**Happy Times are Longer When We are Older:
Emotions Affect Time Perception in Older Adults**

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Abstract

Emotions change people's time perception, which has been evidenced in children and younger adults. However, older adults, who cognitively process positive stimuli to a greater extent than negative and neutral stimuli (Carstensen & Mikels, 2005), had been neglected in most empirical studies examining the role of emotion played in time perception. Using a temporal bisection task, the present study investigated age differences ($N_{older} = 21, N_{younger} = 21$) in time perception of negative (sad and angry), positive (happy), and neutral facial expressions. A significant age by emotion interaction in time perception was found in results, such that older adults perceived the presentation durations of happy faces longer than negative ones, whereas the opposite pattern was observed in younger adults. The present findings could be interpreted by the internal clock model and the "positivity effect" in older adults' cognitive and affective processes.

Keywords: time perception, emotion, positivity effect, older adults, internal clock model

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As people aged, their perception of emotional stimuli changed. Unlike younger adults, according to socioemotional selection theory (i.e., Carstensen, Isaacowitz, & Charles, 1999), older adults are found to prioritize positive emotions over negative ones. This effect has been termed as the emotional “positivity effect” of older adults (Charles, Mather & Carstensen, 2003; Canli et al., 2000; Carstensen, Fung & Charles, 2003; Carstensen, 2006; Fung & Carstensen, 2003; Mather et al., 2004; Scheibe & Carstensen, 2010). Such an aging difference in emotion perception has also been supported by the research about time. Nicol and colleagues (2013) conducted a temporal bisection task with emotional (i.e., angry, sad, happy) and neutral facial expressions, and found older adults perceived the duration of both positive and threatening events longer than neutral events, whereas younger adults only perceived threatening events longer than neutral events.

Previous research explains such emotional distortion of time perception using the internal clock model (Droit-Volet & Wearden, 2001; Droit-Volet & Gil, 2009; Gibbon, 1977; Gil et al., 2007) and through arousal mechanism (Tipples, 2008; see review in Droit-Volet & Gil., 2009). This widely used model generally includes a pacemaker that emits pulses, a switch and an accumulator to count the number of pulses received. Temporal judgments are made in the following memory and decision stages (Gibbon, 1977; Grondin, 2010). When perceiving the emotional stimuli, the higher arousal, the more pulses the accumulator accumulates, the faster the

internal clock runs, and the longer a period of time is judged to be. This explains why younger adults perceive durations of negative emotions longer than that of positive ones (Droit-Volet et al., 2004; Effron et al., 2006). For example, Noulhiane and colleagues (2007) found that emotional sounds were judged to be longer than neutral sounds by using IADS (International Affective Digital Sounds system) among college students. The same overestimation of negative stimuli has also been replicated among children aged 3, 5 and 8 by Gil and colleagues (2007). In this study, children were asked to estimate whether the durations of those facial expressions were more similar to either standard short (400 ms/600ms) or long (1,600 ms/2400ms) that they had learned in the practice part. Results showed that children in three age groups all temporally overestimated the duration of angry faces than that of neutral faces. Consistently, facial expressions rated as more aroused should lead to longer time estimation than those appeared less arousing (Droit-Volet et al., 2004). For instance, Droit-Volet and colleagues (Chambon, Gil, Niedenthal, & Droit-Volet, 2005; Droit-Volet, Brunot, & Niedenthal, 2004) also found that for the duration range used (from 400 to 1,600 ms), adults consistently temporally overestimated the duration of emotional faces compared with neutral ones. Other evidence has been also found in brain areas that associated with emotions, for example, Craig (2009) argued that emotion-induced activation of the anterior insular cortex could influence concurrent temporal processing, resulting in emotion-induced distortions to time. Based upon evidence, it is reasonable to predict that the temporal perception facial expressions should be in line with the finding of perception of other emotional stimuli, that is the higher the arousal of the facial expressions are, the longer the time perception of the facial expressions.

Even though we have evidence from children to younger adults, when examining the aging difference in temporal perception of emotions across lifespan, older adults have been overlooked and findings are not always consistent. Rammsayer (2001) had found that older adults only tend to make longer reproductions of a 1s interval. But Nicol and colleagues (2013) found that older adults perceived the durations of positive facial expressions to be longer, consistent with positivity effect of aging postulated by the socioemotional selectivity theory. With limited evidence, we could predict how older adults make the temporal perception of facial expressions via the arousal mechanism. Theoretically, according to socioemotional selectivity theory, supported by widely existed behavioral and neuroimaging findings, older adults display a higher arousal for positive pictures than younger adults did (Mather et al., 2004). Confirmed in fMRI studies, the average signal change in older adults' amygdale is greater for positive pictures than for negative ones for older adults, indicating a higher arousal of the positive emotion in older adults (Canli et al., 2000; Dolan, Lane, Chua & Fletcher, 2000). It is reasonable to expect that older adults would overestimate the duration of the positive facial expressions.

The present study attempts to replicate Nicol and colleagues (2013) by investigating whether there were age differences in the effect of emotions on time perception with the temporal bisection task (Droit-Volet et al., 2004). Four kinds of emotional facial expressions classified by valence (positive (happiness), neutral, and negative (sadness and anger), were used. According to the arousal mechanism and "positivity effect" in cognition of older adults, we predict that age differences would emerge in the effect of emotion on time perception. Specifically, the durations of positive stimuli would be perceived longer than that of negative stimuli in older adults. It was also expected that the present study would replicate past findings that time perception of negative stimuli would be longer than positive ones in younger adults.

Method

Participants

21 older adults (13 females, $M (SD)_{\text{age}} = 76.05 (7.79)$) and 21 younger adults (10 females, $M (SD)_{\text{age}} = 22.19 (1.99)$) were recruited. All participants completed the experiment separately in a quiet lab room. E-prime software was used to present the stimuli and to automate data collection.

Stimuli

Facial expressions were sixteen black-and-white photographs of four kinds of facial expressions (9.17×10.58 cm, happy, angry, sad, and neutral, see in Figure 1); they were selected from a widely used standardized system, Chinese Facial Affective Picture System (Gong, Huang, Wang & Luo, 2011; Wang et al., 2013). In this system, faces were already cropped to remove hair and ears, only leaving facial masks. A pilot study with another group of older adults ($N = 10$, $M (SD)_{\text{age}} = 68.56 (7.71)$) confirmed that older adults agreed on ratings of emotional certainty and emotional strengths reported in Gong et al. (2011) by younger adults. In this pilot rating, the average emotional certainty reported by older adults was 7.06 ($SD = 0.56$, 9-point scale), and the average emotional strength of the photos was 6.71 ($SD = 0.76$, 9-point scale). In Gong et al. (2011), younger adults' ratings for these two parameters were 94.68 ($SD = 5.43$, 100-point scale) and 6.31 ($SD = 0.48$, 9-point scale), respectively.

Procedure

The procedure was similar to previous studies using the temporal bisection task (Droit-Volet et al., 2004; Gil et al., 2007). All participants performed three phases of the task (learning, practice, and testing). In the learning phase, the standard short (600 ms) and long (2,400 ms) duration were presented and learned. Then, in the practice phase, participants judged whether the

duration of a pink square presented was standard short or standard long by key pressing ('K' or 'D', response keys were counterbalanced across participants). Feedbacks were provided after each trial in this phase. Participants proceeded to the testing phase immediately after their average correct response rate was above 75%. In the testing phase, comparison durations (600, 900, 1,200, 1,500, 1,800, 2,100, and 2,400 ms) of stimuli were presented randomly. Participants classified them into either standard short or standard long without feedback. Each participant finished 112 trials in this phase. Finally, participants were paid, thanked, and debriefed.

Results

Before the formal experiment, both younger and older adults performed the temporal bisection tasks with neutral stimuli. No age differences displayed in this baseline measure of participants' time perception¹. Positive (happy), neutral, and negative (angry and sad) baseline facial expressions impacted time perception of young and older adults differently, whereas the proportion of 'long' responses increased as a function of stimulus duration for both older and younger adults (Figure 2).

To show the magnitude of the difference in time perception between positive and negative stimuli, the corresponding results of neutral stimuli were subtracted from emotional stimuli (Droit-Volet et al., 2004; Gil, Niedenthal & Droit-Volet, 2007). A 7 (duration) $\times$ 2 (emotion: positive-neutral vs. negative-neutral) ANOVA was conducted to analyze the mean proportion of 'long' responses for all participants. The analyses revealed no significant main effect of duration, emotion or age group (all $p > .1$); while the interaction between age group and emotion was significant ($F(1, 40) = 17.982, p < .01, \eta_p^2 = 0.310$). Simple effect analysis revealed a main effect of emotion in both younger ($F(1, 40) = 8.824, p = .05, \eta_p^2 = 0.181$) and older adults ($F(1, 40) = 9.16, p = .04, \eta_p^2 = 0.186$). Consistent with literature, younger adults perceived negative stimuli

($M(SD) = 0.031 (0.019)$) as longer than positive stimuli ($M(SD) = -0.014 (0.02)$) while older adults perceived the durations of positive stimuli ($M(SD) = 0.029 (0.02)$) as longer than negative ones ($M(SD) = -0.017 (0.019)$). The results of the mean proportion of ‘long’ responses of younger adults were in line with the pioneering discoveries (Droit-Volet et al., 2004).

To further examine age differences in temporal perception of emotions, two temporal indexes were assessed: the bisection point (BP) and the Weber ratio (WR, Droit-Volet et al., 2004; Gil et al., 2007; Kopec & Brody, 2010). Bisection point (BP) is the point that participants produced 50% of long responses. In the present study, a linear regression of the individual bisection function was conducted to get the BP value. Additionally, Weber ratio (WR), an index of time sensitivity, was calculated by the following equation:

$WR = (T(PL = 0.75) - T(PL = 0.25)) / T(PL = 0.5)$, where $T(PL = x)$ was the duration at which a participant responded ‘long’ with probability x (Gil et al., 2007; Kopec & Brody, 2010). The mean BP and WR values of each group are shown in Table 1.

Next, the corresponding BP values of neutral expressions were subtracted from that of positive and negative ones. An ANOVA of BP subtraction values revealed no significant main effect of emotion or age group ($p > .1$), while the interaction between age group and emotion was marginally significant ($F(1, 40) = 3.875, p = .052, \eta_p^2 = 0.046$). Then, subsequent analyses found a marginally significant main effect of emotion in older adults ($F(1, 40) = 3.767, p = .059, \eta_p^2 = 0.086$), suggesting that the BP subtraction value of negative stimuli ($M(SD) = -28.23 (129.64)$) was higher than that of positive ones ($M(SD) = -49.97 (131.47)$). However, no significant main effect of emotion emerged in younger adults ($p > .1$). Nevertheless, descriptive data revealed that the BP value of negative stimuli ($BP(SD) = 1410 (153.5)$) was lower than that

of neutral ones ($BP (SD) = 1417 (202.6)$) in younger adults, thus the direction of the results was consistent with previous results (Gil et al., 2007).

When it comes to WR values, consistent with previous studies in children and the young (Droit-Volet & Gil, 2009; Gil et al., 2007), there was no significant main effect of emotion, age group, or interaction effect (all $p > .1$). Accordingly, no age difference appeared in the effect of emotions on temporal sensitivity.

Discussion

In line with Nicol and colleagues (2013), the present study found that older adults perceived the durations of positive (than negative) facial expression longer and younger adults perceived the durations of negative (than positive) ones are longer. In addition to this aging different temporal perception of duration, our results showed that there is no significant age difference in terms of temporal sensitivity. These results, together with previous studies, present the life-span development of human's temporal perception of emotions using temporal bisection task (Droit-Volet et al., 2004; Gil et al., 2007).

In the current study, younger adults replicated Nicol and colleagues (2013) by estimating the presentation durations of negative stimuli longer than positive ones. According to the arousal mechanism (Droit-Volet & Gil, 2009), the higher arousal of negative stimuli made the pacemaker produce more pulses and resulted in longer subjective perception of presentation duration (Grondin, 2010). Older adults; however, judged the durations of positive faces longer than any other emotional ones. One possible explanation for this finding might be the “positivity effect” in older adults' cognitive and affective processes (Carstensen & Mikels, 2005; Scheibe & Carstensen, 2010). Pioneering findings showed that older adults not only reported higher arousal of positive stimuli but also showed greater amygdala activation with positive stimuli (Langeslag

& van Strien, 2009; Leclerc & Kensinger, 2011; Mather et al., 2004; Neiss, Leigland, Carlson & Janowsky, 2009; Kehoe, et al, 2013), suggesting that positive stimuli led to higher arousal among older adults (Langeslag & van Strien, 2009; Mather et al., 2004; Neiss, et al. 2009). With higher arousal, more pulses were emitted from pacemaker and resulted in longer perception of positive stimuli. Thus, we speculated that age differences in arousal levels of positive stimuli might offer a potential explanation for age differences in perception of emotional stimuli.

The overestimation of positive stimuli might also serve social functions. Older adults, according to the socioemotional selectivity theory (SST, Carstensen, Fung & Charles, 2003; Carstensen & Mikels, 2005; Scheibe & Carstensen, 2010), have a stronger desire to realize their emotional goals and meet their needs of emotional satisfaction. Thus, experiencing life positively is more important and meaningful than any other goals for them. Besides, the intervals in the current study, less than 4 secs, are the so-called “psychological present”, defined as a brief period which can be apprehended without calling on memory (Fraisse, 1967), It further indicated that older adults perhaps thus enjoy the moment more by subjectively perceiving the durations of positive stimuli longer.

The present study has a few limitations. First, although all the facial expressions are selected from the Chinese Facial Affective Picture System (Gong, Huang, Wang & Luo, 2011), the black-white faces without hair and ears limited the ecological validity of the stimuli. More ecologically powerful materials such as videos can be considered in the future research. Second, the present study didn't measure the age difference or changes in cognitive abilities associated with aging. This limitation, however, may not weaken the current conclusions *per se*.

Developmental studies using children aged 3, 5, and 8 (Gil et al., 2007) suggested that the temporal distortions of angry faces are not linked to cognitive abilities, which indicates that the

change in cognitive abilities might not affect temporal perception. In addition, we found no age difference in temporal perception of neutral stimuli in our pre-test, and found no age differences in temporal sensitivity, both of which suggested no apparent links between cognitive abilities and temporal perception. Third, the present study is cross-sectional in nature, so it is unclear whether the observed age differences represent developmental changes or cohort effect. The longitudinal observations are needed in the future studies.

In conclusion, the current study contributed to the present literature by provide future evidence of effect of emotion on older adults' time perception. It also extended the "positivity effect" which previously mainly focused on memory, attention, and social functions (Isaacowitz & Blanchard-Fields, 2012) to the realm of time perception under 4 secs. This positive bias in time perception within small units of time implied that compensatory strategies may be developed in cognitive processes for elderly and complemented our understanding of emotional processes in later life.

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Footnotes

¹ This pre-test measured time perception ability at baseline of both the older ($N=21$) and the young ($N=18$) with the temporal bisection task. No significant difference between the older ($M = 0.568$, $SD = 0.379$) and younger adults ($M = 0.537$, $SD = 0.397$) emerged, suggesting that ability of time perception does not decline in older adults ($F(1, 37) = 1.237$, $p > 0.1$, $\eta_p^2 = 0.032$). The statistical equation of time perception in older adults as compared to that of the young might be caused by a temporal compensation of older people suggested by Block, Zakay, & Hancock (1998). Results from the pre-test were consisted with the previous studies, demonstrating that older adults didn't show a decline in time perception; more importantly, these results warranted further exploration of age differences in the effect of emotion on time perception (Hancock & Rausch, 2010).

Figure 1

Examples of Each Emotional Facial Expression

Happy

Neutral

Angry

Sad

Figure 2

Average Proportion of 'Long' Responses for Facial Expressions

Notes. Average proportion of 'long' responses plotted against stimulus durations for positive (happy), neutral, and negative (sad and angry) facial expressions in the 600 to 2,400 ms duration ranges of both older adults (A) and younger adults (B).

Table 1

The Mean Proportion of 'Long' Responses, Bisection Point (BP), and Weber Ratio (WR) results

Emotion type	Older adults						Younger adults					
	Mean proportion of 'long' responses		BP		WR		Mean proportion of 'long' responses		BP		WR	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Positive	0.6327	0.4057	1308	126.7	0.547	0.094	0.5289	0.4235	1466	142.7	0.440	0.093
Neutral	0.6037	0.4146	1358	127.9	0.504	0.131	0.5425	0.4343	1417	202.6	0.463	0.130
Negative	0.5867	0.4105	1387	110.3	0.489	0.073	0.5739	0.4243	1410	153.5	0.479	0.083