, the past may not necessarily be experienced as part of the present (Vogel et al., 2019, p. 29; Vogel & Vogeley, 2021). Sense of time - thinking forwards and backwards in time, may also be altered in autistic individuals (Allman, 2015). As nostalgia is defined as a 'sentimental longing or wistful affection for the past', autistic people's relationship with time and the past, may also impact on proneness to nostalgia and nostalgic experiences in autistic individuals.

Contrary to much of the experimental literature in the general population, Bennett et al. (2024a) did not find that reflecting on a nostalgic (versus ordinary) memory boosted state feelings of happiness in autistic or non-autistic individuals. However, findings suggested that reflecting on nostalgic memories made both autistic and non-autistic participants equally happy, although the researchers only assessed nostalgia evoked affect with a very brief measure (by asking participants how happy it made them feel to reflect on their memory). Therefore, there is very little quantitative evidence about how engaging in nostalgia makes autistic people feel. Another qualitative study used semi-structured interviews to explore nostalgic experiences in autistic young adults (Bennett et al., Submitted b). Participants described several benefits to wellbeing through nostalgia, including increased positive affect, increased feelings of social connectedness and self-esteem. In addition, nostalgic memories provided autistic individuals with glimpses of experienced authenticity or inauthenticity, which helped them to understand more about the authentic self. Above all, autistic individuals in the qualitative study seemed to derive comfort and hope from

their fond nostalgic memories. The current study aimed to build on findings from the above studies, exploring music evoked nostalgia and its influence on mood, state wellbeing and feelings of authenticity in autistic as well as non-autistic individuals. This main aim was broken down into two research questions:

1) Will participants in the nostalgia (versus control) condition report higher state wellbeing (positive affect, social connectedness and self-regard) and higher authenticity after listening to a self-selected nostalgic piece of music? How will participant group influence this? We hypothesised that this would be the case for non-autistic individuals, but we made no prediction about what we expected to find in autistic participants.
2) Will participants in the nostalgia condition demonstrate a change in mood *after* compared to *before* listening to their chosen nostalgic song? How will participant group influence this? To the best of our knowledge, the current study is the first to explore whether engaging in nostalgia causes a momentary change in mood using a visual analogue mood scale (most other studies have explored the effects of induced nostalgia by comparing across nostalgia and control conditions). We did not make any prediction in relation to this research question.

Our second aim was prompted by findings in the qualitative study above by Bennett et al. In interviews with autistic people about their nostalgic experiences, researchers found that reflective individuals were more likely to reap wellbeing benefits from nostalgia compared to ruminators. In addition, another study found that for people with tendencies towards rumination, listening to a nostalgic song tended to make them feel less happy (Garrido, 2018). Therefore, the second aim examined whether dispositional rumination and/or reflection impacted on the benefits gained from engaging in nostalgia. Trapnell and Campbell (1999) described rumination and reflection as two independent tendencies - two motivationally distinct forms of private self-attentiveness (p.287). Rumination is a tendency towards repetitive, negative thinking, *'motivated by perceived threats, losses or injustices to the self'* (p.297). In contrast, reflection, according to Trapnell and Campbell (1999), involves the need for more self-knowledge, *'motivated by curiosity or epistemic interest in the self'* (p.297). As rumination is a form of repetitive thinking which is common in autistic people (Cooper et al., 2022), this may be an especially important avenue of research in this population.

With regards to our second aim, we set two further research questions: 3) What is the role of rumination/reflection in predicting change of mood scores for participants who listen to a nostalgic song? How does autistic trait[2] influence this? We hypothesised that rumination would be a significant predictor of negative affective change. 4) What is the role of rumination/reflection in nostalgia's influence on state wellbeing (positive affect, social connectedness and self-regard) and authenticity? How does autistic trait influence this?

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[2] In research questions 3 and 4, we chose to use Autistic Traits as opposed to Group as independent variable for ease in linear regressions.

Again, we hypothesised that rumination would negatively predict positive affect. We made no predictions about rumination's influence on social connectedness, self-regard, or authenticity and no prediction about the role of reflection in nostalgia's influence on change of mood or any of these aspects of wellbeing – this was exploratory. We pre-registered our hypotheses described above on the Open Science Framework here: https://osf.io/c8qnm/.

1 Methods

1.1 Consultation – Autistic Involvement

Before recruitment began, five autistic individuals aged 18–25 reviewed our recruitment texts, study methods and materials. Where appropriate, their feedback was incorporated into materials. These individuals were remunerated in line with NIHR guidelines.

1.2 Sample Size

A systematic review and meta-analysis of evidence of the effectiveness of nostalgia as a psychological resource showed that nostalgic recollection (versus control) has moderate effects on: positive affect (d=0.51), social connectedness (d=0.72) and self-esteem (d=0.50) (Umar Ismail et al., 2020). Based on these parameters, we conducted power analyses in G*Power 3.1 (Faul et al., 2009) which uses Cohen's conventions (Cohen, 2013), assuming medium effect sizes (Cohen's f 0.25 for research questions 1 and 2 and Cohen's f^2 0.15 for research questions 3 and 4) at 80% power. Our (actual sample sizes)/ versus suggested sample sizes following power analyses were, respectively (n=320)/158 to carry out ANCOVAs in research question 1, (n=162)/120 to carry out repeated measures ANOVAs in research question 2, and (n=155)/92 to carry out linear regressions in research questions 3 and 4. Thus, we had sufficient power to carry out our chosen analyses.

1.3 Participants

Autistic and non-autistic young adults completed an online survey. We recruited individuals who self-reported a diagnosis of autism (n=69), those who had no diagnosis but who self-identified as autistic (n=77) and non-autistic individuals (n=174). To be included in the study, participants were 18–25 years of age, able to write at least 4 sentences without help in fluent English. Participants who had experienced traumatic brain injury or currently or in the past were/had been dependent on alcohol or other substances were not able to take part, as these issues can impact memory.

Participants were recruited through social media platforms including autism support groups online, the researchers' personal and professional networks, the platform Survey Circle https://www.surveycircle.com/en/, and support via Autistica (UK Autism research and campaigning charity). Most participants were from the USA (35%) and UK (20%), with the remaining participants from many other countries.

They were a mixture of students (50%) and people in employment (41%), with the remainder working as self-employed or not currently employed or studying. Most participants (72%) spoke English as a first language. Participant characteristics are presented in relation to age, gender and diagnosis of depression in the three participant groups (see Table 1).

Table 1 Participant characteristics by group and mean (standard deviation) scores for RAADS-14, subjective happiness scale, rumination and reflection ($n=320$)

		non-autistic ($n=174$)	autistic diagnosed ($n=69$)	autistic self-identified ($n=77$)	p	effect size η^2
Age[a]		22.71 (2.08)	21.93 (2.02)	22.63 (1.90)	0.016	0.03
Gender[b]	man	42 (24%)	25 (36%)	35 (46%)	0.006	
	woman	117 (67%)	41 (59%)	37 (48%)		
	non-binary/third gender	3 (2%)	2 (3%)	3 (4%)		
	self-describe[c]	2 (2%)	1 (2%)	1 (2%)		
	prefer not to say	10 (5%)	0 (0%)	0 (0%)		
Depression diagnosis[d] yes		29 (17%)	60 (87%)	32 (41.55%)	< 0.001	
no		140 (80%)	7 (11%)	36 (47%)		
prefer not to say		5 (3%)	1 (2%)	9 (12%)		
Autistic traits[e] (RAADS-14)		16.81 (8.73)	27.78 (6.06)	25.21 (7.14)	< 0.001	0.27
Subjective Happiness Scale[f] (SHS)		4.40 (1.22)	3.45 (0.83)	3.85 (0.98)	< 0.001	0.10
Rumination[g]		3.55 (0.74)	3.28 (0.64)	3.49 (0.58)	*0.015*	0.03
Reflection[h]		3.59 (0.73)	3.21 (SD 0.47)	3.30 (SD 0.49)	<0.001	0.06

Note: * $p<.05$ ** $p<.01$ *** $p<.001$

a Pairwise comparisons showed - autistic diagnosed<non-autistic, ($p=.015$, g=0.38). No other group differences

b Results showed a significant difference in the proportions of genders in each group

c Includes 1 gender non-conforming & transgender woman (autistic diagnosed), 1 gay man (non-autistic) and 1 agender (autistic self-identified) plus 1 who did not state gender

d based on $n=319$ as 1 person did not report depression diagnosis. Results showed a significant difference in the proportions of participants with a diagnosis of depression in each group

e Pairwise comparisons showed autistic diagnosed>non-autistic ($p<.001$, g=1.45), autistic self-identified>non-autistic ($p<.001$, g=1.05), autistic diagnosed=autistic self-identified autistic ($p=.121$)

f Pairwise comparisons showed - autistic diagnosed<non-autistic ($p<.001$, g=0.91), autistic self-identified<non-autistic ($p<.001$, g=0.49), autistic diagnosed=autistic self-identified autistic ($p=.167$)

g Pairwise comparisons showed non-autistic>autistic diagnosed ($p=.011$, g=0.39), non-autistic=autistic self-identified ($p=.746$), autistic self-identified=autistic diagnosed ($p=.142$)g Pairwise comparisons showed non-autistic > autistic diagnosed ($p =.011$, g = 0.39), non-autistic = autistic self-identified ($p =.746$), autistic self-identified = autistic diagnosed ($p =.142$)

h Pairwise comparisons showed non-autistic>autistic diagnosed ($p<.001$, g 0.61), non-autistic>autistic self-identified ($p=.002$, g=0.46), autistic self-identified=autistic diagnosed ($p=.797$)h Pairwise comparisons showed non-autistic > autistic diagnosed ($p <.001$, g 0.61), non-autistic > autistic self-identified ($p =.002$, g = 0.46), autistic self-identified = autistic diagnosed ($p =.797$)

1.4 Measures

We used an anonymous online questionnaire. To reduce the possibility of participant bias, there was no reference to the term *nostalgia* in the participant materials or survey. The title given to the participants was 'Music evoked mood and wellbeing in young adults.' First, all participants were asked to choose one of the following options: (1) I have a diagnosis of autism; (2) I don't have a diagnosis of autism but I do identify as autistic; (3) I don't have a diagnosis of autism and I don't identify as autistic. According to responses to this item, we placed participants into one of three groups: autistic diagnosed, autistic self-identified and non-autistic. Next, all participants completed the following sections in this order:

1.4.1 Wellbeing: Subjective Happiness Scale (Lyubomirsky & Lepper, 1999)

A 4-item scale of global subjective happiness (cohort $\alpha=0.71$). Items include: *In general I consider myself* (1 (*not a happy person*) to 7 (*a very happy person*).

1.4.2 Rumination-Reflection Questionnaire RRQ (Trapnell & Campbell, 1999)

A 24-item scale measuring dispositional rumination and reflection. Rumination items include: *My attention is often focused on aspects of myself I wish I'd stop thinking about.* Reflection items include: *I love exploring my 'inner' self.* Participants respond on a 5-point Likert scale (1–5, 1=strongly disagree – 5=strongly agree). We generated a mean score for both rumination (cohort $\alpha=0.87$) and reflection (cohort $\alpha=0.85$).

1.4.3 Attention Check Question

One attention check question was used (*select the word that is a colour*). Only those participants who responded correctly to this question were included in the analysis.

1.4.4 Ritvo Autism and Asperger Diagnostic Scale 14 (RAADS-14) (Eriksson et al., 2013)

A 14 item self-report measure of autistic traits, assessing three main areas: mentalising differences, social anxiety and sensory reactivity. An example item is: *It is difficult for me to understand how other people are feeling when we are talking.* For each item, participants choose one of the following options (a four-point Likert scale ranging from 0 to 3): 3 - *This is true and describes me now and when I was young*; 2 - *This was true or describes me only now*; 1 - *This was true only when I was young (16 years of younger); 0 - *This was never true and never described me.* Higher scores indicate higher autistic traits (cohort $\alpha=0.86$).

1.4.5 Baseline Measure of Mood

An adapted measure of affect based on another study (Newman et al., 2020), incorporating a circumplex model that distinguishes two bipolar dimensions of affect: valence (positive and negative) and arousal (activated and deactivated) (Feldman Barrett & Russell, 1998). To reduce participant fatigue, instead of four adjectives as in Newman et al., two adjectives were used to measure each of the following dimensions of affect: Positive Activated (happy and excited), Positive Deactivated (calm and contented), Negative Activated (stressed and tense) and Negative Deactivated (disappointed and sad). This assessment was incorporated into a Visual Analogue Mood Scale. Compared to Likert based scales, visual analogue scales have been shown to be able to detect finer changes (Machado et al., 2019). Participants rated their mood using eight adjectives and were requested to '*click the position on the line that best represents how you feel right now*' by dragging the position on a horizontal sliding scale line, from 0 (not at all) to 100 (extremely).

1.4.6 Nostalgia Manipulation task

An adapted music evoked nostalgia task, whereby participants were asked to self-select a nostalgic piece of music (Abeyta et al., 2015; Garrido, 2018; Gibbs & Egermann, 2021). All participants were randomly (and evenly in each participant group) assigned to either the nostalgia or control condition. Participants in the nostalgia condition saw these instructions: *Nostalgia is defined as 'a sentimental longing for the past'. Please select a piece of music that personally makes you feel nostalgic. Find a music video clip from YouTube of your chosen piece of music.* Participants in the control condition received these instructions: Please access link: https://www.youtube.com/playlist?list=PLx0sYbCqOb8Q_CLZC2BdBSKEEB59BOPUM to the UK Top 40 songs for this week. Select one of the songs from the playlist that you are least familiar with.

Participants provided the URL to their chosen YouTube clip. All participants were asked to listen to and watch their clip from start to end and to write 3–4 sentences about what the song made them think about and how listening to the music made them feel. We recorded the time that participants spent listening to and writing about their song and only included those who spent longer than 45 sec on this task in analyses[3], so as to increase the chance that participants had engaged sufficiently in the music task.

1.4.7 Post Nostalgia Manipulation Measure of Mood

All participants completed the same measure of mood as at the start i.e. as described in the baseline measure of mood section. We calculated change of mood scores in

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[3] In our study pre-registration on the Open Science Framework, we planned to exclude participants who spent less than one minute listening to and writing about a song. However, in order to have sufficient participant numbers in groups, we tweaked this to less than 45 s. Using this cut off, 57 participants were excluded from the nostalgia and 76 from the control condition.

Positive Activated, Positive Deactivated, Negative Activated and Negative Deactivated by subtracting the baseline measures of mood from these post manipulation measures of mood.

1.4.8 Nostalgia Manipulation Check

All participants completed one item of state nostalgia: *How nostalgic did listening to this piece of music/watching this YouTube video clip make you feel?* (1=not at all, 7=very much).

1.4.9 State Functions of Nostalgia Scale (SFNS) (Hepper, 2012)

Three aspects of state wellbeing[4] were assessed after the nostalgia manipulation: Positive Affect, Social Connectedness and Self-regard. The stem for each statement was adapted to: '*The thoughts and feelings linked to this piece of music…*'. For example, for Positive Affect: '*make me feel happy'.* For Social connectedness: *'…make me feel connected to loved ones'.* For Self-regard: *'…make me value myself more'.* Participants rated these items on a 6-point scale (1=strongly disagree, 6=strongly agree). Mean scores for Positive Affect (cohort $\alpha=0.87$), Social Connectedness (cohort $\alpha=0.92$) and Self-regard (cohort $\alpha=0.95$) were generated.

1.4.10 Authenticity

One item was used to assess state authenticity incorporating '*the real me'* based on Wood et al. (2008) i.e. '*Thinking about this piece of music makes me feel connected to the real me'.*

1.4.11 Demographics

Participants were also asked to report their gender, age, whether English was their first language or not, their country of residence, occupation and whether they had a diagnosis of depression or not. This study was approved by Oxford Brookes University's Research Ethics Committee and was pre-registered on the Open Science Framework here: https://doi.org/10.17605/OSF.IO/H25FQ, and a copy of the questionnaire can also be found here: https://osf.io/a6qsv.

1.5 Data Analysis

To consider group differences in age, a one-way Kruskal-Wallis test was utilised (a non-parametric test was used due to a violation of the assumption of normality as evidenced by a significant Shapiro Wilk Test), followed up by pairwise comparisons with a Dwass-Steel-Critchlow-Fligner (DSCF) correction. To consider group differences in the proportions of categorical variables, such as gender and diagnosis of depression, we used chi squared tests. For all other analyses of group/condition differences

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[4] Due to researcher oversight, the 4th aspect of this scale (meaning in life) was not assessed.

in continuous variables, we used ANCOVA tests with age as a covariate (because there was a significant difference in age between participant groups) followed up with post hoc comparisons, with Tukey correction applied, where appropriate. To consider differences between group/condition in pre- and post-manipulation mood scores, we used repeated measures ANOVA tests, followed by post-hoc comparisons, with Tukey correction applied, where appropriate. Lastly, we used linear regression analyses[5] with participants in the nostalgia condition only ($n = 155$[6]) to assess the contribution of Rumination, Reflection, Autistic traits (assessed by RAADS-14), age and Depression diagnosis as predictors of change of mood/state wellbeing/authenticity. Two models were created for each predictor. Model 1 examined the contribution of Rumination, Reflection, Age and Depression diagnosis as predictors of change of mood/state wellbeing/authenticity. Model 2 also assessed the contribution of Rumination, Reflection, Age and Depression diagnosis plus the added variable of Autistic traits (RAADS-14 scores).

Age and Depression diagnosis were included in the linear regressions due to the significant differences/proportions between groups in these aspects. Prior to using regression, assumptions were checked. Normality was assessed by a non-significant Shapiro Wilk test. Linearity was assessed by visual inspection of the QQ/ residuals plot. Multicollinearity was assessed by checking the correlations between predictors and a VIF < 2.5. Lastly, outliers were assessed with a Cook's Distance of < 1. All assumptions were met for the regression analyses, except where stated. For all inferential statistics an alpha level of 0.05 was used to determine significance unless otherwise stated. We report effect sizes using Hedges' g for pairwise comparisons and Eta squared for group wise comparisons. Lastly, for research questions 2–4, we conducted our analyses described above in the nostalgia condition only (since this was our area of interest and was pre-registered on the Open Science Framework). However, for completeness, we also conducted additional parallel analyses for research questions 2–4 in the control condition only and report these results in the Supplementary Materials.

2 Results

2.1 Participant Characteristics – Differences Between Groups

The autistic diagnosed group was significantly younger than the non-autistic group (with a small to medium effect size). There were no other group differences in age. There was a greater proportion of women in the non-autistic group compared to the two autistic groups. Both autistic groups reported significantly higher autistic traits

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[5] All assumptions were met with the exception of significant Shapiro Wilk test in linear regressions for Social connectedness (both Model 1 and 2) and for Authenticity (both Model 1 and 2).

[6] Although there were 162 people in total in the nostalgia condition, one person did not report whether they had a depression diagnosis or not and 6 participants reported 'prefer not to say' to depression diagnosis, hence we excluded these 7 participants from our analyses here and only included participants in the analyses who responded either yes or no to whether they had a diagnosis of depression. Therefore, the nostalgia condition included $n = 155$.

compared to the non-autistic group, both with large effect sizes. There was no difference in autistic traits between the two autistic groups. More autistic participants (both those with a diagnosis of autism and those who self-identified as autistic) reported a diagnosis of depression compared to the non-autistic group. Both autistic groups reported significantly lower wellbeing (Subjective Happiness Scale) compared to the non-autistic group (non-autistic versus autistic diagnosed showed a large effect size, whilst the difference between the non-autistic and the autistic self-identified showed a medium effect size). However, there was no difference in wellbeing between the two autistic groups. The non-autistic group scored higher in Rumination compared to the autistic diagnosed group (with a small to medium effect size) but there were no other group differences in Rumination. The non-autistic group scored higher in Reflection compared to both autistic groups (non-autistic versus autistic diagnosed showed a medium effect size, whilst the difference between the non-autistic and the autistic self-identified showed a small to medium effect size) but there was no difference in Reflection between the two autistic groups. For all comparisons between groups, see Table 1.

2.1.1 Research Question 1: Effects of Music Evoked Nostalgia (versus Control) on Positive Affect, Social Connectedness, Self-regard and Authenticity

We carried out one ANCOVA with group as an independent variable to check our nostalgia manipulation within the whole cohort ($n=320$). There was a significant effect of condition ($F(1, 312)=38.96$, $p<.001$, $\eta^2=0.10$), with the effect size suggesting a moderate difference between conditions. That is, our nostalgia manipulation was successful within the whole cohort – participants in the nostalgia condition ($n=162$) (M 5.36, SD 1.34) reported feeling significantly more nostalgic compared to participants in the control condition ($n=158$) (M 3.82, SD 1.91). There was a significant effect of age ($F(1, 312)=4.00$ $p=.046$, $\eta^2=0.01$). There was no significant effect of group ($F(2, 312)=0.28$, $p=.756$).

There was also a significant interaction between group and condition ($F(2, 312)=8.48$, $p<.001$, $\eta^2=0.05$). Post hoc comparisons showed that non-autistic participants in the nostalgia condition ($n=91$) (M 5.66, SD 1.17) reported feeling significantly more nostalgic compared to their counterparts in the control condition ($n=83$) (M 3.42, SD 2.02) ($p<.001$, g=1.35), with the effect size suggesting a large difference. However, the autistic diagnosed participants in the nostalgia condition ($n=34$) (M 4.76, SD 1.52) did not report feeling more nostalgic compared to their counterparts in the control condition ($n=35$) (M 4.34, SD 1.53) ($p=.781$). The same was true for the autistic self-identified participants – nostalgia ($n=37$) (M 5.19, SD 1.37) versus control condition ($n=40$) (M 4.20, SD 1.84) ($p=.107$) (see Fig. 1).

Mean scores are presented for State Functions of Nostalgia Scale (SFNS) subscales: Positive Affect, Social Connectedness, Self-regard and also for Authenticity by condition (nostalgia versus control) and for each participant group (non-autistic, autistic diagnosed and autistic self-identified) in Table 2.

We conducted four separate ANCOVAs within the whole cohort ($n=320$), to test for differences in the three SFNS subscales (Positive Affect, Social Connectedness and Self-regard) and Authenticity between the nostalgia and control conditions with
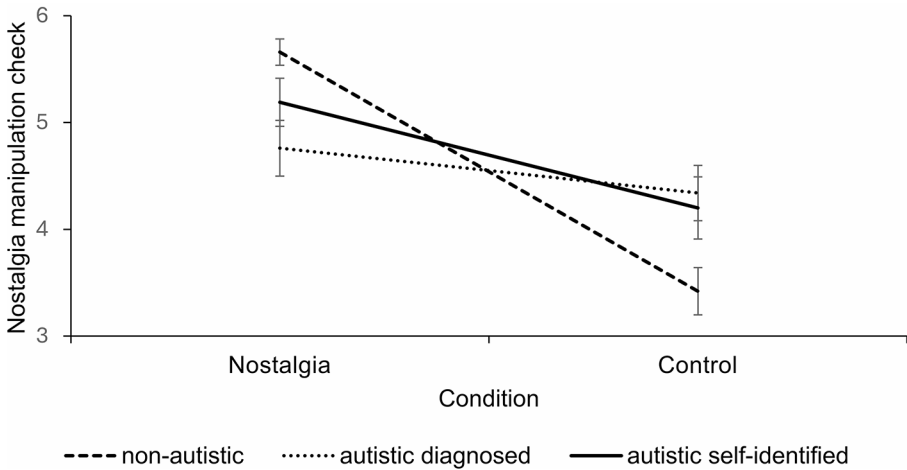
Fig. 1 A line graph showing a significant interaction between condition and group in Nostalgia Manipulation scores (error bars represent standard error)

Table 2 Mean and standard deviation scores for state functions of nostalgia scale (SFNS) subscales (positive affect, social connectedness, self-regard) and authenticity by condition/group. ($n=320$)

	non-autistic		autistic diagnosed		autistic self-identified	
	Nostalgia (n=91) M (SD)	Control (n=83) M (SD)	Nostalgia (n=34) M (SD)	Control (n=35) M (SD)	Nostalgia (n=37) M (SD)	Control (n=40) M (SD)
Positive affect	3.95 (1.18)	3.40 (1.35)	3.19 (1.18)	2.89 (1.09)	3.80 (1.18)	3.56 (1.27)
Social Connectedness	3.75 (1.28)	2.54 (1.50)	3.39 (1.28)	2.87 (1.12)	3.63 (1.14)	3.27 (1.40)
Self-regard	3.84 (1.33)	3.11 (1.58)	3.38 (1.38)	3.07 (1.19)	3.60 (1.24)	3.51 (1.29)
Authenticity	4.21 (1.52)	2.98 (1.69)	3.41 (1.46)	3.03 (1.32)	3.84 (1.30)	3.33 (1.46)

group as an independent variable and age as a covariate. In all SFNS subscales and for Authenticity, there was a significant effect of condition. That is, participants in the nostalgia versus control condition reported significantly higher Positive Affect ($F(1, 312)=5.53$, $p=.019$, $\eta^2=0.02$), representing a small effect; Social Connectedness ($F(1, 312)=19.28$, $p<.001$, $\eta^2=0.05$), representing a small to medium effect; Self-regard ($F(2, 312)=4.62$, $p=.032$, $\eta^2=0.01$), representing a small effect; and Authenticity ($F(1, 312)=16.70$, $p<.001$, $\eta^2=0.05$), representing a medium effect.

There was no significant effect of group in Self-regard, ($F(2, 312)=0.46$, $p=.632$, $\eta^2=0.00$), Social Connectedness ($F(2, 312)=1.57$, $p=.209$, $\eta^2=0.01$) or Authenticity ($F(2, 312)=1.01$, $p=.365$, $\eta^2=0.01$). However, there was a significant effect of group in Positive Affect ($F(2, 312)=5.59$, $p=.004$, $\eta^2=0.03$), suggesting a small to medium effect. Post hoc comparisons showed that the autistic diagnosed group scored significantly lower in Positive Affect (regardless of condition) compared to both the non-autistic ($p=.004$) and autistic self-identified group ($p=.021$). In all SFNS sub-

scales and for Authenticity, there was a significant effect of age: Positive Affect (F(1, 312)=7.67 p=.006, η^2=0.02), Social Connectedness (F(1, 312)=11.89 p<.001, η^2=0.03), Self-regard (F(1, 312)=11.54 p<.001, η^2=0.03) and Authenticity (F(1, 312)=8.50 p=.004, η^2=0.02).

There was one significant interaction between condition and group in Social Connectedness (F(2, 312)=3.17, p=.043, η^2=0.02) (see Fig. 2). Post-hoc comparisons showed that in the non-autistic group, Social Connectedness was significantly higher for the nostalgia compared to the control condition (p<.001, g=0.86), representing a large effect. In contrast, the autistic diagnosed and autistic self-identified participants in the nostalgia condition did not report higher Social Connectedness compared to their counterparts in the control condition, respectively (p=.332) and (p=.923). There was no significant interaction between condition and group in Positive Affect (F(2, 312)=0.64, p=.526), Self-regard (F (2, 312)=1.86, p=.158) or Authenticity (F(2, 312)=2.00, p=.137), therefore we did not carry out post-hoc comparisons in these variables.

In order to test our first hypothesis, we then conducted four separate ANCOVAs within the non-autistic group only (n=174), to test for differences in the three SFNS subscales (Positive Affect, Social Connectedness and Self-regard) and Authenticity between the nostalgia and control conditions with group as an independent variable. In all SFNS subscales (Social Connectedness is already reported above) and Authenticity, there was a significant effect of condition. That is, non-autistic participants in the nostalgia (versus control) condition reported significantly higher Positive Affect (F(1, 171)=7.64, p=.006, η^2=0.04), representing a small to medium effect; Self-
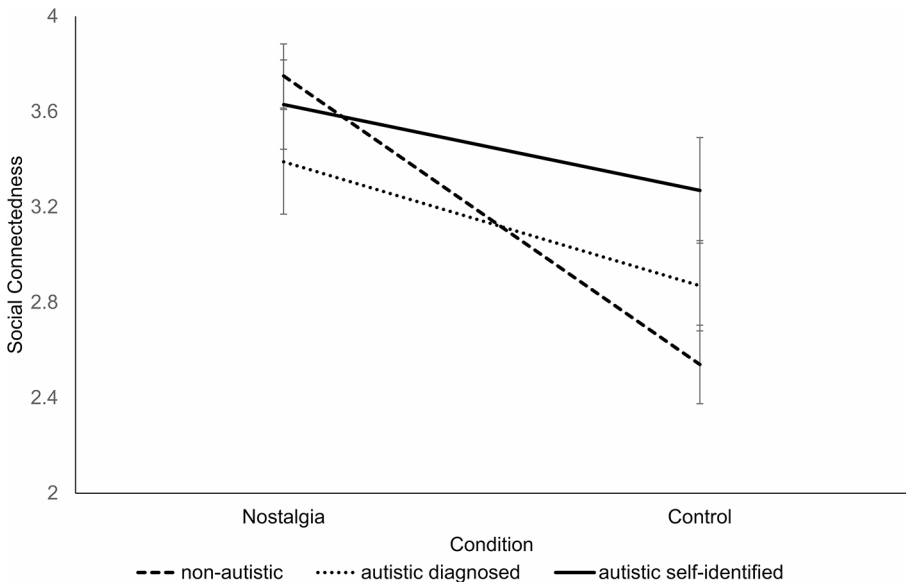

Fig. 2 A line graph showing a significant interaction between condition and group in Social Connectedness (error bars represent standard error)

regard ($F(1, 171)=9.75$, $p=.002$, $\eta^2=0.05$), representing a small to medium effect; and Authenticity ($F(1, 171)=24.67$, $p<.001$, $\eta^2=0.13$), representing a large effect.

There was no significant effect of age in any of these variables – Positive Affect ($F (1, 171)=1.16$, $p=.283$), Social Connectedness ($F(1, 171)=2.46$, $p=.119$), Self-regard ($F(1, 171)=3.01$, $p=.084$), Authenticity ($F(1, 171)=0.76$, $p=.384$).

2.1.2 Research Question 2: Effects of Music Evoked Nostalgia on Mood

Here we report the results for the nostalgia condition only. See Supplementary materials for parallel analyses in the control condition.

Mean mood scores - Positive Activated (PA), Positive Deactivated (PD), Negative Activated (NA) and Negative Deactivated (ND) - for the two timepoints (pre- and post- manipulation) as well as change in mood scores for each mood category are presented in Table 3 for participants in the nostalgia condition only for each participant group.

In order to assess change of mood across the two timepoints (pre- and post- manipulation), we conducted four repeated measures ANOVA tests, with participants in the nostalgia condition only ($n=162$), with group as an independent variable and age as a covariate, comparing pre- and post-mood scores in PA, PD, NA and ND.

Within subjects, in PA, PD, NA and ND, there was no significant effect of time-point, respectively ($F(1, 157)=0.04$, $p=.837$), ($F (1, 157)=0.75$, $p=.389$), ($F(1, 157)=0.26$, $p=.609$) and ($F(1, 157)=0.43$, $p=.511$). That is, within the whole cohort participants did not demonstrate a significant change in PA, PD, NA or ND mood after compared to before listening to their chosen nostalgic song.

Table 3 Pre, post and change in mean mood scores (with standard deviations) – positive activated (PA), positive deactivated (PD), negative activated (NA) and negative deactivated (ND) by group (nostalgia condition only $n=162$)

	non-autistic ($n=91$) M (SD)	autistic diagnosed ($n=34$) M (SD)	autistic self-identified ($n=37$) M (SD)
	Positive Activated (PA)		
Pre	51.16 (21.06)	39.13 (16.14)	44.46 (23.68)
Post	54.37 (24.23)	44.34 (22.14)	48.43 (25.42)
Change	3.21 (19.23)	5.21 (15.85)	3.97 (11.44)
	Positive Deactivated (PD)		
Pre	63.08 (17.98)	48.06 (18.62)	51.53 (20.95)
Post	61.94 (18.26)	50.10 (21.23)	54.20 (22.03)
Change	-1.14 (17.86)	2.04 (17.03)	2.68 (15.64)
	Negative Activated (NA)		
Pre	49.89 (25.10)	43.87 (20.91)	53.78 (25.51)
Post	42.03 (27.46)	46.56 (22.91)	47.03 (27.44)
Change	-7.86 (19.28)	2.69 (13.32)	-6.76 (14.06)
	Negative Deactivated (ND)		
Pre	33.67 (25.45)	50.71 (23.93)	52.57 (24.18)
Post	37.90 (26.31)	48.75 (25.25)	53.15 (27.68)
Change	4.23 (24.24)	-1.96 (18.19)	0.58 (15.16)

There was also no significant interaction between timepoint and group in PA ($F(2$, 157)=0.24, p=.789), in PD ($F(2, 157)$=1.04, p=.357) or in ND ($F(2, 157)$=1.31, p=.273), which suggests that the pattern of no significant effect of timepoint was the same across the individual groups. However, in NA, there was a significant interaction between timepoint and group ($F(2, 157)$=4.63, p=.011, η^2=0.002). Post-hoc comparisons comparing pre- and post-mood scores showed that the non-autistic group demonstrated a significant change (reduction) in NA (p<.001, g=0.29), representing a small effect but the autistic diagnosed (p=.933) and the autistic self-identified group (p=.183) did not.

Within subjects, there was no significant interaction between timepoint and age in PA ($F(1, 157)$=0.23, p=.632), in PD ($F(1, 157)$=0.90, p=.344), in NA ($F(1, 157)$=0.06, p=.800), or in ND ($F(1, 157)$=0.37, p=.542).

Between subjects, there was a significant effect of group in both PD ($F(2, 157)$=7.06, p=.001, η^2=0.04) and ND ($F(1, 157)$=8.19, p=<0.001, η^2=0.04), both representing small to medium effects. Post hoc comparisons in PD scores showed that there was a significant difference in PD scores between the non-autistic and both the autistic self-identified (p=.015) and the autistic diagnosed group (p=.006), i.e. both autistic groups reported lower PD scores in general. Post hoc comparisons in ND scores revealed a significant difference between the non-autistic and both the autistic diagnosed group (p=.010) and the autistic self-identified group (p=.002) but no significant difference in change of ND scores between the two autistic groups. There was no significant main effect of group in PA ($F(1, 157)$=2.03, p=.074) or NA ($F(2, 157)$=0.28, p=.754). There was a significant effect of age in PD ($F(1, 157)$=5.10, p=.025, η^2=0.01), but not in PA ($F(1, 157)$=2.03, p=.156), NA ($F(1, 157)$=0.01, p=.938) or ND ($F(1, 157)$=0.07, p=.795) (see Fig. 3a, b, c and d).
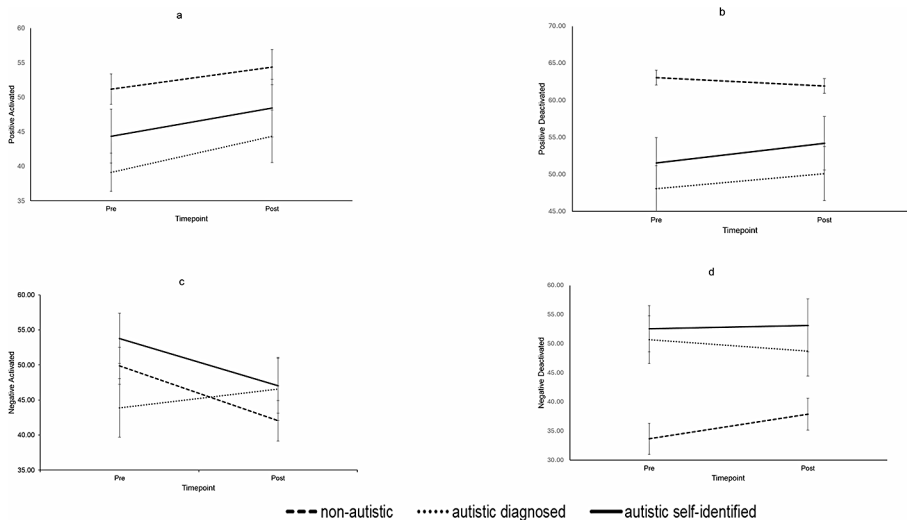

Fig. 3 Line graphs of Pre- and Post Mood Scores in Positive Activated (**a**), Positive Deactivated (**b**), Negative Activated (**c**) and Negative Deactivated (**d**) by participant group (error bars represent standard error)

2.1.3 Research Question 3: Rumination, Reflection, Autistic Traits, Age and Depression diagnosis as predictors of change in mood

Here we report the results for the nostalgia condition only. See Supplementary materials for parallel analyses in the control condition.

Mean scores for Rumination and Reflection for the whole cohort by group are presented in Table 1 above. Here we present the mean scores and standard deviations for Rumination and Reflection in the nostalgia condition only ($n=155$) in the three participant groups. Rumination: non-autistic (M 3.47, SD 0.74), autistic diagnosed (M 3.26, SD 0.73) and autistic self-identified (M 3.42, SD 0.59). Reflection: (M 3.60, SD 0.68), autistic diagnosed (M 3.25, SD 0.55) and autistic self-identified (M 3.33, SD 0.50).

We conducted linear regression analyses with participants in the nostalgia condition only ($n=155$) to assess predictors (Rumination, Reflection, Autistic Traits, Age and Depression diagnosis) of the four change of mood scores (1) change in PA; (2) change in NA; (3) change in PD and (4) change in ND. All four first regression models (Model 1 without Autistic traits) were non-significant: (1) change in PA ($adjR^2 = -0.01$, $F(4, 149)=0.46$, $p=.768$). (2) change in PD ($adjR^2=0.01$, $F(4, 149)=1.52$, $p=.199$). (3) change in NA ($adjR^2=0.01$, $F(4, 149)=1.20$, $p=.312$). (4) change in ND ($adjR^2 = -0.00$, $F(4, 149)=0.90$, $p=.469$).

We then assessed any significant changes across Models 1 and 2 (with and without Autistic traits). There was a significant F change score when comparing change in ND models ($adjR^2=0.05$, $F(1, 148)=8.42$, $p=.004$), suggesting that level of Autistic trait contributed to change in ND scores above and beyond the other key variables. Higher autistic trait scores were associated with a lower change in ND scores. However, there were no significant F change scores when comparing the other regression models: change in PA ($adjR^2=0.02$, $F(1, 148)=3.53$, $p=.062$), change in PD ($adjR^2=0.02$, $F(1, 148)=3.27$, $p=.073$), change in NA ($adjR^2=0.01$, $F(1, 148)=2.30$, $p=.131$), suggesting that level of Autistic trait does not impact on change in PA, PD or NA above and beyond the other predictors.

Rumination was predictive of higher change in ND mood scores. That is, people who scored higher in rumination had a higher tendency to become more disappointed/sad after listening to a nostalgic song than people who scored lower in Rumination (see Fig. 4a). By contrast, Autistic traits negatively predicted change in ND mood.
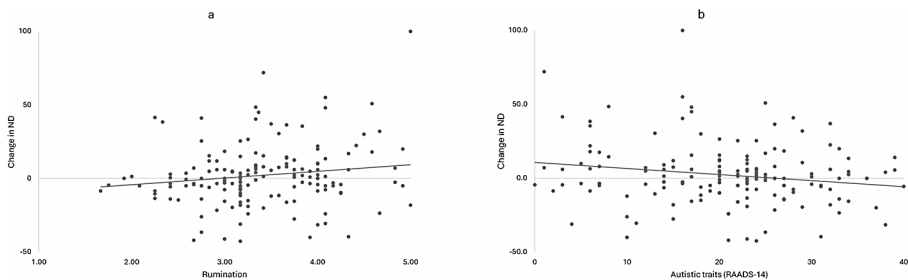

Fig. 4 Scatterplots showing Rumination and Autistic traits as predictors of change in Negative Deactivated mood

That is, people higher in autistic traits were less susceptible to feeling more disappointed/sad after listening to a nostalgic song (see Fig. 4b below). See Table 4 for Model 1 and 2 linear regression coefficients.

2.1.4 Research Question 4: Rumination, Reflection, Autistic Traits, Age and Depression Diagnosis as Predictors of State Wellbeing and Authenticity

Here we report the results for the nostalgia condition only. See Supplementary materials for parallel analyses in the control condition.

We conducted linear regression analyses with participants in the nostalgia condition only ($n=155$) to assess predictors (Rumination, Reflection, Autistic Traits, Age and Depression diagnosis) of the SFNS subscales (1) Positive Affect; (2) Social Connectedness; (3) Self-regard and also (4) Authenticity. All four Model 1s (without Autistic traits) were significant: (1) Positive Affect ($adjR^2=0.07$, $F(4, 149)=4.10$,

Table 4 Rumination, reflection, autistic traits, age and depression diagnosis as predictors of change in mood scores - model 1/Model 2 results (nostalgia condition only - $n=155$)

Model Coefficient	Estimate	Standard Error	Standardised Estimate	95% Confidence Intervals		p-value
				Lower	Upper	
Rumination and Reflection as predictors of change in Positive Activated						
Rumination	-1.00/-1.82	2.07/2.10	-0.04/-0.07	-0.21/-0.24	0.13/0.10	0.630/0.388
Reflection	-0.32/0.29	2.34/2.35	-0.01/0.01	-0.18/-0.16	0.16/0.18	0.893/0.901
Autistic traits	0.29	0.15	0.16	-0.01	0.33	0.062
Age	0.13/0.27	0.68/0.68	0.02/0.03	-0.15/-0.13	0.18/0.20	0.853/0.687
Depression diagnosis	-3.61/-4.74	2.94/2.98	-0.21/-0.28	-0.55/-0.62	0.13/0.07	0.222/0.114
Rumination and Reflection as predictors of change in Positive Deactivated						
Rumination	1.88/1.09	2.07/2.10	0.08/0.04	-0.09/-0.12	0.24/0.21	0.367/0.605
Reflection	-0.00/0.58	2.35/2.35	-0.00/0.02	-0.17/-0.15	0.17/0.19	0.999/0.805
Autistic traits	0.28	0.15	0.15	-0.01	0.32	0.073
Age	0.64/0.78	0.68/0.68	0.08/0.09	-0.08/-0.07	0.24/0.26	0.345/0.250
Depression diagnosis	6.53/5.44	2.95/2.99	0.37/0.31	0.04/-0.03	0.71/0.65	0.028*/0.071
Rumination and Reflection as predictors of change in Negative Activated						
Rumination	1.26/0.59	2.09/2.13	0.05/0.02	-0.12/-0.15	0.22/0.19	0.548/0.781
Reflection	-2.57/-2.08	2.37/2.38	-0.09/-0.08	-0.26/-0.25	0.08/0.10	0.279/0.384
Autistic traits	0.24	0.16	0.13	-0.04	0.30	0.131
Age	0.03/0.15	0.68/0.69	0.00/0.02	-0.16/-0.15	0.17/0.18	0.970/0.832
Depression diagnosis	4.98/4.05	2.97/3.02	0.28/0.23	-0.05/-0.11	0.62/0.57	0.096/0.182
Rumination and Reflection as predictors of change in Negative Deactivated						
Rumination	4.90/6.46	2.61/2.60	0.16/0.21	-0.01/0.04	0.33/0.38	0.063/0.014*
Reflection	-1.15/-2.31	2.95/2.91	-0.03/-0.07	-0.20/-0.24	0.14/0.10	0.699/0.429
Autistic traits	-0.55	0.19	-0.24	-0.41	-0.08	0.004**
Age	-0.11/-0.39	0.85/0.84	-0.01/-0.04	-0.17/-0.20	0.15/0.12	0.898/0.642
Depression diagnosis	-0.30/1.87	3.71/3.70	-0.01/0.09	-0.35/-0.25	0.32/0.42	0.936/0.615

Note: alpha values * $p<.05$ ** $p<.01$

$p=.003$). (2) Social Connectedness ($adjR^2=0.10$, $F(4, 149)=5.36$, $p<.001$). (3) Self-regard ($adjR^2=0.07$, $F(4, 149)=4.04$, $p=.004$). (4) Authenticity ($adjR^2=0.12$, $F(4, 149)=6.54$, $p<.001$).

We then assessed for any significant changes across Model 1 and 2 versions (with and without Autistic traits). There was a significant F change score when comparing Model 1 and 2 in Social Connectedness ($adjR^2=0.02$, $F(1, 148)=3.98$, $p=.048$), suggesting that level of Autistic trait contributed to Social Connectedness scores above and beyond the other key variables. Higher autistic trait scores were associated with higher Social connectedness. However, there were no significant F change scores when comparing the other regression models: Positive affect ($adjR^2=0.002$, $F(1, 148)=0.26$, $p=.607$). Self-regard ($adjR^2=0.01$, $F(1, 148)=2.25$, $p=.135$), Authenticity ($adjR^2=0.001$, $F(1, 148)=0.25$, $p=.613$), suggesting that level of Autistic trait does not impact on Positive Affect, Self-regard or Authenticity above and beyond the other key variables.

Rumination negatively predicted Self-regard within Model 2 only (with Autistic traits) but did not predict Positive Affect, Social Connectedness or Authenticity in either Model 1 or Model 2. Reflection positively predicted Social Connectedness, Self-regard and Authenticity in both Model 1 and 2 but did not predict Positive Affect. Autistic traits positively predicted Social Connectedness but did not predict Positive Affect, Self-regard or Authenticity. Depression diagnosis negatively predicted Positive Affect, Social Connectedness and Authenticity in both Model 1 and 2 but did not predict Self-regard. Age did not predict Positive Affect, Social Connectedness, Self-regard or Authenticity in either Model 1 or 2 (see Table 5 for linear regression coefficients for both Model 1 and 2).

3 Discussion

The first research question investigated whether participants who listened to a nostalgic (versus a non-nostalgic) song would report higher state wellbeing and authenticity. Both within the whole cohort, and, as per our hypothesis, within the non-autistic group only, participants who listened to a nostalgic (versus a non-nostalgic) song reported higher positive affect, social connectedness, self-regard and authenticity. Our findings in relation to this first research question within the whole cohort and in the non-autistic group are consistent with those from other studies in the general population; music evoked nostalgia increased positive affect (Garrido, 2018), boosted feelings of social connectedness (Cheung et al., 2013; Routledge et al., 2011; Sedikides et al., 2016), promoted self-esteem (Cheung et al., 2013; Stephan et al., 2015) and nostalgia (not music evoked) fostered authenticity (Kelley et al., 2022). Importantly, a similar pattern was found within both autistic groups – music evoked nostalgia (versus control) increased positive affect, self-regard and authenticity. However, music evoked nostalgia did not significantly boost feelings of social connectedness in autistic individuals and reasons for this are unknown.

Nevertheless, results of the current study in relation to this first research question are important as they are the first to suggest that music evoked nostalgia (versus control) may increase state wellbeing and authenticity in autistic people. Although

Table 5 Rumination, reflection, autistic traits, age and depression diagnosis as predictors of SFNS subscales: (positive affect, Social Connectedness, Self-regard) and authenticity - model 1/model 2 (*n*=155)

Model Coefficient	Estimate	Standard Error	Standardised Estimate	95% Confidence Intervals		*p*-value
				Lower	Upper	
Predictors of Positive Affect						
Rumination	0.10/0.08	0.14/0.14	0.06/0.04	-0.10/-0.12	0.18/0.22	0.475/0.590
Reflection	0.14/0.12	0.16/0.16	0.07/0.07	-0.09/-0.10	0.24/0.23	0.370/0.435
Autistic traits	0.01	0.01	0.04	-0.12	0.21	0.607
Age	0.08/0.09	0.05/0.05	0.14/0.15	-0.01/-0.01	0.30/0.31	0.072/0.066
Depression diagnosis	-0.54/-0.56	0.20/0.20	-0.44/-0.46	-0.77/-0.79	-0.12/-0.13	0.007**/0.006**
Predictors of Social Connectedness						
Rumination	0.05/-0.02	0.14/0.15	0.02/-0.01	-0.13/-0.17	0.18/0.15	0.755/0.917
Reflection	0.43/0.48	0.16/0.16	0.22/0.24	0.06/0.08	0.38/0.40	0.009**/0.004**
Autistic traits	0.02	0.01	0.16	0.00	0.32	0.048*
Age	0.07/0.08	0.05/0.05	0.12/0.14	-0.03/-0.01	0.28/0.29	0.120/0.074
Depression diagnosis	-0.46/-0.55	0.21/0.21	-0.36/-0.43	-0.68/-0.75	-0.05/-0.11	0.025*/0.009**
Predictors of Self-regard						
Rumination	-0.27/-0.31	0.15/0.16	-0.14/-0.17	-0.30/-0.33	0.02/-0.00	0.088/0.048*
Reflection	0.52/0.55	0.17/0.18	0.25/0.26	0.08/0.10	0.41/0.43	0.003**/0.002**
Autistic traits	0.02	0.01	0.12	-0.04	0.29	0.135
Age	0.05/0.06	0.05/0.05	0.08/0.09	-0.08/-0.07	0.23/0.25	0.331/0.253
Depression diagnosis	-0.34/-0.41	0.22/0.22	-0.25/-0.30	-0.58/-0.63	0.07/0.02	0.123/0.070
Predictors of Authenticity						
Rumination	-0.08/-0.10	0.17/0.17	-0.04/-0.05	-0.19/-0.21	0.12/0.11	0.624/0.560
Reflection	0.75/0.77	0.19/0.19	0.32/0.33	0.16/0.17	0.48/0.49	<0.001***/<0.001***
Autistic traits	0.01	0.01	0.04	-0.12	0.20	0.613
Age	0.03/0.03	0.05/0.05	0.04/0.04	-0.11/-0.11	0.19/0.20	0.620/0.583
Depression diagnosis	-0.49/-0.52	0.24/0.24	-0.33/-0.35	-0.65/-0.67	-0.02/-0.03	0.038*/0.034*

Note: Alpha values * *p*<.05 ** *p*<.01 *** *p*<.001

these represent momentary boosts in mood and state wellbeing, they are nonetheless important. The Broaden-and-Build Theory of positive emotions proposes that such momentary boosts in positive emotion open the mind to new possibilities and aid us to develop lasting personal resources over time (Fredrickson, 2013). Hence, such momentary boosts of positive emotion may be important for autistic people in their daily lives to support them to deal with adversity. Furthermore, in relation to nostalgia boosting authenticity in autistic people, some researchers have suggested that feeling authentic may be especially important for stigmatized groups, who often conceal their true identity (Rivera et al., 2019), and many autistic do people feel stigmatized (Botha et al., 2022).

The second research question explored whether participants demonstrated a change of mood after listening to a nostalgic song. Within the whole cohort (but within the

nostalgia condition only), participants did not demonstrate any significant change in mood. Our findings here (within the whole cohort) are in line with those of Leunissen et al. (2021) who concluded that nostalgia has no significant effect on negative emotions. In contrast, within individual groups, we found that the non-autistic group in the nostalgia condition reported a significant reduction in negative activated mood (they became less stressed and tense) whereas the two autistic groups did not (this differed to findings in our parallel analyses in the control condition which showed no significant decrease in negative activated mood). In addition, our finding (across the whole cohort) that participants did not demonstrate a significant change in positive mood contrasts with findings from Leunissen et al. (2021) which showed that nostalgia increases a range of positive emotions and contrasts also to some degree with our own finding above from the first research question (that participants within individual groups - who listened to a nostalgic (versus a non-nostalgic) song reported increased positive affect). One potential reason to explain this lack of change of positive mood in the current study might be that participants did not spend long enough listening to a nostalgic song during the online survey. Although, to mitigate against this, we excluded all participants who spent less than 45 sec listening to their self-selected song. Alternatively, perhaps the visual analogue mood scale was not sensitive enough to detect this momentary change in positive mood.

The third research question assessed the role of rumination/reflection in predicting change of mood scores after listening to a nostalgic song. Our hypothesis – that rumination would be a significant predictor of negative change in mood scores within the whole cohort – was partially supported. After listening to a nostalgic song, whether participants were prone to rumination only impacted on change in negative deactivated mood. Participants who scored higher in rumination were more likely to report feeling increased disappointment/sadness after listening to a nostalgic song. This is similar to the findings of another study which suggested that for people with tendencies towards rumination, engaging in nostalgic memories may make them feel less happy (Garrido, 2018). In contrast, we found that, after listening to a nostalgic song, whether participants were prone to reflection had no impact on mood scores. However, trust in findings in relation to this third research question may be low. Our use of difference scores as predictors of change may introduce confounding issues that do not allow for meaningful interpretation (Könen & Karbach, 2021). Therefore, these results need to be interpreted with caution.

The third research question also assessed the role of autistic traits in predicting change of mood above and beyond the other key variables (rumination, reflection, diagnosis of depression and age). Here, we found that autistic traits only contributed to change in mood above and beyond the other key variables in negative deactivated scores. Participants in the nostalgia condition who scored higher in autistic traits also tended to report *lower* change in negative deactivated mood following the nostalgia manipulation, i.e. they were *less* susceptible to a rise in negative deactivated mood and reported feeling less disappointed and sad (this contrasted with the control condition whereby the level of Autistic trait did not impact on negative deactivated mood scores). In thinking about how autistic people might use nostalgia as a positive activity to support wellbeing, one could interpret this finding as positive – that is, people who are higher in autistic traits and by extension, in the current study, who are also

more likely to be autistic, might not respond adversely to nostalgic reflection. This finding could be due to differences in *need for affect* in individuals higher in autistic traits (Livingston et al., 2022). Individuals differ in their attitude to emotion, their inclination to engage in emotion and whether they tend to approach or avoid emotion (Appel et al., 2012). Livingston et al. (2022) found that people higher in autistic traits (particularly males) reported reduced need for affect and were less motivated to engage in emotion evoking situations or did not feel the need to experience strong emotions regularly, or they tended to find strong emotions overwhelming and tried to avoid them. Indeed, autistic accounts from qualitative research suggest that many autistic people experience emotions deeply, intensely, at full force – even to the point of experiencing emotions as physical pain (Lewis & Stevens, 2023). In this respect, it is possible that people higher in autistic traits in the current study may have avoided engaging in more negative emotions whilst reflecting on a nostalgic song and associated memory. In terms of nostalgia supporting the wellbeing of autistic people, avoidance of negative or strong emotions may be both an advantage and a disadvantage. As Livingston et al. (2022) point out, avoiding emotion may be adaptive for autistic people who tend to have more adverse childhood experiences (Bottema-Beutel et al., 2020) and more struggles in their transition to adulthood (Lee et al., 2022). On the other hand, avoiding thinking about more momentary negative feelings may be unhelpful for wellbeing in the long run. Avoidance behaviours are negatively associated with authenticity (Kernis & Goldman, 2006).

The last research question assessed the role of rumination/reflection again, but this time in nostalgia's influence on state wellbeing (positive affect, social connectedness, self-regard) and authenticity. Contrary to our hypothesis, after listening to a nostalgic song, participants who were higher in rumination did not report reduced positive affect. Rumination also had no impact on social connectedness or authenticity. However, after listening to a nostalgic song, participants who were more prone to rumination were more likely to report *reduced* self-regard. This differed somewhat to our findings in the control condition. Although participants who were higher in rumination did not report lower positive affect, they were more likely to report lower social connectedness, lower authenticity and lower self-regard. This finding in relation to lower self-esteem is unsurprising since rumination is associated with lower self-esteem (Kuster et al., 2012). However, as Trapnell and Campbell's (1999) construct 'Rumination/ruminative self-focus' is derived from the *neuroticism* component of the Five Factor Model of personality, our result above may be seen to contrast with findings from a study whereby people who were high and low in neuroticism were equally likely to benefit from nostalgia (Frankenbach et al., 2021). In contrast, in the current study, participants in the nostalgia condition who were more prone to reflection were more likely to report *increased* social connectedness, *increased* self-regard and *increased* authenticity (but not increased positive affect). This differed slightly from findings in the control condition. Although participants higher in reflection were more likely to report higher authenticity, they were not more likely to report higher self-regard or social connectedness. Our findings in relation to the nostalgia condition are also in line with those from the qualitative study mentioned above that highlighted that autistic people who were more reflective were more likely to reap

nostalgia's benefits to wellbeing compared to those who were more ruminative (Bennett et al., Submitted b).

Our findings in relation to the last research question also showed that the level of autistic traits contributed to increased feelings of social connectedness above and beyond the other key variables (rumination, reflection, diagnosis of depression and age). People who reported higher autistic traits, also tended to report higher social connectedness after listening to a nostalgic song but *not* after listening to a non-nostalgic song. We note that this finding differed from our first research question which showed that autistic participants who reflected on a nostalgic versus control song did not report increased social connectedness. Of course, we analysed the data in very different ways in our first and fourth research questions, (first comparing across group and condition and fourth using autistic trait in the nostalgia and control conditions separately). Why might people who are higher in autistic traits report higher social connectedness after listening to a nostalgic song? Seven of the items of the scale we used to assess autistic traits (RAADS-14) measure difficulties in social relatedness. Despite often wanting social connections and friendships, individuals who are higher in autistic traits and individuals with a diagnosis of autism are more likely to report reduced social connectedness in their current lives (Stice & Lavner, 2019; Umagami et al., 2022). Might then nostalgic memories of times of social connectedness be especially meaningful for people higher in autistic traits or autistic people? In the qualitative study by Bennett et al., nostalgic memories of close others and of social connectedness were extremely important to young autistic adults.

3.1 Limitations

We acknowledge the limitations of our study. First, our piece of music was not consistent within the nostalgia and control conditions (Routledge et al., 2011). However, YouTube features highly in the lives of many young adults and the fact that participants were able to self-select a piece of music from YouTube potentially made the study more relevant and enjoyable for participants. Second, it's possible that participants in the nostalgia condition reaped wellbeing benefits simply because they were more familiar with their song (Barrett et al., 2010), compared to those in the control condition who were asked to choose a more unfamiliar song. Our rationale for choosing a less familiar song as part of the control condition was so that we could be sure that this song would *not* evoke nostalgia. It is equally possible that participants in the nostalgia condition reaped benefits to wellbeing because they liked the song they chose, as opposed to those in the control condition who may have had to listen to a song that they did not enjoy so much. Although, with respect to liking, it might be possible for one to feel nostalgic about a piece of music but not necessarily like it – rather the nostalgic music is a reminder of something meaningful from that time. Nevertheless, future work could consider familiarity or liking when comparing the effects of nostalgic versus non-nostalgic songs. Third, relates to the nature and diversity of participants. We did not verify autism diagnoses and therefore it's possible that not all the participants in the autistic diagnosed group were autistic. However, both autistic groups reported significantly higher autistic traits compared to the non-autistic group. Although we collected the country of residency and the occupation of

participants (which showed variation), we did not collect the ethnicity of participants and therefore the diversity of ethnicity is unknown. In addition, as our survey was conducted online, our sample may be limited to those who have access and technological skills to use the internet and may not be representative of the broad range of autistic experiences.

Lastly, we did not assess differences in how people may experience emotion, such as *alexithymia* (difficulty in identifying, interpreting and describing one's *own* emotions) or the aforementioned need for affect. Alexithymia is significantly increased in autistic people (Kinnaird et al., 2019). Such differences may have impacted on how individuals either reported or were able to report about their mood and feelings and may explain to some degree why many autistic individuals did not report feeling more nostalgic after listening to a nostalgic song (according to the nostalgia manipulation check). On the one hand one might be tempted to conclude that the nostalgia manipulation did not work as intended with the autistic groups. However, the nostalgia manipulation did work as intended in that it resulted in a variety of benefits to state wellbeing for autistic participants. We used a nostalgia manipulation check which is similar to that often used in other nostalgia studies. This issue in relation to the nostalgia manipulation check could be attributed to affective differences in autistic people such as alexithymia or need for affect. Perhaps, as nostalgia is a complex, mixed emotion, some autistic participants were unsure how they felt when asked after the manipulation. Perhaps they had difficulty in identifying and labelling their feelings as nostalgic. Alternatively, perhaps autistic participants did experience nostalgic feelings but just not as deeply as the non-autistic group (autistic participants in the nostalgia compared to the control condition did report higher nostalgic feelings, but not *significantly* so). Or perhaps they found strong nostalgic emotions overwhelming and so shied away from them. In sum, there could be multiple explanations for this difference. More recent research in the field of affective science may add nuance to this discussion. The classical view of emotion assumes that emotions are natural entities that reside within the brain and that such emotions are triggered which give rise to a distinct pattern of responses (Feldman Barrett, 2006). However, this classical view of emotion has been superseded by the Theory of Constructed Emotion (Feldman Barrett, 2017). This theory argues that when people experience a feeling, they categorise the experience based on prior knowledge, i.e., the brain actively constructs emotions based on social and cultural norms. In line with this theory, researchers argue that how we experience emotions varies across instances, situations, individuals, societies and cultures (Feldman Barrett & Westlin, 2021; Mesquita, 2022). Therefore, it may be that different groups of people will experience nostalgic feelings differently, highlighting the importance of not applying the one-size-fits-all approach. Perhaps also, the nostalgia manipulation check itself was unsuitable for autistic people and could have been worded in a different way, without the word *nostalgia*, potentially drawing on a number of aspects in relation to the distinct appraisal profile of nostalgia, i.e. it involves pleasant feelings, irretrievable loss, positivity and reflection (Van Tilburg et al., 2018, 2019). Future studies assessing nostalgia's effects on wellbeing in autistic people should incorporate alexithymia or need for affect, although measuring such concepts is difficult as people may lack insight into understanding their own emotional skills (Huggins et al., 2020).

3.2 Implications

In the general population, research testing nostalgia interventions has shown promising results in enhancing wellbeing over time (Layous et al., 2021; Zhou et al., 2021). In addition, other researchers have put forward that nostalgia could be used as a positive activity that people can do independently to support their wellbeing in their daily lives (Layous & Kurtz, 2022; Lyubomirsky, 2008). Findings from the current study offer support for the idea of using nostalgia as a positive activity that people in the general population can do independently to support their wellbeing. Insights from the current study also contribute to our understanding of how different forms of self-attentiveness may impact on the nostalgic experience and are useful within both the general and autistic populations. Findings suggest that people who are more reflective (versus ruminative) may stand to benefit more from nostalgia interventions/positive activities. Furthermore, this study contributes to our understanding of how autistic people experience emotion, specifically the emotion of nostalgia. Although the autistic experience of this emotion may be different in some ways, in other ways, the *effects* of the nostalgic experience on state wellbeing and authenticity appear very similar to the non-autistic experience. A recent roundtable discussion concluded that positive activities, such as cultivating positive emotions, may be useful to support the wellbeing of autistic people (Wright et al., 2024). Indeed, autistic people already use different forms of music in their everyday lives to support themselves in a number of ways, such as to manage mood, to regulate emotions, to build their identity and to connect with others socially (Kirby & Burland, 2022). Findings from the current study suggest that listening to nostalgic music could also support autistic people to manage their mood. In addition, findings suggest that listening to and reflecting on nostalgic music offers benefits above and beyond those of listening to non-nostalgic music for autistic people – supporting self-esteem and authenticity. In this respect, nostalgia can be seen as a naturally occurring tool to support wellbeing. Furthermore, given that autistic individuals are at risk of experiencing increased adverse, stressful and traumatic events (Lobregt-van Buuren et al., 2021) and increased sensory overload (MacLennan et al., 2021), it is also possible that autistic people could use nostalgia as a positive activity - a tool to help them to cope with these challenges in their daily lives that arise from living in the non-autistic social world. Further research would be useful, exploring nostalgia's restorative powers (Wildschut & Sedikides, 2022) in autistic people, as well as examining nostalgia's potential benefits testing other forms of nostalgia inductions and with older autistic individuals too.

4 Conclusion

This study advances our understanding of the autistic experience of the emotion of nostalgia and is the first to show that music evoked nostalgia (compared to control) boosts state wellbeing and authenticity in autistic as well as in non-autistic individuals. In addition, results indicate that reflective individuals who engage in music evoked nostalgia are more likely to reap benefits to their state wellbeing (increased social connectedness, self-regard and authenticity) and that ruminators are less likely

to reap benefits and are more likely to report lower self-esteem after engaging in nostalgia. Findings suggest that nostalgia functions as a naturally occurring tool which supports both the wellbeing of autistic and non-autistic individuals. Furthermore, depending on individual tendencies towards rumination and/or reflection, nostalgia could be viewed as a positive activity that autistic people could use to support wellbeing, aiding their day to day living in the non-autistic social world.

Declarations

Ethics Approval This study was performed in line with the principles of the 1964 Declaration of Helsinki. This study was approved by Oxford Brookes University's Research Ethics Committee on 05/07/23, no 231711.

Consent to Participate Informed consent was obtained from all participants included in the study.

Competing Interests The authors have no relevant financial or non-financial interests to disclose.

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