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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

RUNNING HEAD: Social functioning in late-life depression

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Keywords: late-life depression, social function, self-report, wearable technology

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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2 **Abstract (225 words)**

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

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

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

19 **Conclusion:** In order to develop a greater understanding of social functioning in late-life
20 depression, future research should include the development and validation of more direct,
21 objective measures in conjunction with subjective self-report measures.

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1 **Introduction**

2 It is now well-established that the impact of depression goes beyond the core symptoms of
3 depressed mood and anhedonia. For example, patients with depression typically demonstrate a
4 significant amount of social dysfunction. Specifically, patients often experience difficulties
5 maintaining social relationships, such as with family and friends. Such dysfunction can place
6 additional stress on these relationships, creating a negative cycle which contributes to the
7 recurrence of depressive episodes (Hirschfeld et al., 2000). The impact of decreased social
8 functioning is potentially greater in older adults with depression, with several reports
9 suggesting that this population in particular is at risk of increased isolation and loneliness (Isaac
10 et al., 2009). To date, the majority of studies investigating social functioning in depression have
11 relied on self-report, questionnaire-based measures of social function. However, these
12 measures are subject to several limitations, which in turn, impact our current understanding of
13 social functioning in late-life depression. Therefore, the present review was conducted to
14 highlight specific ways in which current measures are lacking, and introduce possible new
15 methods for measuring social function that are not subject to such limitations, with a particular
16 focus on wearable technology. This paper will present a review of the literature on the social
17 functioning in depressed older adults, in which the effect of depression on social function, and
18 the potentially protective effects of good social relationships has been investigated. We will
19 then present an evaluation of the methods commonly used to assess social functioning, before
20 discussing the potential for new technologies, and particularly wearable devices, to improve
21 our ability to measure social functioning in late-life depression.

22 **Depression in later life**

23 Depression is a common psychiatric illness with extensive personal and economic
24 implications for patients, their families, and society in general (Hirschfeld et al., 2000; Kessler

1 et al., 2003). Moreover, depression is purported to be the most common cause of emotional
2 suffering in later life (Blazer et al., 1987; Blazer et al., 1991; Schwarzbach et al., 2013).
3 Consequently, late life depression (LLD) has become a topic of significant research interest
4 (Adams & Moon, 2009). Although other mental health disorders are known to interact with
5 social functioning (Wolitzky-Taylor et al., 2010), there is a need to study depression in
6 particular, due to its high prevalence (13.3%; Beekman, Copeland & Prince, 1999) and
7 significant effect on emotional suffering and activities of daily living (ADL; Colloby, et al.,
8 2011). Therefore, this review will focus on depression in later life.

9 LLD is associated with increased risk of suicide, increased morbidity risk, decreased social
10 functioning, impaired cognitive functioning, and greater self-neglect, than MDD in earlier life
11 (Fiske et al., 2009; Blazer, 2003), compared to depression earlier in the lifespan. Late-life
12 depression may also worsen the outcome of several medical conditions (Alexopoulos, 2005),
13 is a strong determinant of disability in older people (Barry et al., 2011) and is a recognised risk
14 factor for the development of dementia (Blazer et al., 2003). Studies have shown that the
15 magnitude of neurological impairments associated with depression is typically greater in older,
16 rather than younger patients (Fiske et al., 2009; Alexopoulos, 2005) and that this is not due to
17 the ageing process alone (Thomas et al., 2009). Memory impairment is a typical feature of LLD
18 (Thomas et al., 2009; O'Brien et al., 2004; Sheline et al., 2006), and executive functioning is
19 affected to a greater extent in late onset depression compared to early onset (Alexopoulos,
20 2005; Butters et al., 2004; Hermann et al., 2007).

21 The importance of research into LLD becomes clear when the effect of population ageing
22 is considered. Population ageing is a global phenomenon defined by the United Nations as the
23 rising proportion of older people within the total population (United Nations, Department of
24 Economic and Social Affairs, Population Division, 2013). In the United Kingdom, recent
25 estimates suggest that 23% of the population will be aged 65+ years and over and 5% will be

1 aged 85+ years by 2035 (Office for National Statistics, 2012). Therefore, it is likely that LLD,
2 and the complications associated with LLD, will become a significant challenge to current
3 healthcare systems. Critically, in order to improve the assessment of function in patients and,
4 in turn, improve outcomes, there is a need to develop a greater understanding of the
5 psychosocial impact of depression in older adults.

6 **Search strategy and selection criteria**

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

24 **Social functioning in depression**

1 It is important to accurately measure social relationships in LLD patients, since studies
2 show that poor social functioning is not only present in LLD, but that social functioning is an
3 important factor in illness onset, course and outcome (Schwarzbach et al., 2014). These studies
4 typically suggest that (good) social relationships can play a protective role against the onset of
5 depressive symptoms, and can be beneficial during treatment. For example, Issac et al. (2009)
6 reported that higher social activity was negatively associated with case-level depressive
7 symptomatology. In a prospective analysis, this study showed that high social activity was
8 associated with symptom improvement. Similarly, Tanner et al. (2014) demonstrated that
9 decreased satisfaction with family support and increased loneliness were significant predictors
10 of depression. In a 12-month longitudinal study, Bosworth et al. (2002) reported that patients
11 who did not achieve remission reported decreased subjective social support at baseline,
12 compared to those in remission. Prince et al (1997) reported that a perceived lack of social
13 support directly related to depression, while Lee et al. (2012) showed that social support was a
14 significant predictor of improvement in depression. Similarly, Chi and Chou (2001)
15 demonstrated that social support from family related to depressive symptomatology.
16 Mechakra-Tahiri et al. (2009) showed that social support and lack of conflict in intimate
17 relations (e.g. with spouse and children) was associated with less depressive symptoms, while
18 Sugisawa et al. (2002) showed that increased contact with friends, neighbours and relatives, as
19 well as having a spouse, was associated with fewer depressive symptoms. Taken together, these
20 findings suggest that the presence of (good) social relationships are beneficial to the reduction
21 of depressive symptoms in older adults.

22 It has been argued that negative life events, as potential triggers for MDD, are more
23 common to the onset of LLD than MDD in younger adults (Tanner et al., 2014). Such negative
24 events include death of spouse/friends, chronic illnesses (leading to changes in physical and/or
25 cognitive ability), and loss of social roles (Fiske et al., 2009; Prince et al., 1997). Fiest et al.

1 (2011) report a higher prevalence of MDD in older adults with one chronic condition (such as
2 arthritis, asthma, or diabetes) compared to those without (3.7% and 1% respectively). Marks
3 (2013) reported that more than 20% of a sample of older adults with knee osteoarthritis met the
4 diagnostic criteria for MDD. Likewise, disability is common in later-life and is a widely-
5 acknowledged risk factor for LLD (Bruce, 2001). However, many individuals with a disability
6 report a high quality of life, and Jang et al. (2002) argue that good social functioning is related
7 to this. In this study, greater satisfaction with social support was associated with a reduced
8 effect of disability on depression scores in older adults, as compared to patients less satisfied
9 with their social support. More recently, it has been suggested that the relationship between
10 negative life events and LLD is circular, such that negative events may predict LLD symptoms,
11 and in turn, LLD may predict further negative life events (Fiske et al., 2009; Alexandrino-Silva
12 2011). As such, good social functioning (and good social support) may be important to break
13 this effect, acting as a buffer against the effect of negative life events and/or MDD symptoms.

14 Thus, in addition to the 'mere presence' of social relationships, the quality of the
15 relationships as well as the patient's subjective feelings regarding the relationships are also
16 important factors in LLD. Specifically, poor quality social relationships have been highlighted
17 as a risk factor for depression in older adults. In a 10-year follow-up study of a large sample of
18 adults (n = 4642) Teo et al. (2013) demonstrated an increased risk of depression in those
19 reporting greater social strain and poor relationship quality at baseline. Specifically,
20 respondents with the lowest quality of social relationships (e.g. reporting that
21 spouse/family/friends made too many demands, were highly critical, not reliable etc.) had more
22 than double the risk of depression than those with the highest social relationship quality
23 (although it should be noted that this study did not exclusively investigate older adults).
24 Similarly, a number of studies suggest that the subjective feeling of loneliness is strongly
25 related to higher depression scores (Alpass & Neville, 2003; Cacioppo et al., 2006). Moreover,

1 following a large systematic review, Forsman et al. (2012) conclude that psychosocial
2 interventions aimed at strengthening social networks and reducing loneliness were particular
3 effective at reducing depressive symptoms in older patients.

4 Although much evidence to date suggests that social relationships and social
5 functioning are important in LLD, an open question remains regarding the direction of the
6 relationship. Specifically, questions remain regarding causality; is poor social functioning
7 caused by LLD, or does poor social functioning cause LLD? Currently, the consensus of the
8 literature is that the relationship between LLD and social functioning is likely bidirectional.
9 For example, the cardinal symptoms of MDD, (such as anhedonia, irritability, and becoming
10 withdrawn) likely directly contribute to poor social functioning in patients (Steger & Kasdan,
11 2009). Similarly, MDD has frequently been associated with impaired social cognition e.g.
12 impaired emotion recognition (Szanto et al., 2012) and Theory of Mind deficits (Lee et al.,
13 2005; Wolkenstein et al., 2011; for a recent review see Billeke et al., 2013). In addition, there
14 is evidence to suggest that a diagnosis of MDD (and the symptoms of MDD) may, in turn, lead
15 to reduced trust from the patients' social contacts on account of the stereotypes associated with
16 a mental health diagnosis (Aromaa et al., 2012). In turn, there is evidence to suggest that poor
17 social situations (e.g. lack of social support, such as during a negative life event) could also be
18 a triggering factor for LLD, or play a role in illness maintenance (i.e. lack of support during
19 treatment/illness) (Alexandrino-Silva 2011).

20 *Interaction with other issues in LLD*

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

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

18 *Limitations of current measures of social functioning in LLD*

19 The methods employed by the majority of the aforementioned studies rely on the patient
20 accurately recalling autobiographical events. However, this is an ability that can be
21 compromised by the cognitive impairments associated with LLD, as well as by ageing in
22 general (Thomas et al., 2009; O'Brien et al., 2004; Butters et al., 2004; Sheline et al., 2006).
23 For example, Thomas et al. (2009) demonstrated extensive neurocognitive impairments in
24 LLD, including in verbal learning and memory (measured using the Rey Auditory Verbal
25 Learning test), with LLD patients performing significantly worse than younger MDD patients.

1 Additional studies have more directly demonstrated that such measures are susceptible to error
2 (Stone et al., 1998; Rabbi et al., 2011; Haywood et al., 2005). Furthermore, there is a large
3 body of research demonstrating that memory processes in depression are characterised by
4 mood-congruent biases, such that patients recall and interpret events as more negative, as
5 compared to healthy controls (Gotlib, 1983; Romero et al., 2014; Watkins et al., 1996).
6 Moreover, the requirement of EMAs to be conducted repeatedly has proved problematic in
7 psychiatric populations, with some studies reporting low adherence in mood-disordered
8 patients (see Wenze & Miller, 2010 for a review). Taken together, these issues may result in
9 missing data and/or self-reports of social activity that are influenced by negative biases.
10 Therefore, it is perhaps unsurprising that following a review of research on social cognition in
11 MDD, Billeke et al. (2013) conclude that studies using “more ecologically-valid biomarkers”
12 are required.

13 **The use of wearable technology in depression**

14 The ability to obtain direct, objective measures of social functioning in older adults with
15 depression would represent a significant improvement in the assessment tools available when
16 compared to self-reports, such as questionnaires or EMAs, alone. Wearable technology is a
17 potential method to collect such data. This method typically requires the patient to wear a small
18 device, often as a wristwatch or a waist-mounted device, containing small sensors, such as an
19 accelerometer. Moreover, the development of wearable technologies to provide objective data
20 should allow more detailed research to examine important cultural effects and condition
21 differences in self-report and questionnaire-based measures, to allow investigation of their
22 sensitivity and specificity. Previous work using such technology in MDD patients has yielded
23 promising results. For example, early studies of physical activity in depression were also reliant
24 on self-report questionnaires. However, more recent studies have used the Actigraph system, a
25 wearable accelerometer system, which is able to measure physical activity in everyday

1 situations in great detail. The usefulness of such a device to assess physical activity in patients
2 with mood disorders has previously been acknowledged (Teicher, 1995) and has been shown
3 to yield more precise measurements than self-report measures (Sabia et al., 2014; Prince et al.,
4 2008; for a review, see Burton et al., 2013). For example, following a systematic review Prince
5 et al. (2008) concluded that as self-report measures were often either higher or lower than
6 directly measured activity levels, reliance on such measures is problematic. However, in order
7 to objectively address aspects of social functioning in LLD, there is a need to quantify the
8 amount and quality of social activity in a patient's everyday life.

9 One possible method of objectively measuring social activity is by directly measuring the
10 amount of speech the patient engages in. A number of recent technological advances mean it
11 is now possible to record how long and/or how often a patient engages in conversation, as well
12 as how much speech the patient contributes to a conversation relative to others, in such a way
13 that the patient's privacy is maintained. These measures can then be combined with others,
14 such as self-report measures. For example, Maxhuni et al. (2011) combined speech data and
15 EMA measures of mood to investigate the relationship between social interaction and mood in
16 the workplace. In this study, social interaction was defined as the sum of minutes the participant
17 spent talking, as measured by smart phone microphones. The results showed a positive
18 correlation between the amount of social interaction and positive mood states, as assessed via
19 EMA. However, Rabbi et al. (2011) present a case study (as part of a larger study of older
20 adults) demonstrating a significant discrepancy between directly measured speech and self-
21 reported mental health and social integration. Specifically, while the questionnaire data
22 suggested no mental health concerns the speech data suggested a very low level of speech in a
23 conversational context, which raised concerns regarding social isolation. Moreover, the speech
24 data corresponded with direct observations of the patient, made by a medical trainee.
25 Consequently, the authors suggest that the questionnaire data may have been influenced by

1 factors such as misinterpretation of the questions, and direct measurements could be used to
2 provide more accurate measures that do not depend on accurate recall or interpretation on
3 behalf of the patient.

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

17 While the use of such multi-modal measures appears promising in the assessment of social
18 functioning, to date, their use in psychiatric populations has been limited to mood monitoring.
19 For example, Chang (2012) demonstrated that speech analysis via mobile phones could be used
20 to assess and classify the users' current mood state. Such technology has clear potential
21 applications for mental health monitoring. Indeed, Prociów (2011) presents a case study in
22 which smartphone technology was used to monitor movement and social activity in a euthymic
23 bipolar patient. In conjunction with an additional study in healthy controls (Prociów & Crowe,
24 2010), the authors conclude that speech data may prove useful in the early detection of
25 upcoming manic/depressive episodes. A recent study by Karam et al. (2014) expands these

1 findings by demonstrating that speech data (collected through day-to-day mobile phone
2 conversations) can be used to accurately classify hypomanic, depressed and euthymic states in
3 bipolar disorder (see also Muaremi et al., 2014). Similar research has also been conducted in
4 MDD populations. Cummins et al. (2013) showed that specific features of speech (such as
5 spectral variability) could be used to assess the severity of depressive symptoms (see also
6 Sturim et al., 2011). Moreover, Ooi et al. (2013) demonstrated that speech data could be used
7 to predict MDD onset in at-risk adolescents, two years prior to symptom onset, with 73%
8 accuracy. Taken together, these findings suggest that speech data is potentially a rich source of
9 information relevant to the monitoring of various psychiatric conditions.

10 The use of objective measures, such as speech data, to assess social functioning in LLD is
11 yet to be investigated. However, the findings discussed above suggest that speech monitoring
12 (via wearable technology or mobile phones) is a feasible option for this population. Indeed, a
13 recent study has shown that wearable technology is acceptable to patients with LLD, and that
14 it has the potential to provide accurate, objective measures of real-world functioning in this
15 population (O'Brien et al., 2016). In this study, activity levels were assessed in 29 patients with
16 LLD via a bespoke, wrist-worn activity monitor. The authors report that the device was
17 designed to be as unobtrusive and as comfortable as possible, designed much like a standard
18 wrist-watch with an adjustable silicone band and stainless-steel fastening. Home visits by the
19 research team were arranged to replace monitors needing to be recharged with identical, fully
20 charged monitors. In addition to a significant reduction in physical activity in patients with
21 LLD, the authors report a high level of compliance with the monitor in both the depressed
22 patients (92.2%) and the elderly control participants (92.3%). Taken together, this study
23 suggests that wearable technology is a feasible option for monitoring physical activity (and,
24 potentially, social functioning) in older populations.

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

15 In conclusion, it is clear from the evidence discussed above that social functioning is an
16 important aspect of LLD. While social function is significantly impaired by depressive
17 symptoms, the presence of good social relationships and good social support plays an important
18 protective role against depression in later life. However, much research to date has relied on
19 self-report based assessments of social functioning, and these methods are subject to several
20 limitations. The use of wearable technology, such as accelerometers and mobile phones, offer
21 promising new methods of assessing social functioning directly. Specifically, the use of multi-
22 modal (movement and speech) data has been shown to provide a large amount of ecologically
23 valid data in an unobtrusive way. Such technologies also offer new ways of remotely
24 monitoring older populations. For example, speech and movement data can be electronically
25 transferred to clinicians to create detailed records, and up-to-date, precise information (Bloom

1 et al., 2015). Indeed, the use of technology in this way will likely be of great assistance in the
2 management of an ageing population. For example, in addition to their aforementioned
3 research utility, devices such as the one reported by O'Brien et al. (2016) have the potential for
4 use in clinical contexts, such as in the detection of illness onset in "at risk" individuals, relapse
5 detection/prevention, or to monitor outcomes in patients as they undergo treatment. However,
6 it is critical that other measures, such as subjective questionnaires, clinical assessments and
7 clinical judgments, should not be ruled out entirely as there is evidence to suggest that the
8 subjective components of social functioning are important to LLD patients (e.g. Chi and Chou
9 2001). In order to create a full, detailed picture of social functioning in LLD, future research
10 should aim to include direct, objective measures in conjunction with subjective assessments.

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21 **Conflict of interest**

22 The authors are currently involved in the DEMO-POD study (The **D**evelopment and
23 **E**valuation of a **M**onitoring device to **O**bjectively assess functional and **P**sychosocial
24 impairment in **O**lder-age adults with major **D**epression).

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