Age deficits in facial affect recognition: The influence of dynamic cues

Sarah A. Grainger[1], Julie D. Henry[1], Louise H. Phillips[2], Eric J. Vanman[1], & Roy Allen[2]

[1]School of Psychology, University of Queensland, Australia.
[2]School of Psychology, University of Aberdeen, Scotland.

Correspondence should be addressed to either Sarah A. Grainger, School of Psychology University of Queensland, St Lucia QLD 4072, Australia, Tel: +61 4 23734605, Email: sarah.grainger@uq.edu.au or Julie D. Henry, School of Psychology University of Queensland, St Lucia QLD 4072, Australia, Tel: +61 4 2376737, Email: julie.henry@uq.edu.au.

RUNNING HEADER: Dynamic and static facial cues to emotion.

Abstract

Objectives. Older adults have difficulties identifying most facial expressions of emotion. However, most aging studies have presented static photographs of intense expressions, whereas in everyday experience people see emotions that develop and change. The present study was designed to assess whether age-related difficulties with emotion recognition are reduced when more ecologically valid (i.e., dynamic) stimuli are used.

Method. We examined the effect of stimuli format (i.e., static vs dynamic) on facial affect recognition in two separate studies that included independent samples and distinct stimuli sets. In addition to younger and older participants, a middle-aged group was included in Study 1, and eye gaze patterns were assessed in Study 2.

Results. Across both studies, older adults performed worse than younger adults on measures of facial affect recognition. In Study 1, older and middle aged adults benefited from dynamic stimuli, but only when the emotional displays were subtle. Younger adults gazed more at the eye region of the face relative to older adults (Study 2), but dynamic presentation increased attention towards the eye region for younger adults only.

Discussion. Together, these studies provide important and novel insights into the specific circumstances in which older adults may be expected to experience difficulties in perceiving facial emotions.

Keywords: Emotion recognition, Ecological validity, Attentional engagement.

Dynamic and static facial cues to emotion.

Social perception refers broadly to the ability to understand and react appropriately to the social signals sent out by other people, and is a critical predictor of wellbeing, mental health and social competency. Regardless of whether the target is a close friend or a stranger, being able to decode emotional expressions is an important skill that we rely on to navigate through our social world. Thus, while people are often required to pick up on the emotional states of close friends and family members, decoding the emotional expressions of unfamiliar people is also often required in our everyday lives. Correctly recognizing that a stranger is displaying an angry expression, for example, is important in order to guide appropriate avoidance behavior.

There is now a considerable literature showing that normal adult aging disrupts many aspects of social perceptual processing, including recognition of emotional facial expressions (for a review, see Ruffman, Henry, Livingstone & Phillips, 2008). However, how we respond to the cues associated with artificial stimuli in the lab may differ markedly from how we respond to people in everyday life. It is therefore unsurprising that the importance of using tasks that more closely represent the way that we interpret and use cues to socio-emotional states in everyday life has recently been emphasised (Isaacowitz & Stanley, 2011; Phillips & Slessor, 2011; Phillips, Slessor, Bailey & Henry, 2014, although see Ruffman, 2011).

Indeed, whereas in psychology, neural and cognitive models of aging emphasise the losses associated with age that might disrupt social perception, motivational theories such as socio-emotional selectivity theory (Carstensen, Isaacowitz & Charles, 1999) have highlighted possible gains or qualitative changes instead. In their review of this literature, Charles and Carstensen (2010) concluded that, as people grow older, they prioritise close social relationships, focus more on achieving emotional wellbeing, and attend more to positive emotional information. These changing motivational goals have implications for attention to, and processing of, social cues, and may include older adults becoming more selective in where they invest their emotional resources. Indeed, older adults have been found to report fewer experiences of negative affect relative to their younger counterparts (Montepare & Dobish, 2013; but see Birditt, 2014), and have also been shown to display increased motivation to engage in prosocial behaviours in the context of relevant socio-emotional cues (Beadle, Sheehan, Dahlben & Gutchess, 2015; Sze, Gyurak, Goodkind & Levenson, 2012). Older adults have also had more extensive life experience analysing emotional cues in interpersonal communication, and this also predicts that older adults might show gains in some aspects of social perception. Age-related differences on traditional tests of emotion perception might therefore be attenuated – or the direction of age effects possibly even reversed – by the provision of stimuli that more closely approximate the cues older adults encounter in their everyday life.

An important question then, is how older adults' decode and respond to *dynamic* facial expressions. To date, nearly all studies that have investigated age differences in facial emotion recognition have used static images, but this does not reflect what people experience in their day-to-day social interactions, where dynamic facial expressions are the norm. Studies with younger adults have generally provided evidence for improved emotion recognition in response to dynamic stimuli compared to static photographs (Ambadar, Schooler & Cohn, 2005; Bould & Morris, 2008; Bould, Morris, & Wink, 2008, but see Fiorentini & Viviani, 2011). Dynamic stimuli provide information about the relative temporal movements of different facial muscles, which may provide additional clues as to which emotion is present, and this information is typically not available with static images.

Surprisingly, no aging study to date has directly compared the effect of stimulus format (i.e., dynamic vs static) on facial affect recognition ability. This is despite the fact that it has been specifically argued that the use of static displays is a methodological limitation in the literature to date (Isaacowitz & Stanley, 2011). A test of the effect of stimuli format is therefore now critical to both inform interpretation of prior literature, and guide future research designs in this area. While there are a small number of aging studies that have incorporated dynamic cues to look at emotion recognition more broadly (i.e., interactions between people), they have failed to include static measures that are equated methodologically (e.g., Hühnel et al., 2014; Lambrecht et al., 2012; Moraitou et al., 2013; Sze et al., 2012; Krendl & Ambady, 2010). As a consequence it is not possible to draw conclusions about the specific influence of stimuli format because other factors that may also influence emotion recognition ability have been differentially introduced (for instance, spoken dialogue).

While controlled comparisons between dynamic and static displays of facial affect with *younger* adults have revealed that dynamic stimuli enhances their capacity to decode emotional expressions, it remains unclear whether older adults will show similar benefits, and in particular, whether the provision of dynamic cues will attenuate the age-related difficulties seen in relation to static cues. On the one hand, motivational theories suggest that because of the enhanced ecological validity associated with dynamic cues, age effects should be reduced. However, there is also evidence that older adults have difficulty in identifying emotions from dynamic bodily expressions (e.g., Ruffman et al., 2009), and in recognising when one emotion morphs into another (Sullivan & Ruffman, 2004), implying that dynamic cues may not be particularly beneficial in late adulthood.

Here, we report two studies that directly address this issue. In both, we compare younger and older adults on measures of facial affect recognition that differ with respect to format of presentation (i.e., static versus dynamic cues), but which are matched on all other parameters. An obvious important strength of conducting two independent experiments is that it allows us to directly assess whether any identified effects are robust, and generalise across different samples and measures. However, the two experiments were also designed to address additional specific questions to gain a more nuanced understanding of age effects decoding different types of facial cues. Thus, although both studies assessed explicit emotion recognition of static and dynamic facial cues, Study 1 also included a middle-aged cohort to clarify lifespan ageing effects, whereas Study 2 included eye-tracking to quantify younger and older adults' implicit attentional responses.

Specifically, it was important to include a middle-aged cohort in Study 1 because, to date, most research into possible age-related declines in facial emotion recognition has compared performance by a younger group, typically university students aged 18 – 30, with that of an older adult group of retirement age, typically 65 and over. Relatively few have looked at performance in the intermediate, middle-aged group (Williams et al., 2006; Mill et al., 2009; Isaacowitz et al., 2007). Mill et al. (2009) presented evidence of relatively early (aged 40+) declines in identifying some emotions from facial expressions, but no such middle-aged change in identifying other emotions (see also Isaacowitz et al., 2007). However, in each of these studies participants were required to make judgements about emotional states from static facial cues. Study 1 was therefore designed to clarify lifespan ageing effects decoding emotions, not only in relation to static stimuli, but also in response to cues that are closer to the way in which emotions are encountered in everyday life.

Study 1 also included a manipulation of facial expression intensity. Any benefit for perceiving emotions from dynamic compared to static faces should be stronger for low intensity expressions, where the emotion is portrayed more subtly, and the additional cues from movement may be more informative (Bould, Morris & Wink, 2008). The potential benefit of dynamic information at low emotion intensity levels may therefore be more pronounced for older relative to younger adults.

The unique novel strength of Study 2 is that it not only included an assessment of explicit understanding of static versus dynamic facial expression cues (i.e., emotion recognition accuracy), but also a measure of implicit responding to these cues (i.e., allocation of attention to different parts of the face). This is important because prior eye-tracking studies of emotion perception indicate that there are age-related changes in the allocation of attention to different parts of the face, with older adults tending to focus more on the mouth region and less on the eyes relative to younger adults (Murphy & Isaacowitz, 2010; Sullivan, Ruffman & Hutton, 2007; Wong, Cronin-Golomb & Neargander, 2005). Given that the eyes are important in identifying those emotions which older people struggle most to identify (i.e., anger, sadness, fear), this suggests a possible link between attentional biases away from the eyes and emotion recognition abilities in old age. However, in none of these prior studies were dynamic stimuli used. Given the emphasis that has been placed on the potential role of age-related attentional biases in understanding age differences in emotion recognition, it is important to clarify whether the provision of dynamic facial cues which are more true-to-life elicit a similar pattern of attentional responding as static stimuli.

Taken together, these two studies sought to clarify whether age effects in emotion perception are differentially affected by the provision of dynamic as opposed to static emotion cues. As noted previously, although neuropsychological models of aging predict age deficits in accuracy, and age-related attentional biases in response to both types of cues, models of aging that emphasise motivational change (such as socio-emotional selectivity theory) instead predict that age differences should be attenuated in response to dynamic stimuli because they are more true-to-life, capture attention more, and are therefore more likely to be prioritised by older adults.

Study 1

Method

Participants. One hundred and twenty-three participants took part in this experiment. Forty-two were young (15 males), aged 19 – 38 years, 42 were middle-aged (9 males), aged

40 – 64 years, and 39 were older adults (17 males), aged 66 – 86 years. Participants were recruited through the University of Aberdeen student population, an established participation panel or through local community groups, and were paid a small gratuity for their participation. All participants were required to have English as a first language, as well as 20/20 actual or corrected vision. Exclusion criteria for both groups included no history or presence of a psychiatric or neurological illness. All older adults were screened for signs of dementia using the Mini-Mental State Examination (MMSE; Folstein, Folstein & McHugh, 1975) and all scored above the recommended cut-off of 26.

Background characteristics for the three groups are reported in Table 1. It can be seen that the three groups differed significantly in years of formal education, F (2, 119) = 10.67, $p < .001$, $\eta_p^2 = .15$. This reflected the fact that older participants had received less education relative to both younger and middle-aged adults (*p*s = .001 and < .001, respectively). The latter two groups did not differ ($p > .05$). Also, performance on a measure of crystallized intelligence (the Mill Hill Vocabulary test) improved with age. Thus, there was a significant overall effect of group, F (2, 119) = 16.20, $p < .001$, $\eta_p^2 = .21$, which reflected the fact that younger adults performed significantly more poorly than older and middle-aged adults (both *p*s < .001), with these latter two groups not differing ($p = 1.00$). There were no age effects in terms of negative affect as indexed by total scores on the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1982), F (2, 119) = 0.39, $p = .676$, $\eta_p^2 < .01$, or self-rated health on a scale from 1 to 9, F (2, 120) = 0.32, $p = .726$, $\eta_p^2 < .01$, with both groups reporting their health to be above average.

Materials. Stimuli used in this study were based on photographs of two male and two female faces taken from the Facial Emotion Expression Stimuli and Test (Young, Perrett, Calder, Sprengelmeyer & Ekman, 2002, which are based on the original Ekman & Friesen faces). These stimuli were used because they are the most widely used and best validated in emotion research, and have been shown in many separate studies to show age-related differences in emotion perception. The Ekman & Friesen photographs portray six different emotions: anger, disgust, fear, happiness, sadness and surprise, these are the 100% emotion stimuli. In the Young et al. (2002) stimuli the emotional faces of each person were morphed with neutral expressions to produce separate images expressing 25%, 50% and 75% intensity emotional expressions. In the current study, the static stimuli involved presentation of the 50%, 75% and 100% emotional intensity photographs on a screen with the six possible emotion labels presented below. The dynamic stimuli were created using a morphed sequence from the neutral facial expression, through increasing levels of emotional intensity to produce the target emotion. The dynamic stimuli varied in terms of the final level of emotional intensity portrayed, to either 50%, 75%, or 100% intensity. For the dynamic conditions, stimuli were prepared using Fantamorph3 (Abrosoft) software to 'blend' images of neutral, 25%, 50%, 75% and 100% intensity into a 6-s animation. Again, participants saw the video with the unfolding emotion presented with the six possible emotion label choices below.

Creating dynamic stimuli from the best-validated photographs of emotional expressions allowed direct comparison between age effects on static and dynamic conditions where the stimuli are as closely matched as possible on all other perceptual aspects. Previous studies have used similar sequences to assess dynamic emotion perception (e.g. Kamachi et al., 2001; Sato & Yoshikawa, 2007; Smith et al., 2010). While these stimuli do not show a naturalistic timecourse of unfolding emotion (that issue is dealt with in Experiment 2), they do allow understanding of whether having motion information helps to decode the emotion being shown. Also, as pointed out by Sato & Yoshikawa (2007), using manipulations of static images to produce dynamic stimuli reduces idiosyncratic artefacts due to emotion-irrelevant motion such as blinking and eye movements.

Dynamic and static facial cues to emotion.

Stimuli were compiled into two separate blocks (*static*, *dynamic*), each consisting of 72 quasi-randomised trials (6 emotions x 4 faces x 3 different levels of maximum intensity). Each trial consisted of a single image or video, centrally positioned and subtending visual angles of ~15° vertically and ~12° horizontally at a viewing distance of 57cm. On each trial, beneath the image or video was a list of the response options (i.e., anger, disgust, fear, happiness, sadness, surprise). For analyses, performance on each emotion was collapsed across intensity levels to give 24 trials for each emotion in each condition.

Procedure. Participants were tested individually and completed the emotion recognition tasks as part of a larger research programme. The order of stimuli type presentation (i.e., dynamic vs static) was counterbalanced across participants, with other tasks not reported here interspersed between them.

For the *static* condition, the photograph appeared on the screen until the participant said aloud which emotion was present, and this was recorded by the experimenter. Oral responding was used to ensure older adults did not experience any difficulties making responses (i.e., remembering which response buttons to press). Participants then used the computer's spacebar to advance from trial to trial. For the *dynamic* condition, participants watched each animation, activated by the experimenter, then said aloud what they thought the facial expression's emotion was, before again using the spacebar to move on to the next trial. At the end of each animation, the final frame remained on the screen until an answer was given. There were no time limits on trials.

Results and Discussion

Exploratory analyses established that there were no interactions between age and gender or emotion type in determining performance on the emotion perception tasks. These factors were therefore not considered in subsequent analyses. An ANOVA exploring the effects of Age Group (younger, middle-aged, older), Stimulus Type (static, dynamic) and Intensity (50%, 75%, 100%) was carried out. There was an overall effect of Age Group, F (2, 120) = 5.54, p = .005, η_p^2 = .09, with young (M = 80.32, SD = 7.34) and middle-aged (M = 81.38, SD = 5.85) adults being equivalent and performing significantly better than their older counterparts (M = 76.18, SD = 8.81). These results show that age-related performance trajectories are not linear from younger to older, indicating that middle-aged adults perform comparably to younger adults, with older adults significantly worse than both these groups. There was also a significant effect of Stimulus Type, F (1, 240) = 18.29, p < .001, η_p^2 = .13) with performance on dynamic (M = 81.00, SD = 8.71) being significantly better than static (M = 77.74, SD = 8.77).

However, the interaction between Age Group and Stimulus Type was not significant, F (2,120) = 1.81, p = .168. This indicates that although the provision of dynamic information enhanced performance, there were no differential effects across age-groups of providing this additional information. Thus, older adults did not benefit any more from the provision of these cues relative to their younger and middle-aged counterparts.

There was a main effect of intensity, F (1,240) = 284.36, p < .001, η_p^2 = .70, indicating that emotions portrayed at 50% intensity were harder to recognise than those portrayed at 75% or 100%. There was also an interaction between age and intensity, F (4,240) = 8.44, p < .001, η_p^2 = .12, and between intensity and stimulus type (static v dynamic), F (2,240) = 14.85, p < .001, η_p^2 = .11. However, each of these effects and interactions were qualified by the finding of a three way interaction between age group, intensity and stimulus type, F (4,240) = 2.63, p = .035, η_p^2 = .04, which we now discuss in further detail.

To break down this interaction we looked at the effects of age and stimulus type for each level of intensity separately, using mixed design ANOVAs with age group (younger, middle-aged, older) as a between subjects factor and stimulus type (static, dynamic) as a within subjects factor. If a significant age by stimulus type interaction was found, t-tests were used to explore age effects for static and dynamic stimuli separately.

For 50% intensity emotions, an age group by stimulus type ANOVA indicated significant effects of age group, F (2,120) = 10.60, $p < .001$, $\eta_p^2 = .15$, and stimulus type, F (1,120) = 21.94, $p < .001$, $\eta_p^2 = .16$, and an interaction between age and stimulus, F (2,120) = 3.27, $p = .041$, $\eta_p^2 = .052$. Post-hoc *t*-tests revealed that younger adults do not show an advantage of dynamic over static stimuli, $t(41) = 1.11$, $p = .272$, while middle-aged adults, $t(41) = 4.13$, $p < .001$, and older adults, $t(38) = 2.62$, $p = .012$, do show a significant advantage of dynamic over static stimuli. In other words, middle-aged and older adults showed a greater benefit from dynamic stimuli than young when identifying emotions from low intensity stimuli. These data are presented graphically in Fig. 1A.

A separate age group by stimulus type ANOVA at 75% intensity showed no effect of age, F (2,120) = 2.63, $p = .076$, $\eta_p^2 = .04$, an effect of stimulus type, F (1,120) = 23.75, $p < .001$, $\eta_p^2 = .17$, and no interaction between these factors, F (2,120) = 0.98, $p = .378$. These data are presented graphically in Fig. 1B.

As can be seen in Fig. 1C, at 100% intensity, there was a significant age effect, F (2,120) = 4.07, $p = .019$, $\eta_p^2 = .06$. Post hoc tests revealed that middle aged adults performed better than younger, $t(82) = 2.44$, $p = .017$, and older adults $t(79) = 2.54$, $p = .013$, but younger and older adults did not differ, $t(79) = .14$, $p = .888$. There was no effect of stimulus type, $F(1,120) = 0.032$, $p = .859$, nor any interaction between age and stimulus type, F (2,120) = 1.569, $p = .212$.

These data therefore suggest that the age related difficulties identified in the broader emotion recognition literature are not simply an artefact of static presentation format: older adults were poorer than younger and middle-aged at performing both static and dynamic emotion perception tasks. There was an overall benefit of dynamic stimuli, with all age groups finding it easier to identify emotions from video clips compared to photographs. When looking at the stimulus set as a whole there were no age differences in the size of the benefit from dynamic stimuli. However, looking at different levels of emotional intensity revealed a more complex situation. For very subtle, low intensity emotions older and middle-aged participants benefited more from dynamic presentation than younger people did. Emotions portrayed in everyday interactions are likely to be subtle and dynamic, and the current evidence suggests that middle-aged and older adults may be able to take advantage of additional dynamic cues under these circumstances.

However, this is the first study to compare recognition of comparable static and dynamic facial expression cues in younger and older cohorts, and consequently it is possible that these effects do not generalise across different samples or methods. Also, the dynamic stimuli used here were manipulated from static photographs using animation, which does not reflect the time-course or nature of dynamic expressions in real life. This is useful in providing dynamic stimuli which are closely matched in intensity and perceptual properties to the static stimuli, but it would be more ecologically valid to also look at videos of expressions unfolding in real time. In addition, Study 1 provides no information with respect to *implicit* attention to facial cues, focusing only on explicit indicators of accuracy. It is possible that the provision of dynamic facial cues might differentially affect younger and older adults' patterns of attentional engagement. Study 2 was therefore designed to address each of these issues. Specifically, we used different participants and measures to test the robustness of our identified effects, and also included eye-tracking to assess whether attentional biases of the type seen in relation to static stimuli are also evident for dynamic facial expressions.

Study 2

Method

Participants. Forty-four older (25 female) and 40 younger (28 female) adults participated in Study 2. Older adults were recruited from the Brisbane community via advertisements in local community groups and newsletters. All older adults were reimbursed AUD$30 for their time. Younger adults were recruited from a first year psychology research participation pool at the University of Queensland and received 1.5 hours course credit. All participants were required to have English as a first language, as well as 20/20 actual or corrected vision. Exclusion criteria for both groups included no history or presence of a psychiatric or neurological illness. Older adults were screened for dementia using *Addenbrooke Cognitive Examination-Revised* (*ACE-R:* Mioshi, Dawson, Mitchell, Arnold & Hodges, 2006). All participants scored above the recommended age cut-off of 82.

Background characteristics for the two groups are reported in Table 2. It can be seen that the two groups did not differ significantly in years of formal education. The older participants also had higher full-scale IQ as estimated by performance on the National Adult Reading Test (NART; Nelson, 1982), and also reported lower negative affect as indexed by total scores on the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1982). The two groups did not differ with respect to self-rated health on a scale of one to five (1 = very poor, 5 = very good), with both groups reporting their health to be above average.

Measures. The Amsterdam Dynamic Facial Expressions Set (ADFES; van der Schalk, Hawk, Fischer & Doosje, 2011) was developed to provide a standardised and validated set of dynamic facial expressions. The set includes 22 younger actors (12 male, Age range = 18-25 years) expressing the six 'basic' emotions (anger, sadness, happiness, disgust, surprise and fear) as well as three self-conscious emotions (contempt, pride, embarrassment) and a neutral facial expression. Prior to filming, each actor was given a training manual with detailed information about the specific facial action units (AUs) to be used when making each emotional expression. This very detailed training prior to filming was provided to ensure that all emotional expressions were as consistent as possible across actors. The initial validation study for the ADFES was based on emotion recognition scores and valence and arousal ratings from 124 undergraduate students (van der Schalk et al., 2011). Still shots were taken at the apex of each dynamic expression for each actor and these images were compiled to form a static set of emotional expressions. Four dynamic clips and matching static images (two male, two female) were selected for each of the ten emotional expressions. Ten male and ten female actors were randomly selected from the ADFES set and assigned to two different emotions. This resulted in a set of 40 emotional expressions that were then counterbalanced into three different orders for each format type.

SensoriMotoric Instruments (SMI) Experiment Centre software was used to program and present the stimuli for the emotion recognition task. Each dynamic clip was approximately six seconds in length, and consequently each of the static images was also presented for six seconds each. Participants viewed the experiment on an 18-in Dell computer monitor positioned approximately 60 cm away from the participant. Each emotional expression was presented centrally at visual angles of ~23° vertically and ~13° horizontally. Eye movements were monitored using a remote eye tracker (SMI RED500, IViewX software) at a sampling rate of 500Hz.

Procedure. All participants were tested individually. After arriving at the lab and providing informed consent, participants were asked to provide demographic information and complete the NART. Older adults were additionally asked to complete the *ACE-R*. Participants were then asked to sit in front of a computer screen. Prior to presenting the experimental tasks, a 13-point calibration procedure was administered to ensure that the eye-tracker was accurately capturing eye movements. This calibration procedure was repeated halfway through the presentation of each experimental task to ensure that eye movements were being accurately captured throughout the whole task.

After calibration, participants viewed an instruction screen that explained that they were about to view a series of emotional expressions and that they were required to orally identify to the experimenter which emotion was being expressed. All ten possible emotions that might be encountered were presented on this instruction screen, but participants were reassured that they did not have to memorise the names of the different emotions, as the list would be presented following each emotional expression. Participants were asked if they were familiar with all of the emotions listed on the screen and a definition was provided if they were unsure of the meaning of a particular emotion. To ensure participants completely understood the process, they were given one practice trial where they were asked to view and identify a happy expression. Following the practice trial, the experimenter asked the participant if they understood the task and if there were no further questions the experimental trials commenced.

After viewing the expressions in one format (i.e., static), participants completed the same task in the other format (i.e., dynamic), with order presentation counterbalanced between participants. To reduce potential fatigue or practice effects, in between the two format presentations, participants completed a brief unrelated task. After completion of the emotion recognition task, participants completed several background characterisation measures along with the HADS in online format on a desktop computer. Once all measures were completed participants were debriefed and thanked for their time.

Results and Discussion

Explicit emotion recognition accuracy. To assess age differences in accuracy across the two experimental tasks, a 2 (age-group: younger, older) x 2 (format: dynamic, static) mixed ANOVA was conducted.[3] Analyses revealed a main effect of age-group, $F(1, 79) = 35.07$, $p < .001$, $\eta_p^2 = .31$, with overall emotion recognition scores poorer for older (M= 68.84, SD= 11.52) relative to younger (M = 81.70, SD = 7.25) adults. There was also a main effect of format, $F(1, 79) = 16.33$, $p < .001$, $\eta_p^2 = .17$, which reflected better overall performance for the dynamic (M = 77.44, SD = 11.97) relative to the static (M = 72.53, SD = 13.37) condition. However, most importantly, and replicating the results from Study 1, there was no interaction between format and age-group, $F(1, 79) = 19.72$, $p = .531$, $\eta_p^2 < .01$. Mean accuracy for each condition is depicted in Figure 2.

Implicit attentional engagement to facial emotion cues. To analyse eye tracking data, SMI BeGaze software was used. Two areas of interest (AOI's) were created for each emotional expression, in both static and dynamic format. Following a previously reported method (Noh & Isaacowitz, 2013), the AOI for the eye region was a rectangular box that covered the whole eye region from the top outer corner of the eyebrow to the bridge of the nose, and the AOI for the mouth region was a rectangular box that reached from the base of the nose to below the bottom lip and across the entire width of the mouth.

For the dynamic expressions, AOI's were adjusted across the length of video clip to account for movement of the eye and mouth region while the emotion was being expressed. These minor adjustments ensured that the eye and mouth region were constantly positioned within the AOI region throughout the whole expression. Percentage of net dwell time, which refers to the percentage of time at which the participants' eye enters an AOI until the time it leaves the AOI, was the primary measure of gaze behaviour. For each participant, percentage of net dwell time in each AOI, for each emotional expression was calculated.

To assess age differences in gaze patterns towards the eye and mouth region in both format types, a 2 (age-group: younger, older) x 2 (AOI: eye, mouth) x 2 (format: static,

[3] As with Study 1, *gender* and *emotion type* were included in initial analyses but again no age interactions emerged and therefore these factors were not included in subsequent analyses

dynamic) mixed ANOVA was conducted. Results revealed a main effect for AOI, $F(1,65) = 140.22$, $p < .001$, $\eta_p^2 = .68$, and format, $F(1,65) = 7.10$, $p = .01$, $\eta_p^2 = .10$, but not age-group, $F(1,65) = 2.96$, $p = .09$, $\eta_p^2 = .04$. However, superseding these main effects, a significant three-way interaction (format x AOI x age-group) emerged, which was then followed up formally by conducting ANOVAs with AOI and format, separately for older and younger adults.

Older adults. For older adults, a 2 (AOI: eyes and mouth) x 2 (format: static and dynamic) ANOVA showed that there was a main effect of AOI, $F(1,33) = 24.63$, $p < .001$, $\eta_p^2 = .43$, indicating that the eyes were attended to more than the mouth region (M =45.77, SD =17.36, M = 23.54, SD = 13.07). However, as can be seen in Fig. 3A there was no main effect of format or interaction between the two.

Younger adults. For younger adults, a 2 (AOI) x 2 (format) ANOVA showed that there was a main effect of AOI, $F(1,32) = 153.82$, $p <.001$, $\eta_p^2 = .83$, and a main effect of format, $F(1,32) = 12.34$, $p = .001$, $\eta_p^2 = .28$. However, superseding both of these effects, there was an interaction between the two, $F(1,32) = 9.60$, $p =.004$, $\eta_p^2 = .23$. As can be seen in Fig. 3B, across both conditions the eyes were attended to more than the mouth, however this effect was more pronounced in the dynamic relative to the static condition, $F(1,32) = 12.76$, $p = .001$, $\eta_p^2 = .28$.

These data therefore show for the first time that while older adults' gaze behaviour may not be influenced by stimuli presentation, younger adults show more engagement to the eye region when the stimuli are presented dynamically.

Correlational analyses. Finally, Pearson correlation coefficients were calculated for emotion recognition scores and gazing to the eye and mouth regions separately for format type (static, dynamic) and age group (older, younger). No significant associations emerged (r's ranged from -.20 to .15, all p's > .05).

General Discussion

The ability to rapidly and accurately identify others' emotional states is critical for social function, and in turn, mental health and wellbeing. It is therefore of considerable concern that the research literature suggests that this capacity may decline with age (Ruffman et al., 2008; Isaacowitz et al., 2007). However, nearly all the research into age-related differences in facial emotion recognition has concentrated on static images. Given evidence that dynamic presentation can improve emotion perception in younger adult cohorts (e.g. Ambadar et al., 2005), our primary aim was to investigate whether older adults might benefit from the temporal information offered by dynamic emotional stimuli.

In two separate studies involving independent samples and methods, we manipulated facial expression stimuli to compare age effects in decoding static and dynamic stimuli. The main finding to emerge across both datasets was that there was no differential effect of cue type as a function of age group. Specifically, although the provision of dynamic cues benefited older adults, it did not attenuate age-related difficulties. Both studies therefore provide evidence that age related difficulties in identifying facial emotions remain, even when more naturalistic dynamic stimuli are used.

In addition to clarifying whether the provision of dynamic cues differentially affected young and olds' emotion recognition accuracy, Studies 1 and 2 also investigated additional, specific research questions. Study 1 included manipulations of the intensity of the emotional expressions shown in static and dynamic stimuli. The results here showed that the strongest benefits of dynamic stimuli were seen for the most subtle stimuli - but only for middle-aged and older adults. This is a particularly interesting and important finding, as it suggests that it was of particular benefit to these age groups to have additional movement information when trying to interpret low intensity emotions. Given that most everyday encounters are likely to be with subtle emotions, this indicates that dynamic information is important as we grow older, and that previously reported age deficits identified with static, high-intensity facial emotions may over-estimate the difficulties older adults exhibit in their everyday lives.

Collapsed across emotional intensity, overall, it was found that middle-aged adults performed as well as young, and both groups outperformed the older adults. These data indicate that older adults' deficits in facial emotion recognition occur relatively late in the adult lifespan, in contrast with the pattern of relatively early age effects in some cognitive domains, such as processing speed (Park et al., 1996; Salthouse, Atkinson & Berish, 2003), and working memory (Phillips et al., 2011). Interestingly, the Phillips et al. (2011) study showed a similar profile of age effects in an independent social cognitive domain. Specifically, some aspects of false belief reasoning (a core component of theory of mind) did not differ for younger and middle-aged adults, with decline only evident in an older adult cohort.

The key novel feature of Study 2 was to additionally assess implicit attentional focus. The results showed that younger adults gazed more at the eye region when stimuli were presented in dynamic compared to static format. In contrast, older adults did not show any effect of dynamic emotion presentation on time spent looking at the eyes. This finding suggests that younger adults may be implicitly more sensitive to dynamic emotional cues. For both age-groups, there were no associations between gaze patterns and emotion recognition ability for either stimuli type, which suggests that gaze behavior may not play a major role in facial emotion recognition ability. This failure to find any association between gaze patterns and emotion recognition ability is consistent with most prior aging studies (Murphy & Isaacowitz, 2010; Circelli, Clark & Cronin-Golomb, 2013; however see Sullivan, Campbell, Hutton, & Ruffman, 2015).

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Limitations and Future Directions. In both Studies 1 and 2, we wanted to move beyond the photographs of facial expression used in most aging studies to date, and add dynamic information to these stimuli. However, several important limitations must be noted. Firstly, the stimuli used in both of studies were not naturalistic videos of real emotions, and there is still a lack of information about the effects of aging in identifying emotions that are genuine rather than posed or acted. There may be some difficult ethical issues associated with acquiring stimuli that record people displaying genuine emotions, but this is an important goal for future research.

Secondly, to the present authors' knowledge, there is currently no dynamic stimulus set available that includes both younger and older actors, and the stimuli set used in Study 2 (i.e., the ADFES) presents only younger adult facial stimuli. Importantly, a recent review concluded that there are not reliable own-age biases in emotion perception (Fölster, Hess, Werheid & 2014), indicating that it is unlikely that the older adults in our study were disadvantaged by the absence of older adult stimuli. Nevertheless, to further enhance ecological validity, it would be interesting in future research to develop and include stimuli that depict dynamic faces from younger, middle and late adulthood.

In addition, most research to date on age differences in facial emotion recognition involves the participant making judgments about a stranger. Given that (i) we behave very differently with strangers and those known to us, (ii) we may become much more expert in judging the emotional and social signals of our friends, workmates and family over time, and (iii) older adults invest more in close others compared to younger people who may be more open to new encounters; it seems important to explore how older adults' social perception is influenced by familiarity. Recent work by Stanley and Isaacowitz (2015) has provided some of the first evidence that familiarity with the target person can in fact attenuate age deficits in emotion perception. Moreover, motivational factors have also been shown to play a role in improving older adults' performance on emotion recognition tasks (Zhang, Fung, Stanley, Isaacowitz & Ho, 2013).

Put simply, other aspects of ecological validity not tested in the present study may be relevant to understanding age differences in facial emotion perception, and remain an important topic of investigation. Indeed, Noh and Isaacowitz (2013) showed that older adults performed *better* than their younger adults in a static emotion recognition task when congruent contextual cues were present. This study also showed that older adults gazed more at these contextual cues, and consequently may rely on and benefit more from additional contextual information. Together, through a combination of methods and measures such as these, research in this literature has the potential to gain a more nuanced understanding of when and why age-related difficulties with emotion recognition are likely to arise- with the ultimate goal of providing insights into the types of strategies that might be helpful to enhance this critical social cognitive capacity in everyday life.

Conclusions

Across two separate studies involving independent methods and samples, there was evidence that the provision of dynamic facial cues improved recognition of facial emotions for both younger and older adults. This dynamic cue advantage was equivalent in younger and older adults, with the exception of very subtle, low intensity emotional faces, where middle-aged and older adults showed a greater improvement with dynamic cues compared to young. The results also show that age-related differences in responding to dynamic facial cues are evident at an implicit level. Taken together, these results provide important novel insights into when and why older adults may be expected to experience difficulties interpreting facial expressions of emotion. In particular, the results suggest that in many real life situations - where emotional expressions are not only dynamic but also relatively subtle–

older adults may be less disadvantaged than prior studies focused on high intensity static facial emotions have implied.

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Table 1. Background characteristics of the younger, middle-aged and older participants in Study 1.

Characteristic	Younger (*n* = 41)		Middle-aged (*n* = 42)		Older (*n* = 39)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age	26.0	5.91	54.4	7.98	74.0	4.58
Years of education	16.3	2.26	16.9	4.34	13.3	4.27
Mill Hill Vocabulary Test	18.3	4.43	23.2	4.04	22.7	4.39
HADS Negative affect	10.4	5.73	9.2	6.85	9.4	5.20
Self-rated health	7.3	1.55	7.2	1.17	7.1	1.20

Note: HADS refers to the Hospital Anxiety and Depression Scale where higher scores indicate greater negative affect. Self-rated health was scored on a scale of 1 – 9 where 1 indicted very poor health and 9 indicated very good health.

Table 2. Background characteristics of the younger and older participants in Study 2.

Measure	Younger		Older			
	M	*SD*	*M*	*SD*	*t*(55)	*P*
Demographics						
Education	13.11	1.41	14.30	3.60	1.94	.06
Cognitive function						
NART FSIQ	109.8	5.13	116.4	5.79	5.48	< .001
Wellbeing						
Self-rated health	4.23	0.70	4.10	0.66	0.83	.41
HADS Total	17.00	4.70	13.17	3.60	4.13	< .001

Note. NART FSIQ refers to predicted full scale IQ indexed by the NART reading test. Self-rated health was scored on a scale of 1 – 5 where 1 indicated very poor health and 5 indicated very good health. HADS refers to the Hospital Anxiety and Depression Scale where higher scores indicate greater negative affect.

Fig. 1. Mean emotion recognition accuracy in response to static and dynamic facial expressions at 50% intensity, 75% intensity, and 100% intensity for younger, middle-aged and older adults in Study 1. Error bars represent standard error.

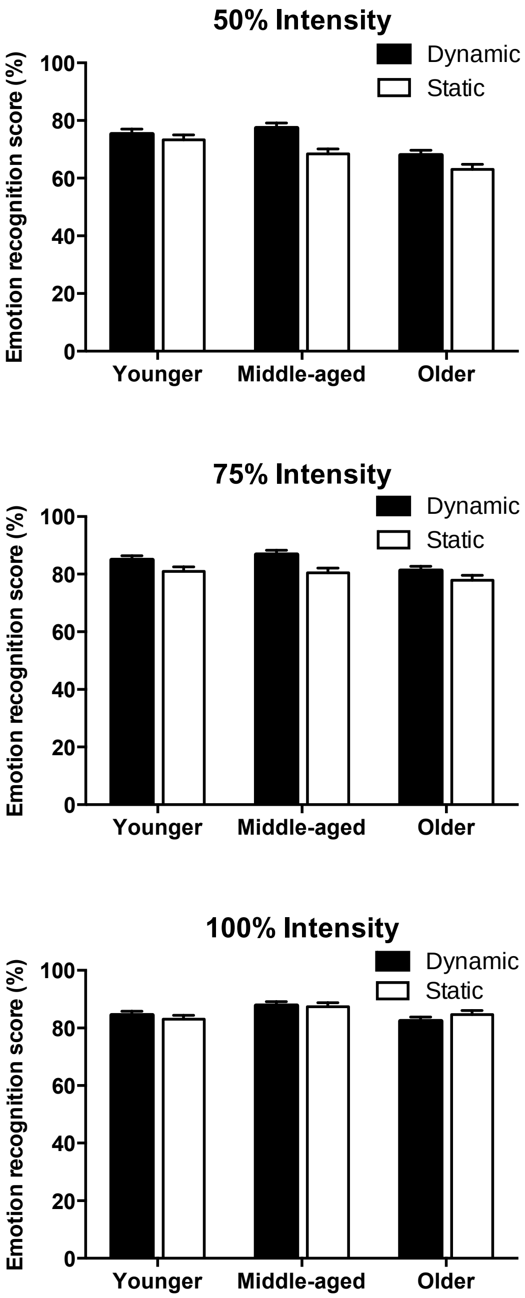

Fig. 2. Mean emotion recognition accuracy in response to static and dynamic facial expressions, separately for younger and older adults in Study 2. Error bars represent standard error.

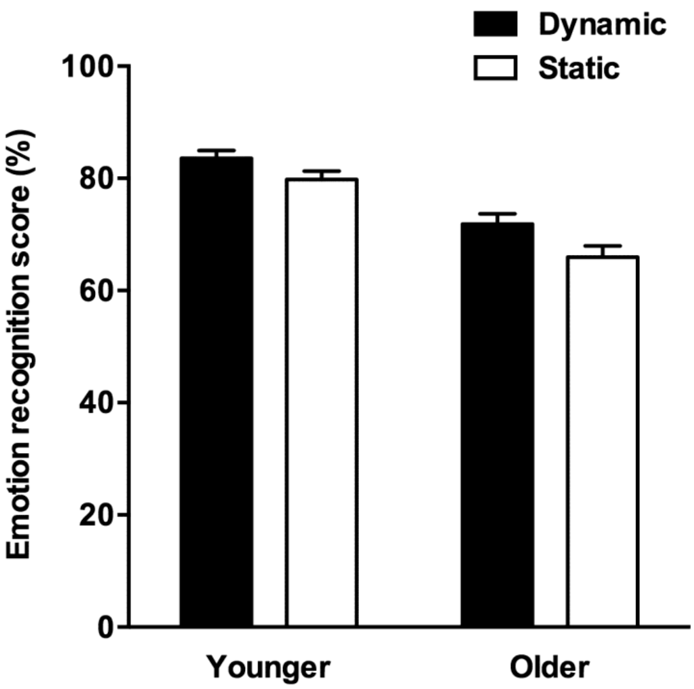

Fig. 3. Mean percentage of net dwell time in each AOI (eye region, mouth region), for dynamic and static format, separately for older adults and younger adults. Error bars represent standard error.