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The dynamic relationship between pain, depression and cognitive function in a sample of newly diagnosed arthritic adults: a cross-lagged panel model

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Original Article

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Abstract

Background. Pain and depression are common in the population and co-morbid with each other. Both are predictive of one another and are also associated with cognitive function; people who are in greater pain and more depressed respectively perform less well on tests of cognitive function. It has been argued that pain might cause deterioration in cognitive function, whereas better cognitive function earlier in life might be a protective factor against the emergence of disease. When looking at the dynamic relationship between these in chronic diseases, studying samples that already have advanced disease progression often confounds this relationship.

Methods. Using data from waves 1 to 3 of the English Longitudinal Study of Ageing (ELSA) ($n = 516$), we examined the interplay between pain, cognitive function and depression in a subsample of respondents reporting a diagnosis of arthritis at wave 2 of the ELSA using cross-lagged panel models.

Results. The models showed that pain, cognitive function and depression at wave 1, prior to diagnosis, predict pain at wave 2, and that pain at wave 1 predicts depression at wave 2. Pain and depression at wave 2 predict cognitive function at wave 3.

Conclusions. The results indicate that better cognitive function might be protective against the emergence of pain prior to an arthritis diagnosis, but cognitive function is subsequently impaired by pain and depression. Furthermore, higher depression predicts lower cognitive function, but not vice versa. This is discussed in the context of the emerging importance of inflammation in depression.

Introduction

Physical (e.g. pain) and psychological (e.g. depression, anxiety) health are closely associated with one another: people in worse physical health often report greater levels of psychological distress, and people reporting poorer mental health tend to report poorer physical health (Campbell *et al.*, 2003). Research suggests that pain is associated with a more rapid decline in cognitive function in older adults (Berryman *et al.*, 2013), while a separate literature argues that greater cognitive function earlier on in life is related to better physical and mental health in senescence (Gale *et al.*, 2012*b*). This study uses data from the English Longitudinal Study of Ageing (ELSA) to untangle the relationship between these three variables by using a cross-lagged panel model to look at the prospective effects of these factors on each other in a sample of respondents diagnosed with arthritis at the second wave of the ELSA. Arthritis is a condition commonly associated with chronic pain, and potentially with cognitive decline (Huang *et al.*, 2015). We modelled the relationship between these variables at the wave before diagnosis, the wave of diagnosis, and the wave after diagnosis with arthritis.

Disordered mood and pain

The biopsychosocial approach to chronic pain holds that pain is not simply caused by damage to the body, but due to a range of cognitive and affective individual differences alongside the wider social context people live in (Gatchel *et al.*, 2007; Quartana *et al.*, 2009). It has been established that pain is moderated by a constellation of individual differences that focus around negative affect and mood, such as psychological distress (Croft *et al.*, 2001; Hurwitz *et al.*, 2003), depression (Geerlings *et al.*, 2002; Kroenke *et al.*, 2011), anxiety (McWilliams *et al.*, 2004; Castillo *et al.*, 2013), catastrophizing (Keefe *et al.*, 1989; Edwards *et al.*, 2011) and neuroticism (Costa, 1987), which all lead to greater subjective pain. However, the interplay

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between these factors has only been partially explored, especially when considering how pain may change over the course of a chronic disease.

Cognitive function, pain and depression

While the relationship between pain, negative affect and cognition is well established, both cross-sectionally (Lépine and Briley, 2004; McWilliams *et al.*, 2004; Stubbs *et al.*, 2017) and longitudinally (Geerlings *et al.*, 2002; Kroenke *et al.*, 2011; Gerrits *et al.*, 2015), less is known about their dynamic inter-play. Amongst older adults, it has been observed that the experience of pain appears to be associated with a reduction in cognitive function, which is thought to be because performance on cognitive tasks is impeded due to resources instead being used to respond to the experience of pain (Moriarty *et al.*, 2011). Indeed, there is evidence that pain appears to interfere with executive functions such as working memory (Berryman *et al.*, 2013). At the same time, other evidence suggests that cognitive function acts as a protective factor against the emergence of disease and symptoms of disease such as pain, particularly chronic widespread pain (Gale *et al.*, 2012*b*). This latter research has identified the importance of cognitive function earlier on in life upon the development of diseases across the lifespan (Deary *et al.*, 2010).

Previous studies using data from the ELSA have found that pain does not cause cognitive decline (Veronese *et al.*, 2018). However, while this study controlled for comorbidities [including cancer, heart disease and arthritis (Huang *et al.*, 2015)], simply grouping people together with a highly prevalent disease like arthritis (affecting around 40% of the ELSA cohort), is a concern as the length of time they have had arthritis for varies considerably, from a few months to several decades and as the disease progresses, the differential effects of cognition, affect and pain may become too comorbid to differentiate [e.g. Hawker *et al.* (2011); Huang *et al.* (2015)]. As such, it is necessary to study the dynamics of pain, affect and cognitive function across the early course of disease. Therefore, this study examines how cognition and affect assessed prior to disease diagnosis affects subsequent pain, and how this subsequent pain influences cognition and affect. Thus, as a disease becomes established we can explore the early interplay of cognition, affect and pain at the onset when their impact is likely to be more apparent and clearly differentiated (Gerrits *et al.*, 2015).

Similar to pain, there is a literature that has found that greater depression severity is associated with poorer cognitive function (McDermott and Ebmeier, 2009), including among older adults. It has been noted that the majority of this literature has looked at the effect of depression and poor mood on cognitive function, rather than the effect of cognitive function on poor mood (Gale *et al.*, 2012*a*). Gale *et al.* (2012*a*) looked at the dynamics of the relationship between depression and cognitive function using data from the ELSA, finding that although depression and cognitive function were associated with each other in older adults under the age of 80, there was limited evidence either was related to the rate of change in the other. Further, there is emerging evidence suggesting an association between depression and inflammation (Maier and Watkins, 1998). These studies report that increased levels of cytokines are associated with increased levels of depression (Valkanova *et al.*, 2013). There is also reason to hypothesise an overlap with pain, as inflammation is linked to both pain (de Goeij *et al.*, 2013) and cognitive function, where in the latter case inflammation appears to be a marker of cognitive decline (Yaffe *et al.*, 2004).

Arthritis, pain and psychological distress

Arthritis is a cause of chronic pain in older adults. It is estimated that around 15% of the adult population have osteoarthritis (Neogi, 2013; Johnson and Hunter, 2014), and a further 1% has rheumatoid arthritis (Alamanos and Drosos, 2005), both of which become more common with advancing age. Osteoarthritis is one of the commonest causes of working age disability and a source of distress for many people who suffer from it (O'Reilly *et al.*, 1998). Physically, arthritis typically involves stiffness, inflammation and soreness of joints in the body, most commonly in the hip or knee, which is associated with chronic pain and disability. While arthritis is thought to be an important cause of distress, there is also evidence from other studies using the ELSA (Chou, 2007), that there is a reciprocal relationship between pain and distress; pain is predictive of future distress and vice versa. A small number of studies have looked at the relationship between individual differences and pain in regard to arthritis. Hawker *et al.* (2011) found in an arthritis cohort that the experience of pain predicted future reports of depression and disordered mood.

Our approach has a number of advantages over the previous literature on the longitudinal relationship between pain in arthritis patients and depression. We examine the early onset of the disease rather than grouping arthritis patients together, which weakly controls for disease onset (Keefe *et al.*, 2000; Sturgeon and Zautra, 2013). While these studies identify associations between affect and pain, there is a clinical need to further understand for purposes of early treatment and management which to prioritise. It is also the case that studies often look at how pain predicts psychological distress, or vice versa, without controlling for the outcome variables at baseline. Because studies of ageing have respondents that report incidence of arthritis at different measurement points, it is possible to model the relationship between relatively recently emerging pain and psychological distress.

Consequently, this study further aims to tease out the relationship between pain, affect and cognitive decline. While one study has found that arthritis is related to cognitive decline (Huang *et al.*, 2015), this finding has been disputed in longitudinal ageing studies (Baker *et al.*, 2017). Therefore, we longitudinally model the relationship between pain and cognitive function in arthritis, to further understand whether the pain is the driving factor in cognitive decline among people with arthritis. This analysis utilises a subsample of respondents to the ELSA that participated in wave 1 of the ELSA and reported a diagnosis of arthritis at wave 2.

Method

Sample

Data were taken from a subsample of 516 respondents who participated in the ELSA (Marmot *et al.*, 2016). At present the ELSA consists of eight waves of data, beginning in 2002 and separated by approximately 2 years. Respondents were assigned to the subsample depending on whether they had participated in wave 1 of the ELSA ($n = 12\,099$), reported a diagnosis of arthritis between waves 1 (2002–2003) and waves 2 (2004–2005) ($n = 596$), did not report a diagnosis of arthritis at wave 1 ($n = 540$), and further reported their arthritis diagnosis did not fall in the five years running up to the beginning of the ELSA study ($n = 519$). Of those 519, three had missing data on all of the pain, depression and cognitive function measurements and were removed from the analysis, leaving 516 respondents (see Fig. 1 for details), of who 420 participated

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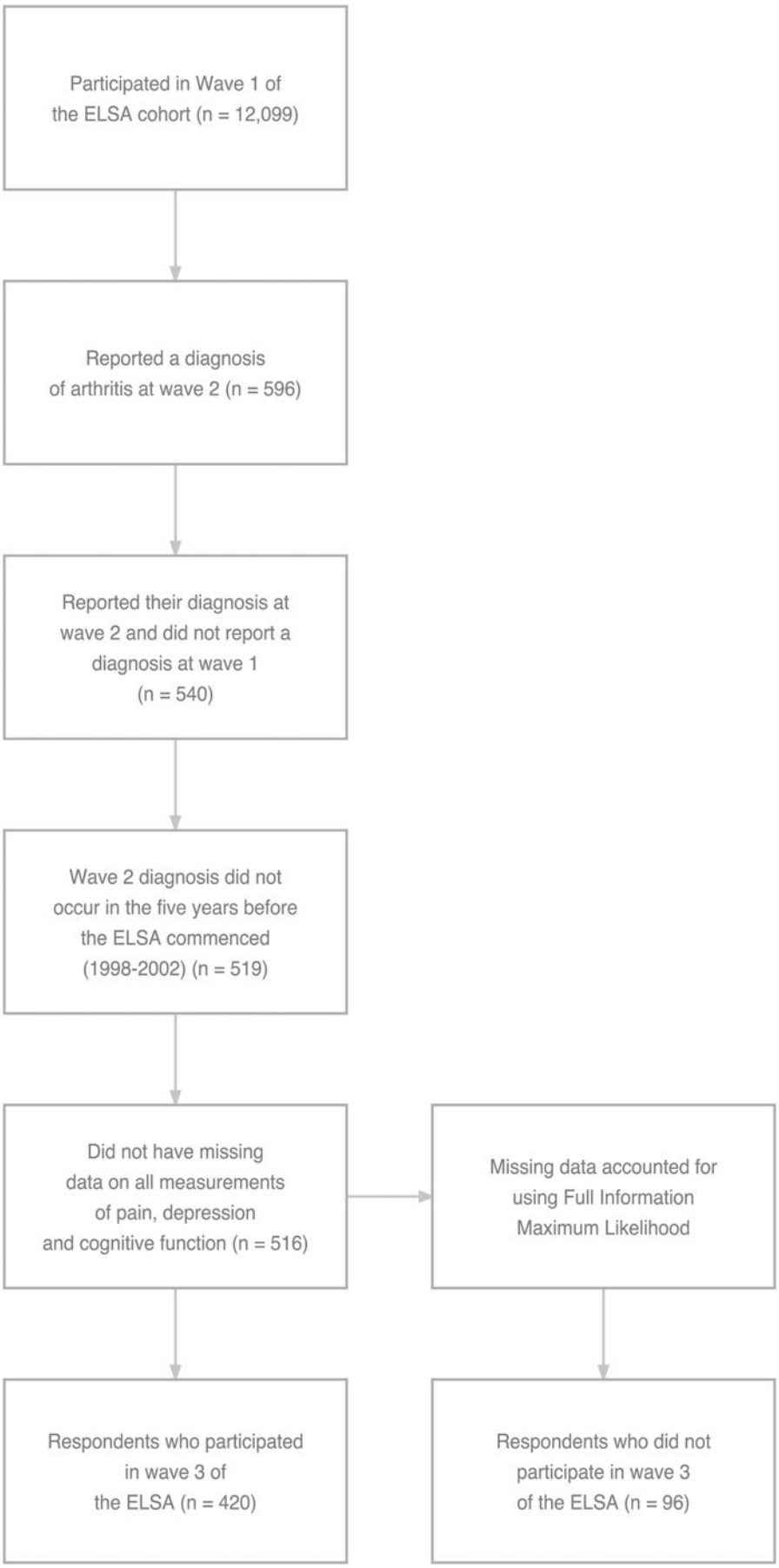


Fig. 1. Flowchart representing the assignment of respondents to the subsample analysed in this study.

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in wave 3 as well; missing data were accounted for using a full information maximum likelihood (FIML) estimation.

Of the 519 eligible for the subsample, 470 reported being diagnosed in the period 2002–2005 (i.e. since their previous ELSA interview), or whom 71 were diagnosed in 2002, 191 in 2003, 194 in 2004 and 14 in 2005. Twenty-eight individuals either refused to answer this question or did not know when they had been diagnosed. Ethical review for the data collection was obtained from the NHS Research Ethics Committees service. The anonymised data were made publicly available by NatCen to download from the UK Data Archive.

Measures

Pain was assessed using two questions that were combined. The first asked (yes/no) whether the respondent has been often troubled by pain. For respondents who affirmed this was the case, they were then asked to rate how bad the pain was (either mild, moderate or severe). These questions were asked as part of the main ELSA interview at each of the eight waves. This was combined into a score from 0 (not troubled by pain) to 3 (troubled by severe pain), representing whether they were troubled by pain, and how severe it was, at each wave. These options, as verbal rating scales, have been used widely in the pain literature (Stubhaug *et al.*, 2008). These verbal rating scales are known to be valid indicators of pain, performing extremely similarly to other, more elaborate pain measurements (e.g. visual analogue scales or numeric rating scales which are continuous or with a greater number of ordinal responses), and are responsive to the introduction of pain, such as through a cold pressor paradigm (Ferreira-Valente *et al.*, 2011).

Depression was measured using a dichotomous eight-item variation of the Center for Epidemiologic Studies Depression Scale (CES-D) (Radloff, 1977), which has been used widely to assess depression. This variant of the CES-D was administered to respondents at each wave as part of the main ELSA interview.

Cognitive function was assessed using principal component scores from five tasks in the main ELSA interview. At the start of the cognitive function module, participants were instructed that they would be given a clipboard and a pencil later in the module, and when they were presented with them they should write their initials in the top left-hand corner of the paper attached to the clipboard (*prospective memory*). Performance on this test was scored from 0 to 5 (5 = completed task correctly without prompting, 4 = partially completed the task (either wrote initials elsewhere or something in top left corner) without prompting, 3 = did something else, or declared they did not remember what to do without prompting, 2 = completed task after prompting, 1 = partially completed task after prompting, 0 = did nothing or failed to remember after prompting). Participants were randomly allocated to receive one of four lists of 10 words, presented to them verbally by the interviewer. They were then asked to immediately recall as many of them as possible (*immediate recall*) and were asked to recall again the list of words again at the end of the cognitive function module (*delayed recall*). They were also asked to list as many animals as they could within 1 min (*fluency*), and complete a letter cancellation task to index *attention*. These five measures were then entered into a principal component analysis, extracting a single factor which all items loaded strongly onto (parallel analyses indicated a single component model was also the best fit of the data). From this, factor scores were used as a measure of cognitive function. This was calculated at each wave, as the cognitive function module included each of these tasks at waves 1, 2 and 3 (online Supplementary Table S1).

Table 1. Descriptive statistics

Measure	M	S.D.
Year of birth	1937.535	9.917
Pain – wave 1	0.683	0.988
Pain – wave 2	1.062	1.069
Pain – wave 3	0.978	1.081
CES-D – wave 1	1.584	1.942
CES-D – wave 2	1.830	1.994
CES-D – wave 3	1.810	1.994
BMI	28.290	4.840
Sex	63.18% female	
Current smoking	19.03% smoke	
Current drinker	69.71% drink regularly	
Education:		
Higher education (with or without degree)	20.66%	
Secondary education (A levels, O levels or CSE, or equivalents)	30.12%	
Other qualifications (e.g. foreign equivalents)	39.96%	
No formal qualifications	9.27%	

As most ELSA wave 2 interviews were completed in 2004, this would give the sample an average age of 66–67. This compares closely with the average age in the ELSA at wave 1 (64.19). Regular drinking is defined as reporting they drank on a more frequent basis than 'never' or 'on special occasions'.

Table 2. Model fit indices

Index	Statistic
AIC	12 542.437
BIC	12 771.726
ABIC	12 600.320
χ^2 test of model fit	93.758 (18) $p < 0.001$
RMSEA	0.090 (0.073–0.109)
CFI	0.950
TLI	0.850
χ^2 test of baseline model	1573.166 (54) $p < 0.001$
SRMR	0.038

Modelling

A cross-lagged panel model was estimated using the pain, depression and cognitive function measurements at waves 1, 2 and 3. It has been previously noted that the use of cross-lagged models with two time points is problematic (Hamaker *et al.*, 2015). To overcome this, we used three time points, and modelled the within-participant variance in each measure using a simplex. At each wave, the covariance between the three pain measures was modelled. A maximal model was used, with pain, depression and cognitive function each predicting all three at the following wave. A simplex was modelled to account for the autoregressive relationship between each variable and measurements of it at

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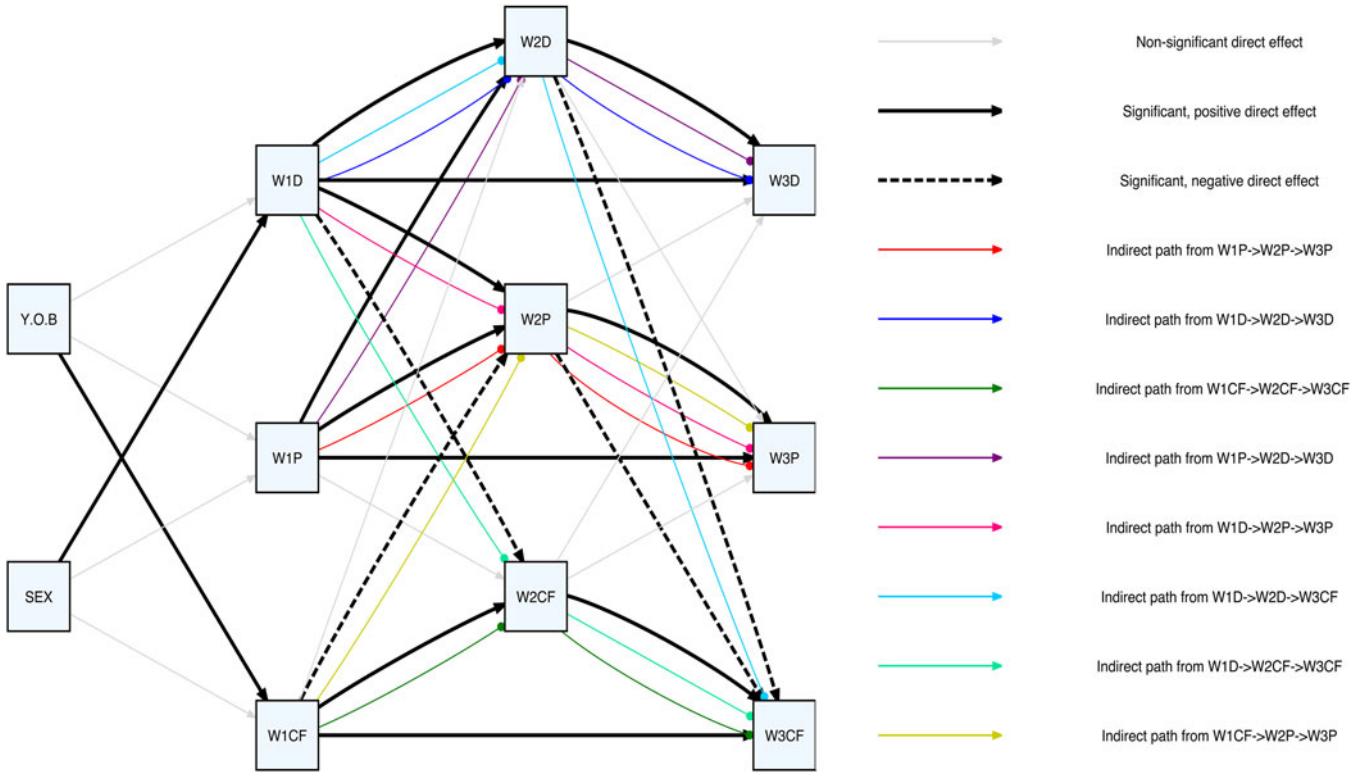


Fig. 2. Path model of the direct and indirect relationships between depression (D), pain (P) and cognitive function (CF) at the three waves (W1, W2, W3) of the ELSA, with wave 1 depression, pain and cognitive function predicted by year of birth (Y.O.B.) and sex.

earlier waves (i.e. wave 3 pain was regressed on both wave 2 and wave 1 pain, as opposed to just wave 2 pain as is common in many cross-lagged panel models). The model was adjusted for age (year of birth, *z*-scored) and sex (0 = male, 1 = female), as both are known to be associated with the variables in the model (e.g. sex and depression, age and cognitive function). The path model included the mean structure.

Model fit was assessed using the χ^2 test of model fit, the Comparative Fit Index, the Tucker Lewis Index, the Root Mean Square Error of Approximation (RMSEA) and the Standardised Root Mean Square Residual (SRMR). Decisions on the cut-off for acceptable fit were determined using the guidelines suggested by Hu and Bentler (1999), who advise the use of combinatorial rules to reduce the likelihood of accepting a poor fitting model.

Modelling was conducted in MPlus v.7.4 (Muthén and Muthén, 1998–2015) with a maximum likelihood estimation. Missing data were handled using the FIML, as the ELSA data are assumed to be missing at random and the level of dropout in this subsample is small (19.8%). Sensitivity analyses conducted using a listwise deletion, to test if the missing data approach biased the findings in any way, did not find substantial differences between the different approaches (see online Supplementary Materials).

Results

Table 1 reports the descriptive statistics for the sample. Online Supplementary Table S2 reports the bivariate correlations between the variables in the model. All of the fit indices suggested the model was an adequate fit (RMSEA = 0.090, 95% CI 0.073–0.109, SRMR = 0.038, CFI = 0.950, TLI = 0.850). Some of the indices (SRMR < 0.04, CFI > 0.95) identified the model was a good fit, others did not (TLI < 0.95), and others suggested the model the model was adequate (RMSEA > 0.06) (Table 2). Using the combinatorial rules that have been previously suggested for CFI and SRMR (Hu and Bentler, 1999), we chose this model as suitable.

The model (Fig. 2, Table 3) shows that pain at wave 2 is predicted by prior pain, depression and cognitive function. Higher levels of depression and pain were associated with greater pain at the wave where respondents reported begin diagnosed with arthritis, and higher cognitive function was associated with less pain, providing support for the idea that cognitive function is a protective factor. Depression at wave 2 was also predicted by pain at wave 1, with greater pain being associated with higher depression scores. Moreover, cognitive function at wave 3 was also predicted by pain and depression, with greater depression and pain being associated with lower subsequent cognitive function. This provides support for the cognitive resources account of cognitive function. We further tested whether treatment engagement mediated the relationship between cognitive function and pain, finding it did not (online Supplementary Table S3).

At wave 1, cognitive function was significantly associated with pain and depression, and pain and depression were significantly associated with each other at all three waves (online Supplementary Table S4). Looking at the indirect relationships between the different measurements of the same constructs (Table 4) showed strong indirect relationships across the three waves (i.e. wave 1 pain -> wave 2 pain -> wave 3 pain). There was also evidence of pain and depression at wave 1 predicting depression and pain at waves 2

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Table 3. Unstandardised model parameters

Measure	Predictor	*B*	S.E.	*p*
W1 Pain	Y.O.B.	−0.071	0.044	0.103
	Sex	−0.025	0.090	0.784
W1 Depression	Y.O.B.	−0.031	0.086	0.715
	Sex	0.355	0.178	0.046*
W1 Cognitive function	Y.O.B	0.351	0.038	<0.001**
	Sex	0.036	0.077	0.642
W2 Pain	W1 Pain	0.361	0.045	<0.001***
	W1 Depression	0.052	0.023	0.025*
	W1 C.F.	−0.165	0.050	0.001**
W2 Depression	W1 Depression	0.537	0.039	<0.001***
	W1 Pain	0.204	0.076	.008**
	W1 C.F.	−0.116	0.083	0.166
W2 Cognitive function	W1 C.F.	0.714	0.034	<0.001***
	W1 Pain	−0.012	0.032	0.708
	W1 Depression	−0.034	0.017	0.039*
W3 Pain	W1 Pain	0.234	0.052	<0.001***
	W2 Pain	0.399	0.046	<0.001***
	W2 Depression	0.046	0.024	0.057
	W2 C.F.	−0.017	0.051	0.733
W3 Depression	W1 Depression	0.408	0.051	<0.001***
	W2 Depression	0.384	0.050	<0.001***
	W2 Pain	0.081	0.079	0.301
	W2 C.F.	−0.023	0.091	0.803
W3 Cognitive function	W1 C.F.	0.344	0.047	<0.001***
	W2 C.F.	0.473	0.045	<0.001***
	W2 Pain	−0.062	0.029	0.032*
	W2 Depression	−0.038	0.016	0.017*

C.F., cognitive function; W, wave. * = $p < .05$, ** = $p < .01$, *** = $p < .001$

Table 4. Indirect paths predicting pain, depression and cognitive function at wave 3

Path	*b*	S.E.	*p*
W1D -> W2P -> W3P	0.021	0.010	0.030*
W1D -> W2D -> W3P	0.025	0.013	0.060
W1D -> W2CF -> W3P	0.001	0.002	0.735
W1CF -> W2P -> W3P	−0.066	0.021	0.002**
W1CF -> W2D -> W3P	−0.005	0.005	0.263
W1CF -> W2CF -> W3P	−0.012	0.036	0.733
W1P -> W2P -> W3P	0.144	0.025	<0.001***
W1P -> W2D -> W3P	0.009	0.006	0.122
W1P -> W2CF -> W3P	0.000	0.001	0.800
W1D -> W2D -> W3D	0.206	0031	<0.001***
W1D -> W2P -> W3D	0.004	0.004	0.348
W1D -> W2CF -> W3D	0.001	0.003	0.804
W1CF -> W2P -> W3D	−0.013	0.014	0.324
W1CF -> W2D -> W3D	−0.044	0.033	0.173
W1CF -> W2CF -> W3D	−0.016	0.065	0.803
W1P -> W2P -> W3D	0.029	0.029	0.306
W1P -> W2D -> W3D	0.078	0.031	0.012*
W1P -> W2CF -> W3D	0.000	0.001	0.835
W1D -> W2P -> W3CF	−0.003	0.002	0.122
W1D -> W2D -> W3CF	−0.020	0.009	0.019*
W1D -> W2CF -> W3CF	−0.016	0.008	0.043*
W1CF -> W2P -> W3CF	0.010	0.006	0.071
W1CF -> W2D -> W3CF	0.004	0.004	0.230
W1CF -> W2CF -> W3CF	0.338	0.036	<0.001***
W1P -> W2P -> W3CF	−0.022	0.011	0.038
W1P -> W2D -> W3CF	−0.008	0.004	0.075
W1P -> W2CF -> W3CF	−0.006	0.015	0.709

W, wave; D, depression; P, pain; CF, cognitive function. * = $p < .05$, ** = $p < .01$, *** = $p < .001$

and 3, further confirming the bidirectional association between pain and depression. There was also evidence that depression at waves 1 and 2 predict subsequent measures of cognitive function. There was also an indirect relationship between cognitive function at wave 1, pain at wave 2 and pain at wave 3, further supporting that higher cognitive function was protective of future pain.

Discussion

The findings reported in this study demonstrates how cognitive function acts as a protective factor against the experience of pain (including an indirect effect via wave 2 pain) when arthritis emerges, but is impaired by pain when arthritis worsens over time. Thus, both the protective function and resource depletion accounts of cognitive ability are supported when considering the dynamic change of the experience of pain. At least in the early stages of arthritis, cognitive ability is associated with greater future well-being, insofar as it is protective against the emergence of pain. At the same time, pain at the point of arthritis diagnosis was predictive of a decline in subsequent cognitive function.

Greater levels of pain and depression were associated with poorer cognitive function at the wave following arthritis diagnosis. It is not clear whether this is driven by disruption to performance on cognitive tests, or cognitive decline (Sofi *et al.*, 2011). The influence pain has on attention (Eccleston and Crombez, 1999), and depression, means that it is liable to reduce performance on cognitive function tests. There are also other factors that might mediate the relationship between pain and reduced cognitive function. For example, increased sleeping difficulties (also a symptom of depression), are often cited as a consequence of pain, and thus may also be a contributing factor to worsening cognitive difficulties (McCracken and Iverson, 2001; Roach *et al.*,

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2009). The relationship between pain and depression might similarly be mediated. Previous research looking at the impact of pain trajectories over time shows how these impact on engagement in wider social and societal engagement, with those in worsening pain less likely to engage in these activities (James *et al*., 2018). Such a lack of social engagement is linked to social isolation and loneliness and thus potentially depression (Nicholson, 2012; Courtin and Knapp, 2017). Moreover, pain is a frequently cited cause of difficulties in activities of daily living (Verbrugge and Juarez, 2006), and limitations to such activities, which may not recede when pain improves (James *et al*., 2019). This may in turn reduce social contact (Drageset, 2004), as well as individual levels of self-efficacy (Salkeld *et al*., 2000) and perceived control (Bowling *et al*., 2007), which both increase the risk of depression (Holahan and Holahan, 1987). While these identify that pain is the overriding cause of these outcomes, it may also be the case that inflammation is a mediating factor between pain and depression as well (see below).

Similar to the previous literature, we found that depression and cognitive function were associated with each other. Depression at waves 1 and 2 was predictive of subsequent cognitive function; in both cases, greater levels of depression were associated with poorer subsequent cognitive function (McDermott and Ebmeier, 2009). There is increasing evidence to support the role of inflammation in depression, with meta-analyses indicating depressed people have higher levels of inflammatory cytokines (i.e. IL-1, IL-6, TNF-α and CRP) (Dowlati *et al*., 2010; Valkanova *et al*., 2013). Furthermore, some of these markers, alongside being associated with depression, are also associated with cognitive decline (Yaffe *et al*., 2004; Leonard, 2007). In addition to being an important consideration for arthritis generally, through the potential role of depression on cognitive decline, this is also of particular relevance for rheumatoid arthritis, which is characterised by chronic inflammation (McInnes and Schett, 2011).

In the run up to a diagnosis of arthritis, both prior pain and depression are strongly related to the future experience of pain and depression, and each other, as wave 1 pain and depression were positive associated with wave 2 depression and pain. This suggests there is a positive feedback loop between pain and disordered mood; people who are troubled by pain become more depressed, and feel more pain. This finding is similar to other studies that have shown how constructs such as catastrophizing are related to the experience of pain (Goubert *et al*., 2004; Sturgeon and Zautra, 2013). Where this study goes further is to show how both of these impacts subsequent performance on tests of cognitive function. As cognitive function is used in a range of activities of daily living vital to independence in old age, this shows how subjective perceptions of pain and affect subsequently affect processes that underpin activities that constitute independence and self-care. Therefore, intervening upon these early in the disease course has a clear clinical utility.

There are a number of limitations to this analysis. There was some attrition in the study, although we conducted sensitivity analyses using all cases with full data to test whether treating the data as missing at random (as we did using a FIML approach) was appropriate. Although dropout was low, restricting the model to cases with full data showed minimal differences with the model used. This is a problem general longitudinal surveys in the first few waves (Banks *et al*., 2011), and is especially pertinent to an ageing study where one might expect additional dropout due to infirmity and mortality. While this study shows how cognitive function is impaired by pain and depression, further work ought to be conducted to determine whether this affects all areas of cognitive function equally. This has an applied purpose as some aspects of daily living, especially instrumental activities of daily living such as remembering to take medications, shopping for groceries, or managing money will rely on certain aspects of cognitive function more than others. The pain measure in this study is of generalised rather than arthritis specific pain, and respondents may well have other conditions causing them pain. However, studies that have looked at longitudinal trajectories of pain using these measures of pain show that people with arthritis and those with cancer, in the ELSA cohort, show different pain trajectories (James *et al*., 2018). Thus, the pattern of pain experience reported using these general pain questions does seem to be disease specific. Therefore, while other factors may be contributing to the respondents' reporting of pain, they are mostly likely reporting arthritic focused pain. The ELSA did not have information about arthritis severity; although the sample was controlled on disease duration, respondents may have differed on the extent to which they were affected (i.e. level of OA pathology, inflammation and flares).

These analyses indicate there is a clear clinical utility to intervening upon pain and especially depression early after arthritis diagnosis, as this has the potential to limit the quality of life for older adults with arthritis.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0033291719001673

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References

Alamanos Y and Drosos AA (2005) Epidemiology of adult rheumatoid arthritis. *Autoimmunity Reviews* **4**, 130–136.

Baker NA, Barbour KE, Helmick CG, Zack M and Al Snih S (2017) Arthritis and cognitive impairment in older adults. *Rheumatology International* **37**, 955–961.

Banks J, Muriel A and Smith JP (2011) Attrition and health in ageing studies: evidence from ELSA and HRS. *Longitudinal and Life Course Studies* **2**, 1–26.

Berryman C, Stanton TR, Bowering JK, Tabor A, McFarlane A and Moseley LG (2013) Evidence for working memory deficits in chronic pain: a systematic review and meta-analysis. *Pain* **154**, 1181–1196.

Bowling A, Seetai S, Morris R and Ebrahim S (2007) Quality of life among older people with poor functioning. The influence of perceived control over life. *Age and Ageing* **36**, 310–315.

Campbell LC, Clauw DJ and Keefe FJ (2003) Persistent pain and depression: a biopsychosocial perspective. *Biological Psychiatry* **54**, 399–409.

Castillo RC, Wegener ST, Heins SE, Haythornthwaite JA, MacKenzie EJ and Bosse MJ (2013) Longitudinal relationships between anxiety, depression, and pain: results from a two-year cohort study of lower extremity trauma patients. *PAIN®* **154**, 2860–2866.

Chou K-L (2007) Reciprocal relationship between pain and depression in older adults: evidence from the English Longitudinal Study of Ageing. *Journal of Affective Disorders* **102**, 115–123.

Costa PT (1987) Influence of the normal personality dimension of neuroticism on chest pain symptoms and coronary artery disease. *The American Journal of Cardiology* **60**, J20–J26.

Courtin E and Knapp M (2017) Social isolation, loneliness and health in old age: a scoping review. *Health & Social Care in the Community* **25**, 799–812.

https://doi.org/10.1017/S0033291719001673 Published online by Cambridge University Press

Croft PR, Lewis M, Papageorgiou AC, Thomas E, Jayson MIV, Macfarlane GJ and Silman AJ (2001) Risk factors for neck pain: a longitudinal study in the general population. *Pain* **93**, 317–325.

de Goeij M, van Eijk LT, Vanelderen P, Wilder-Smith OH, Vissers KC, van der Hoeven JG and Pickkers P (2013) Systemic inflammation decreases pain threshold in humans in vivo. *PLoS ONE* **8**, e84159.

Deary IJ, Weiss A and Batty GD (2010) Intelligence and personality as predictors of illness and death: how researchers in differential psychology and chronic disease epidemiology are collaborating to understand and address health inequalities. *Psychological Science in the Public Interest* **11**, 53–79.

Dowlati Y, Herrmann N, Swardfager W, Liu H, Sham L, Reim EK and Lanctôt KL (2010) A meta-analysis of cytokines in major depression. *Biological Psychiatry* **67**, 446–457.

Drageset J (2004) The importance of activities of daily living and social contact for loneliness: a survey among residents in nursing homes. *Scandinavian Journal of Caring Sciences* **18**, 65–71.

Eccleston C and Crombez G (1999) Pain demands attention: a cognitive–affective model of the interruptive function of pain. *Psychological Bulletin* **125**, 356.

Edwards RR, Cahalan C, Mensing G, Smith M and Haythornthwaite JA (2011) Pain, catastrophizing, and depression in the rheumatic diseases. *Nature Reviews Rheumatology* **7**, 216–224.

Ferreira-Valente MA, Pais-Ribeiro JL and Jensen MP (2011) Validity of four pain intensity rating scales. *PAIN*® **152**, 2399–2404.

Gale CR, Allerhand M and Deary IJ (2012*a*) Is there a bidirectional relationship between depressive symptoms and cognitive ability in older people? A prospective study using the English Longitudinal Study of Ageing. *Psychological Medicine* **42**, 2057–2069.

Gale CR, Deary IJ, Cooper C and Batty GD (2012*b*) Intelligence in childhood and chronic widespread pain in middle age: the National Child Development Survey. *PAIN*® **153**, 2339–2344.

Gatchel RJ, Peng YB, Peters ML, Fuchs PN and Turk DC (2007) The biopsychosocial approach to chronic pain: scientific advances and future directions. *Psychological Bulletin* **133**, 581–624.

Geerlings SW, Twisk JWR, Beekman ATF, Deeg DJH and van Tilburg W (2002) Longitudinal relationship between pain and depression in older adults: sex, age and physical disability. *Social Psychiatry and Psychiatric Epidemiology* **37**, 23–30.

Gerrits MMJG, van Marwijk HWJ, van Oppen P, van der Horst H and Penninx BWJH (2015) Longitudinal association between pain, and depression and anxiety over four years. *Journal of Psychosomatic Research* **78**, 64–70.

Goubert L, Crombez G and Van Damme S (2004) The role of neuroticism, pain catastrophizing and pain-related fear in vigilance to pain: a structural equations approach. *Pain* **107**, 234–241.

Hamaker EL, Kuiper RM and Grasman RPPP (2015) A critique of the cross-lagged panel model. *Psychological Methods* **20**, 102–116.

Hawker GA, Gignac MAM, Badley E, Davis AM, French MR, Li Y and Lou W (2011) A longitudinal study to explain the pain-depression link in older adults with osteoarthritis. *Arthritis Care Res* (*Hoboken*) **63**, 1382–1390.

Holahan CK and Holahan CJ (1987) Self-efficacy, social support, and depression in aging: a longitudinal analysis. *Journal of Gerontology* **42**, 65–68.

Hu LT and Bentler PM (1999) Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal* **6**, 1–55.

Huang S-W, Wang W-T, Chou L-C, Liao C-D, Liou T-H and Lin H-W (2015) Osteoarthritis increases the risk of dementia: a nationwide cohort study in Taiwan. *Scientific Reports* **5**, 10145.

Hurwitz EL, Morgenstern H and Yu F (2003) Cross-sectional and longitudinal associations of low-back pain and related disability with psychological distress among patients enrolled in the UCLA Low-Back Pain Study. *Journal of Clinical Epidemiology* **56**, 463–471.

James RJE, Walsh DA and Ferguson E (2018) General and disease specific pain trajectories as predictors of social and political outcomes in arthritis and cancer. *BMC Medicine* **16**.

James RJE, Walsh DA and Ferguson E (2019) Trajectories of pain predict disabilities affecting daily living in arthritis. *British Journal of Health Psychology* 1–12 (in press).

Johnson VL and Hunter DJ (2014) The epidemiology of osteoarthritis. *Best Practice & Research Clinical Rheumatology* **28**, 5–15.

Keefe FJ, Brown GK, Wallston KA and Caldwell DS (1989) Coping with rheumatoid arthritis pain: catastrophizing as a maladaptive strategy. *Pain* **37**, 51–56.

Keefe FJ, Lefebvre JC, Egert JR, Affleck G, Sullivan MJ and Caldwell DS (2000) The relationship of gender to pain, pain behavior, and disability in osteoarthritis patients: the role of catastrophizing. *Pain* **87**, 325–334.

Kroenke K, Wu J, Bair MJ, Krebs EE, Damush TM and Tu W (2011) Reciprocal relationship between pain and depression: a 12-month longitudinal analysis in primary care. *The Journal of Pain* **12**, 964–973.

Leonard BE (2007) Inflammation, depression and dementia: are they connected? *Neurochemical Research* **32**, 1749–1756.

Lépine J-P and Briley M (2004) The epidemiology of pain in depression. *Human Psychopharmacology: Clinical and Experimental* **19**, S3–S7.

Maier SF and Watkins LR (1998) Cytokines for psychologists: implications of bidirectional immune-to-brain communication for understanding behavior, mood, and cognition. *Psychological Review* **105**, 83–107.

Marmot M, Oldfield Z, Clemens S, Blake M, Phelps A, Nazroo J, Steptoe A, Rogers N, Banks J and Oskala A (2016) *English Longitudinal Study of Ageing: Waves 0–7, 1998–2015. [data collection]. 25th Edition*. SN: 5050, http://doi.org/10.5255/UKDA-SN-5050-12.

McCracken LM and Iverson GL (2001) Predicting complaints of impaired cognitive functioning in patients with chronic pain. *Journal of Pain and Symptom Management* **21**, 392–396.

McDermott LM and Ebmeier KP (2009) A meta-analysis of depression severity and cognitive function. *Journal of Affective Disorders* **119**, 1–8.

McInnes IB and Schett G (2011) The pathogenesis of rheumatoid arthritis. *New England Journal of Medicine* **365**, 2205–2219.

McWilliams LA, Goodwin RD and Cox BJ (2004) Depression and anxiety associated with three pain conditions: results from a nationally representative sample. *Pain* **111**, 77–83.

Moriarty O, McGuire BE and Finn DP (2011) The effect of pain on cognitive function: a review of clinical and preclinical research. *Progress in Neurobiology* **93**, 385–404.

Muthén BO and Muthén LK (1998–2015) *Mplus User's Guide*, 7th Edn. Los Angeles, CA: Muthén & Muthén.

Neogi T (2013) The epidemiology and impact of pain in osteoarthritis. *Osteoarthritis and Cartilage* **21**, 1145–1153.

Nicholson NR (2012) A review of social isolation: an important but underassessed condition in older adults. *The Journal of Primary Prevention* **33**, 137–152.

O'Reilly SC, Muir KR and Doherty M (1998) Knee pain and disability in the Nottingham community: association with poor health status and psychological distress. *Rheumatology* **37**, 870–873.

Quartana PJ, Campbell CM and Edwards RR (2009) Pain catastrophizing: a critical review. *Expert Review of Neurotherapeutics* **9**, 745–758.

Radloff LS (1977) The CES-D scale. *Applied Psychological Measurement* **1**, 385–401.

Roach AR, Solberg Nes L and Segerstrom SC (2009) Executive functions, self-regulation, and chronic pain: a review. *Annals of Behavioral Medicine* **37**, 173–183.

Salkeld G, Cumming RG, Thomas M and Szonyi G (2000) Prospective study of the impact of fear of falling on activities of daily living, SF-36 scores, and nursing home admission. *The Journals of Gerontology: Series A* **55**, M299–M305.

Sofi F, Valecchi D, Bacci D, Abbate R, Gensini GF, Casini A and Macchi C (2011) Physical activity and risk of cognitive decline: a meta-analysis of prospective studies. *Journal of Internal Medicine* **269**, 107–117.

Stubbs B, Vancampfort D, Veronese N, Thompson T, Fornaro M, Schofield P and Koyanagi A (2017) Depression and pain: primary data and meta-analysis among 237 952 people across 47 low- and middle-income countries. *Psychological Medicine* **47**, 2906–2917.

https://doi.org/10.1017/S0033291719001673 Published online by Cambridge University Press

Stubhaug A, Breivik H, Kvarstein G, Romundstad L, Rosseland LA, Allen SM and Borchgrevink PC (2008) Assessment of pain. *BJA: British Journal of Anaesthesia* **101**, 17–24.

Sturgeon JA and Zautra AJ (2013) State and trait pain catastrophizing and emotional health in rheumatoid arthritis. *Annals of Behavioral Medicine* **45**, 69–77.

Valkanova V, Ebmeier KP and Allan CL (2013) CRP, IL-6 and depression: a systematic review and meta-analysis of longitudinal studies. *Journal of Affective Disorders* **150**, 736–744.

Verbrugge LM and Juarez L (2006) Profile of arthritis disability: II. *Arthritis Care Res* (*Hoboken*) **55**, 102–113.

Veronese N, Koyanagi A, Solmi M, Thompson T, Maggi S, Schofield P and Stubbs B (2018) Pain is not associated with cognitive decline in older adults: a four-year longitudinal study. *Maturitas* **115**, 92–96.

Yaffe K, Kanaya A, Lindquist K, Simonsick EM, Harris T, Shorr RI and Newman AB (2004) The metabolic syndrome, inflammation, and risk of cognitive decline. *JAMA* **292**, 2237–2242.

https://doi.org/10.1017/S0033291719001673 Published online by Cambridge University Press