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The impact and measurement of social dysfunction in late-life depression: an evaluation of current methods with a focus on wearable technology

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Objective: Depression is known to negatively impact social functioning, with patients commonly reporting difficulties maintaining social relationships. Moreover, a large body of evidence suggests poor social functioning is not only present in depression but that social functioning is an important factor in illness course and outcome. In addition, good social relationships can play a protective role against the onset of depressive symptoms, particularly in late-life depression. However, the majority of research in this area has employed self-report measures of social function. This approach is problematic, as due to their reliance on memory, such measures are prone to error from the neurocognitive impairments of depression, as well as mood-congruent biases.

Method: Narrative review based on searches of the Web of Science and PubMed database(s) from the start of the databases, until the end of 2015.

Results: The present review provides an overview of the literature on social functioning in (late-life) depression and discusses the potential for new technologies to improve the measurement of social function in depressed older adults. In particular, the use of wearable technology to collect direct, objective measures of social activity, such as physical activity and speech, is considered.

Conclusion: In order to develop a greater understanding of social functioning in late-life depression, future research should include the development and validation of more direct, objective measures in conjunction with subjective self-report measures. Copyright © 2016 John Wiley & Sons, Ltd.

Key words: late-life depression; social function; self-report; wearable technology

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Introduction

It is now well-established that the impact of depression goes beyond the core symptoms of depressed mood and anhedonia. For example, patients with depression typically demonstrate a significant amount of social dysfunction. Specifically, patients often experience difficulties, maintaining social relationships, such as with family and friends. Such dysfunction can place additional stress on these relationships, creating a negative cycle which contributes to the recurrence of depressive episodes (Hirschfeld *et al.*, 2000).

The impact of decreased social functioning is potentially greater in older adults with depression, with several reports suggesting that this population in particular is at risk of increased isolation and loneliness (Isaac *et al.*, 2009). To date, the majority of studies investigating social functioning in depression have relied on self-report, questionnaire-based measures of social function. However, these measures are subject to several limitations, which in turn, impact our current understanding of social functioning in late-life depression. Therefore, the present review was conducted to highlight specific ways in which current

measures are lacking and introduce possible new methods for measuring social function that are not subject to such limitations, with a particular focus on wearable technology. This paper will present a review of the literature on the social functioning in depressed older adults, in which the effect of depression on social function, and the potentially protective effects of good social relationships has been investigated. We will then present an evaluation of the methods commonly used to assess social functioning, before discussing the potential for new technologies, and particularly wearable devices, to improve our ability to measure social functioning in late-life depression.

Depression in later life

Depression is a common psychiatric illness with extensive personal and economic implications for patients, their families and society in general (Hirschfeld *et al.*, 2000; Kessler *et al.*, 2003). Moreover, depression is purported to be the most common cause of emotional suffering in later life (Blazer *et al.*, 1987; Blazer *et al.*, 1991; Schwarzbach *et al.*, 2014). Consequently, late-life depression (LLD) has become a topic of significant research interest (Adams & Moon, 2009). Although other mental health disorders are known to interact with social functioning (Wolitzky-Taylor *et al.*, 2010), there is a need to study depression in particular, due to its high prevalence (13.3%; Beekman, Copeland & Prince, 1999) and significant effect on emotional suffering and activities of daily living (Colloby, *et al.*, 2011). Therefore, this review will focus on depression in later life.

Late-life depression is associated with increased risk of suicide, increased morbidity risk, decreased social functioning, impaired cognitive functioning and greater self-neglect, than MDD in earlier life (Fiske *et al.*, 2009; Blazer, 2003), compared with depression earlier in the lifespan. Late-life depression may also worsen the outcome of several medical conditions (Alexopoulos, 2005), is a strong determinant of disability in older people (Barry *et al.*, 2011) and is a recognised risk factor for the development of dementia (Blazer *et al.*, 2003). Studies have shown that the magnitude of neurological impairments associated with depression is typically greater in older, rather than younger patients (Fiske *et al.*, 2009; Alexopoulos, 2005) and that this is not due to the ageing process alone (Thomas *et al.*, 2009). Memory impairment is a typical feature of LLD (Thomas *et al.*, 2009; O'Brien *et al.*, 2004; Sheline *et al.*, 2006), and executive functioning is affected to a greater extent in late onset

depression compared with early onset (Alexopoulos, 2005; Butters *et al.*, 2004; Hermann *et al.*, 2007).

The importance of research into LLD becomes clear when the effect of population ageing is considered. Population ageing is a global phenomenon defined by the United Nations as the rising proportion of older people within the total population (United Nations, Department of Economic and Social Affairs, Population Division, 2013). In the UK, recent estimates suggest that 23% of the population will be aged 65+ years and over and 5% will be aged 85+ years by 2035 (Office for National Statistics, 2012). Therefore, it is likely that LLD, and the complications associated with LLD, will become a significant challenge to current healthcare systems. Critically, in order to improve the assessment of function in patients and, in turn, improve outcomes, there is a need to develop a greater understanding of the psychosocial impact of depression in older adults.

Search strategy and selection criteria

The initial literature search was conducted in a systematic manner, searching the Web of Science and PubMed database(s) from the start of the databases, until to the end of 2015. Various search terms were used to identify papers related to LLD and measures of social functioning. To identify papers related to LLD, we used the following search terms: old* OR elde* OR age* OR geriatric OR (late life) OR 60+ OR 65+ OR 85+ OR senior; Depress* OR Unipolar OR LLD OR (mood disorder) OR affect*. To identify papers related to (self-report) measures of social dysfunction, the following terms were used: measure OR assess* in conjunction with psychosocial OR social* OR satisfaction OR wellbeing OR well-being OR support OR relations*. To identify papers related to direct, objective measures of social activity (e.g. measures of speech and/or physical activity), the following terms were used: Speech OR vocalisation OR prosody OR pitch OR dynamics, phys* OR activity OR exercise* OR Accelerometer* OR Actigraph* OR movement. While we focussed on papers published within the last 5 years, we did not exclude highly cited and highly regarded older publications. In addition, we scanned the reference lists of the identified papers and selected further papers according to their perceived relevance. This led to the inclusion of unpublished thesis work in the present review. Additional reviews are cited in order to direct the reader to further details on issues beyond the scope of the present review.

Social functioning in depression

Recently, much research into mental health in later life has concerned social functioning, and the effect of LLD on relationships between the patient and their family/friends (Schwarzbach *et al.*, 2013). Such research has typically investigated either the effect of depression on

social functioning, or the potentially protective role of good social relationships against depression (Table 1).

Typically, social functioning is assessed using self-report questionnaires or ecological momentary assessments. Self-report questionnaires include the Duke Social Support Index (Bosworth *et al.*, 2002; Riddle *et al.*, 2015), the Family Support Satisfaction Scale

Table 1 Summary of studies using self-report/questionnaire methods to evaluate social function and social support in late life depression

Measure/ Questionnaire	Studies using the measure	Measure details	Strengths	Limitations
Duke Social Support Index (Koenig <i>et al.</i> , 1993)	George <i>et al.</i> , 1989; Bosworth <i>et al.</i> , 2001; Riddle <i>et al.</i> , 2015	A self-report scale designed to generate information on four dimensions of social support: size of social network, amount of social interaction, amount of instrumental support, and subjective social support.	Good reliability and validity Assesses a range of concepts related to social support	Subject to self-report bias (i.e. mood, poor memory)
Family Support Satisfaction Scale	Tanner <i>et al.</i> , 2014	Thirteen dichotomous items, constructed to assess participant satisfaction with affective social support provided by family members, and subjective perception of social integration and assistance provided by family members.	Assesses patient satisfaction with several different types of support that might be provided by family members.	Subject to self-report bias (i.e. mood, poor memory). Dichotomous items only. Limited to family-based social support/integration
Social Support Scale	Tanner <i>et al.</i> , 2014	Three Likert scale items designed to assess participants' perceptions of loneliness and support availability from family/friends.	Short, easy to administer and not over-burdensome on participants.	Three items only. Subject to self-report bias (i.e. mood, poor memory).
Social contact intensity (single-item measure)	Robitaille <i>et al.</i> , 2014	Single, study-specific item asking participants how many people they see.	Short, easy to administer, can be included as part of questionnaire battery, and not over-burdensome on participants.	Only assesses the number of people seen by the participant, no measure of quality of interaction. Subject to self-report bias (i.e. mood, poor memory).
Social Factors Questionnaire (dichotomised questions)	Sjoberg <i>et al.</i> , 2013	Series of dichotomised questions designed to assess the presence or absence of daily contact with others (either by telephone or email), visits from family/friends, feelings of loneliness, and participation in hobbies.	Assess the presence or absence of a range of factors related to social support, as well as the subjective feeling of loneliness.	Dichotomised items assessing only the presence or absence of support (i.e. no measure of quality of support) Subject to self-report bias (i.e. mood, poor memory).
Assessment of social support	Lee <i>et al.</i> , 2012; Liang <i>et al.</i> , 1999; Lue <i>et al.</i> , 2010	Eight item assessment designed to assess the participant's perceived level of social support, and their satisfaction with the support they received.	Short, easy to administer. Produces a score to provide a measure of perceived quality of social support	Subject to self-report bias (i.e. mood, poor memory).
Assessment of social activity	Lee <i>et al.</i> , 2012	Seven item assessment designed to measure the participant's level of involvement in a range of social activities (e.g. community organisations, religious groups, family events).	Assess the presence or absence of a range of social activities	Dichotomised items assessing only the presence or absence of support (i.e. no measure of quality/satisfaction with social activities). Subject to self-report bias (i.e. mood, poor memory).
Ecological momentary assessments	Barnett & Gotlib, 1988; Gotlib & Lee, 1987; Stone <i>et al.</i> , 1998	Participant is asked to make repeated assessments of their social activity throughout the day.	Assesses recent social experiences and so places fewer demands on memory.	Frequent reports of low adherence when used in psychiatric samples. Subject to self-report biases such as mood and poor memory (albeit to a lesser degree than other self-report measures).

(Tanner *et al.*, 2014), the Social Support Scale (De Guzman *et al.*, 2015). Additional studies have used single-item self-report scales (e.g. Robitaille *et al.*, 2014), dichotomised questions (e.g. Sjoberg *et al.*, 2013) or self-ratings of social involvement/participations (e.g. Lee *et al.*, 2012). Other studies have relied on ecological momentary assessments (EMA) of social functioning. This method requires the patient to make repeated assessments of their social activity, in real-time and in their natural environment (Stone *et al.*, 1998). Although this method still relies heavily on self-report, EMAs typically assess recent experiences and thus are less reliant upon retrospective recall. Studies using such self-report methods have shown that depressed patients report fewer intimate relationships (Gotlib & Lee, 1987), reduced participation in social activities/low social integration (Barnett & Gotlib, 1988; Gotlib & Lee, 1987), are less active within their family roles, but are prone more to arguments with family members and/or marital distress (Barnett & Gotlib, 1988; Gotlib & Lee, 1987), and have smaller social networks (see Gotlib, 1992 for a review).

Social relationships as a protective factor against depression

It is important to accurately measure social relationships in LLD patients, because studies show that poor social functioning is not only present in LLD but that social functioning is an important factor in illness onset, course and outcome (Schwarzbach *et al.*, 2014). These studies typically suggest that (good) social relationships can play a protective role against the onset of depressive symptoms and can be beneficial during treatment. For example, Issac *et al.* (2009) reported that higher social activity was negatively associated with case-level depressive symptomatology. In a prospective analysis, this study showed that high social activity was associated with symptom improvement. Similarly, Tanner *et al.* (2014) demonstrated that decreased satisfaction with family support and increased loneliness were significant predictors of depression. In a 12-month longitudinal study, Bosworth *et al.* (2002) reported that patients who did not achieve remission reported decreased subjective social support at baseline compared with those in remission. Prince *et al.* (1997) reported that a perceived lack of social support directly related to depression, while Lee *et al.* (2012) showed that social support was a significant predictor of improvement in depression. Similarly, Chi and Chou (2001) demonstrated that social support from family related to depressive symptomatology.

Mechakra-Tahiri *et al.* (2009) showed that social support and lack of conflict in intimate relations (e.g. with spouse and children) was associated with less depressive symptoms, while Sugisawa *et al.* (2002) showed that increased contact with friends, neighbours and relatives, as well as having a spouse, was associated with fewer depressive symptoms. Taken together, these findings suggest that the presence of (good) social relationships is beneficial to the reduction of depressive symptoms in older adults.

It has been argued that negative life events, as potential triggers for MDD, are more common to the onset of LLD than MDD in younger adults (Tanner *et al.*, 2014). Such negative events include death of spouse/friends, chronic illnesses (leading to changes in physical and/or cognitive ability) and loss of social roles (Fiske *et al.*, 2009; Prince *et al.*, 1997). Fiest *et al.* (2011) report a higher prevalence of MDD in older adults with one chronic condition (such as arthritis, asthma or diabetes) compared with those without (3.7% and 1%, respectively). Marks (2013) reported that more than 20% of a sample of older adults with knee osteoarthritis met the diagnostic criteria for MDD. Likewise, disability is common in later life and is a widely acknowledged risk factor for LLD (Bruce, 2001). However, many individuals with a disability report a high quality of life, and Jang *et al.* (2002) argue that good social functioning is related to this. In this study, greater satisfaction with social support was associated with a reduced effect of disability on depression scores in older adults, as compared with patients less satisfied with their social support. More recently, it has been suggested that the relationship between negative life events and LLD is circular, such that negative events may predict LLD symptoms, and in turn, LLD may predict further negative life events (Fiske *et al.*, 2009; Alexandrino-Silva, 2011). As such, good social functioning (and good social support) may be important to break this effect, acting as a buffer against the effect of negative life events and/or MDD symptoms.

Thus, in addition to the 'mere presence' of social relationships, the quality of the relationships as well as the patient's subjective feelings regarding the relationships are also important factors in LLD. Specifically, poor quality social relationships have been highlighted as a risk factor for depression in older adults. In a 10-year follow-up study of a large sample of adults ($n=4642$), Teo *et al.* (2013) demonstrated an increased risk of depression in those reporting greater social strain and poor relationship quality at baseline. Specifically, respondents with the lowest quality of social relationships (e.g. reporting that

spouse/family/friends made too many demands, were highly critical and not reliable) had more than double the risk of depression than those with the highest social relationship quality (although it should be noted that this study did not exclusively investigate older adults). Similarly, a number of studies suggest that the subjective feeling of loneliness is strongly related to higher depression scores (Alpass & Neville, 2003; Cacioppo *et al.*, 2006). Moreover, following a large systematic review, Forsman *et al.* (2011) conclude that psychosocial interventions aimed at strengthening social networks and reducing loneliness were particularly effective at reducing depressive symptoms in older patients.

Although much evidence to date suggests that social relationships and social functioning are important in LLD, an open question remains regarding the direction of the relationship. Specifically, questions remain regarding causality: is poor social functioning caused by LLD, or does poor social functioning cause LLD? Currently, the consensus of the literature is that the relationship between LLD and social functioning is likely bidirectional. For example, the cardinal symptoms of MDD (such as anhedonia, irritability and becoming withdrawn) likely directly contribute to poor social functioning in patients (Steger & Kasdan, 2009). Similarly, MDD has frequently been associated with impaired social cognition, for example, impaired emotion recognition (Szanto *et al.*, 2012) and Theory of Mind deficits (Lee *et al.*, 2005; Wolkenstein *et al.*, 2011; for a recent review, see Billeke *et al.*, 2013). In addition, there is evidence to suggest that a diagnosis of MDD (and the symptoms of MDD) may, in turn, lead to reduced trust from the patients' social contacts on account of the stereotypes associated with a mental health diagnosis (Aromaa *et al.*, 2012). In turn, there is evidence to suggest that poor social situations (e.g. lack of social support, such as during a negative life event) could also be a triggering factor for LLD or play a role in illness maintenance (i.e. lack of support during treatment/illness; Alexandrino-Silva, 2011).

Interaction with other issues in late-life depression

Still further research has suggested that poor social functioning in LLD may mediate other issues related to the illness. For example, a recent study demonstrated that LLD patients with a history of suicide attempts reported restricted social networks (less likely to talk to their children, fewer close friends), hostility in relationships and a lack of social support as compared with non-suicidal LLD patients (Szanto *et al.*,

2012; see also Duberstein *et al.*, 2004). Szanto *et al.* (2012) also demonstrated poor social emotion recognition and poor global cognition in suicidal LLD patients, relative to both healthy controls and non-suicidal LLD patients. Consequently, the authors argue that cognitive decline and social deficits likely interact and lead to an increased risk of suicidality in LLD (Wiktorsson *et al.*, 2010). Still, further research suggests that social support can mediate the effects of LLD on other aspects of the patient's life. For example, Litwin (2012) reported that older adults with restricted social networks are most at risk of decreased physical activity and in turn, more depressive symptoms. Moreover, Travis *et al.* (2004) found that while a depression diagnosis *per se* was not directly associated with any measures of disability, lack of social support and less social interaction were associated with instrumental (activities not necessary for fundamental functioning, e.g. housework and use of telephone) and basic (activities necessary for fundamental functioning, e.g. bathing, dressing and self-feeding) disability, respectively (see also Stuck *et al.*, 1999). Jeste *et al.* (2006) demonstrated that LLD patients with comorbid anxiety reported poor subjective social support, as well as increased suicidality. These authors suggest that interventions designed to improve subjective social support might prove beneficial for anxious LLD patients.

Limitations of current measures of social functioning in late-life depression

The methods employed by the majority of the aforementioned studies rely on the patient accurately recalling autobiographical events. However, this is an ability that can be compromised by the cognitive impairments associated with LLD, as well as by ageing in general (Thomas *et al.*, 2009; O'Brien *et al.*, 2004; Butters *et al.*, 2004; Sheline *et al.*, 2006). For example, Thomas *et al.* (2009) demonstrated extensive neurocognitive impairments in LLD, including in verbal learning and memory (measured using the Rey Auditory Verbal Learning test), with LLD patients performing significantly worse than younger MDD patients. Additional studies have more directly demonstrated that such measures are susceptible to error (Stone *et al.*, 1998; Rabbi *et al.*, 2011; Haywood *et al.*, 2005). Furthermore, there is a large body of research demonstrating that memory processes in depression are characterised by mood-congruent biases, such that patients recall and interpret events as more negative as compared with healthy controls (Gotlib, 1983; Romero *et al.*, 2014; Watkins *et al.*, 1996).

Moreover, the requirement of EMAs to be conducted repeatedly has proved problematic in psychiatric populations, with some studies reporting low adherence in mood-disordered patients (see Wenzel & Miller, 2010 for a review). Taken together, these issues may result in missing data and/or self-reports of social activity that are influenced by negative biases. Therefore, it is perhaps unsurprising that following a review of research on social cognition in MDD, Billeke *et al.* (2013) conclude that studies using 'more ecologically valid biomarkers' are required.

The use of wearable technology in depression

The ability to obtain direct, objective measures of social functioning in older adults with depression would represent a significant improvement in the assessment tools available when compared with self-reports, such as questionnaires or EMAs, alone. Wearable technology is a potential method to collect such data. This method typically requires the patient to wear a small device, often as a wristwatch or a waist-mounted device, containing small sensors, such as an accelerometer. Moreover, the development of wearable technologies will provide objective data that should allow more detailed research to examine important cultural effects and condition differences in self-report and questionnaire-based measures and allow investigation of their sensitivity and specificity. Previous work using such technology in MDD patients has yielded promising results. For example, early studies of physical activity in depression were also reliant on self-report questionnaires. However, more recent studies have used the Actigraph system, a wearable accelerometer system which is able to measure physical activity in everyday situations in great detail. The usefulness of such a device to assess physical activity in patients with mood disorders has previously been acknowledged (Teicher, 1995) and has been shown to yield more precise measurements than self-report measures (Sabia *et al.*, 2014; Prince *et al.*, 2008; for a review, see Burton *et al.*, 2013). For example, following a systematic review, Prince *et al.* (2008) concluded that as self-report measures were often either higher or lower than directly measured activity levels, reliance on such measures is problematic. However, in order to objectively address aspects of social functioning in LLD, there is a need to quantify the amount and quality of social activity in a patient's everyday life.

One possible method of objectively measuring social activity is by directly measuring the amount of speech the patient engages in. A number of recent

technological advances mean it is now possible to record how long and/or how often a patient engages in conversation, as well as how much speech the patient contributes to a conversation relative to others, in such a way that the patient's privacy is maintained. These measures can then be combined with others, such as self-report measures. For example, Maxhuni *et al.* (2011) combined speech data and EMA measures of mood to investigate the relationship between social interaction and mood in the workplace. In this study, social interaction was defined as the sum of minutes the participant spent talking, as measured by smart phone microphones. The results showed a positive correlation between the amount of social interaction and positive mood states, as assessed via EMA. However, Rabbi *et al.* (2011) present a case study (as part of a larger study of older adults), demonstrating a significant discrepancy between directly measured speech and self-reported mental health and social integration. Specifically, while the questionnaire data suggested no mental health concerns, the speech data suggested a very low level of speech in a conversational context, which raised concerns regarding social isolation. Moreover, the speech data corresponded with direct observations of the patient, made by a medical trainee. Consequently, the authors suggest that the questionnaire data may have been influenced by factors such as misinterpretation of the questions, and direct measurements could be used to provide more accurate measures that do not depend on accurate recall or interpretation on behalf of the patient.

In light of the evidence provided by Rabbi *et al.* (2011), as well as the aforementioned limitations of self-report measures, particularly when used in the LLD population, a more attractive option is to use multi-modal assessments (Godfrey & Knight, 1984). For example, it is possible to use wearable technology to directly measure both physical activity and speech, in order to gain a more complete picture of how depression affects the patient's day-to-day life. Indeed, with the exception of the aforementioned case study, Rabbi *et al.* (2011) report that direct measures of speech and physical activity 'correlate highly' (p. 393) with several well-established questionnaires. Similarly, Choudry and Pentland (2002) demonstrate that speech and movement data, gathered using a 'sociometer', can be used to analyse the wearer's face-to-face interactions (including the frequency and duration of conversations, and wearer's contribution to the conversations). Moreover, using various modelling techniques, this data can be used to investigate the structure and dynamics of the wearer's social network (Choudry & Pentland, 2002).

While the use of such multi-modal measures appears promising in the assessment of social functioning, to date, their use in psychiatric populations has been limited to mood monitoring. For example, Chang (2012) demonstrated that speech analysis via mobile phones could be used to assess and classify the users' current mood state. Such technology has clear potential applications for mental health monitoring. Indeed, Prociów (2011) presents a case study in which smartphone technology was used to monitor movement and social activity in a euthymic bipolar patient. In conjunction with an additional study in healthy controls (Prociów & Crowe, 2010), the authors conclude that speech data may prove useful in the early detection of upcoming manic/depressive episodes. A recent study by Karam *et al.* (2014) expands these findings by demonstrating that speech data (collected through day-to-day mobile phone conversations) can be used to accurately classify hypomanic, depressed and euthymic states in bipolar disorder (Muaremi *et al.*, 2014). Similar research has also been conducted in MDD populations. Cummins *et al.* (2013) showed that specific features of speech (such as spectral variability) could be used to assess the severity of depressive symptoms (Sturim *et al.*, 2011). Moreover, Ooi *et al.* (2013) demonstrated that speech data could be used to predict MDD onset in at-risk adolescents, 2 years prior to symptom onset, with 73% accuracy. Taken together, these findings suggest that speech data are potentially a rich source of information relevant to the monitoring of various psychiatric conditions.

The use of objective measures, such as speech data, to assess social functioning in LLD is yet to be investigated. However, the findings discussed earlier suggest that speech monitoring (via wearable technology or mobile phones) is a feasible option for this population. Indeed, a recent study has shown that wearable technology is acceptable to patients with LLD and that it has the potential to provide accurate, objective measures of real-world functioning in this population (O'Brien *et al.*, 2016). In this study, activity levels were assessed in 29 patients with LLD via a bespoke, wrist-worn activity monitor. The authors report that the device was designed to be as unobtrusive and as comfortable as possible, designed much like a standard wristwatch with an adjustable silicone band and stainless-steel fastening. Home visits by the research team were arranged to replace monitors needing to be recharged with identical, fully charged monitors. In addition to a significant reduction in physical activity in patients with LLD, the authors report a high level of compliance with the monitor in both the depressed patients (92.2%) and the elderly control participants

(92.3%). Taken together, this study suggests that wearable technology is a feasible option for monitoring physical activity (and, potentially, social functioning) in older populations.

Moreover, wearable technology may be more sensitive to changes in social functioning compared with current self-report based measures (e.g. Rabbi *et al.*, 2011). Improving the accuracy with which social functioning is measured is important for several reasons. Firstly, as highlighted at the beginning of this review, social functioning is negatively affected by depression and as such, is a potential target for treatment. Indeed, studies suggest that patients rate improvements in social functioning as a particularly important treatment outcome (Billeke *et al.*, 2013). Therefore speech data have the potential to be an ecologically valid outcome measure. Secondly, good social functioning has been shown to play a protective role against LLD. Accurate measures are important in this respect, as they may be used to highlight need to improve the patient's social situation; self-report measures can fall short in this respect, as demonstrated by Rabbi *et al.* (2011). Furthermore, using technology in this way means that information on social functioning can be gathered in everyday situations, with minimal inconvenience or interruption to the patient's daily routine. Thus, patient adherence to the assessment procedure is likely to improve.

In conclusion, it is clear from the evidence discussed earlier that social functioning is an important aspect of LLD. While social function is significantly impaired by depressive symptoms, the presence of good social relationships and good social support plays an important protective role against depression in later life. However, much research to date has relied on self-report based assessments of social functioning, and these methods are subject to several limitations. The use of wearable technology, such as accelerometers and mobile phones, offers promising new methods of assessing social functioning directly. Specifically, the use of multi-modal (movement and speech) data has been shown to provide a large amount of ecologically valid data in an unobtrusive way. Such technologies also offer new ways of remotely monitoring older populations. For example, speech and movement data can be electronically transferred to clinicians to create detailed records, and up-to-date, precise information (Bloom *et al.*, 2015). Indeed, the use of technology in this way will likely be of great assistance in the management of an ageing population. For example, in addition to their aforementioned research utility, devices such as the one reported by O'Brien *et al.* (2016) have the potential for

use in clinical contexts, such as in the detection of illness onset in 'at risk' individuals, relapse detection/prevention or to monitor outcomes in patients as they undergo treatment. However, it is critical that other measures, such as subjective questionnaires, clinical assessments and clinical judgments, should not be ruled out entirely as there is evidence to suggest that the subjective components of social functioning are important to LLD patients (e.g. Chi and Chou, 2001). In order to create a full, detailed picture of social functioning in LLD, future research should aim to include direct, objective measures in conjunction with subjective assessments.

Conflict of interest

The authors are currently involved in the DEMO-POD study (The Development and Evaluation of a Monitoring device to Objectively assess functional and Psychosocial impairment in Older-age adults with major Depression).

Key points

- Social relationships are a protective factor against depression.
- The majority of research in this area has relied on problematic self-report measures.
- Wearable technology is a promising new method for the collection of objective data on social functioning.

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