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Network of Mental Activities, Cognitive Function and Depression in Older Men and Women

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Abstract

Background: Evidence suggests that lifestyle activities impact cognitive and mental health in older populations. However, how lifestyle factors are associated with one another, and which factors are most important for cognitive function and mental health has received comparatively little attention.

Design: Bayesian-Gaussian network analysis was used to investigate unique associations between mental activities (MA; i.e., activities involving cognitive engagement), global cognition, and depression at three time-points in a large sample of older adults (baseline, 2 years, and 4 years).

Setting: This study used longitudinal data from participants living in Australia and participating in the Sydney Memory and Ageing Study.

Participants: The sample included 998 participants (55% female) aged between 70 and 90, without a diagnosis of dementia at baseline.

Measurements: Neuropsychological assessment of global cognition, self-reported depressive symptoms, and self-reported information about daily MA.

Results: Cognitive functioning was positively associated with playing tabletop games and using the internet in both sexes at all time-points. MA were differentially linked in men and women. Depression was not consistently associated with MA in men across the three time-points; women who visited artistic events consistently had lower depressive scores.

Conclusions: Engaging with tabletop games and using the internet was associated with better cognition in both sexes, however sex acted as a modifier for other associations. These findings are useful for future investigations that consider interactive associations between MA, cognition, and mental health in older adults, and their possible roles in promoting healthy aging.

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Cognitive aging in healthy individuals is a natural process involving psychophysiological changes over time that effect the functioning of the brain. In tests of working memory, episodic memory, and attention, older individuals perform more poorly on average than younger individuals (Dumas, 2017). There is evidence that the onset of cognitive aging occurs as early as age 45 years (Singh-Manoux et al., 2012). While older adults may not perform as well as younger adults in these domains, significant productive value to society is provided through the roles they play in childcare, volunteering, and the insights they can provide through their life experience (Leist et al., 2014; Peisah et al., 2022). The population of adults 60 years and older is increasing globally, and is projected to account for 22% of the total population by 2050 (World Health Organization, 2022). The overall amount of time in later years is also increasing, as healthcare interventions are raising life expectancy (Leist et al., 2014). However, age-related deterioration in physical and mental health presents specific challenges to maintain the quality of life in older adults (Treichler, 2022). In particular, these disabilities are associated with increased depression and reduced likelihood of living independently (Lorenzo et al., 2023; Senra & McPherson, 2021).

Mental activities (MA) are operationally defined as leisure activities or behaviours that involve cognitive engagement, and recent research suggested that these behaviours influence mental health in older adults (Berezuk et al., 2021; Hallgren et al., 2020; Harvey, 2022). Investigating MA is an important topic, which is useful to finding effective and low-cost protective measures to maintain cognitive

functioning and good mental health. Moreover, MA are practical and accessible activities that have minimal risk, and are often engaged in by the adult population.

Past research into healthy aging has investigated the effects of various lifestyle activities over time on the cognitive and mental wellbeing of older adults. This research has shown that MA are beneficial in improving mental health and reducing cognitive decline (Huang et al., 2020; Visser et al., 2019). Leisure activities including watching television and using smartphones may also reduce the risk of cognitive decline (Yuan et al., 2018). Additionally, socially engaging activities have been positively associated with cognitive functioning in later life, and evidence exists that such activities can decrease symptoms of depression (Forsman et al., 2011; Lee et al., 2009). Specifically, MA such as playing board games, volunteering, and reading have been shown to have protective value against cognitive and mental health decline (Chen et al., 2022; Hallgren et al., 2020). While several factors were implicated in understanding how decline in cognitive function and mental health abated, there is little research investigating the interactive links between different MA, global cognition, and depression. Understanding the associations between certain MA and mental health in older adults would provide valuable information to identify protective mechanisms against cognitive and mental health decline.

The lack of research on interactive links between MA and mental health outcomes may be due to the methodological complexity of analysing the range of areas of related activity simultaneously, while connecting these with psychological outcomes. Such an investigation can be conducted using a novel methodology - network analysis, that graphically presents and statistically analyses the interactive associations between relevant variables (Borsboom, 2017). This allows deeper investigation into the unique associations among variables by simultaneously

accounting for all associations in the network (Epskamp & Fried, 2018). However, to identify a causal source of a mental health condition appears problematic because the interaction between a variety of symptoms manifest as a disorder (Epskamp & Fried, 2018). Borsboom (2017) conceptualised mental health disorders using a “network approach” as disorders caused by an interaction between a collection of symptoms that may have both causal and indirect connections between them.

Recent studies using network analysis have found differences between older men and women in terms of associations among lifestyle factors, inflammatory biomarkers, depression, and global cognition (Chalmers et al., 2022a). This illustrates that network analysis can be useful to distinguish how variables associate differently across sexes and to estimate relative importance of each variable in the network using predictability estimates. The Bayesian-Gaussian Graphical Model (BGGM) offers several advantages over the Gaussian Graphical Model (GGM), including flexibility in incorporating prior information, improved estimation and uncertainty quantification, robustness with small sample sizes, and the ability to handle missing data and integrate multiple sources of information. Given the nature of our study and the data, we chose to use the BGGM because BGGMs can handle dynamic and time-varying networks, making them suitable for analyzing complex health-related data that evolves over time. The BGGM estimates predictability of nodes, which is a measure of how much a variable influences other variables in the network (Haslbeck & Waldorp, 2018). Predictability provides important information relevant to creating clinical interventions, as it is possible to interpret variables which should be targeted to create change because such variables with high predictability can influence change in associated variables (Chalmers et al., 2022b).

network of mental activities

The present study examined similarities and differences in the interactive networks of MA, global cognition and depression in older women and men to identify relevant MA and their interactive mechanisms associated with mental health (i.e., depression) and global cognition in older age. Prior research has demonstrated associations between mental and lifestyle activities and cognitive function and depression. For example, Stern (2009) found that engaging in paid work, reading, and using the internet were positively associated with cognitive function. In light of these findings, we hypothesize that these activities would be positively associated with cognitive functioning and negatively associated with depression in the generated networks, while we also expected differences between male and females. This study can inform further research on effective and low risk interventions to promote healthy cognitive aging in the future. The study used longitudinal data from the Sydney Memory and Ageing Study (MAS; Sachdev et al., 2010). Exploratory network analysis was conducted with the baseline data and confirmatory network analyses with 2- and 4 -years follow up assessment data. Longitudinal predictive models were used to establish which MA most strongly predicted later global cognitive function and depression in our sample.

Method

Participants

Participants (n=1037) were selected from the MAS study (Sachdev et al., 2010). The MAS is a longitudinal cohort study that recruited older adults without dementia aged 70-90 years old from the Eastern Suburbs of Sydney, Australia between 2005 and 2007 (Sachdev et al., 2010; see Figure 1). Exclusion criteria in

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this study included major psychological or neurological disorder, prior diagnosis of dementia, and lack of proficiency in English. Participants were also excluded if initial assessments indicated a diagnosis of dementia, they scored under 24 on the Mini-Mental State Examination (MMSE; Folstein et al., 1975). In addition, 39 participants did not complete the mental activities assessment and were also excluded from the current study. After exclusions, the full baseline sample for the current study included 895 MA participants as illustrated in Figure 1. Participants completed follow-up assessments biannually, with Wave 1 consisting of 409 males and 486 females; Wave 2: 346 males and 412 females; and Wave 3: 299 males and 340 females. These sample sizes were appropriate for separate network analysis of males and females as demonstrated by Van Borkulo et al. (2014). Moreover, Bayesian methods can perform better with smaller sample sizes (e.g., $n=250$) compared to frequentist methods, particularly when prior information is available (Epskamp & Fried, 2018). More detailed information on recruitment and demographics of the sample are published elsewhere (Sachdev et al., 2010). Use of the MAS data in this research was approved by the University of New South Wales Human Research Ethics Committee (HC 05037, 09382, 14327, 190962).

<Insert Figure 1 Here>

Measures

MA variables used in this study are based on those described in Verghese et al. (2003) and used in Sachdev et al. (2010). MA were measured via a self-report questionnaire that contained 13 items. Participants responded using a 5-point Likert-scale that indicated the frequency of participation in each MA (1=not at all; 2=once a year or less; 3=several times a year; 4=several times a month; 5=every day or almost every day). Participants' score on each item was recorded at each wave of

the study (Supplementary Table S1). The MA comprised: doing any kind of paid work (PWork); participating in any volunteer work (VWork); listening to classical music (CMusic); playing tabletop games such as cards, board games, crosswords or doing other puzzles (Games); visiting artistic events such as movies and museums (SeeArts); using the internet for emails, chats or web browsing (Internet); engaging in artistic activities (DoArts); speaking or reading in a second language (SLang); reading books (Books); watching television; reading newspapers; listening to the radio; and reading magazines. Because the final four MA were highly correlated, we combined these into the variables: watching television and listening to the radio (TV_R), and reading newspapers and magazines (NewsMag). We combined these MA both because of the strong correlations and because of the high degree of content similarity. This reduced the overall number of nodes on the network, making the network more legible.

Cognitive functioning (Cogn) was calculated based on composite domain scores of a comprehensive battery of 10 neurological tests as outlined in the Sachdev et al. (2010) study. These tests captured the domains of memory, executive functioning, language, processing speed and visuo-spatial assessments, which represent the diverse areas of cognition affected by the aging process. Composite scores from each domain were calculated from raw scores based on the overall performance across assessments and standardised into quasi z-scores utilising a cognitively healthy sub-sample of the MAS population, such that the mean and Standard Deviation of scores was 0 and 1, respectively. Global cognition was calculated as an average of scores across individual domains and was again standardised against the normative reference group.

Depression (Depr) was measured using the Geriatric Depression Scale (GDS) a 15 item self-report assessment (Yesavage et al., 1982). The GDS items ask about common depressive symptoms such as “Are you basically satisfied with your life?” and are scored dichotomously; ranging from 0–15, where higher scores indicate more depressive symptoms (Yesavage & Sheikh, 1986). This scale has been well validated for assessing the presence of depressive symptoms in older adults (Brink et al., 1982); a total score greater than 5 indicates that depression may be present. The GDS demonstrated acceptable reliability in the current dataset (McDonald’s $\omega=0.72$ and Cronbach’s $\alpha=0.73$, in line with previous studies (Gana et al., 2017; Van Marwijk et al., 1995).

Data Analyses

Network analysis was conducted to study the relationships between MA, global cognition, and depression using baseline data to formulate hypotheses. Wave 2 and 3 data were used to test these hypotheses. R software (version 4.0.4) and the BGGM package facilitated the network analyses, which examined associations between nodes (R Team, 2013). BGGM with Copula estimators was chosen since it is not sensitive to data deviations from normal distribution (Williams & Mulder, 2020).

In exploratory analyses, the "explore" function within the BGGM package estimated pairwise relations between nodes using a semi-parametric copula model with a ranked likelihood basis, accounting for other relations within the full set of nodes (Chalmers et al., 2022b). This process yielded a partial correlation matrix, with associations having 95% credible intervals (CI) that did not include zero, signifying a 95% probability that the population parameter falls within that range (Chalmers et al., 2022b).

network of mental activities

To compare associations between women and men, separate BGGM were estimated for each group at every wave. Using the "ggraph" function from the R library, networks were generated based on the Fruchterman-Reingold algorithm, with an averaged layout to facilitate comparisons. In these networks, nodes with the highest number and strongest edges were centrally positioned, while pairs of nodes connected by strong edges were placed close together, minimizing overlap (Fruchterman & Reingold, 1991). Nodes without edges connecting them to the rest of the network were placed on the periphery, representing non-significant associations. To avoid misinterpretation due to instability, centrality indices like nodal strength centrality and predictability were also estimated and compared using the BGGM method (Kappelmann et al., 2021). Longitudinal predictive models, specifically linear regression models with predictors at Wave 1 and outcomes at subsequent waves, were employed to assess the effects of the most robust predictors over time.

For hypothesis testing and statistical inferences, potential differences between men and women in node-to-node associations were examined by developing and testing hypotheses in R Studio. Statistical differences were determined by estimating 95% CIs of the mean differences using 5000 posterior estimates. All possible associations were entered into R Studio, separated by sex. Mean difference estimates with 95% CIs that did not include zero were considered statistically significant differences. Based on significant baseline associations, hypotheses were generated for subsequent testing at each wave.

Results

Descriptive Statistics and Sex Differences

Supplementary Table S2 presents the descriptive statistics of mental activities (MA), depression, and global cognitive functioning used as nodes in network analyses for each of the three waves, split by sex. Men showed significantly higher engagement in paid work, reading newspapers and magazines, using the internet, and higher depression scores compared to women, as evidenced by independent t-tests. These differences were consistent across all three waves. Men also used a second language more than women, but this difference was only significant at waves 1 and 2. In contrast, women scored significantly higher on reading books, playing tabletop games, and seeing arts across all three waves.

Network Associations at Baseline (Wave 1)

Figure 2 displays the networks of unique associations between global cognition, depression, and MA for women and men at Wave 1 (baseline). Edges in red represent negative associations, while blue edges represent positive associations. The depth of color and thickness of the edge represent the strength of the association, with darker, bolder edges representing stronger associations. These stronger associations are the primary focus of the study.

A strong positive association was found between playing tabletop games and global cognition, listening to classical music and using a second language, and paid work and the Internet, with no significant difference between sexes. Both male and female networks showed a moderate negative association between paid work and depression and using a second language and global cognition, with no statistical difference between sexes (Figure 2). Supplementary Tables S4-S9 provide zero-order

correlation matrices, and Supplementary Figures S1-S3 include statistical comparisons of associations between nodes in male and female networks at waves 1-3 with 95% CIs.

<Insert Figure 2>

<Note: Network associations between mental activities, cognition, and depression in men and women at baseline (Wave 1). Edges in red represent negative associations, blue edges represent positive associations. The depth of colour and thickness of the edge represents the strength of the association, with darker, bolder edges representing stronger associations.>

Sex-Specific Associations

A strong significant link between volunteer work and doing artistic pastime was found only in men, while a strong negative association between visiting arts and depression was significantly stronger in women compared to men (PP=98.20%). A moderate positive link between playing tabletop games and internet use was observed only in women, while a moderate link between artistic pastime and visiting artistic events was found in men but not in women. Using a second language and the Internet were moderately associated in men only, and a positive link between reading books and newspapers and magazines was significantly stronger in men (PP=98.74%). These similarities and differences between men and women were hypothesized as true links in networks and summarized in Table 1, along with the results of testing these associations in subsequent waves.

Longitudinal Network Associations (Waves 2 and 3)

The positive associations between listening to classical music and using a second language; watching television/listening to the radio and listening to classical

music; reading books and listening to classical music; playing tabletop games and global cognition; and using the internet and global cognition remained present and equal between men and women across all waves (Table 1). This supports the hypotheses generated at baseline, where these associations were predicted to remain similar across sexes and statistically significant over time. Figures 3 and 4 present the networks of MA, global cognition, and depression for Waves 2 and 3, respectively. The link between volunteer work and doing arts was confirmed to be significantly stronger in men at all waves, supporting the baseline hypothesis. The hypothesis that the positive association between playing tabletop games and Internet would be stronger in women compared to men was also supported. However, other associations found at the baseline were inconsistent across waves.

<Insert Table 1 here>

<Insert Figure 3>

<Note: Network associations between mental activities, cognition and depression in men and women at 2-year follow-up (Wave 2).>

<Insert Figure 4>

<Note: Network associations between mental activities, cognition and depression in men and women at 4-year follow-up (Wave 3).>

Predictability and Centrality of Nodes

Supplementary Figure S4 displays the predictability of all nodes in the network, separated by sex, across all time-points. Doing arts, paid work, using a second language, and global cognition were consistently identified as the most influential nodes in the networks across waves and sexes. In contrast, watching

television/listening to the radio, playing tabletop games, and reading newspapers/magazines were consistently found among the less predictive nodes. In addition to predictability, other centrality indices were estimated, such as nodal strength (Supplementary Figure S5). Classical music (CMusic) consistently displayed as the strongest node in the network across sexes and waves, followed by global cognition (Cogn). On the other hand, depression (Depr) and volunteer work (VWork) were consistently found as the weakest nodes in terms of centrality.

Tabletop Games, Internet Use, and Cognition Predictions

Given that tabletop games and internet were consistently linked to better cognition across all three waves for both sexes, their predictive value at baseline for cognition at 2- and 4-year follow-ups was examined. Results, presented in Supplementary Table S3, demonstrated that playing tabletop games at baseline significantly predicted global cognition at 2- and 4-years follow-up, explaining 10% (Wave 2) and 7.6% (Wave 3) of the variance, with no significant difference between sexes. Similarly, internet use at baseline predicted better global cognition at 2- and 4-years follow-up, accounting for 7.7% (Wave 2) and 7.6% (Wave 3) of the variance.

Discussion

This study investigated how different mental activities were associated with each other and with depression and global cognition in an older people over time, and whether important differences could be found between sexes. Our network analysis suggested that global cognition was positively associated with playing tabletop games and using the internet in both men and women, which was consistent over time. Follow-up longitudinal regression analyses demonstrated that playing tabletop games, puzzles and internet use at baseline significantly predicted better global cognition at 2- and 4-years follow-up with no significant differences between sexes, suggesting that these activities may be associated with enhanced cognitive function.

Artistic activities, paid work, using a second language, and global cognition were the most influential variables in both male and female networks over time. This suggests that higher engagement in artistic activities is likely to be associated with a better cognition and changes in other MA in the network. Conversely, watching television and listening to the radio, playing tabletop games, and reading newspapers and magazines consistently appeared as less influential variables in the network.

The current research demonstrated that an association exists between internet use and maintaining cognitive function in older men and women consistently across time. Internet use can also be considered a complex MA, as it involves processing visual stimuli such as images and words, navigating websites and using internet tools (Small et al., 2009). Similarly, Small et al. (2009) showed that using the internet when searching for information is cognitively engaging, and we can

speculate that by repeatedly activating neural pathways within the brain cognitive decline can be potentially mitigated, which needs an experimental evidence.

Men were found to participate more in paid work, reading newspapers and magazines, and using the internet compared to women across all time-points. The differences in participation in paid work may be influenced by the societal norms of the cohort, as men in this generation were encouraged to gain employment while women were encouraged to become homemakers (Weiss, 2000). While there were differences between male and female networks at baseline and Wave 2, only the association between volunteer work and doing arts, where men had a significantly stronger positive association compared to women was consistent over all waves and is considered as a true difference. This may reflect the cohort of participants, as this age group might have stronger adherence to traditional gender roles and may engage in forms of volunteer work that conform to these roles. That is, women may be more likely to participate in creative activities across many areas of their lives whereas men may not engage in much creative activity outside of volunteering (Windsor et al., 2008). Within volunteering positions, men are able to realise their artistic potential while providing an altruistic service where they are viewed as an important member or leader in their community (Bendle & Patterson, 2008). These may include positions as mentors to children, such as coaching or within church organisations (Windsor et al., 2008; Wymer Jr, 1999).

Women were significantly more likely to read books, play tabletop games, and view artistic media or exhibitions compared to men across all three waves. However, it is demonstrated within the networks that using the internet is highly associated with paid work in older women in two out of the three networks (Figure 2, 3). This may suggest that women use the internet most when participating in paid work, and as

their frequency of participation is lower compared to men, this may explain the discrepancies in internet use between the sexes.

Older men had significantly higher levels of depression compared to older women. Also, an indirect negative association to depression was only demonstrated in female networks, while male networks show a lack of consistent associations between MA and depression, which suggests that depression in males may be associated with other factors than their current MA. There is evidence that in older age, depressive symptoms can result from losing competence in everyday life, and in those who highly value control and personal success, this can pose a great risk to their mental health (Fiske et al., 2009; Pfund et al., 2022). It could be inferred that in this cohort, older men may not experience feelings of mastery or control when engaging in MA other than paid work, which may harken back to social norms of their time, which valued men in their role of 'provider' for their families. (Vafaei et al., 2016).

We found the most influential variables within the networks include participating in artistic activities, engaging in paid work, using a second language, and global cognition. This suggests participation in these activities highly impacted the overall network structure. With these findings it is inferred that involvement in any of these MA may potentially influence engagement in other MA, as many associations branched off these nodes. As illustrated in Figures 2-4, the nodes representing artistic activities and paid work had strong associations with many nodes both directly and indirectly, such as nodes representing using the internet, visiting artistic events, and playing tabletop games among others. The present study has uncovered important associations between engagement in tabletop games including puzzles as well as using the internet and enhanced cognitive function. In

reviewing the networks of older men and women, differences in direct and indirect associations between MA, global cognition, and depression exist that may reflect the effect of social context on protective factors for mental health and cognition. These differences necessitate further investigation to examine if they arise from social contexts.

Limitations and Directions for Future Research

Some nodes became disassociated over time, which may have been related to the cohort of participants being aged between 70-90 at baseline. As participants aged, engagement in MA may have declined due to age-related limitations. The youngest participant was two decades younger than the oldest at baseline, which may have impacted what types of MA the younger participants engaged in compared with the older participants. For example, older participants may have had less exposure to, and therefore less willingness to engage in, internet use. The women of this group may have been less likely to engage in paid work while raising children and participating in the role of homemaker. Future research should consider stratifying the analyses based on age brackets to determine whether age-cohort effects impact the associations within the networks.

Another limitation of this research is the heterogeneity of the sample, as the participants all resided in the Eastern area of Sydney. The sample was largely Caucasian, upper-middle class to upper class, with higher education levels than the general population. The education and wealth of the participants, alongside their adherence to traditional social roles likely influenced the MA this population could afford to engage in, and their interest in certain MA. This sample likely also have higher rates of volunteering than the general population, evidenced by their volunteering to participate in the MAS study. Future studies should consider

including a more diverse population comprised of culturally and linguistically diverse populations.

It is important to consider the potential influence of physical conditions and life events on cognitive function and depression in older individuals. While only healthy individuals were included in the study, factors such as sleep disturbances, nutritional deficiencies, social isolation, or bereavement may have impacted our findings. Future research could investigate the role of these factors in conjunction with mental activities to better understand their interplay in shaping cognitive function and depression in older adults.

The findings of this research have established estimated associations between MA, depression, and global cognition, however, while the responses indicated there was a range of participation rates across MA, the average participation rate in some MA was low. MA with an average reported frequency across all time-points of 'once a year' or lower were doing paid work, doing volunteer work, using a second language, and engaging in artistic activities. This may have impacted on the associations that were able to be demonstrated in the networks.

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Conflicts of interest

None.

Description of author roles

EGH led and designed the study, conducted data analyses, and wrote the manuscript. PL supervised the study and edited the manuscript. MC supervised the analyses and edited the manuscript. KN managed data, collaborated with the study design and edited the manuscript. HB sourced funding in the original MA, collected data and edited the manuscript. NK managed data collection and edited the manuscript. PS sourced funding, supervised data collection, advised on the study design and edited the manuscript. ONM supervised the study and data analyses and edited the manuscript. All authors reviewed the final version.

Ethical standards

The MA was approved by the University of New South Wales Human Research Ethics Committee (HC 05037, 09382, 14327) and all participants provided written consent to participate in the study.

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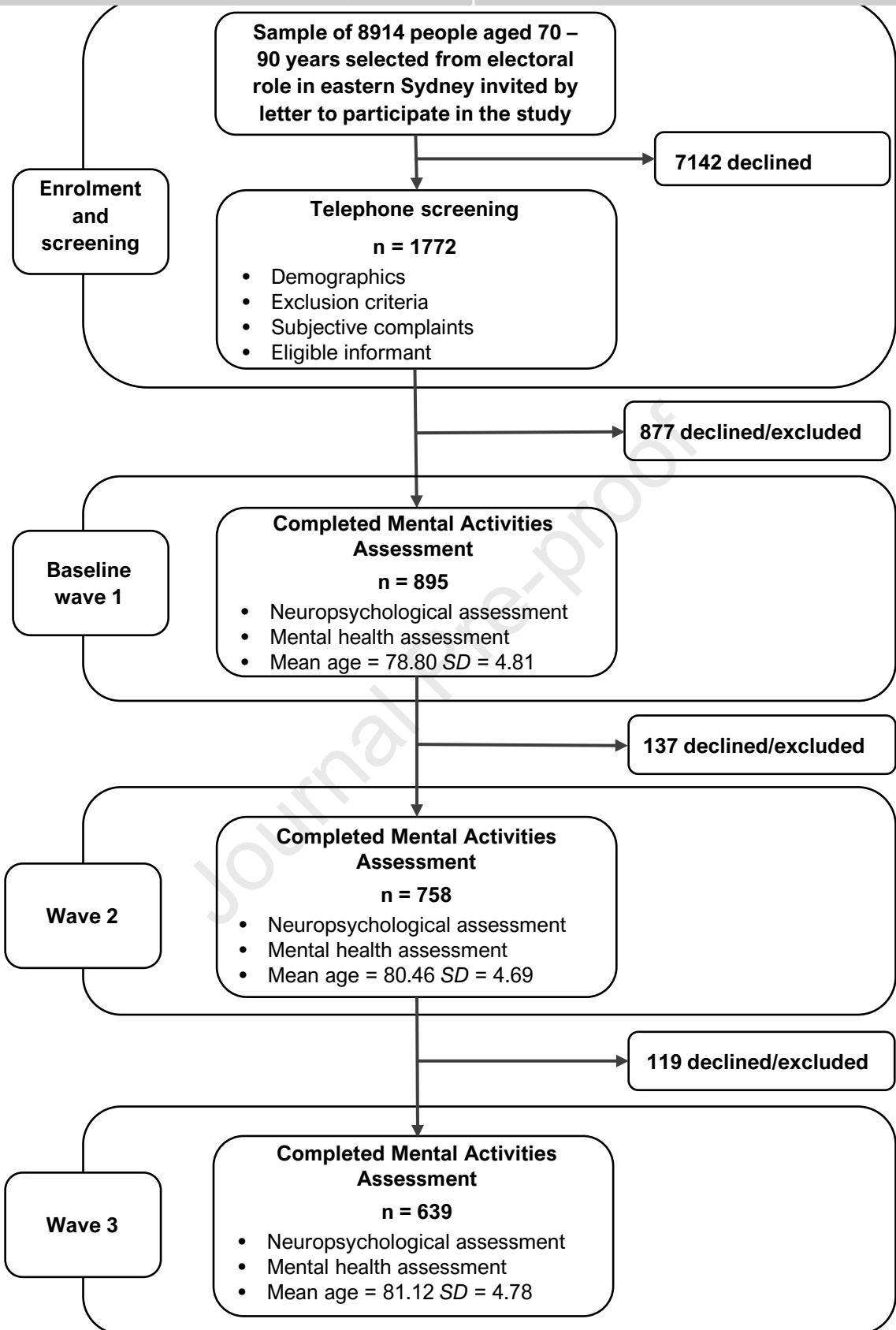
Table 1 Summary of significant network links and differences between men and women across the three waves of data for MA, depression, and global cognition.

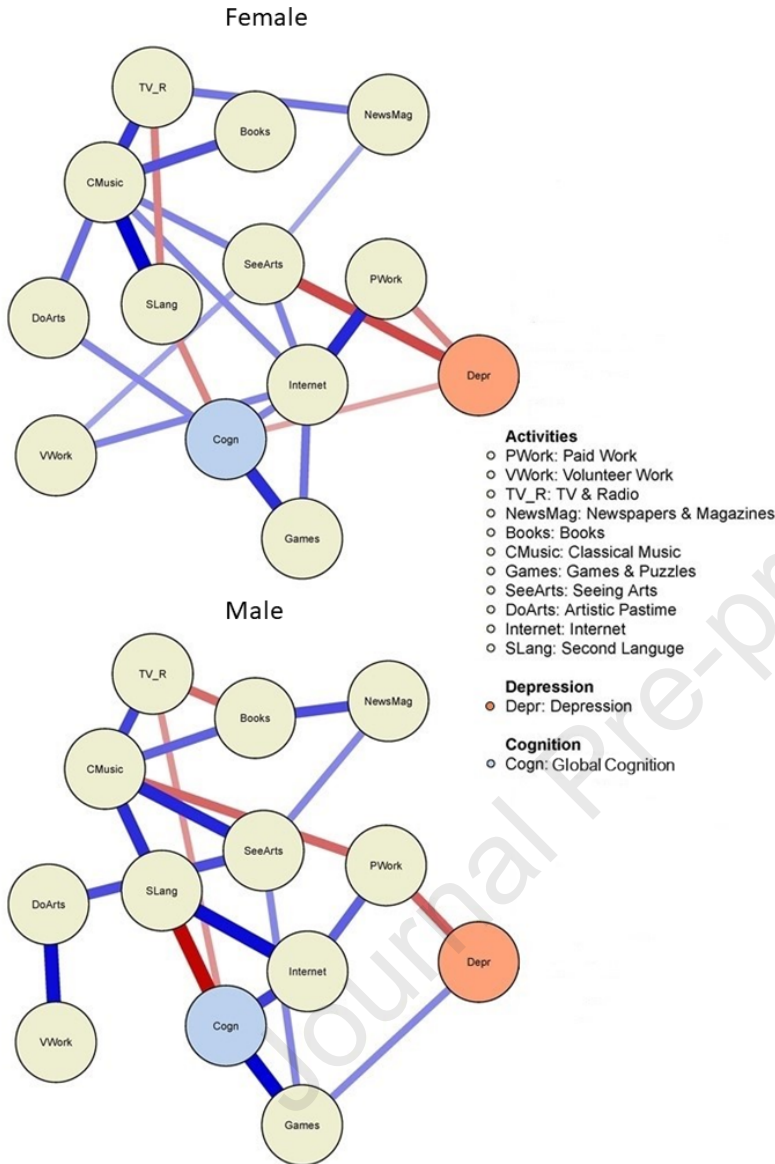
Unique associations between nodes	Exploratory Network Wave 1		Confirmatory Network	
	Sex Baseline	Difference	Wave 2	Wave 3
Games - Internet	F* (+)	M < F*	M < F*	F < F*
PWork - CMusic	M* (-)	--	--	--
VWork - SeeArts	F* (+)	--	--	--
TV_R - NewsMag	F*	--	F	M < F*
SLang - Cogn	M&F* (-)	M=F	M=F	M
PWork - Internet	M&F* (+)	M=F	M=F	M<F*
CMusic - SLang	M&F* (+)	M=F	M=F	M=F
TV_R - Cogn	M* (-)	--	--	--
TV_R - Books	M* (-)	--	M>F*	M>F*
SeeArts - Internet	F* (+)	--	F	M<F*
CMusic - DoArts	F* (+)	--	F	F
DoArts - Cogn	F* (+)	--	--	F
VWork - Internet	F* (+)	--	--	--
TV_R - CMusic	M&F* (+)	M=F	M=F	M=F
Books - CMusic	M&F* (+)	M=F	M=F	M=F
PWork - Depr	M&F* (-)	M=F	--	F
Games - Cogn	M&F* (+)	M=F	M=F	M=F
NewsMag - SeeArts	M&F* (+)	M=F	--	--
Depr - Cogn	F* (-)	--	F	F
TV_R - SLang	F* (-)	--	--	--
Internet - Cogn	M&F* (+)	M=F	M=F	M=F
CMusic - SeeArts	M&F* (+)	M=F	F (+)	M (+)
Games - Depr	M* (+)	--	--	--
Games - SeeArts	M* (+)	--	--	--
SeeArts - Depr	F* (-)	--	F (-)	F (-)
NewsMag - Books	M* (+)	M>F*	M (+)	M (+)
SeeArts - DoArts	M* (+)	M>F*	M (+)	--
Internet - SLang	M* (+)	M>F*	M (+)	--
VWork - DoArts	M* (+)	M>F*	M>F*	M>F*

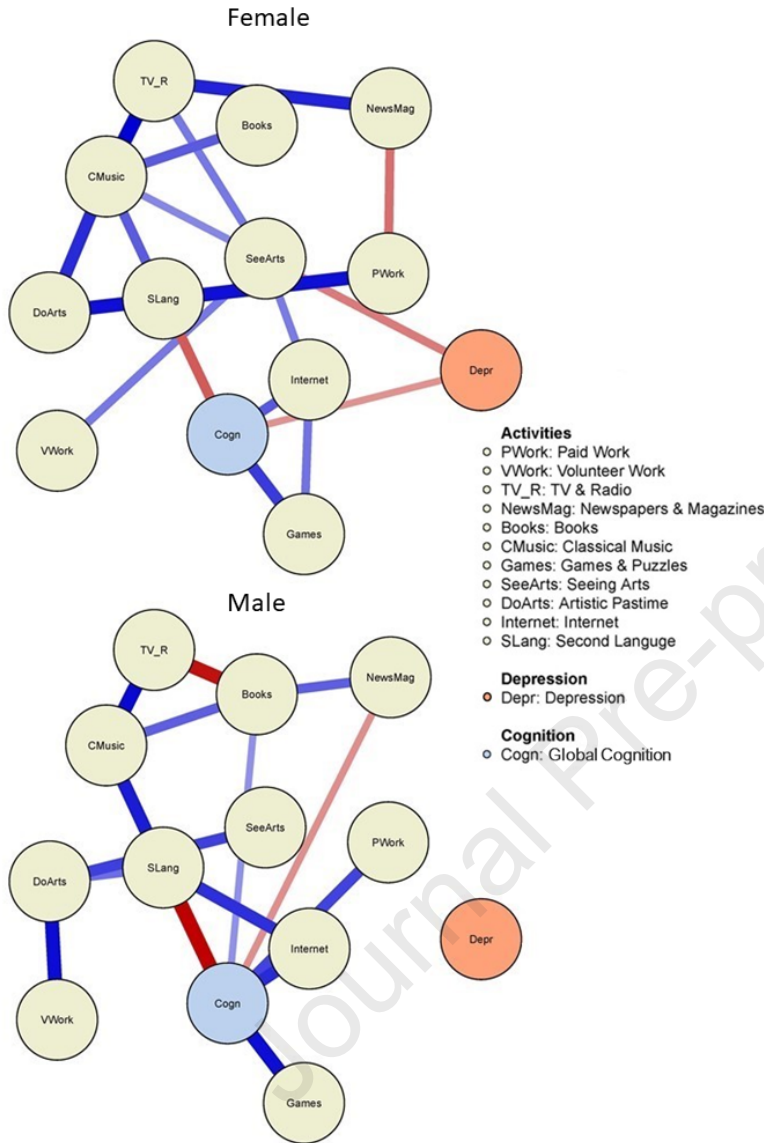
Note: M = men, F = women, asterisk (*) indicates significant association/difference $p < 0.05$

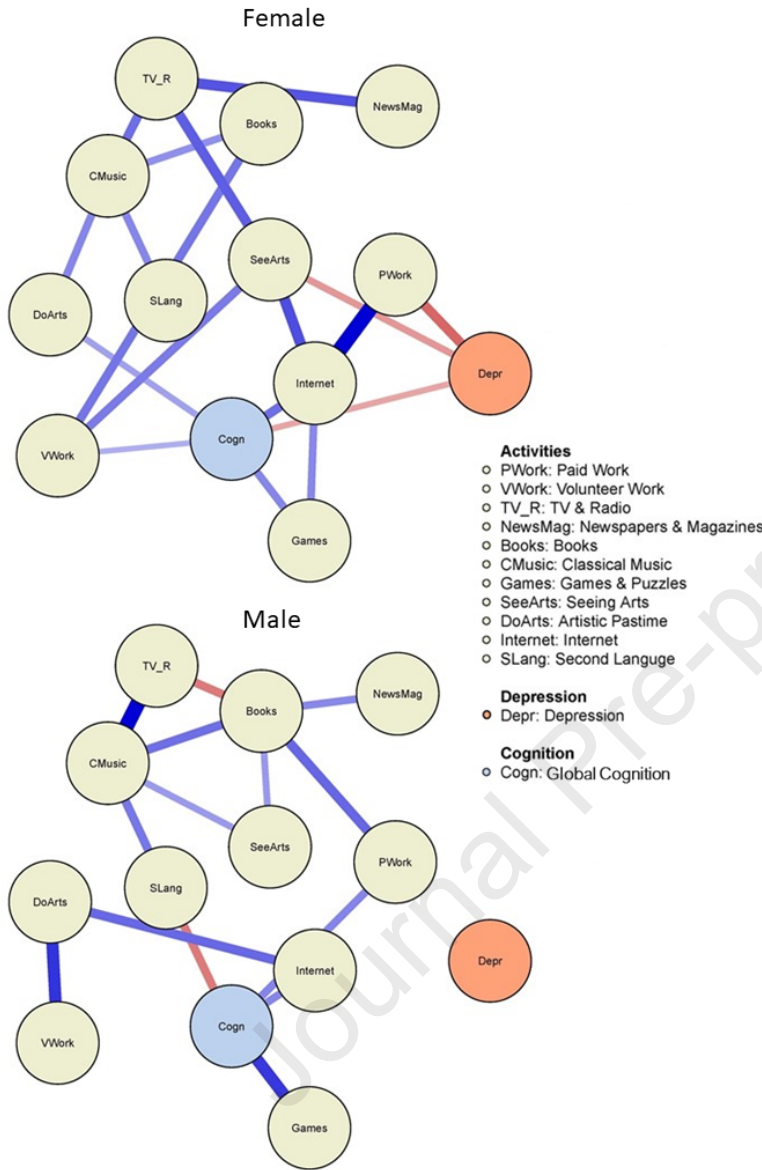
(+) = Positive association, (-) = Negative association

Rows in bold indicate hypotheses that are confirmed across all waves of data.









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