


Arts, Culture & the Brain

A literature review and new
epidemiological analyses

January 2022

Dr Jessica K Bone & Dr Daisy Fancourt




This report is part of a research project funded by Arts Council England (grant INVF-00404365) focused on arts and cultural engagement and the brain.

Questions about this report may be directed to:

Dr Daisy Fancourt
Associate Professor of Psychobiology & Epidemiology Research
Department of Behavioural Science and Health
Institute of Epidemiology & Health Care
University College London
1-19 Torrington Place, London, WC1E 7HB

Suggested citation:



Bone, JK & Fancourt, D. 2022. Arts, Culture & the Brain: A literature review and new epidemiological analyses. London: Arts Council England.

Contents

Executive summary	1
1 Introduction	2
2 Methods	3
3 Subjective wellbeing	4
3.1 Literature review.....	4
3.2 New analyses.....	8
4 Psychological capabilities	13
4.1 Literature review.....	13
4.2 New analyses.....	14
5 Neurophysiology	16
5.1 Literature review.....	16
6 Motivational processes	19
6.1 Literature review.....	19
6.2 New analyses.....	22
7 Discussion	25
7.1 Implications for arts organisations	26
7.2 Priorities for future research	27
7.3 Conclusion.....	28
Acknowledgements	28
References	28
Appendix	41
List of papers	41

Executive summary

In this report, we provide an overview of the current evidence on the associations between arts and cultural engagement and the brain, and we also add to this evidence, conducting our own new analyses of cohort data.

We performed a comprehensive review of the brain-based mechanisms of action that could link arts engagement to health. We grouped these mechanisms within four domains: subjective wellbeing, psychological capabilities, neurophysiology, and motivational processes. To date, the strongest evidence is for the associations between arts engagement and subjective wellbeing. Engaging in receptive and participatory arts activities can lead to subsequent improvements in wellbeing, even after accounting for previous levels of wellbeing and a wide range of confounders. There is also extensive evidence that arts engagement is associated with changes in psychological capabilities and motivational processes in children, adolescents, adults, and older adults, ranging from the development of behaviour to cognitive decline. In contrast, evidence for the association between arts engagement and neurophysiology is the weakest of the domains we reviewed. Literature in this domain has largely focused on the effects of music and dance, with a reliance on inadequate experimental studies, and has not yet explored other forms of arts engagement in detail. The potential effects of arts engagement on neurophysiology in the general population thus remain unclear.

We have also outlined the findings of new analyses, undertaken to address the limitations of research to date. Across nine studies, we used data from cohort studies with large representative samples and long-term follow-ups. We tested a range of brain-based mechanisms of action that could link arts engagement to mental and physical health outcomes. We demonstrated that the associations between various forms of arts engagement and subjective wellbeing are present across diverse subgroups of the population, such as people of different ages, with specific medical conditions, and living in different areas. However, after using more sophisticated methods to account for confounding, we found that participation in community arts groups may only be associated with the positive, and not negative, elements of subjective wellbeing. We also demonstrated that not all artistic and creative activities are directly associated with subjective wellbeing, indicating that a variety of mechanisms link different forms of arts engagement to health. In terms of psychological capabilities, we addressed the issue that factors related to later life cognition are also likely to influence arts engagement, which may have led to an overestimation of the impacts of arts engagement on cognition in previous studies. We found no evidence for associations between arts engagement and cognition in older adults, demonstrating the importance of fully accounting for demographic and socioeconomic confounders when exploring arts engagement and the brain. Finally, addressing motivational processes, we demonstrated that engagement in extracurricular participatory and receptive arts activities during adolescence is associated with reductions in a range of behaviours that are often perceived as negative, including externalising behaviours, reportedly antisocial or criminalised behaviours, and substance use.

Overall, there is a large body of evidence on the associations between arts engagement and the brain, but more high-quality research is still needed. We have identified various priorities for future research, including the use of larger and more diverse samples, more systematic reviews, research that uses a complex systems approach, and further consideration of various contextual factors. Despite the limitations of the literature, a familiarity with this evidence base is important for arts organisations and policymakers, and we hope that it can be used to increase and diversify arts engagement in the general population.

1 Introduction

Over the past few decades, there has been heightened interest in the effects of arts and cultural participation on health. Recent studies have shown that arts engagement is associated with better overall mental health (1), lower risk of depression (2), enhanced positive health behaviours, reduced loneliness, better childhood adjustment (3), and reduced engagement in adverse health behaviours. Arts engagement has also been associated with lower risk of physical illness, including the onset and progression of chronic pain (4), frailty (5), age-related disability, dementia (6), and premature mortality. Notably, these findings are independent of demographic, socioeconomic, health-related, behavioural, and social confounders.

Despite this wealth of evidence, a key question that remains is how arts engagement can achieve such benefits. A recent review identified over 600 mechanisms linking arts and culture to health outcomes via psychological, neurological, biological, social, and behavioural pathways, which can be framed within a new theoretical model - the Multi-level Leisure Mechanisms Framework - for understanding the health benefits of the arts (7). However, many of these specific mechanisms have been tested only in small-scale studies, with limitations including small sample sizes, non-representative samples, exploration of short-term rather than long-term mechanisms, and a stronger focus on the effects of specific “interventions” rather than ubiquitous engagement in the arts as part of daily life. We lack research using large representative samples with long-term follow-up. One area in which these limitations are particularly apparent is in studies testing brain-based mechanisms that might link arts and culture to health outcomes.

In this report, we aimed to overview and extend the current evidence on the effects of arts and cultural engagement on the brain. While the arts are conceptually difficult to define, there are several cross-cultural characteristics recognized as fundamental to art. These include the art being valued in its own right (and not just as a utility), providing imaginative experiences for both the producer and audience, and comprising or provoking an emotional response (8). Arts and culture are commonly split into activities that are receptive, involving art that has been created and is now experienced by an audience, and those that are participatory, requiring creation and involvement in the arts (7,9,10). Arts engagement can also encompass broader creative activities that, whilst not always labelled as ‘arts’, share similar properties of creative skill and imagination, such as gardening, cooking, and other hobbies (7). We have used the Multi-level Leisure Mechanisms Framework to structure our review of mechanisms related to the brain, which we group under four domains of subjective wellbeing, psychological capabilities, neurophysiology, and motivational processes. These domains include a wide range of mechanisms within the brain that may be influenced by arts and cultural engagement. In this report, we focus on the potential impacts of the arts on each type of mechanism, rather than the downstream impacts of each mechanism on health. For each domain, we first review the literature, considering how the effects of engagement might differ depending on the mode and frequency of engagement and amongst different populations, and then report the findings of our new analyses undertaken to address some of the limitations of research to date. Finally, we consider the implications of our findings for arts organisations designing and delivering arts programmes, and then outline the key priorities for future research.

2 Methods

Within each of the four domains included in this report, we performed a series of literature reviews and primary empirical research. First, we performed a scoping review using keyword searches of the following databases: PubMed, Google Scholar, ScienceDirect, Taylor & Francis Online search engine, Scopus, and Web of Science. This review was not systematic but was intended to provide an overview of the current evidence on arts, culture, and the brain. Although we included all literature published in English, regardless of its region of origin, most of the included studies are from the UK and Europe.

Second, we performed a series of new analyses of cohort data from to address the limitations of existing evidence. In a total of nine studies, we used a range of analytical approaches to explore the associations between arts, culture, and the brain in large longitudinal datasets. This included causal inference methods and sophisticated statistical methods to identify the direction of associations and simulate intervention studies. Each paper used a unique approach, which we describe alongside a summary of the findings (see Appendix for full details). In these papers, we used data from six large cohort studies in the UK and US. These are described in more detail in the Appendix but consist of:

- Understanding Society: The UK Household Longitudinal Study (UKHLS), which follows over 50,000 individuals of all ages from 30,000 households annually (11).
- The Health and Retirement Study (HRS), which has followed over 22,000 US adults aged 50 and above every two years since 1992 (12).
- The Wisconsin Longitudinal Study (WLS), a longitudinal study of 10,317 high school graduates in the US state of Wisconsin that started in 1957 (13).
- The National Longitudinal Study of Adolescent to Adult Health (Add Health), which is a nationally representative study of 20,745 individuals aged 12 to 18 in the US in 1994 and followed to the present (14).
- The Early Childhood Longitudinal Study Kindergarten Class of 1998-9 (ECLS-K), a longitudinal study of 14,000 children in the US tracked from kindergarten through to age 14 (15).
- The National Education Longitudinal Study of 1988 (NELS:88), a nationally representative longitudinal study of over 24,000 adolescents aged 13-14 years in the US in 1988 and followed for 12 years (16).

In this report, we outline the findings from new analyses testing whether arts engagement is associated with aspects of subjective wellbeing, psychological capabilities, and motivational processes. For the fourth domain of mechanisms related to the brain (neurophysiology), research investigating factors related to neurological, biological, and physiological markers in cohort studies is very time-intensive due to the additional data processing required for analyses. These analyses therefore were not possible in the short timeframe of this project. Nonetheless, we have several studies involving such markers currently underway through other research grants, findings from which will be reported in 2023.

3 Subjective wellbeing

Subjective wellbeing is a multidimensional construct that is very closely tied to mental health. Broadly, it describes how people experience and appraise themselves and their lives overall, as well as specific activities and other parts of their lives. Subjective wellbeing is sometimes split into three components - experienced, evaluative, and eudaimonic wellbeing (17). Experienced wellbeing relates to people's emotional states and other factors that may be closely associated with mood and affective responses, such as the experience of stress and pleasure and emotion regulation. Evaluative wellbeing, in contrast, refers to judgments about how satisfying one's life is, which can be applied generally or to specific aspects of life, influencing work, relationships, and health. Finally, eudaimonic wellbeing relates to finding meaning and value in life, including a sense of purpose and personal growth and concepts such as flourishing, autonomy, resilience, and self-acceptance (17). Alongside these aspects of subjective wellbeing, social wellbeing (relating to peoples' subjective perceptions of their social relationships) is also highly relevant when considering the potential impacts of arts engagement. Given the interconnection of social wellbeing with subjective wellbeing, we chose to include social wellbeing in this report.

3.1 Literature review

Experienced Wellbeing

One aspect of subjective wellbeing is the elicitation of affective responses, such as feeling positive and negative emotions, stress, pleasure, and changes in mood, often referred to as experienced wellbeing (17). There is extensive evidence that arts engagement can enhance experienced wellbeing, from systematic reviews, randomised controlled trials (RCTs), other intervention studies, and large observational studies. For example, a systematic review found that regular participation in community-based music and singing programmes can enhance and maintain subjective wellbeing for young, middle-aged, and older adults (18). Another review found that receptive cultural engagement is associated with greater happiness and positive affect and reduced negative affect and low mood for older adults (19). Findings from large observational studies of varied forms of arts engagement are also similar. In older adults, participating in community education, arts, or music classes was associated with lower negative affect (but not positive affect) measured ten years later (1) and doing creative hobbies, music, art, theatre, reading, or writing was associated with greater happiness six years later (20). However, longitudinal associations with experienced wellbeing may require sustained arts engagement over several years (21). In other words, the arts may be a "perishable commodity"; if people engage but then cease their engagement, the benefits associated may also atrophy. Further, benefits may require people to be satisfied with their engagement (22). Frequency and diversity of arts engagement might also be more important than the total time spent on arts activities (22). In addition to improving mood, meta-analyses have demonstrated that listening to music or singing can decrease stress, measured both physiologically and psychologically, in a variety of settings for healthy individuals, people with cancer, and people awaiting surgery (23,24).

Emotion regulation is important in determining subjective wellbeing, as it influences the intensity, duration, and type of emotion experienced, allowing people to manage their emotional experiences and adapt to daily life (25). It involves strategies such as distraction, detachment, acceptance, and problem solving. Although there is extensive evidence that arts engagement influences our emotions, the arts have only recently been recognised as tools for regulating emotions. A novel questionnaire demonstrated that arts engagement can

influence various emotional regulation strategies, from avoidance (including distraction, suppression, and detachment from feelings or problem) to approach (acceptance, reappraisal, and problem solving) and to development of the self (26). Historically, studies of arts engagement and emotion regulation have relied on small randomised controlled trials (RCTs) of university students. These have shown that drawing, writing, listening to music, and making art can be used to reduce negative mood, particularly when used as a distraction strategy or to think in a more rational way, rather than as a way of venting emotions (27–31). More recently, larger observational studies with more representative samples have demonstrated that there may be sociodemographic differences in the use of arts engagement to regulate emotions, and that training in an artistic activity, regular engagement, and enjoyment are all associated with a greater ability to regulate emotions (32). Additionally, despite often having impairments in emotion regulation, people with depression still experience benefits of arts engagement for emotion regulation (33).

Evaluative wellbeing

Arts engagement may enhance evaluative wellbeing, allowing people to live more satisfying lives. One scoping review concluded that engaging in meaningful arts and crafts over the long-term could enhance life satisfaction for older adults (34). However, very few RCTs have tested the associations between arts engagement and life satisfaction. In one small RCT, participating in a creative dance programme improved life satisfaction for older women (35). In another RCT, an expressive arts intervention increased the life satisfaction of adolescent refugees (36). Other evidence for the role of arts engagement in life satisfaction comes from observational studies. Cross-sectionally, there is extensive evidence that many forms of arts engagement are associated with enhanced life satisfaction, including dancing and attending cultural events, art clubs, museums, and heritage sites (37–42). Longitudinally, visiting heritage sites, museums, galleries, and other cultural events has been associated with higher life satisfaction three years later (43). Additionally, participating in community education, arts, or music classes was associated with higher life satisfaction ten years later (1). In another study, sustained arts engagement over several years was associated with enhanced evaluative wellbeing in older adults (21). However, also in older adults, engaging in creative hobbies, music art or theatre, and reading or writing were not associated with life satisfaction six years later (20). These inconsistent findings could be a result of the bidirectional relationship between arts engagement and wellbeing; people with higher wellbeing are more likely to engage in the arts (44). Observational studies are also likely to be confounded by the demographic and socioeconomic factors that influence both arts engagement and wellbeing, and residual imbalances may bias results even after adjusting for potential confounders. Using more sophisticated methods to overcome these limitations, a study that matched adults who did and did not engage in the arts on a range of sociodemographic factors found that neither participatory nor receptive engagement were associated with life satisfaction three years later (45). However, in a study using fixed effects models, which only measure within-individual variation and thus account for differences between participants, increases in both participatory and receptive arts engagement were associated with higher life satisfaction three years later (46). It is thus likely that arts engagement does enhance evaluative wellbeing, but further research using more sophisticated methods is needed.

Eudaimonic wellbeing

There is a large body of literature on how the arts can enable flourishing, which encompasses aspects of meaning and purpose in life, autonomy, perceived control, and empowerment (47,48). A systematic review synthesising quantitative and qualitative intervention studies found that music, theatre, visual arts, and integrative arts were associated with positive changes in flourishing, including a range of emotional, social, and sense of self outcomes (49). This evidence from intervention studies is mainly supported by observational

studies. Cross-sectionally, there is observational evidence that both participating in creative activities and attending cultural events is associated with flourishing (50). In one study, access to a range of arts and cultural resources was the second most important determinant of psychological wellbeing, exceeding income, age, and education (51). Additionally, even after matching adults who did and did not engage in the arts on a range of sociodemographic factors, another study found that participatory engagement was associated with higher concurrent meaning in life (52). However, longitudinal evidence has been less consistent. In older adults, participating in community education, arts, or music classes was not associated with autonomy or self-realisation ten years later (1). This might be because the arts are a “perishable commodity”, as outlined above. In another study of older adults, frequent arts engagement sustained over a few years was associated with enhanced eudaimonic wellbeing ten years later, although short-term arts engagement did not demonstrate this longitudinal association (21).

Participating in the arts may also enhance resilience, another form of subjective wellbeing that describes one’s ability to recover from or adjust easily to change, through processes such as supporting coping, buffering stress, reducing catastrophising and suicidal ideation, and managing grief. Scoping reviews have outlined evidence for using the arts to support coping, including theatre arts and dramatic play for children to learn how to cope with adversities (35); use of musical activities, particularly listening to music, to cope with stress during adolescence (36); music interventions to reduce coping anxiety in people with cancer (37); and expressive arts such as music, movement, art making, and drama to cope with loss (38). However, several of these reviews have concluded that further evidence is needed, including from high-quality trials and longitudinal studies including more representative samples. There is currently limited evidence on the role of arts engagement in reducing catastrophising or suicidal ideation. A very small quasi-experimental study found that participating in a short-term creative art intervention after a traumatic event substantially reduced both suicidal ideation and attempts (39). However, some types of music listening, such as to songs about suicide or to certain genres with associated subcultures, may increase people’s risk of suicide (40). This can sometimes occur because the narratives in popular music provide opportunities for social learning, contributing to people’s beliefs and behaviour surrounding suicide, particularly when reinforced within music-based subcultures (40). Further research is thus needed to explore how the arts can influence catastrophising and suicidal ideation.

In addition to supporting coping, arts engagement may build psychological strength by enhancing self-confidence, vitality (being full of life and energy), and tolerance of uncertainty among other processes. A systematic review of both quantitative and qualitative evidence found that visual arts programmes can improve the self-confidence of adults with mental health conditions, although evidence was limited in terms of both scope and quality (41). Similarly, for both adults and children, a systematic review found quantitative and qualitative evidence that participating in dance programmes can increase self-confidence, despite the small number of studies on this construct and methodological issues of these studies (42). In adolescence, two reviews identified that a range of arts activities (music, dance, singing, drama, and visual arts) can all have a positive effect on self-confidence (43,44). Small experimental studies have also provided preliminary evidence that various activities, including dance, group drumming, producing visual art, and art therapy, can increase resilience in healthy adults, students, older adults, carers, mental health service users, and people who have experienced trauma (45–48). There is also higher quality evidence, from two small RCTs, that participating in a dance intervention and an arts activity chosen from films, concerts, art exhibitions visits, or singing in a choir can increase vitality (49,50).

Alongside enhancing self-confidence, arts engagement may influence peoples' overall sense of self by building their self-identity and developing self-acceptance. Through the arts, people may better understand themselves by learning about their own character, motives, and positive qualities, as well as enhancing their sense of self-worth and personal value. The reviews outlined in the previous paragraph also found that visual arts, dance programmes, and music, singing, and drama can enhance self-esteem and help children, adolescents, and adults to develop and appreciate their self-identity (59–62). Another systematic review of creative arts interventions for older adults identified common mechanisms of change across art, dance, drama, and music, which included an enhanced self-concept, as people developed more positive perceptions of themselves through these activities (69). For people receiving palliative care or in mental health rehabilitation settings, reviews have found that arts engagement could contribute to a newly discovered or a reframed sense of self as well as opportunities for self-expression (70,71). Evidence from population-based observational research also supports the findings of intervention studies, particularly for the development of self-esteem in young people. Listening to or playing music, drawing, painting, making things, and reading for enjoyment were all associated with higher levels of self-esteem after matching adolescents who did and did not participate on a range of sociodemographic factors (72). Additionally, childhood artistic ability was associated with self-esteem six years later (73) and attending music festivals strengthened young peoples' self-identity and increased self-acceptance (74).

Participation in the arts may also lead to personal transformation, supporting changes in identity and character development. Evidence in this area is mainly from qualitative or mixed-method studies that explore people's perceptions of their identities, growth, and other characteristics. A range of studies have investigated how the arts can be used to understand one's own narrative and identity, particularly surrounding perceptions of health and illness. In healthcare settings and nursing homes, artmaking and art therapy often aim to enable older adults to achieve personal growth by developing a personal narrative and allowing for reminiscence (75). Other reviews have found that using novels, poems, paintings, movies, and music can help people to understand and express the impact of their illness on them, including how it aligns with or changes their sense of self (76–78). There is also evidence that the way in which people choose to engage in the arts is linked to their identity: adolescents' music preferences, both in terms of listening and creating music, are relatively stable over time, and are consistently related to their personality characteristics, such as levels of extraversion, openness to experience, and conscientiousness (79,80). Associations between arts engagement and wellbeing may even differ according to peoples' personality characteristics. For example, engaging in the arts is more strongly associated with enhanced life satisfaction for those who are high in neuroticism than those low in neuroticism (81).

Social wellbeing

A final aspect of subjective wellbeing that may be influenced by arts engagement is social wellbeing. This includes loneliness and beliefs about the quantity and quality of support available from their social contacts and loneliness. In a large qualitative study, 82% of adults reported that arts engagement helped them feel connected to other people (82). Reviews have shown that participatory arts interventions can reduce loneliness and social isolation in older adults (83,84). For example, choir groups, making music, and arts and crafts programmes can decrease loneliness, facilitate new social relationships, and increase perceptions of closeness among participants (85–88). More frequent receptive arts engagement (e.g., going to a theatre or museum) is also associated with lower loneliness in older adults, both cross-sectionally and ten years later (89). Another observational study, which included adults of all ages but tested only cross-sectional associations, found that more receptive engagement was associated with less loneliness and more social

support (10). In contrast, participatory arts activities (e.g., painting or dancing) were not consistently associated with loneliness or social support (10). For young adults, music, recreational dance, and theatre groups can promote social connectedness and improve peer relationships (90–93). However, this evidence is mainly from small intervention studies that are prone to self-selection bias and often focus on specific diagnostic groups, only have short follow-up periods, and do not randomise participants or account for previous levels of social connectedness. Further evidence on the role of arts engagement for younger adults' social wellbeing is therefore needed.

3.2 New analyses

Having identified the gaps in existing evidence on arts engagement and subjective wellbeing, we built on this literature using a variety of approaches. Across five studies, we aimed to compare the potential benefits of different forms of arts engagement on subjective wellbeing, test whether there was still evidence for these associations after using more sophisticated methods to account for confounding, and finally evaluate whether associations were maintained across diverse subgroups of the population, such as people of different ages, with specific medical conditions, and living in different areas.

Engagement in leisure activities and depression in older adults in the United States: Longitudinal evidence from the Health and Retirement Study (Paper 1)

A wide range of participatory creative and arts-based leisure activities can be done in the home, many of which are inexpensive or free. Despite these activities potentially being more accessible than receptive cultural activities for older adults, there is less evidence on the associations between them and depression. Previous research has typically grouped a range of participatory creative activities, therefore combining conceptually distinct behaviours. We therefore investigated whether a diverse range of creative leisure activities, which differed in how much creativity they might involve as well as whether they were likely to be social or include physical activity, were associated with depression in older adults, both concurrently and two years later.

We included 19,183 participants from the Health and Retirement Study (HRS). We measured seven activities common among older adults: reading books, magazines, or newspapers; writing; baking or cooking something special; making clothes, knitting, or embroidery (sewing); working on a hobby or project; going to a sport, social, or other club; and attending meetings of non-religious organizations. We fitted population-averaged panel data models using generalized estimating equations to test whether doing these activities monthly or weekly, compared to not at all, was associated with a lower likelihood of meeting the criteria for depression concurrently and two years later (after accounting for previous levels of depression).

Frequency of engagement differed considerably across activities; 85% of participants read weekly, whereas only 4% attended meetings of non-religious organizations weekly. After reading, the most common activities were baking or cooking something special, working on a hobby or project, and writing. Concurrently, spending time on hobbies monthly or weekly and clubs monthly or weekly was associated with lower odds of depression (versus not engaging). Longitudinally, the odds of depression two years later were reduced by weekly baking/cooking, hobbies, and weekly or monthly club attendance. However, writing, reading, sewing, and attending non-religious organizations were not consistently associated with depression.

Overall, we found the strongest evidence that doing hobbies and being part of sport, social, or other clubs was associated with lower depression, both concurrently and two years later. Of the activities we included, those most often referred to as the arts (writing, reading, sewing) were not associated with depression. This contrasts with previous evidence that creative activities provide additional benefits for older adults over other leisure activities. Engaging in hobbies and clubs may have been particularly beneficial if they provided additional opportunities for socialising and exercise. Overall, our findings build on previous evidence by showing that specific participatory activities, with diverse characteristics, are differentially related to depression.

Associations between participation in community arts groups and aspects of wellbeing in older adults in the United States: A propensity score matching analysis (Paper 2)

There is a social gradient in both arts engagement and wellbeing that has not always been fully accounted for in previous research and may have led to an overestimation of the impact of arts engagement on wellbeing. Additionally, many previous studies have investigated the associations between arts engagement and one or two elements of wellbeing but have not fully considered the multidimensional nature of wellbeing. In this study, we tested whether participation in local community arts groups was associated with evaluative, experienced, and eudaimonic wellbeing in older adults.

We included 12,111 adults aged 50 and above who participated in the Health and Retirement Study (HRS) in 2014 or 2016. Participants were asked whether they had participated in a local community arts group (e.g., choir, dance, photography, theatre, or music group) in the last month. We addressed the issue that certain types of individuals may be more likely to participate in these groups by using propensity score matching (PSM). This involves estimating how likely each participant is to participate in arts groups based on a range of demographic, socioeconomic, and health-related factors, and matching those who did and did not participate in arts groups on these characteristics. In this way, PSM simulates a trial with the measured covariates randomized between groups, meaning any differences in wellbeing are more likely to be due to participation in arts groups, and not covariates. After matching, we tested differences in a range of subjective wellbeing outcomes measured concurrently and four years later: life satisfaction, positive and negative affect, purpose in life, mastery, and constraints on personal control.

Overall, 10% of participants reported attending a community arts group in the last month. After matching, we found evidence that participating in a community arts group was associated with higher life satisfaction, positive affect, purpose in life, and mastery. However, arts group participation was not associated with negative affect or constraints on personal control. These associations were all maintained four years later.

Our findings indicate that, after accounting for a range of demographic, socioeconomic, and health-related covariates, participating in a community arts group is associated with the positive, but not negative, aspects of evaluative, experienced, and eudaimonic wellbeing. This has not previously been demonstrated. It is possible that community arts groups provide sources of positive affect without reducing negative affect from other sources. Being part of these groups may also increase mastery by helping people to believe they are able to achieve their goals, without reducing perceptions of other obstacles in life (i.e., constraints on personal control). Our study builds on previous evidence by using more advanced statistical methods to address the issue that certain types of older adults may be more likely to participate in the arts and demonstrates that doing so may alter the evidence for associations between arts engagement and subjective wellbeing.

Arts engagement amongst people with chronic pain and their later life satisfaction and other health outcomes in the Health and Retirement Study (Paper 3)

Given the wide range of evidence for the benefits of arts engagement on wellbeing, recent guidelines advocate the use of the arts for people experiencing chronic pain. Creative activities may form part of a sustainable self-management framework and thus improve wellbeing outcomes for this population. In this study, we tested whether engaging in creative activities could improve wellbeing for older adults with chronic pain.

We included a sample of 1,037 adults aged 50 and above who reported bothersome pain on two consecutive waves of the Health and Retirement Study (HRS). We measured the frequency of engagement in creative activities, which included doing textile crafts, writing, and participation in community arts groups. We tested the associations of engagement with depression and life satisfaction two years later using logistic and ordinal logistic regression models respectively.

Although we initially found that people with chronic pain who did creative activities more than once a month were less likely to experience depression (compared to those who never participated), this association did not survive adjustment for socioeconomic position. We also found no evidence that frequency of participation in creative activities was associated with life satisfaction two years later for people. However, when limiting the sample to those experiencing moderate or severe chronic pain, people who did creative activities more than once a month were more likely to experience life satisfaction two years later. This association was independent of a range of demographic and socioeconomic covariates.

Overall, we found some evidence that more frequent participation in creative activities improved wellbeing two years later, particularly for people with moderate to severe chronic pain. Creative activities could have a protective role in maintaining independence, providing a source of life satisfaction, and improving mood for those experiencing more severe pain. Our findings provide preliminary evidence that creative activities are beneficial for wellbeing specifically for older adults with chronic pain.

Associations between community cultural engagement and life satisfaction, mental distress and mental health functioning using data from the UK Household Longitudinal Study: are associations moderated by area deprivation? (Paper 4)

In the UK, there is a social and geographical gradient in cultural engagement, in which engagement is higher among people living in more affluent areas. Most cultural assets are unevenly distributed and usually correspond with deprivation. Even when cultural assets are available, the characteristics of neighbourhoods, including local services and safety, affect whether people can engage in cultural activities. The association between cultural engagement and wellbeing may therefore differ according to geographical factors. Bringing cultural resources to deprived areas could have a greater impact on people's wellbeing than in affluent areas as, in more deprived areas, there may otherwise be limited assets and opportunities to build positive mental health. Therefore, in this study, we investigated whether the association between community cultural engagement and subsequent wellbeing differed according to area deprivation.

We included 14,783 participants who completed waves two and five of Understanding Society (UK Household Longitudinal Study; UKHLS). We measured frequency of attendance at cultural events and museums or

heritage sites at baseline, and three indicators of wellbeing three years later (life satisfaction, mental distress, and mental health functioning). We determined the relative deprivation of the neighbourhood in which participants lived with a score that considers income, employment, health deprivation and disability, education, skills and training, crime, barriers to housing and services and living environment. We used linear regression models (ordinary least squares regression) to test the associations between cultural engagement and subsequent wellbeing, and then tested whether these associations differed according to area deprivation.

After adjusting for sociodemographic factors, both types of cultural engagement were associated with a greater life satisfaction, lower mental distress, and higher mental health functioning. There was some evidence that the associations with mental distress and mental health functioning differed according to area deprivation. On average, individuals in the least deprived areas had the lowest mental distress and the highest mental health functioning scores, whereas those in the most deprived areas had the opposite. However, for those with more frequent cultural engagement, the difference in mental distress and mental health functioning was significantly smaller across varying levels of area deprivation. For mental distress, this difference occurred only for attending cultural events, whereas for mental health functioning, it was present for both attending cultural events and museums or heritage sites. This indicates that cultural engagement was more strongly related to wellbeing in more deprived areas.

Overall, in line with previous research, our findings show that cultural engagement was consistently and positively associated with subsequent subjective wellbeing. Although the magnitude of these associations was small, they were evident for over three years and even after considering levels of area deprivation, demographics, and socioeconomic factors. This suggests that, while social and geographical factors can influence engagement, cultural engagement is consistently associated with small improvements in mental wellbeing regardless of where people live. Notably, our analysis also shows that individuals who live in highly deprived areas may benefit more from cultural engagement in terms of their mental wellbeing. However, this does not mitigate the problem that individuals in areas of high deprivation are less likely to engage in cultural activities. Our findings thus demonstrate the importance of investment in areas of higher deprivation to improve engagement rates in such areas.

Cross-sectional and longitudinal associations between arts engagement, loneliness, and social support in adolescence (Paper 5)

Previous research in older adults has demonstrated that arts engagement holds promise for improving social wellbeing. However, no observational studies have yet investigated whether engaging in extracurricular arts activities is associated with social wellbeing during adolescence. This is particularly important as adolescents and young adults are at increased risk of feeling lonely and lacking social support. In this study, we explored whether arts engagement was associated with concurrent and subsequent loneliness and social support during adolescence.

We included 11,060 adolescents who participated in the National Longitudinal Study of Adolescent to Adult Health (Add Health) at baseline and one year later. We measured the number of extracurricular arts activities engaged in at baseline. Loneliness and perceived social support were measured at the same time point and one year later. We used logistic and linear regression to test whether engagement was associated with concurrent and subsequent loneliness and social support.

We found no evidence that arts engagement was associated with concurrent or subsequent loneliness. In contrast, engaging in more arts activities was associated with higher levels of social support, both concurrently and one year later. This association was independent of sociodemographic factors and whether adolescents engaged in other extracurricular activities, suggesting arts activities may provide additional benefits. However, once we adjusted the longitudinal model for previous levels of social support, there was no longer evidence for the association. This was likely due to the consistency of social support scores between waves one and two; the longitudinal association looked for a change in social support over one year, but little change was apparent in this time, let alone in association with arts engagement.

The lack of association with loneliness contrasts with previous evidence that participatory arts interventions reduce loneliness in older adults. This could be because of differences in the causes and subjective experience of loneliness between older adults and adolescents. However, it may also have been a result of the measure of loneliness used in Add Health, which was a single item asking how often adolescents felt lonely over the last week. This might not have been sensitive enough to detect any associations or may not have measured loneliness if adolescents did not realise that their feelings were symptomatic of being lonely. Further research should thus explore the associations between arts engagement and loneliness in adolescence in more detail. Given that arts engagement was associated with social support, even if not with a change in social support over time, our findings indicate that participating in extracurricular arts activities could enhance social support during adolescence. Further intervention studies are needed to explore whether arts activities can causally change social support over time.

4 Psychological capabilities

Psychological capabilities are the ways in which we interpret, understand, and interact with the world around us. Cognitive learning is one subset of psychological capabilities that includes information processing, memory, convergent and divergent thinking, reasoning, and use of heuristics. Psychological capabilities also include overarching cognitive processes, such as processing fluency, cognitive restructuring, curiosity, creativity, imagination, cognitive development in childhood and adolescence, and cognitive decline in later life. Emotional learning is another psychological capability, including skills such as emotion recognition, theory of mind, empathy, and compassion, all of which are important for successful social interactions.

4.1 Literature review

Reviews of a range of intervention studies demonstrate that participating in the arts, such as music training, dance, expressive writing, theatre arts, and visual arts, may lead to improvements in several aspects of cognitive learning, including memory, problem solving, and executive function, for people of all ages (94,95). There is also experimental evidence in adults that listening to music can enhance specific aspects of spatial-temporal performance (96), as well as divergent (creative) thinking, although it may not affect convergent thinking (97,98). Evidence from a small study comparing adult musicians to non-musicians also indicates that musical training enhanced information processing speed (99). Additionally, adults' self-reported interest, ability and performance of visual arts, literature, music and performing arts is correlated with their working memory, attention, and verbal intelligence scores (100). Although these associations are likely to be bidirectional, or may even result from reverse causation, there is longitudinal evidence that more frequent cultural engagement is associated with better memory up to ten years later in older adults (101,102). A meta-analysis also demonstrated that dance interventions benefit memory functioning in older adults, although may not improve executive functioning (103). In children, meta-analyses have demonstrated that dance instruction improves non-verbal reasoning (104) and active music instruction enhances concurrent spatial-temporal performance for the duration of the intervention (105,106). However, a more recent comparison of children with and without musical instrument training found no evidence that musical training was associated with better spatial skills, although it was associated with better auditory discrimination abilities, fine motor skills, vocabulary, and non-verbal reasoning (107). Existing evidence thus indicates that arts engagement could benefit a range of cognitive learning processes, although it is mainly from small studies that focus on participatory arts.

There is also a large body of evidence demonstrating that arts engagement can support overarching cognitive processes, particularly in older adults. For example, large observational studies have shown that more frequent cultural engagement is associated with lower rates of cognitive decline and dementia over the following 12 years (6,101,108). Additionally, having a hobby, reading books, dancing, and other creative activities (e.g., painting, sewing, playing music) have been linked to increased intellectual functioning, reduced cognitive decline, and lowered incidence of dementia and Alzheimer's disease over periods of up to 20 years (109–116). In line with this evidence, several systematic reviews have found that dance interventions, musical training, creative art or story-telling groups, and receptive cultural engagement have small to large effects on global cognition and prevent cognitive decline in older adults (19,103,117–120). In children, studies have focused on musical training and are generally limited by small non-representative samples with a lack of randomization or active control groups. Despite the inconsistent evidence due to methodological limitations,

a review and a meta-analysis have indicated that musical training has a small but significant positive effect on cognitive development of children, including overarching processes such as intelligence, executive functions, and phonological processing (121,122). A large quasi-experimental study also found evidence that both drama and visual arts interventions led to enhanced creativity for children, although it did not include a non-arts control group (123).

There is an assumption that arts engagement promotes prosocial behaviour and empathy, which was supported by analyses of four large longitudinal studies in the US; more engagement in visual arts, performing arts, or literature were all associated with increased prosocial behaviour up to seven years later (124). In a review, most studies showed a positive relationship between arts engagement, empathy, and prosocial behaviour (125), although associations differed according to art and engagement type, population, and study design. For example, a range of moderately sized to large experimental studies in adults have found that mindful dancing can increase compassion (126), listening to music from other cultures can increase theory of mind and reduce prejudice against other groups (127), and increased reading of some (but not all) types of fiction can enhance theory of mind and mentalising (128). A review found that engaging in “behavioural synchrony” (doing an action in time with others), such as in music or dance, can improve theory of mind, with most evidence from studies in children (129). Also in children, a very small study indicated that acting classes improved theory of mind (130), but this was not replicated in a larger study of a drama intervention (131), indicating that more research using robust methods is needed.

4.2 New analyses

Much of the evidence on psychological capabilities is from relatively small intervention studies or, in observational studies, rely on participants’ self-reports. There is limited population-level evidence due to the lack of objective tests of cognition in cohort studies. Additionally, factors related to later life cognition (e.g., age, gender, socioeconomic status, educational attainment) are likely to influence arts engagement, which may have led to an overestimation of the impacts of arts engagement on cognition in previous studies. Therefore, in one study, we used more advanced statistical methods to adjust for demographic and socioeconomic factors and compared whether different types of arts engagement (participatory versus receptive) were more beneficial for performance on objective tests of cognition in older adults.

Participatory and receptive arts engagement in older adults: Associations with cognition over a seven-year period (Paper 6)

In this study, we tested the associations between frequency of participatory and receptive arts engagement and cognition seven years later in older adults after accounting for demographic and socioeconomic factors. We included 4,344 participants from the Wisconsin Longitudinal Study (WLS), aged 63 to 67 years at baseline. We measured frequency of engagement in participatory and receptive arts activities and receptive art activities in 2004. Cognition was measured in 2004 and 2011 using six tests, grouped under memory and executive function (EF)/language. We aimed to address the issue that certain types of individuals may be more likely to engage in the arts by using inverse probability of treatment weighting (IPTW). This approach removes all confounding by a range of measured demographic and socioeconomic factors as well as baseline cognition, simulating a trial in which participants are randomized to different levels of arts engagement. We estimated

the difference in memory and EF/language seven years later between each level of participatory and receptive arts engagement (low, moderate, high) and no engagement.

Overall, 61% of participants reported engaging in participatory arts activities and 71% reported engaging in receptive arts activities. We found no evidence that doing either participatory or receptive arts was associated with subsequent memory or EF/language. In sensitivity analyses, we also found no evidence that vigorous physical activity was associated with subsequent memory or EF/language. These findings were robust to cross-validation using another statistical approach.

Our findings are surprising given evidence from other longitudinal population-based studies that more frequent participatory and receptive arts engagement is associated with better memory, EF, and intellectual functioning, and lower rates of cognitive decline, dementia, and Alzheimer's disease in older adults. However, this is the first study to use more sophisticated statistical techniques to account for demographic and socioeconomic factors, such as age, gender, socioeconomic status, and educational attainment, which influence both the frequency of arts engagement and later life cognition. Our findings are in line with previous evidence that socioeconomic factors explain much of the association between arts engagement and cognition. Additionally, some previous studies did not find consistent evidence for associations between arts engagement and all aspects of cognition. However, given the number of previous studies finding small but positive effects of arts engagement on cognition, it is unlikely that these associations are only the result of confounding by demographic and socioeconomic factors. We also did not find evidence for an association between doing vigorous physical activity and cognition, which is a well-established effect. These findings should be added to the existing evidence and do not negate positive findings presented elsewhere. Nonetheless, they highlight that the relationship between arts engagement and cognition at a population level is not a given. There are two important factors that should be considered when understanding the evidence base on arts and cognition. First, symptoms of cognitive decline, including prodromal symptoms of dementia, can have effects on behaviours years or even decades before symptoms manifest themselves. As such, individuals on course to experience declines in cognition may have already reduced their engagement in arts and cultural activities before older age. Further changes over the course of relatively short periods such as 7 years may not therefore register in research studies. Analyses that take account of much longer timescales are needed. Second, there is a social gradient in both arts engagement and cognitive decline. Whilst this gradient exists, disentangling the effects of the arts on cognition will be challenging. However, if this gradient can be reduced and more opportunities for arts engagement presented to individuals from lower socioeconomic backgrounds across the life course, there may be more opportunities for tangible effects on cognitive ageing.

5 Neurophysiology

Neurophysiology is the functioning of the brain and the nervous system. This includes the wide range of perceptual processes that occur in the brain, such as the auditory, visual, somatosensory, gustatory, olfactory, and vestibular systems. Brain activation can be studied to understand the regions and systems underlying these processes and overall levels of activity. Brain physiology is also important, including brain structure, grey and white matter density and integrity, and processes such as neuroplasticity, neurogenesis, and cognitive reserve. Other aspects of neurophysiology include biomarkers in the brain, such as neurotransmitters and indicators of inflammation, as well as arousal, as measured in electrodermal activity, activation of the autonomic nervous system, brainwaves, muscle tension, and nerve stimulation.

5.1 Literature review

Although there is much experimental evidence on the associations between arts engagement and neurophysiology, most studies in this area focus on music and dance. There is very limited evidence on other art forms and neurophysiology. Additionally, most research either i) compares professional musicians and dancers to those with no experience or ii) focusses on the immediate neural effects of listening to music and dancing. Both approaches have significant weaknesses. Comparing professionals to amateurs or those with no experience may be subject to confounding by a range of factors (e.g., socioeconomic status, education, gender, ethnicity), and reverse causality, whereby early differences in neurophysiology influenced whether individuals became professional musicians or dancers. Alongside this, whilst studying the neural activity underlying music listening and dancing is useful, it does not help us to understand whether arts engagement can elicit long-term changes in neurophysiology. Research into neurophysiology is limited by the resources required to study outcomes such as brain activation, physiology, and biomarkers, meaning this information is often not available in cohort studies. Using robust methods to explore the impact of arts engagement on long-term neurophysiological outcomes should thus be a priority for future research.

There is very little research on how arts engagement can affect the activation and functioning of perceptual processes in the brain. Two reviews have found strong evidence that musical training leads to robust, long-lasting benefits to auditory function, with the extent of training correlated with changes in the neural encoding of sound, auditory perception, and auditory-cognitive skills (132,133). Preliminary findings indicate that other forms of arts engagement, such as visual arts training, may not have as widespread impacts on auditory or general neural mechanisms as musical training (133). However, a recent study of older adults did find evidence that three months of music or visual art training both led to sustained changes in auditory responses, as well as short-term alterations to visual processing (134). Additionally, another review identified that dance movement therapy may affect perceptual processes such as mental representations of bodily functions (embodied cognition), awareness of bodily movement and location (proprioception), and sense of the internal state of the body (interoception; 135). This has been found only in relatively small experimental studies with adults, older adults, and young children (136–138).

Studies of brain activation can also show the influence of arts engagement on neurophysiology. Although we know that the effect of music on our emotions occurs through activation of the reward circuitry in the brain, the longer-term effects of listening to or making music on these neural mechanisms is unclear. Two reviews have found that, although there is robust evidence for concurrent activation in regions associated with reward

processing whilst listening to music (e.g., amygdala, nucleus accumbens, hypothalamus), existing research is primarily cross-sectional and correlational (139,140). An earlier review suggested that musical training might alter future neural activation when listening to music, but there were large individual differences in these effects (141). Another review, focusing on musicians, found that the degree of functional adaptation in the brain correlated with the intensity and duration of musical practice (142). However, it is still unclear whether these changes are the product of music training or other factors such as pre-existing biological markers of musicality. Similar effects have also been found in reviews of both short- and long-term dance training, with increased brain activity in the action observation network (mirror neuron system) and simulation network after learning to dance (143,144). Participating in dance may also help to increase neural synchrony, leading to neural oscillations that enable the synchronization of activity within and across brain regions, allowing for more effective communication in the brain (144). Differences in neural activation when watching recorded versus live dance performance also indicates that attending live performances could be more beneficial than watching them on a screen (143).

In addition to altering brain activation, sustained arts engagement may lead to changes in underlying brain physiology. Neuroplasticity is a broad term that describes the brain's ability to change with experience by modifying old and forming new neural connections. Several reviews have demonstrated that both dance and musical training are associated with enhanced neuroplasticity in young people, which is not surprising given that neuroplasticity is much higher in children and adolescents than later in life (120,144). There is also preliminary evidence that both dance and musical training can induce neuroplasticity in older adults, which may increase cognitive reserve and delay the onset of cognitive impairment or dementia (117,119,120,143–145). Evidence from a small experimental study even suggests that dancing is better than other repetitive physical activity for increasing neuroplasticity in older adults (146). However, for both dance and music, several months of engagement or more may be required to have lasting impacts on physiology (119,120). Other aspects of physiology that may be influenced by dancing include grey and white matter structure in sensory, motor, and auditory regions and the connections between these regions, enabling better and faster coordination between these areas, which may be required to dance (119,143–145).

Biomarkers in the brain, such as neurotransmitters and indicators of inflammation, may also be influenced by arts engagement. In a systematic review, both active music participation and listening to recorded music reduced levels of cortisol and generally seemed to decrease the monoamine neurotransmitters epinephrine and norepinephrine, which are associated with stress (147). Although the evidence for immunological responses to music was inconsistent, the cytokine interleukin-6 (inflammatory markers produced in response to infections and associated with mental health) changed significantly in response to music in four of the five studies reviewed, and most studies showed decreases in immunoglobulins (antibodies) following musical interventions (147). Several small experimental studies performed since this review have also demonstrated that group drumming and group singing can lead to reduced cortisol, immune enhancement, and reduced inflammatory activity as well as changes in oxytocin levels, a hormone known for its role in social bonding (64,148,149). Additionally, a recent systematic review found moderate to high quality evidence that performing arts, specifically music and dance, had positive effects on immune function (150).

The final aspect of neurophysiology we consider is arousal, as can be measured by activation of the autonomic nervous system. There is relatively little evidence on music and autonomic nervous system activation in comparison to the central nervous system (151). According to a systematic review, the physiological impact of making music may depend on whether it is stressful or not but, in general, music can decrease heart and

respiration rates and lower blood pressure, as well as improving expiratory flow in children with asthma (151). Both listening to music and music assistant relaxation techniques have been found to significantly decrease arousal due to stress in a meta-analysis (152). For those who consciously attend to and enjoy music, listening to recorded music can arouse “chills” that occur in the form of goosebumps or shivers down the spine (153,154). There is even some evidence from a small experiment that listening to relaxing music can speed up the recovery of fatigued muscles (155). Considering other forms of arts engagement, a small experimental study attempted to extend findings on arousal to receptive arts engagement, demonstrating that self-reported stress and arousal were both significantly reduced by visiting a museum, although levels of cortisol were unchanged (156). This indicates an interesting direction for future research.

6 Motivational processes

Motivational processes are the intentions, desires, goals, needs, and automatic responses that lead to human behaviour. They are much broader than the colloquial term “motivation”, often used to describe the subjective sense of desiring a change in the self or in the environment. Motivational processes can be divided into four broad categories: developing habits, behavioural decisions, behavioural drive, and behavioural development. Behavioural decisions include processes that explain why, when, and how people make choices. Relating to behavioural drive, research has explored behavioural activation (e.g., initiative, goal setting, self-efficacy), motivation (e.g., apathy, extrinsic and intrinsic motivation, expectations), and achievement (e.g., attaining goals, sense of reward). Behavioural development refers to the change in motivational processes early in life, from infant behaviours to school readiness to adaptive behaviour and academic outcomes later in childhood and adolescence.

6.1 Literature review

Several studies have shown that leisure engagement can affect the development of leisure-specific habits and thus longer-term engagement, but most focus on lifestyle interventions and physical activity (7). Specific to the arts, there is longitudinal evidence that people who gave more attention to reading in their youth, such as being library members for longer, have a higher reading level in adulthood and a stronger preference for literary books and novels, suggesting that reading early in life contributes to habit formation (157). More broadly, arts education during childhood is strongly associated with increased arts engagement later in life (158,159). Arts engagement can also influence other habits. For example, listening to music at bedtime has been shown to improve sleep quality, which may be because it replaces other bad habits (such as ruminating, or hyperarousal from activities such as screen time) and forms a new link between bedtime and sleep through classical conditioning (160). There is also experimental evidence that listening to music can facilitate reinforcement learning, which requires reward-based decision making, and previous musical experience may alter learning (161).

Arts engagement may also influence factors that support decision-making. For example, cognitive dissonance is an inconsistency between our attitudes and behaviours that causes discomfort and must be resolved. Two scoping reviews have identified a range of small experimental studies indicating that listening to music can help people to overcome cognitive dissonance and to hold contradictory attitudes or beliefs without discomfort (162,163). The arts can also be used to create cognitive dissonance and, in this way, lead to more critical thinking and challenge beliefs and stereotypes. Creative writing can cause cognitive dissonance if it includes inconsistencies between expectations and reality, or if it challenges the beliefs of the writer or reader (164,165). There is also qualitative evidence that unfamiliar behaviours or actions that differ to one’s attitudes in theatre can cause performers and audience members to experience cognitive dissonance that is internalised and leads to attitude change, with the potential to reduce biases and stereotypes about other ethnicities or genders (166).

Choosing behaviours is another important process, including response inhibition (suppressing actions that are inappropriate given the context or interfere with goal-driven behaviour) and inhibitory control (overcoming impulses or dominant behavioural responses to select a more appropriate behaviour). Two randomised controlled trials tested a music intervention in young children, showing that music significantly improved

response inhibition compared to a motor skills programme, visual arts intervention, or control condition (167,168). Additionally, a systematic review found that dance interventions can improve response inhibition in middle aged and older adults (119). Arts engagement may also impact behaviour by enhancing inhibitory control. In a review, formal musical training, active musical performance, and music-based interventions all enhanced inhibitory control (169). This has also been demonstrated in small experimental studies that focus on participatory arts activities such as music (170–172), theatre acting (173), and street dance (174).

Engaging in the arts may also influence mechanisms related to behavioural activation, such as by increasing self-efficacy, goal setting, and mental stimulation. A systematic review concluded that evidence for the impact of dance interventions on self-efficacy is poor because of the small number of studies on each construct, methodological limitations, and inconsistent findings (60). However, qualitative and some quantitative evidence does suggest that adults and children can benefit from dance in terms of self-efficacy (60,175,176). Small quasi-experimental studies have also found that group singing can enhance self-efficacy after bereavement and in postnatal depression (177,178). There is limited evidence on other forms of arts engagement. In a large observational study, visiting heritage sites, museums, galleries, and other cultural events was associated with higher self-efficacy three years later (43). For young people, sustained visual arts instruction and group creative writing have been found to increase self-efficacy in small quasi-experimental studies (179–181). Attending community arts festivals has also been reported to enhance self-efficacy by participants in a small qualitative study (182). Finally, in a study of people recovering from a stroke, both listening to audiobooks and music provided a source of mental stimulation (179), which could improve thinking about future behaviour and potential outcomes.

A growing number of intervention studies have demonstrated that arts engagement can influence aspects of motivation, including reducing apathy (a lack of interest, enthusiasm, or concern) and enhancing intrinsic motivation (the desire to engage in activities or behaviours because they are personally rewarding and fulfil our expectations and beliefs). A systematic review identified that music-based interventions were the strongest non-pharmacological method for reducing apathy in people with dementia and, although more robust research is needed, art therapy also had favourable effects on apathy (183). Another review found that dance interventions could improve feelings of apathy for people with Parkinson's disease and other groups of older adults (184). According to findings from small experimental studies, listening and moving to music can also lead to higher intrinsic motivation, particularly if the music is liked (185,186). In a qualitative study, adolescents reported both positive and negative relationships between arts education and motivation, but peer interactions that were part of arts-based courses did enhance motivation (187).

There is also a large body of evidence showing that the arts can contribute to the development of behaviour in childhood and adolescence. In early years, social musical experiences such as a parent singing to their baby can increase social referencing, whereby infants use parental behaviour to adapt their own behaviour to a new situation (188). Musical activities and music-based group play can also promote positive parent-child relationships, enhance communication, and lead to more collaboration between parents and children (189,190). Qualitative evidence also shows that engaging in leisure activities together can enhance intergenerational bonding between grandparents and grandchildren (191). Later in childhood, quasi-experimental studies have found that taking part in daily music, dance, and visual arts classes at preschool is associated with greater school readiness, including greater social and self-awareness and better vocabulary, particularly for economically-disadvantaged children (192–194).

This evidence has been extended through development, with much research exploring whether the arts can support achievement in later childhood and adolescence. Although the evidence on music and educational attainment is the most extensive, it has been mixed. Many quantitative and qualitative studies suggest benefits of music on achievement, such as cross-sectional associations between childhood instrument playing or singing and higher educational achievement (195,196), and longitudinal associations of shared musical activities at home in childhood with better subsequent numeracy (197). One systematic review found that music education improved literacy skills for children with dyslexia (198). However, in a recent larger review of research on all children and adolescents, effect sizes were small to moderate, and significant results were found only in studies not using randomisation, suggesting that they may not be reliable (199). Another systematic review concluded that results may be inconclusive because of the lack of uniform research methods across studies (200). Further RCTs are thus needed to test whether music can enhance achievement in childhood and adolescence. For other art forms, the evidence base is currently weak as it also lacks RCTs, but quantitative and qualitative data indicate that arts engagement may enhance educational attainment. For example, a systematic review found that longer term arts education can enhance academic achievement, although the length and integrated nature of arts programmes is key for their success (201). Large observational studies have tested the longitudinal associations between arts engagement and academic outcomes using sophisticated methods to adjust for confounding by demographic and socioeconomic factors. They have found strong effects of selection into arts education in childhood, as much of the association with academic outcomes is due to socioeconomic factors (202). However, after accounting for these factors, there was still evidence that arts education and in-school arts participation were associated with academic performance in several studies (203–205). Arts involvement may even be particularly beneficial for academic outcomes in socially and economically disadvantaged young people (203). Outside of school, family trips to cultural attractions also benefit achievement in both reading and mathematics, even after accounting for socioeconomic differences (206). Nevertheless, RCTs are needed to confirm whether there is a causal association between arts engagement and educational attainment.

As well as increasing positive outcomes, research has investigated whether arts engagement can reduce behaviours often perceived as negative, thereby supporting behavioural adjustment through childhood and adolescence. A range of arts-based intervention programs have been developed to prevent or reduce risky, antisocial, or criminalised behaviours among adolescents, with some success, although according to systematic reviews high-quality evidence is lacking (62,207–209). For example, arts education programmes consisting of drama or visual arts have been used to reduce bullying in schools (210,211). In observational studies, participation in extracurricular arts activities has generally been associated with fewer risky behaviours in adolescence (212,213). Participation in performing and fine arts has been associated with lower rates of health risk and antisocial behaviours, including alcohol use, drug use, smoking, skipping school, and a lower likelihood of being arrested (214–217). In a large study of a nationally representative sample in the UK, creativity in activities such as writing, storytelling, crafts, painting, drawing, or drama at age 7 was associated with a lower risk of social and behavioural maladjustment at the onset of adolescence, including fewer internalizing and externalising behaviours and symptoms of social and behavioural instability (3). A systematic review also found that boredom in leisure time (which arts engagement could help to overcome) was associated with more risky behaviours such as cigarette and alcohol use, sensation seeking, and social disruption (218). While one study indicated that students participating in performing arts had higher rates of alcohol consumption (219), overall, the literature suggests that arts engagement is associated with healthier behaviours. However, studies have tended to include non-representative and relatively small samples, so further research is needed.

6.2 New analyses

Motivational processes are not often measured in cohort studies of adults, making them difficult to assess in observational research. However, more attention has been paid to the development of behaviour in childhood and adolescence, which is particularly relevant given recent drives to improve adolescent mental health, and a general lack of evidence of the impact of arts engagement for children and adolescents. Therefore, across three studies, we explored how arts engagement might influence the development of several behaviours that are often perceived as negative during adolescence, namely externalising behaviours, reportedly antisocial or criminalised behaviours, and substance use.

Associations between extracurricular arts activities, school-based arts engagement, and subsequent externalising behaviours: Findings from the Early Childhood Longitudinal Study (Paper 7)

As outlined above, arts engagement has been linked to numerous beneficial factors surrounding externalising behaviours, but longitudinal evidence for the association between arts engagement and subsequent externalising behaviours in adolescence is lacking. It is also unclear whether arts engagement as part of school curriculum or as an extracurricular activity is more effective for reducing externalising behaviours. Therefore, in this study, we explored whether extracurricular and school-based arts engagement in adolescence were associated with externalising behaviours three years later.

We included a sample of 8,586 participants from the Early Childhood Longitudinal Study (ECLS) who were aged 10-11 years at baseline and 13-14 years at follow-up. At the individual level, parents reported whether their child had participated in extracurricular dance, music, or art classes or lessons or organised performing art programmes and completed a measure of their child's externalising behaviour. At the school level, teachers and administrators reported how often children worked on lessons or projects in music, musical instruments, music composition, art, or art materials and rated the adequacy of school arts facilities. School administrators reported the frequency of externalising behaviours in the school overall (e.g., theft, vandalism, bullying). We used linear regression to test individual-level associations and Poisson regression to test school-level associations between arts engagement and externalising behaviour.

Approximately half of participants had participated in at least one extracurricular dance, music, or art class or lesson or organised performing art programme. At the individual level, engaging in a greater number of extracurricular arts activities at ages 10-11 was associated with fewer externalising behaviours at ages 13-14. These associations were independent of a range of sociodemographic factors. In contrast, level of arts engagement at school was not associated with individual externalising behaviours, or with the overall number of externalising behaviours within each school.

Our findings suggest that extracurricular arts activities may reduce the risk of subsequent externalising behaviours, but arts engagement as part of school curriculum is less beneficial. It is possible that school arts provision was not associated with externalising behaviours because of the distinction between having access to the arts versus actively engaging in them. In other words, it may be the level of engagement a child has with the arts that drives the associations with externalising behaviours and not the level of exposure. Nonetheless, our individual-level findings are in line with existing preliminary evidence and indicate that the arts could be considered a strategy for reducing the risk of externalising behaviours at the population level, and not just an intervention for specific groups.

Arts and cultural engagement, reportedly antisocial or criminalised behaviours, and potential mediators in two longitudinal cohorts of adolescents (Paper 8)

Although arts-based intervention programs have had some success in reducing risky behaviours among adolescents, there is a lack of rigorous longitudinal studies testing the associations between arts engagement and risky behaviours at a population level. In this study, we investigated whether engagement in extracurricular arts activities was associated with reportedly antisocial or criminalized behaviours (RACBs) in mid- to late adolescence.

We included participants from both the National Longitudinal Study of Adolescent to Adult Health (Add Health; n=10,610) and the National Education Longitudinal Study of 1988 (NELS:88; n=15,214). We measured adolescents' overall levels of arts engagement, including extracurricular artistic and creative clubs, hobbies, and receptive cultural engagement. Adolescents reported the number of RACBs that they had engaged in, such as damaging property, stealing, selling drugs, using a weapon, and taking part in a fight. Using structural equation modelling, we also explored mechanisms that might link arts engagement to RACBs. These were positive perceptions of RACBs (measured in NELS:88) and self-control, which includes constructs such as impulsivity, forward-thinking skills, and self-centredness (measured in Add Health).

Across both samples, more arts engagement in mid-adolescence was associated with fewer concurrent RACBs and reduced RACBs one to two years later, with some evidence that this relationship was maintained up to seven years later, even after adjusting for a range of sociodemographic confounders. Overall, our results were remarkably consistent across Add Health and NELS:88. We also sought to identify mediating factors that could explain the relationship between arts engagement and RACBs. In Add Health, more arts engagement was associated with higher self-control scores concurrently and one to two years later. Although there was some evidence that self-control partially mediated the association between arts engagement and RACBs, this was not consistent. In NELS:88, more engagement was associated with fewer positive perceptions of RACBs, but these attitudes did not mediate the association between arts engagement and RACBs.

Our findings build on results from previous intervention studies by demonstrating that ubiquitous arts engagement, such as extracurricular artistic and creative clubs, hobbies, and receptive activities, also has the potential to reduce subsequent RACBs in adolescence. Although perceptions of RACBs did not mediate the association between arts engagement and RACBs, this could be because of the questions included in this study, which measured general attitudes towards RACBs but measured only school-based behaviours. Future research should extend these findings by identifying whether specific types of arts engagement are particularly beneficial for improving RACBs, attitudes, and self-control during adolescence.

Associations of arts and cultural engagement with substance use trajectories in adolescence and early adulthood: a latent growth curve analysis of the Add Health cohort (Paper 9)

Substance use (e.g., alcohol, marijuana, tobacco) is a risky health behaviour that becomes increasingly common during adolescence. Although there is evidence that arts engagement can reduce substance use in adolescence, it is limited by using small and unrepresentative samples, cross-sectional designs, and inclusion of only one arts activity or substance use outcome. It remains unclear whether any level of arts engagement is effective in reducing the risk of substance use and how long any risk reduction lasts. The current study

addressed these limitations by examining whether arts engagement was associated with trajectories of substance use throughout adolescence.

We included 6,965 participants from the National Longitudinal Study of Adolescent to Adult Health (Add Health), who completed the first four waves of this study and were aged 12-17 at baseline. We measured how frequently adolescents did artistic or creative hobbies and the number of extracurricular arts clubs attended at baseline. We also measured alcohol intoxication, marijuana use, and tobacco use in the past month at baseline and over the subsequent three waves (up to 14 years later). We used latent growth curve modelling to test whether arts engagement was associated with i) each type of substance use at baseline and ii) the trajectories of substance use over the following 14 years.

At baseline, participating in more arts clubs was associated with lower likelihood of alcohol intoxication and tobacco use. However, the association decreased over time. We found similar results for engagement in hobbies; adolescents who did hobbies more often were less likely to report alcohol intoxication, tobacco use, or marijuana use at baseline, but these associations decreased in strength over time. For both types of arts engagement, associations with substance use were sustained two years later, but were attenuated seven and 14 years later.

Overall, we found evidence that engaging both extracurricular arts clubs and artistic or creative hobbies was associated with a reduced risk of concurrent substance use. However, this reduced risk attenuates over time, with no sustained influence of baseline arts engagement on substance use 14 years later. As we only examined arts activities at baseline, it remains possible that sustained arts engagement continues to reduce the risk of substance use. If arts engagement does causally influence substance use, then frequent and sustained engagement may be required to have the maximum impact. Our findings are in line with previous intervention studies demonstrating that art interventions can lower substance use.

7 Discussion

In this report, we have provided a comprehensive review of brain-based mechanisms of action that could link arts engagement to health. We used the Multi-level Leisure Mechanisms Framework (7) to structure our review of mechanisms, which we grouped under four domains of subjective wellbeing, psychological capabilities, neurophysiology, and motivational processes. The strongest evidence to date is for the associations between arts engagement and subjective wellbeing. This is likely to be a bidirectional relationship, whereby arts engagement enhances wellbeing, and people with better wellbeing are also more likely to engage in the arts. There is causal evidence from intervention studies and longitudinal evidence from observational studies that engaging in receptive and participatory arts activities can lead to subsequent improvements in wellbeing, even after accounting for previous levels of wellbeing and a wide range of confounders. There is also extensive evidence, albeit mainly from intervention studies, that arts engagement is associated with changes in psychological capabilities and motivational processes in children, adolescents, adults, and older adults, ranging from the development of behaviour to cognitive decline. In contrast, evidence for the association between arts engagement and neurophysiology is the weakest of the domains we have reviewed. This literature has focused on the effects of music and dance and has not yet explored other forms of arts engagement. Additionally, it largely relies on inadequate experimental studies that only provide evidence on short-term changes in neurophysiology, or differences in neurophysiology between professional musicians or dancers and those with no experience. The longitudinal effects of arts engagement on neurophysiology in the general population thus remain unclear.

We have also outlined the findings of new analyses undertaken to address the limitations of research to date. Across nine studies, we used data from cohort studies with large representative samples and long-term follow-ups to test a range of brain-based mechanisms of action that could link ubiquitous arts engagement (that is part of daily life) to mental and physical health outcomes. We demonstrated that the associations between various forms of arts engagement and subjective wellbeing are present across diverse subgroups of the population, such as people of different ages, with specific medical conditions, and living in different areas. However, after using more sophisticated methods to account for confounding, we found that participation in community arts groups may only be associated with the positive, and not negative, elements of subjective wellbeing. We also demonstrated that not all artistic and creative activities are directly associated with subjective wellbeing, indicating that a variety of mechanisms link different forms of arts engagement to health. In terms of psychological capabilities, we addressed the issue that factors related to later life cognition are likely to influence arts engagement, which may have led to an overestimation of the impacts of arts engagement on cognition in previous studies. Using more advanced statistical methods, we found no evidence for associations between arts engagement and cognition in older adults, demonstrating the importance of fully accounting for demographic and socioeconomic confounders when exploring arts engagement and the brain. Finally, addressing motivational processes, we showed that engagement in extracurricular participatory and receptive arts activities during adolescence is associated with reductions in a range of behaviours that are often perceived as negative, including externalising behaviours, reportedly antisocial or criminalised behaviours, and substance use.

7.1 Implications for arts organisations

Understanding the theoretical basis linking the arts to health is not only key to research in this field but is also important for organisations and individuals designing and delivering arts and cultural assets. Awareness of these mechanisms will enable the design of arts programmes that have maximal effects on health. Understanding mechanisms is particularly pertinent given the roll-out of schemes such as social prescribing, which involves health services referring individuals to arts and cultural activities. To refer individuals to appropriate activities with realistic potential for a positive effect on mental and physical health, as well as to design and test bespoke interventions for targeted patient groups, it is crucial that practitioners understand the mechanisms by which arts activities affect health. Arts organisations could provide additional training for cultural workers on the role of arts in health to facilitate these processes. Where possible, those developing arts programmes should consider whether a specific intervention is likely to be disruptive enough to bring about the desired change in the brain, and ultimately influence health outcomes, particularly when targeting deep-seated patterns of behaviours or traits.

The range of potential benefits of the arts on the brain could also be used by arts organisations to promote arts engagement. Increasing public awareness could encourage more people to engage in the arts as well as increasing support of community assets. This is particularly important given the social gradient in many forms of arts engagement and many of the mechanisms identified in this report. Arts organisations are playing a key role in widening access to the arts, and social prescribing schemes should support these efforts.

We hope that arts organisations will also use this evidence base to support funding applications, allowing them to demonstrate the importance of their activities, and offer potential processes through which they may influence health. This is particularly relevant when the boundary between these mechanisms and health is blurred; many of the topics included in this report (e.g., life satisfaction, self-esteem, behavioural development) can be considered health outcomes in and of themselves. Increasing evidence on these mechanisms should also translate into policy decisions, with the goal of widening arts audiences and increasing support for arts organisations as well as targeting specific mechanisms. For example, the UK government's strategy for reducing loneliness emphasised the importance of the arts and creativity to help people become more connected (220).

It is important to acknowledge that we have identified and reviewed a wide range of evidence, which could give the impression that all arts activities could trigger every possible mechanism to improve health. This is not the case. Some mechanisms are probably not easily activated and might only emerge in a gradual and small way over time, so they should not necessarily be the primary target for arts activities. Although there is limited evidence exploring this to date, mechanisms may also differ by audience or context. For example, organisations should consider whether the mode of delivery of arts activities could influence the mechanisms activated; online recorded performances might lead to activation of fewer mechanisms than live performances in person but the evidence on virtual or online arts engagement and health remains in its infancy.

7.2 Priorities for future research

Although there is a large body of literature investigating the impacts of arts and cultural engagement on subjective wellbeing, psychological capabilities, neurophysiology, and motivational processes, much of this research suffers from similar weaknesses. Many studies include small samples that are not representative of the general population in these countries and only investigate the impacts of arts engagement over short follow-up periods, meaning it remains unclear whether arts engagement can lead to long-term changes in the brain. In this report, we identified many systematic reviews with conclusions recommending that more robust evidence for the associations between arts engagement and the brain is needed. Intervention studies should thus aim to include larger samples that are more diverse and include longer follow-up periods. This could be achieved using large natural experiments, such as evaluating the implementation of national schemes like social prescribing in the UK and the US.

Additionally, much of the evidence reviewed is from studies of specific arts-based interventions, which may have different mechanisms of action on health to ubiquitous engagement in the arts as part of daily life. To supplement this evidence, more observational studies of everyday arts engagement are needed, particularly using larger and more representative samples with longer follow-up periods. To date, observational studies have not always fully accounted for the demographic and socioeconomic differences between people who do and do not engage in the arts, leading to biases in their findings. We therefore recommend that further research uses more advanced statistical methods, such as propensity score matching, fixed effects approaches, and models testing the direction of associations, allowing the study of the causal effects of arts engagement on the brain.

In this report, to provide an overview of potential mechanisms linking the arts to health, we have broken down this complex system into individual elements. We acknowledge that this is an oversimplification. There are many brain-based mechanisms that may be influenced by arts engagement, and these are likely to interact and be part of complex indirect pathways linking the arts to health, such as through feedback loops, recursive cycles, and self-reinforcement (7). No single arts activity is likely to activate just one brain-based mechanism, and studies that use simple approaches to assess one mechanism (as in most of the research reviewed here) are likely to overstate the causal contribution of individual mechanisms (7). Studies that take an exposure-wide or outcome-wide approach could enable research into the effects of multiple arts activities on multiple mechanisms simultaneously.

In our literature reviews, we identified that some mechanisms have been tested comprehensively across multiple different arts activities, some have been tested only in relation to specific activities, and some lack evidence entirely. However, we have not attempted to identify or review every single study ever done on arts engagement and the brain. Such work would be beyond the scope of any individual review and should be the focus of systematic reviews and meta-analyses that explore specific mechanisms or groups of mechanisms in more detail. These reviews will be important for identifying where more research is needed.

Arts activities occur within societal, cultural, and political contexts, and mechanisms may depend on these contexts. Given the little information we have on the effect of moderating factors on the workings of individual mechanisms, future research could also consider whether some mechanisms work only in the presence of specific contextual factors. It will also be important to explore whether similar mechanisms are activated by the arts across different groups of the population, such as adolescents and older adults, or people with existing

health conditions. Most evidence to date is from the UK, Europe, or the US, making it unclear whether findings will generalise to other countries, particularly lower income countries where type and availability of cultural assets may differ. Considering broader definitions of the arts and including more varied types of engagement, as well as measuring engagement over longer periods, should be a priority for future research.

7.3 Conclusion

Using the Multi-level Leisure Mechanisms Framework (7), we have reviewed and extended the evidence on the associations between arts engagement, subjective wellbeing, psychological capabilities, neurophysiology, and motivational processes. These domains all contain a wide range of mechanisms that may contribute to the influence of the arts on health. Overall, there is a large body of evidence on the associations between arts engagement and the brain, but more high-quality research is still needed. We have identified various priorities for future research, including the use of larger and more diverse samples, more systematic reviews, research that uses a complex systems approach, and further consideration of various contextual factors. Despite the limitations of the literature, a familiarity with this evidence base is important for arts organisations and policymakers, and we hope that it can be used to increase and diversify arts engagement in the general population.

Acknowledgements

We would like to thank Dr Hei Wan Mak, Dr Meg E Fluharty, Dr Feifei Bu, Dr Elise Paul, and Catherine Borra for their work on the new analyses outlined in this report. We also thank Alexandra Bradbury for her contributions to this report. We are particularly grateful to Arts Council England for funding this report as part of a research project (INVF-00404365) focused on arts, culture, and the brain.

References

1. Fancourt D, Steptoe A. Community group membership and multidimensional subjective well-being in older age. *Journal of Epidemiology and Community Health*. 2018;72(5):376–82.
2. Fancourt D, Tymoszuk U. Cultural engagement and incident depression in older adults: Evidence from the English Longitudinal Study of Ageing. *British Journal of Psychiatry*. 2019;214(4):225–9.
3. Fancourt D, Steptoe A. Effects of creativity on social and behavioral adjustment in 7- to 11-year-old children. *Annals of the New York Academy of Sciences*. 2019;1438(1):30–9.
4. Fancourt D, Steptoe A. Physical and Psychosocial Factors in the Prevention of Chronic Pain in Older Age. *Journal of Pain*. 2018 Dec 1;19(12):1385–91.
5. Rogers NT, Fancourt D. Cultural Engagement Is a Risk-Reducing Factor for Frailty Incidence and Progression. *Journals of Gerontology - Series B Psychological Sciences and Social Sciences*. 2020 Feb 14;75(3):571–6.
6. Fancourt D, Steptoe A, Cadar D. Cultural engagement and cognitive reserve: Museum attendance and dementia incidence over a 10-year period. *British Journal of Psychiatry*. 2018;213(5):661–3.
7. Fancourt D, Aughterson H, Finn S, Walker E, Steptoe A. How leisure activities affect health: a narrative review and multi-level theoretical framework of mechanisms of action. *The Lancet Psychiatry* 2021;8(4):329–39.

8. Adajian T. The definition of art. In: Zalta E, editor. *Stanford Encyclopedia of Philosophy* Stanford, CA: Stanford University; 2018. Available from: <https://plato.stanford.edu/archives/fall2018/entries/art-definition>
9. Fancourt D, Finn S. What is the evidence on the role of the arts in improving health and well-being? A scoping review. Copenhagen; 2019. Available from: <https://europepmc.org/article/NBK/nbk553773>
10. Tymoszuk U, Spiro N, Perkins R, Mason-Bertrand A, Gee K, Williamon A. Arts engagement trends in the UK and their mental and social wellbeing implications: HEartS Survey. *Plos One*. 2021;16(3):e0246078.
11. Buck N, McFall S. Understanding Society: design overview. *Longitudinal and Life Course Studies* 2012;3(1):5–17.
12. Sonnega A, Faul JD, Ofstedal MB, Langa KM, Phillips JWR, Weir DR. Cohort profile: The Health and Retirement Study (HRS). *International Journal of Epidemiology*. 2014;43(2):576–85.
13. Herd P, Carr D, Roan C. Cohort profile: Wisconsin longitudinal study (WLS). *International Journal of Epidemiology*. 2014 Feb;43(1):34–41.
14. Harris KM, Halpern CT, Whitsel E, Hussey J, Tabor J, Entzel P, et al. The National Longitudinal Study of Adolescent to Adult Health: Research Design. 2009.
15. Tourangeau K, Nord C, Lê T, Sorongon AG, Najarian M. Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K): Combined User's Manual for the ECLS-K Eighth-Grade and K-8 Full Sample Data Files and Electronic Codebooks. NCES 2009-004. . 2009.
16. Curtin TR, Ingels SJ, Wu S, Heuer R. National Education Longitudinal Study of 1988: Base-Year to Fourth Follow-up Data File User's Manual (NCES 2002-323). Washington, DC; 2002.
17. Stone AA, Mackie CE. Subjective well-being: measuring happiness, suffering, and other dimensions of experience. Washington, D.C.: National Academies Press; 2013.
18. Daykin N, Mansfield L, Meads C, Julier G, Tomlinson A, Payne A, et al. What works for wellbeing? A systematic review of wellbeing outcomes for music and singing in adults. *Perspectives in Public Health*. 2018;138(1):39–46.
19. Bernardo LD, Carvalho CRA de. The role of cultural engagement for older adults: an integrative review of scientific literature. *Revista Brasileira de Geriatria e Gerontologia*. 2020;23(6):1–12.
20. Menec VH. The Relation Between Everyday Activities and Successful Aging: A 6-Year Longitudinal Study. *Journal of Gerontology: Social Sciences*. 2003;58(2):74–82.
21. Tymoszuk U, Perkins R, Spiro N, Williamon A, Fancourt D. Longitudinal Associations Between Short-Term, Repeated, and Sustained Arts Engagement and Well-Being Outcomes in Older Adults. *The Journals of Gerontology: Series B*. 2019;75(7):1609–19.
22. Kuykendall L, Tay L, Ng V. Supplemental Material for Leisure Engagement and Subjective Well-Being: A Meta-Analysis. *Psychological Bulletin*. 2015;141(2):364–403.
23. de Witte M, Spruit A, van Hooren S, Moonen X, Stams GJ. Effects of music interventions on stress-related outcomes: a systematic review and two meta-analyses. *Health Psychology Review*. 2020;14(2):294–324.
24. Panteleeva Y, Ceschi G, Glowinski D, Courvoisier DS, Grandjean D. Music for anxiety? Meta-analysis of anxiety reduction in non-clinical samples. *Psychology of Music*. 2018;46(4):473–87.
25. Mennin D, Farach F. Emotion and evolving treatments for adult psychopathology. *Clinical Psychology: Science and Practice*. 2007;14(4):329–52.
26. Fancourt D, Garnett C, Spiro N, West R, Müllensiefen D. How do artistic creative activities regulate our emotions? Validation of the Emotion Regulation Strategies for Artistic Creative Activities Scale (ERS-ACA). *PLoS ONE*. 2019;14(2):1–22.

27. van Goethem A, Sloboda J. The functions of music for affect regulation. *Musicae Scientiae*. 2011;15(2):208–28.
28. James C, Drake JE, Winner E. Expression Versus Distraction: An Investigation of Contrasting Emotion Regulation Strategies When Drawing, Writing, Talking, and Thinking. *Empirical Studies of the Arts*. 2018;36(2):162–79.
29. Drake JE, Coleman K, Winner E. Short-term mood repair through art: Effects of medium and strategy. *Art Therapy*. 2011;28(1):26–30.
30. de Petrillo L, Winner E. Does art improve mood? a test of a key assumption underlying art therapy. *Art Therapy*. 2005;22(4):205–12.
31. Dalebroux A, Goldstein TR, Winner E. Short-term mood repair through art-making: Positive emotion is more effective than venting. *Motivation and Emotion*. 2008;32(4):288–95.
32. Fancourt D, Garnett C, Müllensiefen D. The Relationship Between Demographics, Behavioral and Experiential Engagement Factors, and the Use of Artistic Creative Activities to Regulate Emotions. *Psychology of Aesthetics, Creativity, and the Arts*. 2020;
33. Fancourt D, Ali H. Differential use of emotion regulation strategies when engaging in artistic creative activities amongst those with and without depression. *Scientific Reports*. 2019;9(1):1–9.
34. Adams-Price CE, Morse LW. Crafts as serious hobbies: Impact and benefits in later life. *Craft Research*. 2018;9(1):93–102.
35. Cruz-Ferreira A, Marmeleira J, Formigo A, Gomes D, Fernandes J. Creative Dance Improves Physical Fitness and Life Satisfaction in Older Women. *Research on Aging*. 2015;37(8):837–55.
36. Meyer DeMott MA, Jakobsen M, Wentzel-Larsen T, Heir T. A controlled early group intervention study for unaccompanied minors: Can Expressive Arts alleviate symptoms of trauma and enhance life satisfaction? *Scandinavian Journal of Psychology*. 2017;58(6):510–8.
37. Cuypers K, Krokstad S, Holmen TL, Knudtsen MS, Bygren LO, Holmen J. Patterns of receptive and creative cultural activities and their association with perceived health, anxiety, depression and satisfaction with life among adults: The HUNT study, Norway. *Journal of Epidemiology and Community Health*. 2012;66(8):698–703.
38. Wheatley D, Bickerton C. Subjective well-being and engagement in arts, culture and sport. *Journal of Cultural Economics*. 2017;41(1):23–45.
39. Pagán R. How Do Leisure Activities Impact on Life Satisfaction? Evidence for German People with Disabilities. *Applied Research in Quality of Life*. 2015;10(4):557–72.
40. Weinberg MK, Joseph D. If you're happy and you know it: Music engagement and subjective wellbeing. *Psychology of Music*. 2017;45(2):257–67.
41. Muro A, Artero N. Dance practice and well-being correlates in young women. *Women and Health* 2017;57(10):1193–203.
42. Hansen E, Sund E, Knudtsen MS, Krokstad S, Holmen TL. Cultural activity participation and associations with self-perceived health, life-satisfaction and mental health: The Young HUNT Study, Norway. *BMC Public Health*. 2015;15(1):1–8.
43. Lakey J, Smith N, Oskala A, McManus S. Culture, sport and wellbeing: Findings from the Understanding Society adult survey 2017. Available from: https://www.artscouncil.org.uk/sites/default/files/download-file/Culture_sport_and_wellbeing_adults.pdf
44. Steptoe A, Fancourt D. Leading a meaningful life at older ages and its relationship with social engagement, prosperity, health, biology, and time use. *Proceedings of the National Academy of Sciences of the United States of America*. 2019;116(4):1207–12.

45. Weźniak-Białowolska D. Attendance of cultural events and involvement with the arts—impact evaluation on health and well-being from a Swiss household panel survey. *Public Health*. 2016;139:161–9.
46. Wang S, Mak HW, Fancourt D. Arts, mental distress, mental health functioning & life satisfaction: Fixed-effects analyses of a nationally-representative panel study. *BMC Public Health*. 2020;20(1):1–18.
47. Vanderweele TJ. On the promotion of human flourishing. *Proceedings of the National Academy of Sciences of the United States of America*. 2017;114(31):8148–56.
48. Iwasaki Y, Messina ES, Hopper T. The role of leisure in meaning-making and engagement with life. *Journal of Positive Psychology* 2018;13(1):29–35.
49. Shim Y, Jebb AT, Tay L, Pawelski JO. Arts and Humanities Interventions for Flourishing in Healthy Adults: A Mixed Studies Systematic Review. *Review of General Psychology*. 2021;25(3):258–82.
50. Renton A, Phillips G, Daykin N, Yu G, Taylor K, Petticrew M. Think of your art-eries: Arts participation, behavioural cardiovascular risk factors and mental well-being in deprived communities in London. *Public Health*. 2012;126(SUPPL.1):2–9.
51. Grossi E, Blessi GT, Sacco PL, Buscema M. The Interaction Between Culture, Health and Psychological Well-Being: Data Mining from the Italian Culture and Well-Being Project. *Journal of Happiness Studies*. 2012;13(1):129–48.
52. Ho AHY, Ma SHX, Ho MHR, Pang JSM, Ortega E, Bajpai R. Arts for ageing well: A propensity score matching analysis of the effects of arts engagements on holistic well-being among older Asian adults above 50 years of age. *BMJ Open*. 2019;9(11):1–12.
53. Schnyder SS, Wico DM, Huber T. Theater arts as a beneficial and educational venue in identifying and providing therapeutic coping skills for early childhood adversities: A systematic review of the literature. *International Electronic Journal of Elementary Education*. 2020;13(4):457–67.
54. Miranda D. A review of research on music and coping in adolescence. *Psychomusicology: Music, Mind, and Brain*. 2019;29(1):1–9.
55. Zhang JM, Wang P, Yao JX, Zhao L, Davis MP, Walsh D, et al. Music interventions for psychological and physical outcomes in cancer: A systematic review and meta-analysis. *Supportive Care in Cancer*. 2012;20(12):3043–53.
56. Torres C, Neimeyer RA, Neff ML. The Expressive Arts in Grief Therapy: An Empirical Perspective. In: *Grief and the expressive arts*. Routledge; 2014. p. 307–14.
57. Abdulah DM, Abdulla BMO. Suicidal ideation and attempts following a short-term period of art-based intervention: An experimental investigation. *Arts in Psychotherapy* 2020;68(February):101648.
58. Stack S, Lester D, Rosenberg JS. Music and suicidality: A quantitative review and extension. *Suicide and Life-Threatening Behavior*. 2012;42(6):654–71.
59. Tomlinson A, Lane J, Julier G, Grigsby-Duffy L, Payne A, Mansfield L, et al. Qualitative findings from a systematic review: Visual arts engagement for adults with mental health conditions1. *Journal of Applied Arts & Health*. 2020;11(3):281–97.
60. Schwender TM, Spengler S, Oedl C, Mess F. Effects of dance interventions on aspects of the participants' self: A systematic review. *Frontiers in Psychology*. 2018;9(JUL).
61. Zarobe L, Bungay H. The role of arts activities in developing resilience and mental wellbeing in children and young people a rapid review of the literature. *Perspectives in Public Health*. 2017;137(6):337–47.
62. Bungay H, Vella-Burrows T. The effects of participating in creative activities on the health and well-being of children and young people: A rapid review of the literature. *Perspectives in Public Health*. 2013;133(1):44–52.

63. Leseho J, Maxwell LR. Coming alive: Creative movement as a personal coping strategy on the path to healing and growth. *British Journal of Guidance and Counselling*. 2010;38(1):17–30.
64. Fancourt D, Perkins R, Ascenso S, Atkins L, Kilfeather S, Carvalho L, et al. Group Drumming Modulates Cytokine Response in Mental Health Services Users: A Preliminary Study. *Psychotherapy and Psychosomatics*. 2016;85(1):53–5.
65. Bolwerk A, Mack-Andrick J, Lang FR, Dörfler A, Maihöfner C. How art changes your brain: Differential effects of visual art production and cognitive art evaluation on functional brain connectivity. *PLoS ONE*. 2014;9(7):1–8.
66. Çulhacik GD, Durat G, Eren N. Effects of activity groups, in which art activities are used, on resilience and related factors in families with disabled children. *Perspectives in Psychiatric Care*. 2021;57(1):343–50.
67. Bygren LO, Weissglas G, Wikström BM, Konlaan BB, Grjibovski A, Karlsson AB, et al. Cultural participation and health: A randomized controlled trial among medical care staff. *Psychosomatic Medicine*. 2009;71(4):469–73.
68. Pisu M, Demark-Wahnefried W, Kenzik KM, Oster RA, Lin CP, Manne S, et al. A dance intervention for cancer survivors and their partners (RHYTHM). *Journal of Cancer Survivorship*. 2017;11(3):350–9.
69. Dunphy K, Baker FA, Dumaresq E, Carroll-Haskins K, Eickholt J, Ercole M, et al. Creative arts interventions to address depression in older adults: A systematic review of outcomes, processes, and mechanisms. *Frontiers in Psychology*. 2019;9(JAN).
70. Lee JB, McIlpatrick S, Fitzpatrick L. Arts engagement facilitated by artists with individuals with life-limiting illness: A systematic integrative review of the literature. *Palliative Medicine*. 2021;35(10):1815–31.
71. van Lith T, Schofield MJ, Fenner P. Identifying the evidence-base for art-based practices and their potential benefit for mental health recovery: A critical review. *Disability and Rehabilitation*. 2013;35(16):1309–23.
72. Mak HW, Fancourt D. Arts engagement and self-esteem in children: results from a propensity score matching analysis. *Annals of the New York Academy of Sciences*. 2019;1449(1):36–45.
73. Mak HW, Fancourt D. Longitudinal associations between ability in arts activities, behavioural difficulties and self-esteem: analyses from the 1970 British Cohort Study. *Scientific Reports* 2019;9(1):1–7.
74. Packer J, Ballantyne J. The impact of music festival attendance on young people’s psychological and social well-being. *Psychology of Music*. 2011;39(2):164–81.
75. Vaartio-Rajalin H, Santamäki-Fischer R, Jokisalo P, Fagerström L. Art making and expressive art therapy in adult health and nursing care: A scoping review. *International Journal of Nursing Sciences*. 2021;8(1):102–19.
76. Kaptein AA, Meulenberg F, Smyth JM. A breath of fresh air: Images of respiratory illness in novels, poems, films, music, and paintings. *Journal of Health Psychology*. 2015;20(3):246–58.
77. Cheung MMY, Saini B, Smith L. Using drawings to explore patients’ perceptions of their illness: A scoping review. *Journal of Multidisciplinary Healthcare*. 2016;9:631–46.
78. Broadbent E, Schoones JW, Tiemensma J, Kaptein AA. A systematic review of patients’ drawing of illness: implications for research using the Common Sense Model. *Health Psychology Review* 2019;13(4):406–26.
79. Torrance TA, Bugos JA. Music Ensemble Participation: Personality Traits and Music Experience. Update: Applications of Research in Music Education. 2017;36(1):28–36.
80. Delsing M, ter Bogt T, Engels R, Meeus W. Adolescents’ Music Preferences and Personality Characteristics. *European Journal of Personality*. 2008;22:109–30.

81. Weziak-Bialowolska D, Bialowolski P, Sacco PL. Involvement With the Arts and Participation in Cultural Events-Does Personality Moderate Impact on Well-Being? Evidence From the U.K. Household Panel Survey. *Psychology of Aesthetics, Creativity, and the Arts*. 2019;13(3):348–58.
82. Perkins R, Mason-bertrand A, Tymoszuk U, Spiro N, Gee K, Williamon A. Arts engagement supports social connectedness in adulthood: findings from the HEartS Survey. *BMC Public Health*. 2021;21(1208):1–15.
83. Cutler D. Tackling Loneliness in Older Age - The Role of the Arts. 2012.
84. Dadswell A, Wilson C, Bungay H, Munn-Giddings C. The role of participatory arts in addressing the loneliness and social isolation of older people: A conceptual review of the literature. *Journal of Arts & Communities*. 2017;9(2):109–28.
85. Cohen GD, Perlstein S, Chapline J, Kelly J, Firth KM, Simmens S. The impact of professionally conducted cultural programs on the physical health, mental health, and social functioning of older adults—2-year results. *Journal of Aging, Humanities, and the Arts*. 2007;1(1–2):5–22.
86. Gutheil IA, Heyman JC. Older Adults and Creative Arts: Personal and Interpersonal Change. *Activities, Adaptation and Aging*. 2016;40(3):169–79.
87. Perkins R, Williamon A. Learning to make music in older adulthood: A mixed-methods exploration of impacts on wellbeing. *Psychology of Music*. 2014;42(4):550–67.
88. Skingley A, Martin A, Clift S. The Contribution of Community Singing Groups to the Well-Being of Older People: Participant Perspectives from the United Kingdom. *Journal of Applied Gerontology*. 2016;35(12):1302–24.
89. Tymoszuk U, Perkins R, Fancourt D, Williamon A. Cross-sectional and longitudinal associations between receptive arts engagement and loneliness among older adults. *Social Psychiatry and Psychiatric Epidemiology*. 2020;55(7):891–900.
90. Papinczak ZE, Dingle GA, Stoyanov SR, Hides L, Zelenko O. Young people’s uses of music for well-being. *Journal of Youth Studies* 2015;18(9):1119–34.
91. Gardner SM, Komesaroff P, Fensham R. Dancing beyond exercise: Young people’s experiences in dance classes. *Journal of Youth Studies*. 2008;11(6):701–9.
92. Koch SC, Mehl L, Sobanski E, Sieber M, Fuchs T. Fixing the mirrors: A feasibility study of the effects of dance movement therapy on young adults with autism spectrum disorder. *Autism*. 2015;19(3):338–50.
93. Bradley BS, Deighton J, Selby J. The “Voices” Project: Capacity-building in Community Development for Youth at Risk. *Journal of Health Psychology*. 2004;9(2):197–212.
94. Noice T, Noice H, Kramer AF. Participatory arts for older adults: A review of benefits and challenges. *Gerontologist*. 2014;54(5):741–53.
95. Tomporowski PD, Pesce C. Exercise, sports, and performance arts benefit cognition via a common process. *Psychological Bulletin*. 2019;145(9):929–51.
96. Hetland L. Listening to Music Enhances Spatial-Temporal Reasoning: Evidence for the “Mozart Effect.” *Journal of Aesthetic Education*. 2000;34(3):105–48.
97. He WJ, Wong WC, Hui ANN. Emotional reactions mediate the effect of music listening on creative thinking: Perspective of the arousal-and-mood hypothesis. *Frontiers in Psychology*. 2017;8:1680.
98. Ritter SM, Ferguson S. Happy creativity: Listening to happy music facilitates divergent thinking. *PLoS ONE*. 2017;12(9):1–14.
99. Bugos J, Mostafa W. Musical Training Enhances Information Processing Speed. *Bulletin of the Council for Research in Music Education*. 2011;187:7–18.

100. Lunke K, Meier B. Disentangling the impact of artistic creativity on creative thinking, working memory, attention, and intelligence: Evidence for domain-specific relationships with a new self-report questionnaire. *Frontiers in Psychology*. 2016;7:1089.
101. Fancourt D, Steptoe A. Cultural engagement predicts changes in cognitive function in older adults over a 10 year period: Findings from the English Longitudinal Study of Ageing. *Scientific Reports* 2018;8(1):1–8.
102. Petrovsky D v, Wu B, Hodgson NA, Dong XQ. Art Attendance and Change in Cognitive Function Among U.S. Community-Dwelling Chinese Older Adults. *Journal of Applied Gerontology*. 2021;
103. Meng X, Li G, Jia Y, Liu Y, Shang B, Liu P, et al. Effects of dance intervention on global cognition , executive function and memory of older adults : a meta-analysis and systematic review. *Aging Clinical and Experimental Research* 2020;32(1):7–19.
104. Keinänen M, Hetland L, Winner E, Keinanen M. Teaching Cognitive Skill through Dance: Evidence for near but Not Far Transfer. *Journal of Aesthetic Education*. 2000;34(3/4):295–306.
105. Hetland L. Learning to Make Music Enhances Spatial Reasoning. *Journal of Aesthetic Education*. 2000;34(3/4):179–238.
106. Hetland L, Winner E. The arts and academic achievement: What the evidence shows. *Arts Education Policy Review*. 2001;102(5):3–6.
107. Forgeard M, Winner E, Norton A, Schlaug G. Practicing a musical instrument in childhood is associated with enhanced verbal ability and nonverbal reasoning. *PLoS ONE*. 2008;3(10):1–8.
108. Fancourt D, Steptoe A, Cadar D. Community engagement and dementia risk: Time-to-event analyses from a national cohort study. *Journal of Epidemiology and Community Health*. 2020;74(1):71–7.
109. Schooler C, Mulatu MS. The reciprocal effects of leisure time activities and intellectual functioning in older people: a longitudinal analysis. *Psychology and Aging*. 2001;16:466–482.
110. Iwasa H, Yoshida Y, Kai I, Suzuki T, Kim H, Yoshida H. Leisure activities and cognitive function in elderly community-dwelling individuals in Japan: A 5-year prospective cohort study. *Journal of Psychosomatic Research* 2012;72(2):159–64.
111. Hui-Xin Wang, Karp A, Bengt W, Laura F. Decreased Risk of Dementia: A Longitudinal Study from the Kungsholmen. *American Journal of Epidemiology*. 2002;155(12):1081–7.
112. Wang HX, Jin Y, Hendrie HC, Liang C, Yang L, Cheng Y, et al. Late life leisure activities and risk of cognitive decline. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences*. 2013;68(2):205–13.
113. Bavishi A, Slade MD, Levy BR. A chapter a day: Association of book reading with longevity. *Social Science and Medicine* 2016;164:44–8.
114. Verghese J, Lipton RB, Katz MJ, Hall CB, Derby CA, Kuslansky G, et al. Leisure Activities and the Risk of Dementia in the Elderly. *The New England Journal of Medicine*. 2003;348(25):2508–16.
115. Sugita A, Ling L, Tsuji T, Kondo K, Kawachi I. Cultural engagement and incidence of cognitive impairment: A 6-year longitudinal follow-up of the Japan gerontological evaluation study (JAGES). *Journal of Epidemiology*. 2021;31(10):545–53.
116. Rajan KB, Rajan RS, Manning LK, Evans DA. Aging Audiences: Association of Live Performance Attendance and Cognitive Decline in a Biracial Sample. *Journal of Aging and Health*. 2018;30(3):445–57.
117. Benz S, Sellaro R, Hommel B, Colzato LS. Music Makes the World Go Round : The Impact of Musical Training on Non-musical Cognitive Functions — A Review. *Frontiers in Psychology*. 2016;6:2023.

118. Whitty E, Mansour H, Aguirre E, Palomo M, Charlesworth G, Ramjee S, et al. Efficacy of lifestyle and psychosocial interventions in reducing cognitive decline in older people : Systematic review. *Ageing Research Reviews* 2020;62(June):101113.
119. Muiños M, Ballesteros S. Does dance counteract age-related cognitive and brain declines in middle-aged and older adults? A systematic review. *Neuroscience and Biobehavioral Reviews*. 2021;121(November 2019):259–76.
120. Christie GJ, Hamilton T, Manor BD, Farb NAS, Farzan F, Sixsmith A, et al. Do lifestyle activities protect against cognitive decline in aging? A review. *Frontiers in Aging Neuroscience*. 2017;9:381.
121. Dumont E, Syurina E v, Feron FJM, Hooren S van. Music Interventions and Child Development: A Critical Review and Further Directions. *Frontiers in Psychology*. 2017;8:1694.
122. Sala G, Gobet F. When the music's over. Does music skill transfer to children's and young adolescents' cognitive and academic skills? A meta-analysis. *Educational Research Review* 2017;20:55–67.
123. Hui ANN, He MWJ, Ye SS, Hui ANN, He MWJ, Sam S, et al. Arts education and creativity enhancement in young children in Hong Kong. *Educational Psychology* 2015;3410:1–13.
124. Kou X, Konrath S, Goldstein TR. The relationship among different types of arts engagement, empathy, and prosocial behavior. *Psychology of Aesthetics, Creativity, and the Arts*. 2020;14(4):481–92.
125. Konrath S, Kisida B. Does Arts Engagement Increase Empathy and Prosocial Behavior? In: Hersey LN, Bobick B, editors. *Engagement in the City: How Arts and Culture Impact Development in Urban Areas*. Rowman & Littlefield; 2021. p. 7–38.
126. Pizarro JJ, Basabe N, Amutio A, Telletxea S, Harizmendi M, van Gordon W. The Mediating Role of Shared Flow and Perceived Emotional Synchrony on Compassion for Others in a Mindful-Dancing Program. *Mindfulness*. 2020;11(1):125–39.
127. Bodner E, Bergman YS. The power of national music in reducing prejudice and enhancing theory of mind among Jews and Arabs in Israel. *Psychology of Music*. 2017;45(1):36–48.
128. Kidd D, Castano E. Different Stories: How Levels of Familiarity With Literary and Genre Fiction Relate to Mentalizing. *Psychology of Aesthetics , Creativity, and the Arts*. 2017;11(4):474.
129. Baimel A, Severson RL, Baron AS, Birch SAJ. Enhancing “theory of mind” through behavioral synchrony. *Frontiers in Psychology*. 2015;6(June):1–6.
130. Goldstein TR, Winner E. Engagement in Role Play, Pretense, and Acting Classes Predict Advanced Theory of Mind Skill in Middle Childhood. *Imagination, Cognition and Personality*. 2011;30(3):249–58.
131. Mages WK. Early Childhood Research Quarterly Does theatre-in-education promote early childhood development ? The effect of drama on language , perspective-taking , and imagination &. *Early Childhood Research Quarterly* 2018;45:224–37.
132. Barrett KC, Ashley R, Strait DL, Kraus N. Art and science: how musical training shapes the brain. *Frontiers in Psychology*. 2013;4(October):1–13.
133. Moreno S, Bidelman GM. Examining neural plasticity and cognitive benefit through the unique lens of musical training. *Hearing Research* 2014;308:84–97.
134. Alain C, Moussard A, Singer J, Lee Y, Bidelman GM, Moreno S. Music and visual art training modulate brain activity in older adults. *Frontiers in Neuroscience*. 2019 Mar 1;13:1–15.
135. Millman LSM, Terhune DB, Hunter ECM, Orgs G. Towards a neurocognitive approach to dance movement therapy for mental health: A systematic review. *Clinical Psychology and Psychotherapy*. 2020;28:24–38.
136. Maheu M, Behtani L, Nooristani M, Jemel B, Delcenserie A, Champoux F. Gait & Posture Influence of dance training on challenging postural control task. *Gait & Posture* 2019;69(January):31–5.

137. Marmeleira JF, Pereira C, Cruz-Ferreira A, Fretes V, Pisco R, Fernandes OM. Creative dance can enhance proprioception in older adults. *Journal of Sports Medicine and Physical Fitness*. 2009;49(4):480–5.
138. Chatzopoulos D, Doganis G, Kollias I. Effects of creative dance on proprioception, rhythm and balance of preschool children. *Early Child Development and Care* 2019;189(12):1943–53.
139. Gustavson DE, Coleman PL, Iversen JR, Maes HH, Gordon RL, Lense M. Mental Health and Music Engagement: Review, Framework, and Guidelines for Future Studies. *PsyArXiv*. 2021;
140. Geethanjali B, Adalarasu K, Jagannath M. Music induced emotion and music processing in the brain-a review. *Journal of Clinical and Diagnostic Research*. 2018;12(1):11–3.
141. Altenmüller E, Gruhn W, Parlitz D, Liebert G. The impact of music education on brain networks: Evidence from EEG-studies. *International Journal of Music Education*. 2000;35(1):47–53.
142. Miendlarzewska EA, Trost WJ. How musical training affects cognitive development: Rhythm, reward and other modulating variables. *Frontiers in Neuroscience*. 2014;7:279.
143. Karpati FJ, Giacosa C, Foster NEV, Penhune VB, Hyde KL. Dance and the brain: A review. *Annals of the New York Academy of Sciences*. 2015;1337(1):140–6.
144. Basso JC, Satyal MK, Rugh R. Dance on the Brain: Enhancing Intra- and Inter-Brain Synchrony. *Frontiers in Human Neuroscience*. 2021;14:584312.
145. Teixeira-Machado L, Arida RM, de Jesus Mari J. Dance for neuroplasticity: A descriptive systematic review. *Neuroscience and Biobehavioral Reviews*. 2019;96(August 2018):232–40.
146. Rehfeld K, Lüders A, Hökelmann A, Lessmann V, Kaufmann J, Brigadski T, et al. Dance training is superior to repetitive physical exercise in inducing brain plasticity in the elderly. *PLoS ONE*. 2018;13(7):1–15.
147. Fancourt D, Ockelford A, Belai A. The psychoneuroimmunological effects of music: A systematic review and a new model. *Brain, Behavior, and Immunity* 2014;36:15–26.
148. Schladt TM, Nordmann GC, Emilius R, Kudielka BM, de Jong TR, Neumann ID. Choir versus solo singing: Effects on mood, and salivary oxytocin and cortisol concentrations. *Frontiers in Human Neuroscience*. 2017;11(September):1–9.
149. Fancourt D, Williamon A, Carvalho LA, Steptoe A, Dow R, Lewis I. Singing modulates mood, stress, cortisol, cytokine and neuropeptide activity in cancer patients and carers. *Ecancermedicalscience*. 2016;10:1–13.
150. McCrary JM, Redding E, Altenmüller E. Performing arts as a health resource? An umbrella review of the health impacts of music and dance participation. *PLoS ONE*. 2021;16(6 June):1–18.
151. Ellis RJ, Thayer JF. Music and autonomic nervous system (dys)function. *Music Perception*. 2010;27(4):317–26.
152. Pelletier CL. The effect of music on decreasing arousal due to stress: A meta-analysis. *Journal of Music Therapy*. 2004;41(3):192–214.
153. Salimpoor VN, Benovoy M, Longo G, Cooperstock JR, Zatorre RJ. The rewarding aspects of music listening are related to degree of emotional arousal. *PLoS ONE*. 2009;4(10).
154. Grewe O, Nagel F, Kopiez R, Altenmüller E. How does music arouse “chills”? Investigating strong emotions, combining psychological, physiological, and psychoacoustical methods. *Annals of the New York Academy of Sciences*. 2005;1060:446–9.
155. van Criekinge T, D’Août K, O’Brien J, Coutinho E. Music and Hypertonia: Can Music Listening Help Reduce Muscle Tension and Improve Movement Quality? *Music and Science*. 2021;4:1–12.
156. Ter-Kazarian K, Luke JJ. Influence of an art museum visit on individuals’ psychological and physiological indicators of stress. *Museums and Social Issues* 2021;0(0):1–15.
157. Kraaykamp G. Literary socialization and reading preferences. Effects of parents, the library, and the school. *Poetics*. 2003 Jun;31(3–4):235–57.

158. Elpus K. Music education promotes lifelong engagement with the arts. *Psychology of Music* 2018;46(2):155–73.
159. Rabkin N, Hedberg EC. Arts education in America: What the declines mean for arts participation 2012. Available from: <https://www.arts.gov/sites/default/files/2008-SPPA-ArtsLearning.pdf>
160. Dickson GT, Schubert E. Music on Prescription to Aid Sleep Quality: A Literature Review. *Frontiers in Psychology*. 2020;11(July):1–8.
161. Gold BP, Frank MJ, Bogert B, Brattico E. Pleasurable music affects reinforcement learning according to the listener. *Frontiers in Psychology*. 2013;4(AUG):1–19.
162. Perlovsky L. Cognitive Function of Music and Meaning-Making. *Journal of Biomusical Engineering*. 2016;01(S1).
163. Perlovsky L. The cognitive function of music. Part II. *Interdisciplinary Science Reviews*. 2014;39(2):162–86.
164. Harper G. Creative writing you're cognitive dissonance. Vol. 13, *New Writing*. Routledge; 2016. p. 1–2.
165. Leeke PA. Fake narratives and critical thought: how creative writing can facilitate critical thinking in an age of fake news and false accounting. *New Writing*. 2020 Apr 2;17(2):199–207.
166. Courtney T, Battye J. Investigating processes of internalisation of values through theatre for development. *Journal of Social and Political Psychology*. 2018;6(1):27–48.
167. Bolduc J, Gosselin N, Chevrette T, Peretz I. The impact of music training on inhibition control, phonological processing, and motor skills in kindergarteners: a randomized control trial. *Early Child Development and Care*. 2021;191(12):1886–95.
168. Jaschke AC, Honing H, Scherder EJA. Longitudinal Analysis of Music Education on Executive Functions in Primary School Children. *Frontiers in Neuroscience*. 2018 Feb 28;12.
169. Koshimori Y, Thaut MH. New Perspectives on Music in Rehabilitation of Executive and Attention Functions. *Frontiers in Neuroscience*. 2019 Nov 19;13.
170. Mansouri FA, Acevedo N, Illiparampil R, Fehring DJ, Fitzgerald PB, Jaberzadeh S. Interactive effects of music and prefrontal cortex stimulation in modulating response inhibition. *Scientific Reports*. 2017 Dec 1;7(1).
171. Alain C, Moussard A, Singer J, Lee Y, Bidelman GM, Moreno S. Music and visual art training modulate brain activity in older adults. *Frontiers in Neuroscience*. 2019;13(March):1–15.
172. Moreno S, Farzan F. Music training and inhibitory control: A multidimensional model. *Annals of the New York Academy of Sciences*. 2015 Mar 1;1337(1):147–52.
173. Rajesh A, Noice T, Noice H, Jahn A, Daugherty AM, Heller W, et al. Can a Theater Acting Intervention Enhance Inhibitory Control in Older Adults? A Brain-Behavior Investigation. *Frontiers in Human Neuroscience*. 2021 Mar 18;15.
174. Shen Y, Zhao Q, Huang Y, Liu G, Fang L. Promotion of Street-Dance Training on the Executive Function in Preschool Children. *Frontiers in Psychology*. 2020 Oct 22;11.
175. McRae C, Leventhal D, Westheimer O, Mastin T, Utley J, Russell D. Long-term effects of Dance for PD® on self-efficacy among persons with Parkinson's disease. *Arts and Health* 2018;10(1):85–96.
176. Lau C, Goodloe J, Eatman-Williams J, Dudovitz R, Wentz S. Dancetricians: A Street Dance Intervention to Improve Physical Activity Self-efficacy and Motivation Among Urban Minority School Children. In: *Pediatrics*. 2018. p. 182.
177. Fancourt D, Finn S, Warran K, Wiseman T. Group singing in bereavement: Effects on mental health, self-efficacy, self-esteem and well-being. *BMJ Supportive and Palliative Care*. 2019;1–9.

178. van Puyvelde M, Rodrigues H, Loots G, de Coster L, du Ville K, Matthijs L, et al. Shall we dance? Music as a port of entrance to maternal-infant intersubjectivity in a context of postnatal depression. *Infant Mental Health Journal*. 2014;35(3):220–32.
179. Forsblom A, Särkämö T, Laitinen S, Tervaniemi M. The Effect of Music and Audiobook Listening on People Recovering From Stroke: The Patient’s Point of View. *Music & Medicine*. 2010;2(4):229–34.
180. Chandler GE. A Creative Writing Program to Enhance Self-Esteem and Self-Efficacy in Adolescents. *Joumcil of Child arid Adolescent Psychiatric Nursing*. 1999;12(3):70–8.
181. Catterall JS, Peppler KA. Learning in the visual arts and the worldviews of young children. *Cambridge Journal of Education*. 2007;37(4):543–60.
182. Brownett T. Social capital and participation: the role of community arts festivals for generating wellbeing. *Journal of Applied Arts & Health*. 2018;9(1):71–84.
183. Cai Y, Li L, Xu C, Wang Z. The Effectiveness of Non-Pharmacological Interventions on Apathy in Patients With Dementia: A Systematic Review of Systematic Reviews. *Worldviews on Evidence-Based Nursing*. 2020;17(4):311–8.
184. McNeely ME, Duncan RP, Earhart GM. Impacts of dance on non-motor symptoms, participation, and quality of life in Parkinson disease and healthy older adults. *Maturitas* 2015;82(4):336–41.
185. Craig DG. An overview of evidence-based support for the therapeutic use of music in occupational therapy. *Occupational Therapy in Health Care*. 2008;22(1):73–95.
186. Dwyer JJ. Effect of perceived choice of music on exercise intrinsic motivation. *Health Values: The Journal of Health Behavior, Education & Promotion*. 1995;19(2):18–26.
187. Moorefield-Lang HM. Arts voices: Middle school students and the relationships of the arts to their motivation and self-efficacy. *Qualitative Report*. 2010;15(1):1–17.
188. Ilari B. Music in the early years: Pathways into the social world. *Research Studies in Music Education*. 2016;38(1):23–39.
189. Nicholson JM, Berthelsen D, Abad V, Williams K, Bradley J. Impact of music therapy to promote positive parenting and child development. *Journal of Health Psychology*. 2008;13(2):226–38.
190. Teggelove K, Thompson G, Tamplin J. Supporting positive parenting practices within a community-based music therapy group program: Pilot study findings. *Journal of Community Psychology*. 2019;47(4):712–26.
191. Hebblethwaite S, Norris J. Expressions of generativity through family leisure: Experiences of grandparents and adult grandchildren. *Family Relations*. 2011;60(1):121–33.
192. Brown ED, Garnett ML, Velazquez-Martin BM, Mellor TJ. The art of Head Start: Intensive arts integration associated with advantage in school readiness for economically disadvantaged children. *Early Childhood Research Quarterly* 2018;45:204–14.
193. Brown ED, Benedett B, Armistead ME. Arts enrichment and school readiness for children at risk. *Early Childhood Research Quarterly*. 2010;25(1):112–24.
194. Phillips RD, Gorton RL, Pinciotti P, Sachdev A. Promising findings on preschoolers’ emergent literacy and school readiness in arts-integrated early childhood settings. *Early Childhood Education Journal*. 2010;38(2):111–22.
195. Burnard P. A phenomenological study of music teachers’ approaches to inclusive education practices among disaffected youth. *Research Studies in Music Education*. 2008;30(1):59–75.
196. Trent A, Riley J. Re-Placing the Arts in Elementary School Curricula: An Interdisciplinary, Collaborative Action Research Project. *Perspectives on Urban Education* 2009;Fall:14–27.

197. Williams KE, Barrett MS, Welch GF, Abad V, Broughton M. Associations between early shared music activities in the home and later child outcomes: Findings from the Longitudinal Study of Australian Children. *Early Childhood Research Quarterly* 2015;31:113–24.
198. Rolka EJ, Silverman MJ. A systematic review of music and dyslexia. *Arts in Psychotherapy* 2015;46:24–32.
199. Sala G, Gobet F. Cognitive and academic benefits of music training with children: A multilevel meta-analysis. *Memory and Cognition*. 2020;48(8):1429–41.
200. Jaschke AC, Eggermont LHP, Honing H, Scherder EJA. Music education and its effect on intellectual abilities in children: A systematic review. *Reviews in the Neurosciences*. 2013;24(6):665–75.
201. Jindal-Snape D, Davies D, Scott R, Robb A, Murray C, Harkins C. Impact of arts participation on children’s achievement: A systematic literature review. *Thinking Skills and Creativity* 2018;29(December 2017):59–70.
202. Foster EM, Marcus Jenkins J v. Does Participation in Music and Performing Arts Influence Child Development? Vol. 54, *American Educational Research Journal*. 2017. 399–443.
203. Catterall JS, Dumais SA, Hampden-Thompson G. *The Arts and Achievement in At-Risk Youth: Findings from Four Longitudinal Studies*. National Endowment for the Arts. 2012. Available from: <http://eric.ed.gov/?id=ED530822>
204. Winsler A, Gara T v., Alegrado A, Castro S, Tavassolie T. Selection into, and academic benefits from, arts-related courses in middle school among low-income, ethnically diverse youth. *Psychology of Aesthetics, Creativity, and the Arts*. 2020;14(4):415–32.
205. Martin AJ, Mansour M, Anderson M, Gibson R, Liem GAD, Sudmalis D. The role of arts participation in students’ academic and nonacademic outcomes: A longitudinal study of school, home, and community factors. *Journal of Educational Psychology*. 2013;105(3):709–27.
206. Park SY, Pan B, Ahn J bin. Family trip and academic achievement in early childhood. *Annals of Tourism Research* 2020;80(September 2019):102795.
207. Grigorenko EL. Twice Exceptional Students: Gifts and Talents, the Performing Arts, and Juvenile Delinquency. *New Directions for Child and Adolescent Development*. 2020;2020(169):59–74.
208. Daykin N, Orme J, Evans D, Salmon D, Mceachran M, Brain S. The impact of participation in performing arts on adolescent health and behaviour: A systematic review of the literature. *Journal of Health Psychology*. 2008;13(2):251–64.
209. Hughes J. *Doing the Arts Justice: A Review of Research Literature, Practice and Theory* 2005. Available from: <http://www.artsevidence.org.uk/media/uploads/evaluation-downloads/doing-the-arts-justice-2005.pdf>
210. Bickley-Green C. Visual Arts Education: Teaching a Peaceful Response to Bullying. *Art Education*. 2007;60(2):6–12.
211. Belliveau G. An arts-based approach to teach social justice: Drama as a way to address bullying in schools. *International Journal of Arts Education*. 2005;3(2):136–65.
212. Feldman AF, Matjasko JL. The role of school-based extracurricular activities in adolescent development: A comprehensive review and future directions. *Review of Educational Research*. 2005;75(2):159–210.
213. Feldman Farb A, Matjasko JL. Recent advances in research on school-based extracurricular activities and adolescent development. *Developmental Review*. 2012;32(1):1–48.
214. Denault AS, Poulin F, Pedersen S. Intensity of participation in organized youth activities during the high school years: Longitudinal associations with adjustment. *Applied Developmental Science*. 2009;13(2):74–87.

215. Eccles JS, Barber BL. Student council, volunteering, basketball, or marching band: What kind of extracurricular involvement matters? *Journal of Adolescent Research*. 1999;14(1):10–43.
216. Zill N, Winquist Nord C, Spencer Loomis L. *Adolescent Time Use, Risky Behavior, and Outcomes: An Analysis of National Data*. Washington, DC; 1995.
217. McNeal RB. Extracurricular Activities and High School Dropouts. *Sociology of Education*. 1995;68(1):62–80.
218. Wegner L, Flisher AJ. Leisure boredom and adolescent risk behaviour: A systematic literature review. *Journal of Child and Adolescent Mental Health*. 2009;21(1):1–28.
219. Barber BL, Eccles JS, Stone MR. Whatever happened to the Jock, the Brain, and the Princess? Young adult pathways linked to adolescent activity involvement and social identity. *Journal of Adolescent Research*. 2001;16(5):429–55.
220. Department for Digital Culture Media and Sport. *A connected society: A strategy for tackling loneliness*. HM Government Strategy. 2018;84.

Appendix

List of papers

Paper 1 Bone, J. K., Bu, F., Fluharty, M. E., Paul, E., Sonke, J. K., & Fancourt, D. (2022). Engagement in leisure activities and depression in older adults in the United States: Longitudinal evidence from the Health and Retirement Study. *Social Science & Medicine*, 294, 114703.

<https://doi.org/10.1016/j.socscimed.2022.114703>

Paper 2 Bone, J. K., Fancourt, D., Fluharty, M. E., Paul, E., Sonke, J. K., & Bu, F. (2021 preprint & under review). Associations between participation in community arts groups and aspects of wellbeing in older adults in the United States: A propensity score matching analysis. *Preprint available from medRxiv*.

<https://doi.org/10.1101/2021.06.01.21258135>

Paper 3 Borra, C., & Mak, H. W. (in prep) Arts engagement amongst people with chronic pain and their later life satisfaction and other health outcomes in the Health and Retirement Study.

Paper 4 Mak, H. W., Coulter, R., & Fancourt, D. (2021). Associations between community cultural engagement and life satisfaction, mental distress and mental health functioning using data from the UK Household Longitudinal Study (UKHLS): are associations moderated by area deprivation? *BMJ Open*, 11(9), e045512.

<https://doi.org/10.1136/bmjopen-2020-045512>

Paper 5 Bone, J., Fancourt, D., Fluharty, M., Paul, E., Sonke, J., & Bu, F. (2021 preprint & under review). Cross-sectional and longitudinal associations between arts engagement, loneliness, and social support in adolescence. *Preprint available from PsyArXiv*. <https://doi.org/10.31234/osf.io/64d7c>

Paper 6 Bone, J., Fancourt, D., Fluharty, M., Paul, E., Sonke, J., & Bu, F. (in prep). Participatory and receptive arts engagement in older adults: Associations with cognition over a seven-year period.

Paper 7 Fluharty, M., Bone, J., Bu, F., Sonke, J., Fancourt, D., & Paul, E. (2021 preprint & under review). Associations between extracurricular arts activities, school-based arts engagement, and subsequent externalising behaviours: Findings from the Early Childhood Longitudinal Study. *Preprint available from PsyArXiv*.

<https://doi.org/10.31234/osf.io/gdk3t>

Paper 8 Bone, J., Bu, F., Fluharty, M., Paul, E., Sonke, J., & Fancourt, D. (2021 preprint & under review) Arts and cultural engagement, reportedly antisocial or criminalized behaviors, and potential mediators in two longitudinal cohorts of adolescents. *Preprint available from PsyArXiv*.

<https://doi.org/10.31234/osf.io/v2f6p>

Paper 9 Fluharty, M., Bu, F., Bone, J., Sonke, J., Fancourt, D., & Paul, E. (in prep). Associations of arts and cultural engagement with substance use trajectories in adolescence and early adulthood: a latent growth curve analysis of the Add Health cohort.