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Facial Recognition and Visual Processing as We Age: Using the Thatcher Illusion with Famous and Non-Famous Faces

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Abstract

This paper reports a study examining preferred visual processes in recognition of facial features in older vs younger age groups, using Thatcherised images of famous and non-famous people in the one study. The aims were to determine whether *decline in visual system processing occurs increasingly* as we grow older, and whether there is less decline in recognition of famous (or familiar) faces. Three groups (younger, middle-old and older) made up the sample of 73 people (aged 19-82 years). Visual decline in face recognition across the age groups was assessed based on the Thatcher illusion—using four famous and four non-famous faces either with normal features or with distorted features. The faces were presented one at a time on computer screen, and participants were asked to judge whether the face was distorted (eyes and/or mouth not aligned in relation to the face); in addition, time taken to decision (latency) was also measured. Decline was found in visual processing such that older individuals gave limited attention to facial details (processing faces holistically, with detail errors) and they took longer to decide. Whether the faces were famous or not did not have significant effects on the decisions and there was no interaction with age, though famous faces were given longer attention. Our visual system processes decline as we age in that we give less attention to details and more to holistic processing and so make more errors in recognition. Implications for treatment or amelioration of the effects are discussed.

Keywords: aging, visual processing, Thatcher illusion, face recognition

1. Introduction

1.1 Introduction—Facial Recognition and Decline with Age

The current paper reports the results of a study on how facial recognition, visual processing of features, and age are related to each other, across both familiar and non-familiar faces.

There is evidence that as we age our ability to recognise faces declines and this may be related to a decline in the ability also to identify facial *features*. How or why the decline occurs is not fully understood. However, there is indication (e.g., Andersen & Ni, 2008) that *visual processing* declines with age; this decline can occur at the same time as a decline in the ability to recognise emotions in faces and may be a contributor to errors we make in assessing emotions (cf., Alexander, Bahr, & Hicks, 2014; Calder et al., 2003; Iidaka et al., 2002; Issacowitz et al., 2007; Wright et al., 2006). In terms of visual processing of facial features there have been several important studies and these will be outlined; however, there have been few studies on visual processing in relation to famous and non-famous faces compared, or in relation to age. We examined these aspects.

1.2 Assessment of Visual Processing: The Thatcher Studies

To assess visual processing, earlier studies developed a novel task based on the *Thatcher illusion* (Thompson, 1980: see Method where a description of the multiple faces used and of the feature details in the current study is given). These earlier studies have been numerous and the relevance to people relationships highlighted (e.g., Donnelly et al., 2011; Mestry et al., 2011, 2012; Utz & Carbon, 2016). However, a study of the relationships among visual processing features, age and familiarity in the one project, could, we hoped, add new information and understanding of how the decline occurs and could lead to new procedures that help reduce the decline and its effects.

In the original "Thatcher" studies, when Margaret Thatcher's face is shown in an upright position the face looks (and is) normal. When selected features (that is, the eyes and mouth) are inverted or "Thatcherised" in relation to the face, the face looks grotesque due to the inversion of the features (cf., Donnelly et al., 2012; Valentine, 1988). However, if the face is inverted and the features are also inverted or "Thatcherised" (with eyes and mouth correctly oriented in relation to the viewer), the face is commonly seen as normal (that is, is seen -wrongly- as being the face of the individual as though there were no featural distortion). Conversely, if a normal face is inverted and the integral features of the eyes and mouth are also inverted in reference to the viewer, then the overall face does not appear normal or "coherent" again, wrongly in terms of how accurate our perceptions are of the faces (e.g., Carbon & Leder, 2005) (See Figure 1 for example). These studies did not generally examine the impacts of age or familiarity/fame; the current study addresses these aspects in an expanded replication of the previous studies.

We therefore in this current paper examined the hypothesis that in regard to visual processing difficulties, older adults when compared with younger adults may have problems in processing faces either as a whole, or in relation to processing the details (features) of the face (e.g., eyes and mouth). Decline in facial recognition is related to inability to process or integrate features (Carbon & Leder, 2005). We tested this hypothesis further in this current reported study but included a variety of famous and non-famous (unfamiliar) faces in the one study, and we also included younger, middle-old and older age groups in our study so that the effects of ageing could be indicated. Though cognitive decline studies have examined general decline as we age (cf., Agrigoroaei & Lachman, 2011; Stern, 2009) few have examined decline of visual processing aspects over the age range. Exceptions include those of Anderson and Ni (2008) whose study suggested that visual processing declined with age, and Calder et al. (2003) who examined facial expressions across the life-span also indicating overall declines. We believed that further exploration to confirm or otherwise previous findings (using assessment of visual declines across three age groups and using both familiar and less familiar faces) would add to our knowledge concerning what is happening in our visual processing as we age. How did we assess visual processing declines?

1.3 Assessment: The Thatcher Illusion-Our Study's Approach

The original Thatcher illusion (Thompson, 1980) used four pictures of the previous British prime minister (Margaret Thatcher): presented as normal upright; normal but upside down; upright but with eyes or mouth inverted in relation to the face; and upside down but with eyes or mouth inverted in relation to the face. When the faces are presented with distortion (that is the inversion of the eyes or mouth in relation to the face) the faces are referred to as being "Thatcherised".

We developed a visual computerised task involving facial images of famous and non-famous people, with the study design based on the work of earlier researchers examining how we process facial images. These earlier researchers, beginning with Thompson (1980), used normal and "Thatcherised" images (faces with distorted elements) mostly images of celebrity faces (e.g., Julia Roberts's face), but none had combined both in the one study to our knowledge (see also Utz & Carbon, 2016). The faces are usually presented inverted or upright in conjunction with feature distortions (e.g., Bartlett & Searcy, 1993; Carbon & Leder, 2005; Donnelly, Cornes, & Menneer, 2012; Donnelly et al., 2011; Milivojevic, Clapp, Johnson, & Croballis, 2003; Rakover, 1999; Tanaka, Kaiser, Hagen, & Pearce, 2014; Valentine, 1988; Xu & Tanaka, 2013).

Our approach was similar to and different from this earlier research. It was similar in that we used celebrities but *different* in that we also used non-celebrity faces in the same study; *similar* in that we set up all faces with and without distorted images (that is, for distortion effects, with eyes or eyes and mouth upside down in relation to the normal face); and *new* in that we examined the effects across three age groups and in that each of these aspects were examined in the one study. See Figure 1 for an example of a normal face, a distorted face, and an upside-down distorted face and see Method for detailed explanation of the presentations. Next, we discuss visual processing and why it is important.

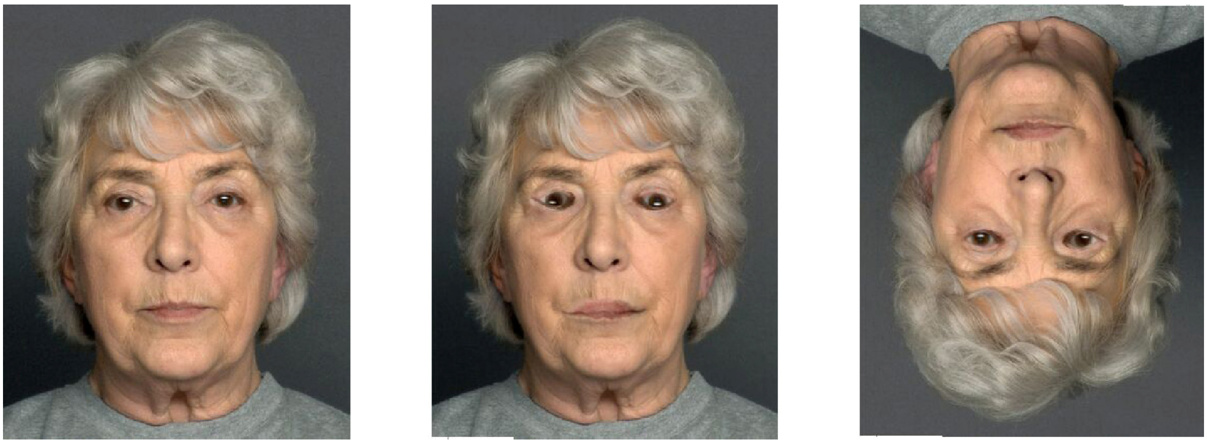

Figure 1. Example of normal and distorted faces (including upside down distorted face)

1.4 What Is Visual Processing and Why Are We Studying It?

Visual processing may be a key component in face processing. Several studies have examined whether verbal processing (language decline) is associated directly with facial emotion recognition but with mixed results, some supporting decline in verbal processing as a key ingredient in errors in face recognition (cf., Murre, Janssen, Rouw, & Meeter, 2013), others not (e.g., Alexander et al., 2014). Decline of the visual processing system could be an alternative or contributing reason for decline in facial and emotion recognition, as decline in visual processing is likely to impact on the recognition of faces. Visual processing is either top-down (holistic) processing, or bottom-up (or detail, featural) processing. In the latter, people process facial features feature by feature, in a step by step fashion leading to integration (recognition). We decided to examine whether decline in visual processing occurred with increasing age.

1.4.1 Holistic vs Featural Processing

Two types of processing appear, therefore, to be involved in facial recognition: *holistic* and *featural* processing. *Holistic processing* is commonly defined as occurring when features are processed simultaneously as a whole (gestalt). *Featural processing* is defined as the processing of single features with subsequent integration or decision-recognition of the face (e.g., Carbon & Leder, 2005).

Featural and holistic processing can be dissociated (separated) as when the Thatcher illusion is used enabling both holistic and featural processing abilities to be assessed. The use of the Thatcher illusion in examining visual processing has been extensive though somewhat different findings have been reported. For example, Lewis (2001) found Thatcherised faces were detected faster than normal faces when presented upright and that processing time was comparable for normal and Thatcherised faces when the faces were inverted. Carbon and Leder (2005), however, found that faces presented upright were recognised more quickly than were inverted faces. The findings from the two studies were, therefore, somewhat different. We replicated in part these earlier studies.

1.4.2 Famous and Non-Famous Faces

Is there a difference in perception? Earlier studies as part of their experiments tended to use only famous faces or only non-famous faces with some agreement in results but no direct comparisons being possible—that is, as to whether faces of celebrities or famous persons (such as Margaret Thatcher) would be more readily perceived than the faces of non-famous people: these and other studies had not examined these differences (Utz & Carbon, 2016). We were interested in whether older adults were more likely to process faces as a whole hence making errors in reading or recognizing the features; however whether the more familiar faces were recognised accurately more often than the less familiar faces was also of interest.

1.4.3 Age and Visual Processing, and Mild Cognitive Decline

There have been numerous studies on mild and more severe cognitive decline as we age, because of the importance in dealing with non-normal decline such as in Alzheimers' disease and generally aiming to identify what was occurring and to assist in alleviation of normal or mild cognitive decline or impairment (e.g., Agrigoroaei & Lachman, 2011; Albert et al., 2011; Hartshorne & Germine, 2015; Luchetti et al., 2014; Palop &

Mucke, 2010; Salthouse, 2012). Some studies suggested no or limited decline (e.g., Ramscar et al., 2014) at least for some people and not others due to individual differences (cf., Petersen, Caracciolo, Brayne, Gauthier, Jelic, & Fratiglioni, 2014; Ramscar, Hendrix, Shaoul, Milin, & Baayen, 2014). However, no studies had differentiated across age groups in relation to visual processing and facial recognition using celebrity and non-celebrity faces in the one study. We examined the effects of age on visual processing and face recognition in our study.

1.5 Summary

We set up a study that replicated earlier research into facial recognition but also extended the work by examining the effect across age, and the effect of familiarity or non-familiarity of the faces, on recognition accuracy and time taken to make decisions.

2. Method

2.1 Participants

A sample of 77 participants from South-Eastern Queensland participated in the study. A purposive sampling technique was used to give a balance of individuals across the three age ranges of interest. The participants who comprised the young old sample were first year psychology university students who received course credit for participation in the research. The other participants (middle-old and older groups) were recruited from the local community. Screening of the data resulted in the final sample of 73 comprising of 52 females (71.2%) and 21 males (28.8%). The age of the entire sample ranged from 19 to 82 years (M = 51.44, SD = 19.70). For highest education obtained, 50 (68.5%) participants nominated high school, 14 (19.2%) university, 6 (8.2%) nominated T.A.F.E/college and 3 nominated primary school (4.1%). From the participants, 36 (49.7%) were currently taking medication for illnesses, e.g., high blood pressure, high cholesterol, diabetes, vascular problems. The other 37 participants (50.7%) were not currently taking medication.

2.2 Design of Our Study Using the Thatcher Illusion: Faces, Features, and Age

Our study design model involved "*faces x levels of distortion x levels of age*". We used eight facial images: four "famous people" or celebrities (Justin Timberlake, Alicia Silverstone, Jack Nicholson, & Helen Mirren) and four non-famous or non-celebrity people (these were of a young man, young woman, older man or older woman). For each face (or image) there were six levels or conditions. There were two faces each with no distortions at all—one upright normal face, the other upside down but normal face; and four faces each with distorted features in relation to the presented face. We described these six images as—two that were not distorted with face right way up and the face inverted; plus four that were distorted with presentations of each face as follows—eyes distorted, face right way up; eyes and mouth distorted face right way up; eyes distorted with face upside down; eyes and mouth distorted face upside down.

In this study we were aiming to replicate earlier findings on visual processing but extend the facial images to include both famous and non-famous faces, distortions (of eyes or eyes + mouth distorted-that is, inverted, in relation to the face), and age groups. The experimental process we used is now described.

2.2.1 Process

Instructions and materials were presented on screen on a 15 inch Toshiba Satellite 1.540 laptop. The laptop involved an Intel Core i5 2410M 2.3 GHz Processor, running Windows 7 with 4GB of ram. The screen resolution was 32 bit and set at 1366 x 768 pixels.

Just before the commencement of the testing phase the following instructions were presented to participants on the laptop screen (Alexander, 2014, p. 143):

> *"You are about to be presented with a series of images of people's faces. Some of these images will have been deliberately distorted by the researcher. Your task is to identify which are the normal faces. Half of these faces are presented the right way up and the remainder are upside down. Press the '/' key on the left if the face is distorted, press the '-' on the right if the face is intact. Your responses are timed but don't rush. Make up your mind and then press the appropriate response key. Press any key to continue."*

On each trial in the *testing phase*, participants were asked "does the following picture show an original facial picture of *(name)?*" (name of one of the prior presented faces). Participants were then shown on screen one of the eight faces, presented in either an original or Thatcherised version. The responses of the participants were recorded (by pressing the yes or the no key for their answers as to whether this face was an original or a distorted face). Participants were to answer yes only if the face was the original picture of the person, and *also* was not Thatcherised or distorted.

The participants completed 50 trials (50 faces presented in turn on screen). On each trial, the face was presented in the centre of the screen with buttons underneath labeled "Press for Distorted" and "Press for Normal". Each face (trial) was presented in turn for 30,000 ms (30 secs) before a timeout occurred and the next trial was presented. Computerised records were kept of the presented face, the decision response (recognition accuracy), and the time taken (latency) to the decision.

2.3 Visual Processing Study

We assessed whether ability to recognise facial images was affected by the distortions in facial features, by age group and/or by degree of fame or familiarity of the face presented. For the analysis on age, a central part of our study, we divided our sample into three age groupings—Young Old (18-49), Middle Old (50-64), and Older Adults (65+).

2.3.1 Facial Image Recognition—Holistic and Featural Processing

We hypothesized first, that in general the processing of the faces would reflect the majority of findings from earlier studies (that is, that there are problems with featural processing, especially when the features -eyes and mouth- are inverted in relation to the faces); second, however, we further hypothesised that there would be age effects with increased errors among the older age groups; and third, we made no hypotheses about but were interested in whether famous faces would yield different results than found for non-famous faces.

2.3.2 Age

More specifically with respect to age effects our hypotheses were that *with increasing age* visual processing accuracy and time taken would be impaired. Our reason for incorporating three levels of age were that earlier studies on declines in mild cognitive impairment had observed that as people grew older, memory for faces also declined; however, only younger and older groups alone had usually been used. We added a middle group to see whether there was a monotonic (straight line) increase in decline, or an inconsistency—that is whether declines occurred at an earlier age level --the middle-age group-- than had previously been observed (see studies such as those of Alexander et al., 2014, 2015). There had been no earlier studies linking increasing age with increasing deterioration in the specific facial recognition processes we were studying, though several studies had suggested that some aspects requiring different abilities such as memory processes declined for selected aspects but not for others (as in emotion recognition: see for example: Agrigoroaei & Lachman, 2011; Alexander et al., 2015; Lim, Lee, Barton, & Moon, 2011; Luchetti, Terracciano, Stephan, & Sutin, 2014).

2.3.3 Fame

We also wished to explore the effects of *famous vs non-famous faces* but had no specific hypotheses as to whether there would be a difference. Though some researchers have demonstrated that *unfamiliarity* matters (Russo, Ward, Geurts, & Scheres, 1999), it could be that there are affects from familiarity also. It is possible that familiarity might lead to quicker and presumably more accurate judgement based on the familiarity (though rushing to a decision was also possible, leading to error). This issue was examined by using the Thatcher illusion with famous (familiar) and non-famous faces. However, the research hypotheses were kept open.

3. Results

Initial data screening was conducted using IBM SPSS Statistics 21 and more conservative significance levels set where needed. MANOVA is robust to violations of normality with larger sample sizes. Box's M was violated for some conditions and consequently a more conservative *Pillai's criterion* was used to evaluate multivariate significance. All other assumptions required for MANOVA were met. The α level was set at .05 *apriori*. The MANOVAs were conducted in turn, one with facial recognition *accuracy* as the dependent variable and the other with *latency* (time taken) as the dependent variable.

3.1 Facial Recognition (Accuracy) in Visual Processing—In Relation to Age, Face Distortions and Fame

A mixed factorial MANOVA was conducted to assess the effect of the independent variables Age (Young Old, Middle Old, and Older Adults), Fame (Famous vs. Non Famous) and Distortion (6 levels) on the dependent variable Facial Recognition (Accuracy). α was set at .05 apriori, with a Geisser-Greenhouse correction used as it is robust, there were more than 10 participants per cell (Tabachnick & Fidell, 2007), and the assumption of sphericity had been violated for Distortion and for the Fame x Distortion interaction (the correction helps control for the violation). We examined the MANOVA output step by step, first identifying age x distortion x fame effects (3-way), then examining the 2-way effects, the one-way ANOVA effects, and finally the remaining age effects, as indicated by the analyses.

The results showed there was no significant three-way *Age* x *Fame* x *Distortion* interactions. We therefore examined the two-way interactions.

The examination of the two-way interactions showed no significant *Age* x *Fame*, or *Fame* x *Distortion* interactions but a significant interaction for *Age* x *Distortion levels* [$F_{pillai's}(5, 259) = 2.84$, $p = .003$, partial $\eta^2 = .18$, power = .97].

To assess the influence of Age within the six levels of Distortion, a series of one-way ANOVAs was then applied. As Age had not varied with Fame, the effect of Age was examined collapsed across fame; α was set at .05 apriori.

3.1.1 Result-Age x Distortions

There were significant effects of *Age* on *Eyes and Mouth Distorted Right Side Up Faces* [$F(2, 70) = 15.31$, $p < .001$] and on *Not Distorted Upside Down Faces* [$F(2, 70) = 12.50$, $p < .001$]. However, there were no significant effects of *Age* on *Not Distorted Right Side Up Faces*; *Eyes Distorted Right Side Up Faces*; *Eyes Distorted Upside Down Faces*; or *Eyes and Mouth Distorted Upside Down Faces*. That is, the elements causing difficulties in processing as we age were when the eyes and mouth were upside down (in relation to either the upright face or to the inverted face). This is as hypothesized and in line with previous studies. We next examined this finding further by checking how age affected the two significant age x distortion effects.

The differences across Age, were assessed by post hoc analyses using *Tukey's HSD* with $\alpha = .05$ in both instances of *Eyes and Mouth Distorted Right Side Up Faces* and *Not Distorted Upside Down Faces*. There were significant differences between younger and middle old adults (middle old adults being less accurate); between younger and older adults (older adults being less accurate); and between middle old and older adults (older adults being less accurate). The overall pattern in both instances was of monotonic decline with age with the most pronounced differences (declines) evident in the oldest group. That is, difficulties in coping with the "eyes and mouth upside down" distortion was evident most significantly in the oldest age group, then the mid-old and then the young-old groups. *As the group age increased so did the inability to cope effectively with feature processing*. The results indicated that it was these two featural distortions that were common across the three age groups, with exacerbation with increasing age.

Table 1. Accuracy of judgments of distorted faces by age group: mean and standard deviations for young old, middle old, and older adults

	Age Group		
	Young Old	Middle Old	Older Adults
Level of Distortion	*M (sd)*	*M(sd)*	*M(sd)*
Not Distorted Right Side Up	3.92 *(.18)*	3.63 *(.76)*	3.48 *(.98)*
Eyes Distorted Right Side Up	3.96 *(.14)*	3.81 *(.36)*	3.76 *(.37)*
Eyes and Mouth Distorted Right Side Up	*2.98* $_{ab}$ *(.69)*	2.29^{c} *(.91)*	1.65 *(.92)*
Not Distorted Upside Down	2.69 $_{ab}$ *(.90)*	2.02$_{c}$ *(.94)*	1.37 *(.94)*
Eyes Distorted Upside Down	3.88 *(.21)*	3.90 *(.25)*	3.70 *(.46)*
Eyes and Mouth Distorted Upside Down	3.17 *(.69)*	3.08 *(.94)*	2.71 *(.96)*

Note. a-Difference between young and older adults, b-Difference between young and middle old adults, c-Difference between middle and older adults.

3.1.2 Result-Age x fame

There was no age x fame interaction. However, there was a significant main effect of *Fame*, with distortions in the famous faces recognised *less accurately* than in the non-famous faces [$F(1, 70) = 8.57$, $p = .005$, partial $\eta^2 = .11$, power = .82]. There were no other main or interactive effects in relation to famous and non-famous faces. This finding, that famous faces (with or without distortion in features) were recognized less accurately than were non-famous faces, was assessed further in "Study 2" in regard to the *latency* (time taken to decision).

3.2 Latency (Time Taken) in Face Recognition in Visual Processing—In Relation to Age, Face Distortions and Fame

No significant *Age* x *Fame* x *Distortion* three-way interaction was found in relation to latency after a mixed factorial MANOVA was applied. α was set at .05 apriori and corrections made for sphericity for *Distortion* and for the *Fame* x *Distortion* interaction (using more conservative degrees of freedom).

The two-way interactions were then considered, yielding a significant *Fame* x *Distortion* interaction [$F(4, 277) = 2.86$, $p = .020$, partial $\eta^2 = .18$, power = .81], but no significant interactions for *Age* x *Fame* or *Age* x *Distortion.* The significant interaction (fame x distortion) was then analysed.

3.2.1 Latency in Relation to Fame x Distortion

Paired *t*-tests (see Table 2) assessed whether there was an effect of *Fame* within each of the six levels of *Distortion* (α was set at .05 *apriori*). There were significant effects for three of the six levels—of *Fame* on *Not Distorted Right Side Up* (non-famous faces having shorter latencies than famous faces) [$t(72) = 2.59$, $p = .012$, partial $\eta^2 = .08$]; of *Fame* on *Normal Upside Down (*famous faces having shorter latencies) [$t(72) = 2.36$, $p = .021$, partial $\eta^2 = .07$]; and of *Fame* on *Eyes Distorted Upside Down* (non-famous faces having shorter latencies) [$t(72) = 2.51$, $p = .014$, partial $\eta^2 = .08$].

Table 2. Latency in ms to judgments on distorted faces by fame

	Fame	
	Famous	Non Famous
Level of Distortion	*M (sd)*	*M (sd)*
Not Distorted Right Side Up	1932 *(1435)*	1567* *(964)*
Eyes Distorted Right Side Up	1540 *(783)*	1568 *(942)*
Eyes and Mouth Distorted Right Side Up	2622 *(1629)*	2280 *(1226)*
Not Distorted Upside Down	2067* *(1298)*	2537 *(1418)*
Eyes Distorted Upside Down	2102 *(1267)*	1831* *(1046)*
Eyes and Mouth Distorted Upside Down	2487 *(1628)*	2392 *(1289)*

Note. *-$p < .05$.

There were no significant effects for the remaining three of the six Distortion levels. That is, in terms of time taken to make decisions, mixed results are present regarding fame with no differences in three of the famous vs non-famous comparisons, with two where the non-famous faces were decided upon more quickly than the famous faces, and one where the famous faces were decided upon more quickly. We then examined (next) whether there would be more consistent results with respect to latency and age.

3.2.2 Latency and Age

There was a significant main effect of Age, with older adults having significantly longer latencies than young adults [$F(2, 70) = 5.29$, $p = .007$, partial $\eta^2 = .13$, power = .82]. That is, the older age groups took longer to make their decisions. Post hoc analyses using *Tukey's HSD* with $\alpha = .05$, identified a significant difference between young and older adults, with older adults having significantly longer overall latencies than younger adults, but there were no significant differences in latency between the young and middle-old or middle-old and older adults. This means the effect of age (slowing in time taken to decision) was evident in the older age group (over 65) though could be starting earlier (there was no significant difference between the middle-old and the older age groups). In summary the older adults took longer to make their decisions. However, as indicated in the face recognition accuracy study (#1 above), older adults were also less accurate than younger adults.

4. Discussion

We examined facial recognition accuracy and latency in decision making in the current study in relation to three main aspects: age, attention to visual processing (whether we give attention to details or use holistic approaches), and fame (whether well-known faces are treated differently). Our main attention was on visual processing of the images presented using a visual task that involved recognising famous and non-famous faces and whether they included simple distorted or "Thatcherised" features (such as mouth inverted on the image); we presented these images in computerised form in a sample of younger, mid-old and older participants.

Our hypothesis, that, when the features are inverted (whether in a face that is in the upright position or in a face that is itself inverted), older aged individuals would be less capable of detecting errors in the specific features, was supported. This finding is consistent with many previous studies in the general trends where age had not been considered, and in addition demonstrates that there is an age decline in ability to detect featural differences.

There was also a significant age by distortion interaction on facial recognition when distortions were present, or when the face was presented inverted but features were upright from the observer's viewpoint. Both middle-old and older adults were significantly less accurate than younger adults when faces were *upright* and eyes and mouth distorted and when faces were *upside down but otherwise undistorted*. This suggests that middle and older adults are emphasising processing of overall cues, not detecting the errors in individual features (or that the individual features were in fact undistorted—as in the upside down face with distorted features). This is consistent with making sense of features holistically, rather than processing each of the elements and integrating them.

This finding, that middle-old and older adults are more likely to process overall cues rather than taking time and processing individual features, parallels the findings of verbal gist studies of stories (which suggest that older people process the whole story rather than the specific detail in stories: for example, see Alexander, Bahr, & Hicks, 2015). Middle-old and older adults were found to be less accurate than the younger adults. *This indicates a breakdown in feature processing in the visual system with age and the development of more reliance on holistic processing*. Gestalt psychological processes are applied leading to error when the full environment is not searched (details are overlooked). It could be that as we age we decline in certain areas and use cognitive reserve processes more (of which gist and holistic processing may be part, even though there are errors associated with the emphases). Considerable attention has been given to cognitive reserve (e.g., Barulli & Stern, 2013; Stern, 2009) but further studies and linkages are still needed. Giving attention to processes which help us retain some ability to identify details may help us to interact more effectively with our environment as we age, including in personal relationships.

Older adults also had significantly longer latencies (time taken) for the task than the younger adults. The increase in latencies was not specific to any levels of distortion. This suggests that older adults were persisting at the task, or found the task difficult. A decrease in accuracy and increase in latency provides some support for generalised slowing. It is possible that this is a consequence of amyloid β build-up which may then result in disturbances of neural network activity or neuronal death (Cramer et al., 2012; Palop & Mucke, 2010). Others have suggested a variety of contributors from neurological studies also as being associated with slowing, though our cognitive reserve resources assist in handling changes (e.g., Barulli & Stern, 2013; Luchetti et al., 2014; Tanaka, Kaiser, Hagen, & Pierce, 2014).

4.1 Famous vs Non-Famous Faces: Findings

We had used a task that examined whether well-known ("famous") faces and images were more easily handled as we grow older. This did not seem to be the case though unclear results overall were obtained. Normal or non-famous faces were recognized similarly by all age groups in terms of features presented. They were dealt with more quickly, by the younger rather than by the older groups though there was inconsistency. It could be that our respondents were spending more time (with less accuracy) on the famous faces, exploring in more detail these faces that were more familiar, but what attributes are involved will need further study regarding the effects of fame/familiarity on recognition accuracy.

4.2 Conclusion

The current study has confirmed old information on visual processing (that limited or weaker detailed or featural processing is a source of error in the cases of eyes and mouth distorted in relation to the upright or inverted face). It has also confirmed and added new information on the ageing process in recognising faces (that *as we age* we use holistic processing more than detailed featural processing), and that the decline begins earlier than previously thought, as early as in middle adulthood. Further, we seem to spend more time examining well known or familiar faces than unknown faces, indicating we are processing something in the faces- though as this study and others have shown, we seem to do this with growing inaccuracy as we age.

These results have potential implications for earlier-age assessment and earlier and more effective pharmacological and-or behavioural and psychological interventions that can help slow the declines perceived in visual processing in face recognition. It may be that the reason why older individuals appear to have difficulty recognising some *emotions* in the faces of others is related to this decline in the visual processing of faces and their features. The links between the established visual processing declines in face recognition and the declines as we age in recognition *of some of the emotions* portrayed in faces (Alexander et al., 2014) need further study; one of our studies linking these elements is to be reported in due course. Regardless, further research on psychological and neurological bases associated with what we see or do not see as we age continues apace (cf., Barulli & Stern, 2013; Hartshorne & Germine, 2015; Konar, Bennet, & Sekular, 2013; Salthouse, 2012; Utz & Carbon, 2016). Increasing understanding of the processes should help bring about more effective treatment, and exercise and educational programs that help reduce the effects of errors in our face recognition processes and hopefully add to the quality of our lives as we age.

References

Agrigoroaei, S., & Lachman, M. E. (2011). Cognitive functioning in mid-life and old age: Combined effects of psychosocial and behavioural factors. *The Journals of Gerontology B: Psychological Sciences and Social Sciences*, *668*(Suppl 1), 130-140. https://doi.org/10.1093/geronb/gbr017

Albert, M. S., DeKosky, S. T., Dickson, D., Dubois, D., Feldman, H. H., Fox, N. C., … Snyder, P. J. (2011). The diagnosis of mild cognitive impairment due to Alzheimer's disease: Recommendations from the national Institute on Aging-Alzheimer's Association workshops on diagnostic guidelines for Alzheimer's disease. *Alzheimer's and Dementia*, *7*(3), 270-279. https://doi.org/10.1016/j.jalz.2011.03.008

Alexander, V. E. (2014). *Age-related decline: Detecting mild cognitive impairment* (Unpublished Doctoral thesis). Bond University, Gold Coast, Australia.

Alexander, V., Bahr, M., & Hicks, R. (2014). Emotion recognition and verbal and non-verbal memory changes among older adults: Is decline generalised or modular? *GSTF Journal of Psychology*, *1*(2), 14-21. https://doi.org/10.5176/2345-7872_1.2.14

Alexander, V., Bahr, M., & Hicks, R. E. (2015). Ability to Recall Specific Detail and General Detail (Gist) in Young Old, Middle Old, and Older Adults. *Psychology*, *6*(16), 2071-2080. https://doi.org/10.4236/psych.2015.616202

Andersen, G. J., & Ni, R. (2008). Aging and visual processing: Declines in spatial not temporal integration. *Vision Research*, *48*, 109-118. https://doi.org/10.1016/j.visres.2007.10.026

Bartlett, J. C., & Searcy, J. (1993). Inversion and configuration of faces. *Cognitive Psychology*, *25*, 281-316. https://doi.org/10.1006/cogp.1993.1007

Barulli, D., & Stern, Y. (2013). Efficiency, capacity, compensation, maintenance, plasticity: Emerging concepts in cognitive reserve. *Trends in Cognitive Sciences*, *17*(10), 502-509. https://doi.org/10.1016/j.tics.2013.08.012

Calder, A. J., Keane, J., Manly, T., Sprengelmeyer, R., Scott, S., Nimmo-Smith, I., … Young, A. W. (2003). Facial expression across the adult life span. *Neuropsychologia*, *41*, 192-195. https://doi.org/10.1016/S0028-3932(02)00149-5

Carbon, C. C., & Leder, H. (2005). When feature information comes first! Early processing of inverted faces. *Perception*, *34*, 1117-1134. https://doi.org/10.1068/p5192

Cramer, P. E., Cirrito, J. R., Wesson, D. W., Lee, D. C. Y., Karlo, C. J., Zinn, A. E., … James, M. J. (2012). ApoE-directed therapeutics rapidly clear *B*-amyloid and reserves deficits in AD mouse models. *Science*, *335*(6075), 1503-1506.

Donnelly, N. et al. (2011). Discriminating grotesque from typical faces: Evidence from the Thatcher illusion. *PloS One*, e23340. https://doi.org/10.1371/journal.pone.0023340

Donnelly, N., Cornes, K., & Menneer, T. (2012). An examination of the processing capacity of features in the Thatcher illusion. *Attention, Perception & Psychophysics*, *74*, 1476-1487. https://doi.org/10.3758/s13414-012-0330-z

Hartshorne, J. K., & Germine, L. T. (2015). When does cognitive functioning peak? The asynchronous rise and fall of different cognitive abilities across the lifespan. *Psychological Science*, *26*(4), 433-443. https://doi.org/10.1177/0956797614567339

Iidaka, T., Okada, T., Murata, T., Omori, M., Kosaka, H., Sadato, N., … Yonekura, Y. (2002). Age-related differences in the medial temporal lobe responses to emotional faces as revealed by fMRI. *Hippocampus*, *12*, 352-362. https://doi.org/10.1002/hipo.1113

Konar, Y., Bennet, P. J., & Sekular, A. B. (2013). Effects of aging on face identification and holistic face processing. *Vision Research*, *88*, 38-46. https://doi.org/10.1016/j.visres.2013.06.003

Lewis, M. B. (2001). The lady's not for turning: Rotation of the Thatcher illusion. *Perception*, *30*, 769-774. https://doi.org/10.1068/p3174

Lim, T. S., Lee, H. Y., Barton, J. J. S., & Moon, S. Y. (2011). Deficits in face perception in the amnestic form of mild cognitive impairment. *Journal of the Neurological Sciences*, *309*(1-2), 123-127. https://doi.org/10.1016/j.jns.2011.07.001

Luchetti, M., Terracciano, A., Stephan, Y., & Sutin, A. R. (2014). Personality and cognitive decline in older adults: Data from a longitudinal sample and meta-analysis. *The Journals of Gerontology B: Psychological Sciences and Social Sciences*.

McDowell, C. L., Harrison, D. W., & Demaree, H. A. (1994). Is right hemisphere decline in the perception of emotion a function of aging? *International Journal of Neuroscience*, *79*, 1-11. https://doi.org/10.3109/00207459408986063

Mestry, N., Donnelly, N., Menneer, T., & McCarthy, R. A. (2012). Discriminating Thatcherised from typical faces in a case of prosopagnosia. *Neuropsychologia*, *50*(14), 3410-3418. https://doi.org/10.1016/j.neuropsychologia.2012.09.034

Mestry, N., Menneer, T., Wenger, M. A., & Donnelly, N. (2012). Identifying sources of configurality in three face processing tasks. *Frontiers in Psychology*, *3*(456). https://doi.org/10.3389/fpsyg.2012.00456

Milivojevic, B., Clapp, W. C., Johnson, B. W., & Croballis, M. C. (2003). Turn that frown upside down: ERP effects of Thatcherisation on misoriented faces. *Psychophysiology*, *40*, 967-978. https://doi.org/10.1111/1469-8986.00115

Murre, J. M., Jansen, S. M., Rouw, R., & Meeter, M. (2013). The rise and fall of immediate and delayed memory for verbal and visuospatial information from late childhood to late adulthood. *Acta Psychologia*, *142*(1), 96-107. https://doi.org/10.1016/j.actpsy.2012.10.005

Palop, J. J., & Mucke, L. (2010). Amyloid-β-induced neuronal dysfunction in Alzheimer's disease: From synapses toward neural networks. *Nature Neuroscience*, *13*(7), 812-818. https://doi.org/10.1038/nn.2583

Petersen, R. C., Caracciolo, B., Brayne, C., Gauthier, S., Jelic, V., & Fratiglioni, L. (2014). Mild cognitive impairment: A concept in evolution. *Journal of Internal Medicine*, *275*(3), 214-228. https://doi.org/10.1111/joim.12190

Rakover, S. S. (1999). Thompson's Margaret Thatcher illusion: When inversion fails. *Perception*, *28*, 1227-1230. https://doi.org/10.1068/p2774

Ramscar, M., Hendrix, P., Shaoul, C., Milin, P., & Baayen, H. (2014). The myth of cognitive decline: Non-linear dynamics of life-long learning. *Topics in Cognitive Science*, *6*(1), 5-41. https://doi.org/10.1111/tops.12078

Russo, R., Ward, G., Geurts, H., & Scheres, A. (1999). When unfamiliarty matters: Changing environmental context between study and test affects recognition memory for unfamiliar stimuli. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *25*(2), 488. https://doi.org/10.1037/0278-7393.25.2.488

Salthouse, T. A. (2012). Consequences of age-related cognitive declines. *Annual Review of Psychology*, *63*(1), 201-226. https://doi.org/10.1146/annurev-psych-120710-100328

Stern, Y. (2009). Cognitive reserve. *Neuropsychologia*, *47*, 2015-2028. https://doi.org/10.1016/j.neuropsychologia.2009.03.004

Tanaka, J. W., Kaiser, M. D., Hagen, S., & Pierce, L. J. (2014). Losing face: Impaired discrimination of featural and configural information in the mouth region of an inverted face. *Attention, Perception & Psychophysics*, *76*, 1000-1014. https://doi.org/10.3758/s13414-014-0628-0

Thompson, P. (1980). Margaret Thatcher: A new illusion. *Perception*, *9*, 483-484. https://doi.org/10.1068/p090483

Treisman, A. (1986). Features and objects in visual processing. *Journal of Scientific American*, *255*(5), 114-125. https://doi.org/10.1038/scientificamerican1186-114B

Utz, S., & Carbon, C. C. (2016). Is the Thatcher Illusion Modulated by Face Familiarity? Evidence from an Eye Tracking Study. *PLoS ONE*, *11*(10), e0163933. https://doi.org/10.1371/journal.pone.0163933

Valentine, T. (1988). Upside-down faces: A review of the effect of inversion upon face recognition. *British Journal of Psychology*, *79*, 471-491. https://doi.org/10.1111/j.2044-8295.1988.tb02747.x

Wright, C. I., Wedig, M. M., Williams, D., Rauch, S. L., & Albert, M. S. (2006). Novel fearful faces activate the amygdala in healthy young and elderly adults. *Neurobiology of Aging*, *27*, 361-374. https://doi.org/10.1016/j.neurobiolaging.2005.01.014

Xu, B., & Tanaka, J. W. (2013). Does face inversion qualitatively change face processing: An eye movement study using a face change detection task. *Journal of Vision*, *13*(2), 1-16. https://doi.org/10.1167/13.2.22

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