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Emotion recognition and verbal and non-verbal memory changes among older adults: Is decline generalised or modular?

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Abstract—Declines in cognitive abilities among ageing adults are observed phenomena. But are these declines ‘across the board’ or are they modular? The answer affects theory and practice, including potential treatments that may reduce the declines. Deficits in emotion recognition may provide a window into what is occurring in the ageing brain. We investigated whether changes in recognition of emotion could be attributed to a decline in memory processes. Sixty-two participants recruited from South-Eastern Queensland divided into young (19-49), middle old (49-64) and old (65 and above) cohorts performed computer administered tasks assessing emotion recognition, verbal and non-verbal memory. Older adults evidenced decline in recognition of anger, surprised and fearful faces. In addition, age related decline was evident in verbal memory performance. However, there was no corresponding decline in non-verbal memory performance. The dissociation of non-verbal memory performance from emotion recognition performance provides support for a modular decline model of age-related decline. The detection of decline in both verbal memory performance and emotion recognition suggests a common underlying process may be associated with both. Performance on the emotion recognition task may be verbally mediated. This study provides valuable insight into the ageing process and suggests decline may occur asynchronously- that is, is modular.

Keywords- Ageing, cognitive decline, emotion recognition

I. INTRODUCTION

A. Emotion Recognition

One of the intriguing age related differences of the past decade has been the claim that people’s ability to recognise emotions declines with age [1]. On the face of it this seems an unlikely finding, however it may be that decline in the recognition of emotions may indicate that age related decline of cognitive function is modular in nature. Others suggest that age related decline reflects a more broadly based generalised decline of function. This generalised decline approach attributes decline to a wide range of influences including beta-amyloid plaque related damage, oxidative

stress and vascular damage, or the general wear and tear of aging. These are collectively termed *insults to the nervous system*. In such a model, cognitive decline strikes broadly and relatively unpredictably. There is still some debate as to the mechanisms of age related decline and one way to further clarify this question of whether decline is the result of widespread insults to the nervous system or the failure of particular subsystems is to adopt a dissociation paradigm. If for example, emotion processing is associated with activation of the amygdala and prefrontal cortex [2], then decline in emotion recognition may be accounted for by decline in those regions of the cortex alone. If this decline is accompanied by decline more broadly in cognitive function for example in associated declines in memory the argument may be made that decline is generalised. If however, emotion recognition declines independently from memory, one potential explanation is that the regions associated with emotion processing are declining independently of the regions associated with memory. That is, there would be evidence of a dissociation of process between emotion recognition and memory. Performance on both a non-verbal and verbal measure of memory performance will be investigated.

Several sources have claimed evidence of age related decline in emotion recognition. In particular, it has been found that older adults have difficulty in recognising negative emotions such as anger. One group of researchers [3] as part of their research assessed emotion recognition and found middle and older adults had significantly less accurate anger recognition than the younger adults. An earlier study [4] had also found a significant age related decrement for the recognition of angry faces. These results were confirmed by another study in the mid 2000’s [5] which also found older adults showed some decrement in the recognition of anger when compared to younger adults. A subsequent meta-analysis [1] in 2008 and a further study [6] reported in 2009, identified older adults were significantly less accurate than younger adults on the recognition of angry faces. These studies provide evidence for an age related decline in anger recognition and there is some evidence that decline is evident in negative emotions more broadly. Yet the question is by no means resolved. Whilst a number of studies have investigated age related changes in emotion recognition in many of these studies a subset of emotional states are often assessed. Few

studies investigate changes in emotion more broadly. In the literature search conducted by [3], two studies found older adults performed similarly to younger adults. Despite these studies not finding evidence of decline, the balance of evidence more strongly suggests that older adults do most consistently show decrements on the recognition of anger.

In addition, there is evidence for an age related decline for the recognition of sadness. This was supported by [7], who found older adults were significantly less accurate in the recognition of sadness compared to the young and middle old adults. As part of their research, [4] found older adults also had significant decrement in the recognition of sadness compared to younger adults. This was further supported in the meta-analysis [1] which found that older adults performed significantly worse in the recognition of sad faces. However, intriguingly, another study [6] found that there was a moderate decrease in sadness recognition from the age of 40. It may be that decline in emotion recognition may be a useful early indicator of cognitive decline. However, there is some indication that sadness may remain preserved. In another study [3], there was only an age difference in processing sadness stimuli on a lexical emotion processing task and not in a facial emotion processing task; and researchers in the same study [3] did not find evidence of decline at all in four prior studies in their review. Therefore as with the recognition of anger the findings in regard to recognition of sadness are somewhat mixed though the preponderance of the evidence supports a decline in sadness recognition.

Contempt, which could also be classified as a negative emotion, has not been extensively studied and sparse literature exists in relation to how it functions in the elderly. One study [6] found that there was an age related decline in contempt recognition after the age of 61. Due to the paucity of literature that has assessed contempt recognition, it was also assessed in the current study.

However, it is unclear whether age related decline in recognition of emotions extends to faces showing disgust, as there is some evidence that disgust recognition may even increase with age [5]. A meta-analysis [3] examined 10 studies that assessed disgust: 5 found older adults had performance equal to the younger adults, and in 3 the older adults were more accurate than the younger adults. Another meta-analysis [1] likewise concluded that older adults performed significantly better than younger adults in recognising faces showing disgust. Whilst some studies suggested that disgust recognition may decline with age these differences could simply reflect stimulus artefacts in those studies. On balance it would appear from the meta-analytic evidence that age related decrement does not extend to disgust recognition.

Recognition of surprise is also an area where the results are somewhat equivocal. In the meta-analytic study [3] of 10 studies that assessed surprise recognition, there was no evidence of an age related decline. Likewise, the meta-analysis conducted by [1], indicated older adults had similar surprise recognition to younger adults. Although there is some evidence for a lack of age related decrement in surprise recognition this could also indicate a task characteristic. Using

a different set of facial stimuli [6], an age related decrement in surprise recognition was found for those aged over 61.

Similar to disgust and surprise recognition, the research regarding happiness recognition is also inconclusive. There is some evidence that the recognition of happiness may remain preserved. In [4], it was found that that an elderly group did not perform significantly differently from younger adults on the identification of happy faces. There is even evidence that older adults may have superior recognition of positive stimuli. One study [7] found that middle and older adults (over the age of 40) had higher accuracy of happiness stimuli than younger adults. This might suggest that older adults are still able to recognise happy faces. However, ceiling effects may have confounded the happiness data [3]. Therefore it is difficult to assess whether the lack of age related decrement might reflect a task characteristic, or whether happiness recognition remains preserved from aging. It is possible this may also reflect a type of positivity bias.

Some investigations provide evidence of decline in happiness recognition with age. In a meta-analysis conducted by [1], it was found that older adults were significantly less accurate than younger adults on the recognition of happy faces. This was further supported by the research of [6] who found a decline in happiness recognition from the age of 61.

The current study aimed to clarify some of the inconsistencies in the research by investigating age related changes across the full spectrum of emotions discussed above. To reduce the possibility that subtle changes in emotion recognition were being masked by ceiling effects, an emotion recognition task of sufficient difficulty was developed.

B. Nonverbal memory

One possible mechanism of failure in emotion recognition is simple memory failure. Several studies have identified age related decline for non-verbal memory using a range of stimuli from faces to geometric patterns [8, 9]. It is possible that poor apparent emotion recognition performance may be attributable to failure to remember the initial stimulus rather than degradation of emotion processing itself. In the current study an observation of decline in emotion recognition accompanied by decline in non-verbal memory would suggest that the older individual may have forgotten what a previously studied face looked like.

In a study [9] that assessed memory for non-verbal stimuli geometric art patterns were used (in a sample divided into six age cohorts), based on signal detection theory. This study found that the two older age groups made significantly fewer correct responses on the task when compared to the younger age cohorts. In addition, there was an age related decrease in d' (sensitivity) identified across age cohorts. In a different study [10] that also examined memory for non-verbal stimuli, line drawings of flowers, and different varieties of animals and insects were used with a sample divided into eight separate age cohorts. The authors found evidence for an age related decrease in performance with a lower hit rate for the two older age cohorts than the younger cohorts. In addition, it was found that the eldest group had significantly higher false alarm rate suggesting that they were more likely to identify

that they had seen the stimulus regardless of whether they could remember seeing it previously.

Age related decline for non-verbal memory has also been found when using faces as stimuli [11]. In one study [11], half of the participants were provided standard learning instructions, and half were provided an elaborate encoding task where they had to attend to a structural characteristic of the face and indicate whether the face looked friendly. The results showed a significant effect of instruction on recognition (d') with the more elaborate condition leading to better memory. In addition, the results suggested that the older participants had a significantly lower recognition than the younger participants. Moreover, it was found that older adults had a significantly higher false alarm rate suggesting they were likely to say they had seen the face even if they were unsure whether they had seen it previously.

C. Verbal Memory

An alternative account of failure of emotion recognition may lie in the use of verbal memory to encode emotional states. It may be that the initial emotional state is encoded as a verbal representation in memory and that a subsequent verbal memory failure results in failure to correctly identify the emotional state seen in the study phase. However, verbal memory historically has been identified as being robust to age related change [12]. This may be a consequence of the richness of verbal mappings available to adults which provide redundant pathways to learned verbal material. This is the cognitive reserve model. However, on a simple verbal task with limited access to cognitive reserve and sufficient task load, evidence of decline in verbal memory tasks have been detected. [12] found although the young, older and impaired individuals were not significantly different on a span forward task, the individuals with impairment had significantly poorer performance on a backward span task when compared to the two control cohorts. In addition, short-term memory decline may be task dependent and tasks involving only the maintenance of information may be less likely to be affected by aging than tasks involving the manipulation and maintenance of information in memory [13]. The tasks involved in assessing short-term memory are usually verbal in nature (e.g., digit span, word recall). If emotion recognition is accompanied by changes in both non-verbal and verbal memory this would be indicative of a generalised cognitive decline affecting multiple different aspects of behaviour. Decline in emotion recognition accompanied by change in verbal memory dissociated from non-verbal memory would on the other hand be more consistent with a view of cognitive ageing as being modular in nature.

Given the robustness of verbal memory to age related decline we adopted a staircase span measure of verbal memory performance. Digit span encodes a verbal representation but one which is relatively semantically impoverished. As such performance on the span task provides some evidence of verbal memory with limited impact of cognitive reserve effects. We hypothesised that verbal memory performance would not decline with age, but as there was evidence for an

age related decrement in non-verbal memory [12], it was predicted that decline in emotion recognition would be accompanied by decline in non-verbal memory. If this occurred it would provide support for a dissociation of process and therefore for modular decline.

II. METHOD

A. Participants

A sample of 62 participants was recruited using purposive sampling from South-Eastern Queensland community. The majority of the participants that comprised the young old sample were first year Psychology students from a University in South-Eastern Queensland. The older participants were drawn from the local community. Screening of the data lead to the final sample of 62 participants comprised of 48 females (77.4%) and 14 males (22.6%). The age of the participants ranged from 18 to 84 years ($M = 50.47$, $SD = 20.83$). For the entire sample, 28 participants (45.2%) were taking medication for illnesses e.g., high blood pressure, high cholesterol, diabetes, depression, vascular problems and 34 (54.8%) were not taking medication. Forty-one (66.1%) nominated high school, 13 (21.0%) nominated university, 6 (9.7%) nominated TAFE (a technical college) and 2 (1.3%) nominated primary school, as their highest level of education.

B. Instruments

Verbal memory. To assess verbal memory, a computer administered digit span task was used. Participants were presented with random sequences of digits using the staircase method. Initially all participants were presented with a 3 digit list and the stimulus list length increased by 1 for each successful recall and decreased by 1 digit for each unsuccessful recall. Participants were presented with 30 trials. Span was recorded as the average of the last 10 trials.

Non-verbal memory. To assess nonverbal memory, a memory for faces task was used. This was one of a suite of computerized cognitive tasks used for the current research. The database of faces was comprised of photographs taken from a cohort of students at a university in Southeast Queensland. All photographs were of neutral faces (showing no affect). To minimize the possibility of stimuli artifacts contributing to facial distinctiveness faces with piercings were excluded. An oval mask was applied to the faces to remove the potential confounding effect of hair style. The faces were presented in monochrome to similarly avoid artifacts. Pilot testing was conducted to exclude any faces with particularly memorable characteristics.

Emotion recognition. To assess emotion recognition, participants were required to identify emotions of 8 different types (neutral, sad, happy, angry, disgusted, contemptuous, surprised and fearful) in stimulus faces. To reduce the likelihood of cohort familiarity effects (e.g., young adults performing better on younger faces), the stimulus set contained both young and old faces portraying the eight different emotional states. The images used in this task were of a young man, young woman, older man and older woman. Crazy Talk 6 software to generate emotional stimuli ensured

the derivation of a consistent set of emotion cues in the resultant stimulus set. The emotional states were derived by applying morphing algorithms to one of the four neutral source images to generate a stimulus image showing the emotional state from a template of features.

C. General Procedure

The study was conducted in accordance with the Australian National Statement on Ethical conduct in Human Research (2007); prior to commencement of the study the research protocol was approved by the Bond University Human Research Ethics Committee.

Verbal memory. Participants were administered a forward span task using a staircase method. Initial list length presented was three digits. Each successful reproduction of the stimulus string resulted in an increase in the stimulus list length by one digit. Each error resulted in a reduction of the list length by one digit. Participants were presented with 30 trials. The display time of the stimuli was 3000 ms, followed by a 2000ms blank time. Participants had 10,000ms to respond after which time the stimulus timed out, and the response was excluded from the analysis. There was a 1000ms inter-stimulus interval.

Non-verbal memory. The measure of non-verbal memory was a computerised memory for faces task. The faces were not those used in the emotion recognition task. In the study phase participants were shown 20 *target faces* of varying age and gender were shown in the centre of a computer screen for 2000ms. After the 20 faces were shown, participants were required to identify the Target faces from a recognition set including the target faces and an equal number of distractor faces (40 faces in total).

Recognition of the faces was indicated by pressing the “Z” key on a standard QWERTY keyboard if the face was recognised from the study phase and the “/” key of the face was new (not recognised from the study set).

Each button had a label underneath which stated Press Z and Press / for Yes and No Responses respectively. Participants were not provided a set time limit to respond.

Emotion recognition. Upon commencement of the task, the following instructions were presented on the screen.

‘You are about to be shown some faces, you have to tell me which description matches the face shown, by pressing number 1 to 8 on the keyboard. Press 1 – if the face looks neutral Press 2 – if the face looks sad Press 3 – if the face looks happy Press 4 if the face looks angry Press 5 – if the face looks disgusted Press 6 – if the face shows contempt Press 7 – if the face looks surprised Press 8 – if the face looks fearful

Once the participant read the instructions, they were required to click begin at the bottom to start the task. In the experiment phase, participants were presented with 100 trials of four different stimuli (young man, young woman or old man or old woman) with one of the eight facial expressions. Each presentation of the face was shown in the centre of the screen for two seconds, was then masked so that the face could not be seen. Participants were then asked on the screen “*What word best described the face?*” and were required to select from 1-8

the expression which description they thought best fit the facial expression. The stimuli were presented for 2000ms with a blank time of 200ms. Participants were not provided with a time limit to respond.

D. Design

Emotion recognition. The independent variable was *Age* (Young, Middle Old, and Older Adults) that varied between subjects. The dependent variable was *Accuracy in identifying emotional state* (Neutral, Happy, Surprised, Anger, Sad, Fear, Disgust and Contempt).

Verbal and nonverbal memory. The independent variable was *Age* (Young Adults, Middle Old Adults, and Older Adults). The dependent variables were *Accuracy* (Target Accuracy, False Negative, and Span) and *Latency* (Latency to Locate Target Face).

To control for the potential contribution of education level on cognitive reserve in verbal performance, highest education level in years was measured and included as a covariate in statistical analysis.

III. RESULTS

Initial data checking using IBM SPSS Statistics 21, confirmed the data met the assumptions for subsequent analysis by Multivariate analysis of variance (MANOVA).

Several One-way MANOVA’s were conducted to assess the effect of *Age* (Young Old (18-49), Middle Old (50-64), and Older Adults (65+), on *Identification of Emotional State* (Neutral, Happy, Surprised, Anger, Sad, Fear, Disgust and Contempt). α was set at .05 a priori. Unless otherwise indicated, all results are reported as Wilks’ approximations to *F*. Analysis of the combined variables showed that there was a significant multivariate main effect of *Age* on the combined variables of *Identification of Emotional State* ($F(16, 104) = 4.45, p = .000, \text{partial } \eta^2 = .41, \text{ power approaching } 1$). As the overall test of the weighted linear composite was significant, each of the dependent variables was then considered separately.

TABLE 1: MEAN AVERAGE RECOGNITION LEVELS FOR EIGHT FACIAL EXPRESSIONS BROKEN DOWN BY YOUNG OLD, MIDDLE OLD, AND OLDER ADULTS

Emotion	Age Group		
	Young Old Mean (sd)	Middle Old Mean (sd)	Older Adults Mean (sd)
Neutral	.55 (.16)	.50 (.12)	.57 (.21)
Happy	.47 (.18)	.49 (.18)	.37 (.20)
Surprised	.43 ^a (.13)	.41 ^c (.15)	.28 (.14)
Anger	.42 ^{ab} (.13)	.25 (.15)	.20 (.09)
Sad	.32 (.22)	.25 (.17)	.18 (.14)
Fear	.08 (.10)	.14 ^c (.09)	.05 (.08)
Disgust	.12 (.11)	.13 (.09)	.13 (.09)
Contempt	.19 (.14)	.24 (.12)	.20 (.10)

a - Difference between younger and older adults
 b - Difference between younger and middle old adults
 c - Difference between middle and older adults

The univariate analyses and post-hoc analyses revealed significant age related differences in the recognition of three emotional states (Surprise, Anger and Fear), there were no significant differences in identification rates by age for the remaining emotions.

There was a significant effect of Age on Identification of Surprised Faces ($F(2, 58) = 6.22, p = .004$, partial $\eta^2 = .17$, power = .88). Young Old participants had greater accuracy in identifying surprised faces than Older Adults (Tukey's HSD, $\alpha = .05$). Older Adults were also significantly less accurate than the middle old group. There was no significant difference between the Young Old and Middle Old adults. (Refer to Table 1 below).

Identification of Angry Faces significantly varied with Age ($F(2, 59) = 16.88, p = .000$, partial $\eta^2 = .36$, power approaching 1). Post hocs revealed that the both Older Adults and Middle Old accuracy in identifying an angry faces was significantly lower than the Young Old. However, there was no significant difference between the Middle Old and Older Adults. (Refer to Table 1 above).

Identification of Fearful Faces also significantly varied with age ($F(2, 59) = 4.65, p = .013$, partial $\eta^2 = .14$, power = .76). Older Adults had significantly poorer recognition of fearful faces than the Middle Old group (Tukey's HSD, $\alpha = .05$). However, there was no significant difference between the young and middle adults or the young and older adults (Refer to Table 10 below).

There was no significant effect of Age on Identification of Neutral Faces ($F(2, 59) = .85, p = .433$, partial $\eta^2 = .03$, power = .19). As can be seen in Table 1 below, there is approximately .7 of a difference in accuracy for identifying a neutral face between the young, middle and older adults. In addition, there was no significant effect of Age on Identification of Happy Faces ($F(2, 59) = 2.63, p = .081$, partial $\eta^2 = .08$, power = .50). Nor was there a significant effect of Age on Identification of Sad Faces ($F(2, 59) = 2.90, p = .063$, partial $\eta^2 = .089$, power = .55). As can be seen in Table 1 above, there is approximately .14 of a difference in accuracy for identifying a sad face between the younger, middle and older adults. Somewhat surprisingly sad faces were poorly recognised in all groups. There also was no significant effect of Age on Identification of Disgusted Faces ($F(2, 59) = .06, p = .940$, partial $\eta^2 = .00$, power = .06). As can be seen in Table 1 above, the difference in accuracy for identifying a disgusted face between the younger, middle and older adults is negligible. In addition, Identification of Contemptuous Faces was not significantly affected by Age ($F(2, 59) = .84, p = .438$, partial $\eta^2 = .03$, power = .19). As can be seen in Table 1 above, there is approximately .5 difference in accuracy for identifying a Contemptuous face between the younger, middle and older adults.

TABLE 2: SCORES: RECOGNITION FOR TARGET ACCURACY, FALSE NEGATIVES (NON VERBAL MEMORY), AND SPAN (VERBAL MEMORY) FOR YOUNG OLD, MIDDLE OLD, AND OLDER ADULTS

Variable	Age Group		
	Young Old Mean (sd)	Middle Old Mean (sd)	Older Adults Mean (sd)
Target Accuracy	75.95 (16.48)	74.29 (15.76)	71.50 (15.90)
False Negative	27.90 ^a (5.92)	25.71 (4.77)	21.85 (5.80)
Mean Span	7.37 ^a (1.24)	6.85 (1.05)	6.08 (1.69)

a - Difference between younger and older adults

A multivariate analysis of covariance (MANCOVA) was run to assess the effect of Age on Memory tasks (Target Accuracy, False Negative, Span) with Education as a covariate. Target Accuracy was the number of faces correctly identified (non-verbal memory accuracy). False Negative is the numbers of target faces missed (non-verbal memory error). Span is the number of digits recalled (Verbal Memory). There was a significant effect of Education ($F(3, 56) = 2.94, p = .041$, partial $\eta^2 = .14$, power = .67). As expected, Education was found to significantly co-vary with Verbal Memory ($F(1, 58) = 8.12, p = .006$, partial $\eta^2 = .12$, power = .80). Analysis of the combined variables showed that after controlling for Education there was a significant main effect of Age on Accuracy ($F(6, 114) = 3.35, p = .004$, partial $\eta^2 = .15$, power =

.93). As the overall test of the weighted linear composite was significant, each of the dependent variables was then considered separately. It was identified that *Target Accuracy* was not significantly affected by *Age* ($F(2, 59) = .40, p = .671$, partial $\eta^2 = .01$, power = .11).

However, there was a significant effect of *Age* on *False Negative* ($F(2, 58) = 6.10, p = .004$, partial $\eta^2 = .17$, power = .87) with the older adults missing the most target faces. Post hoc analyses were conducted using Tukey's HSD ($\alpha = .05$). There was a significant difference between the young and older adults with the older adults having a lower rate of false negatives than the young adults. (Refer to Table 2 above). There was no significant difference between the young and middle adults or the middle and older adults. (Refer to Table 2 above). In addition, there was a significant effect of *Age* on *Span* ($F(2, 58) = 4.96, p = .010$, partial $\eta^2 = .15$, power = .79). Post hoc analyses were conducted using Tukey's HSD ($\alpha = .05$). Older adults had a significantly lower span than the young adults. However, there was no significant difference between the young and middle adults or the middle and older adults. (Refer to Table 2 above).

A Oneway ANOVA assessed the effect of *Age* on *Latency*. There was a significant effect of *Age* on *Latency* ($F(2, 59) = 9.28, p = .000$, partial $\eta^2 = .24$, power = .97). Post hoc analysis were conducted using Tukey's HSD, $\alpha = .05$. Both Middle and older adults took significantly longer to identify the target face than the young (Refer to Table 3 below). However, there was no significant difference between the middle old and older adults. The increase in latency from young to middle old adults suggests that there is an increase in generalized slowing until middle adulthood. However, as there was no difference between middle and older adults, it suggests that older adults do not become slower after the age of 50. This may be indicative of a floor effect in the task.

TABLE 3: MEAN LATENCY TO REMEMBER FACES (NON VERBAL MEMORY) BROKEN DOWN BY YOUNG OLD, MIDDLE OLD AND OLDER ADULTS

Variable	Age Group		
	Young Old	Middle Old	Older Adults
	M (sd)	M (sd)	M (sd)
Mean Latency to Remember Faces (Milliseconds)	1217 ^{ab} (343)	1912 (1013)	2165 (681)

a - Difference between younger and older adults
b- Difference between younger and middle old adults

IV. DISCUSSION

Decline in emotion recognition may provide a window into what is happening in the aging brain. Periodically evidence emerges which indicates that emotion recognition

becomes more impoverished with increasing age [3]. However, the findings are somewhat inconsistent. Therefore, one of the aims of the study was to investigate recognition of emotional stimuli across adulthood using a comprehensive set of emotion stimuli. It was predicted that older adults would have significantly poorer performance than the younger cohorts on the emotion recognition task.

A further aim was to assess whether decline in emotion recognition was accompanied by changes in verbal or non-verbal memory. The decoupling of decline in different systems may provide insight into how age related cognitive decline progresses. If performance on one domain is decoupled from performance on another, this would be consistent with a view of cognitive decline as modular. Such a result would have (has) implications for early detection of disorder, for differential diagnosis and perhaps eventually also for treatment. If decline is observed to occur in a generalized fashion this would suggest that at heart cognitive decline is the result of a more broad based degradation of cognitive architecture.

We predicted on the basis of the literature [12], and our prior work that if emotion processing was a function of non-verbal memory failure there would be evidence for decline in both emotion recognition and non-verbal memory. From our previous work, we found no evidence of decline in verbal memory. If we saw this pattern and preservation of verbal memory it would provide support for a dissociation of process and hence modular decline.

As predicted, there was age related decline on the recognition of emotional stimuli. However, it was found that older adults did not decline on all emotional states. It was identified that there was no effect of age on the recognition of neutral faces. This face is considered a control condition and any findings of decrement would be unanticipated.

However, there was an age related decrement on anger recognition, with middle and older adults less accurate than the younger adults. In addition, the older adults were significantly less accurate than the middle old adults. This finding supports the research of [4] who found that older adults were significantly less accurate in the recognition of anger compared to the younger adults. [6] also found older adults were significantly less accurate than younger adults on the recognition of anger. This finding suggests that older adults may decline on the ability to recognise anger.

However, it was identified that there was no effect of age on sadness recognition. This finding supports 4 studies identified in [3], who found no age differences on the recognition of sad faces. However, it does not support the research of [7] who found older adults were significantly less accurate in recognising sad faces than young and middle old adults. This finding also contrasts the 10 studies in [3] that found older adults to be less accurate than younger adults on the recognition of sad faces. This finding also does not support the research of [6] who found a moderate decrease in sadness recognition from the age of 40.

In addition, it was identified that there was no significant age decline on contempt recognition. Although

there is a paucity of literature on contempt, the current finding does not support the earlier study [6] that found there was a decline in contempt recognition from the age of 61. As there are few studies that have assessed contempt recognition in an aging cohort, it is difficult to assess whether the lack of decrement found would be likely to be replicated in further studies.

However, it was found that older adults were significantly less accurate on the recognition of fearful faces. An interesting finding was that there was no difference between the young and older adults. This finding provides partial support for the research of [3] which found age differences only on the facial emotion task. However, it does not support other research [14] where older adults were found to be particularly less accurate in their recognition of fearful faces than the younger adults. In addition, the meta-analysis [3] found evidence of an age related decline in fear recognition for 6 out of 10 studies but another study [5] found no age effect on the recognition of fear. Again as we find both decline for fear recognition and decline in verbal memory, this may suggest that the older adults encoded a phonemic representation of fear that was later unable to be retrieved.

In addition, there was also no effect of age on disgust recognition with the older adults performing similarly to both middle and young adults. This finding is not entirely surprising, as there is evidence in the literature to suggest that disgust recognition remains preserved. The lack of age related decrement in disgust recognition supports earlier research [5] and a meta-analytic overview [3] that found in 5 out of the 10 studies that older adults equalled the performance of the younger adults, and in another 3 of the 10 studies actually performed better than the younger adults.

However, there was an age related decrement on surprise recognition, with older adults less accurate than the younger and middle old adults. This finding supports the research of [6] who found an age related decrement for surprise recognition after the age of 61. However, the majority of studies have found that surprise recognition did not decline. This was supported by the research of [3] who found no evidence of age related decrement for the recognition of surprised faces. In addition, [3] also identified that in the 10 studies that assessed surprise recognition, there was no evidence of age related decrement- consistent also with another meta-analytic review [1]. As mentioned earlier, the lack of finding of a decrement for surprise recognition in the older adults could indicate a task characteristic.

Moreover, we found no evidence of age related decline in happiness recognition. This finding supports the research of [4] who found the elderly group and the young adults perform equally on the identification of happy faces. In addition, [3] identified in 11 out of 13 studies that older adults performed equally to younger adults but argued that ceiling effects may have confounded the data. The current study used an entirely different set of stimuli and therefore we suggest that happiness recognition may remain preserved. However, the finding does not support [3] who found that older adults were significantly less accurate than middle and older adults

on lexical and facial tasks nor the research [1], [6] that found that happiness recognition began to decrease in older adults. In addition, this finding does not support the research of [7] who found middle and older adults had superior recognition of happiness compared with younger adults. We found an equality of performance.

A further aim was to assess whether decline in emotion recognition could be attributed to change in verbal or non-verbal memory, as well as to assess whether age related cognitive decline occurs in modular or generalized fashion. For example, if we found that nonverbal memory declined and verbal memory remained intact, this would provide evidence for a dissociation of process and would support a theory that age related changes occur in distinctive parts of the brain and decline at different rates. From the literature [12], there is evidence for an age related decrement in non-verbal memory. However, there is evidence from our previous work to suggest that verbal memory might remain preserved from the effects of aging. Therefore, it was predicted in our study that decline in emotion recognition would be attributed to non-verbal rather than verbal memory - which would provide support for a dissociation of process and modular decline.

Contrary to the hypothesis, it was found that there was an effect of age on verbal memory (span). However, there was only a significant difference between the young and older adults. These results suggest that verbal memory in the form of span decay only starts after the age of about 65. However, the findings of the current study do not support the literature [13] that suggests tasks which require the maintenance of information in short-term memory are more likely to remain intact. As we found decline in both verbal memory and in emotion recognition, this might suggest that the older adults encoded emotions phonemically that were later unable to be retrieved.

Despite finding evidence of decline for span, older adults were not found to decline in target accuracy on the memory for faces task. On the basis of this finding, this might suggest that non-verbal memory is independent of emotion recognition. This finding does clearly not support the research of [9] and [10] who found evidence of an age related decrement in non-verbal memory. Whilst there was no apparent decline in non-verbal memory in the form of the memory for faces task in the presence of emotion decline this finding does not entirely rule out the possibility that other types of visual processing may not be breaking down as a result of cognitive decline in aging and this may be expressed in the form of decline in emotion recognition. In addition, there was an effect of latency on the memory for faces task with older adults taking longer to recognize a target face than the younger adults. As accuracy on the memory for faces task remained intact in the older adults and there was a decline in latency, this might suggest dissociation between accuracy and latency for nonverbal material.

The results provide some evidence for an age related decline in emotion recognition. In particular, we identified that older adults had significant decline for anger, sadness and surprise. The finding of a decline in span may indicate a

relationship between short term verbal memory performance and emotion recognition. For example, it may be that older adults have encoded phonemic representations of the emotional state displayed and then over the course of the study have forgotten them (as evidenced by decline in span). This was somewhat contrary to our expected relationship. There is some evidence that non-verbal memory performance may be independent of emotion recognition. As span and emotion recognition both declined and non-verbal memory was found to remain intact this provides evidence for dissociation of process. The dissociation provides some support for a modular view of cognitive decline.

The finding that non-verbal memory in the form of memory for faces did not decline provides some evidence for preservation of visual processing in an aging population. However, *this* finding does not entirely rule out the possibility that other types of visual processing may not be breaking down as a result of cognitive decline in aging and that this may be expressed in the form of decline in emotion recognition. Future research will assess whether rather than memory for the whole face breaking down, that decline in emotion recognition may be reflected in the processing of specific features. This study provides valuable insight into the ageing process and suggests decline occurs asynchronously: that is, decline is modular not general. These results have implications for early detection of cognitive disorder, for differential diagnosis and eventually also for treatment.

Note- this paper is an update of a conference paper presented by the authors [15].

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