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Perceiving arousal and valence in facial expressions: Differences between children and adults

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ABSTRACT

Arousal and valence have long been studied as the two primary dimensions for the perception of emotional stimuli such as facial expressions. Prior correlational studies that tested emotion perception along these dimensions found broad similarities between adults and children. However, few studies looked for direct differences between children and adults in these dimensions beyond correlation. We tested 9-year-old children and adults on rating positive and negative facial stimuli based on emotional arousal and valence. Despite high significant correlations between children's and adults' ratings, our findings also showed significant differences between children and adults in terms of rating values: Children rated all expressions as significantly more positive than adults in valence. Children also rated positive emotions as more arousing than adults. Our results show that although perception of facial emotions along arousal and valence follows similar patterns in children and adults, some differences in ratings persist, and vary by emotion type.

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Introduction

Perception of facial expressions is critical for social interaction. To understand the mechanisms involved, two primary dimensions of emotional perception of faces have been identified (Russell, 1980; Schubert, 1999): valence and arousal. Valence represents the pleasantness of a face, and is measured on a linear scale with pleasant/positive emotions on one end, and unpleasant/negative emotions on the other. Arousal indicates the degree to which a face brings an observer to a state of greater alertness. Arousal is also measured on a linear scale, with

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lower values indicating no alerting effect on the observer, and higher values indicating a strong effect of increasing alertness.

The 'Circumplex Model of Affect', proposed by Russell (1980), is a model for understanding emotion with valence and arousal as orthogonal axes of a plane upon which emotion terms are positioned. Unfortunately, there have been relatively few studies examining the differences in the perception of emotional facial expressions between children and adults along these dimensions. One such study (Russell & Bullock, 1985) examined correlations between the results of 4- to 5-year-old children and adults in an emotional-similarity grouping task. Participants sorted faces varying by emotion into two piles based on perceived similarity. A two-dimensional solution was calculated for each age group based on the frequencies with which each face ended up in the same pile as other faces. Explicit ratings of valence and arousal were also collected from all participants for each face. A correlational analysis was then carried out to determine the similarity between the explicitly-rated dimensions of arousal and valence, and the dimensions calculated from the similarity-grouping data. The authors found similarly high correlations in both children and adults. Using an analogous similarity-grouping task, Vieillard and Guidetti (2009) likewise found similar patterns, and high correlations between the explicit valence/arousal ratings and grouping-results of older children (6- and 8-year-olds) and adults when viewing videos of dynamic facial expressions. Another correlational study (McManis, Bradley, Berg, Cuthbert, & Lang, 2001) using Self-Assessment Manikin (SAM) scales, a set of pictorial representations to aid rank-based emotional judgments, also found high correlations in ratings of general affective images (such as human faces, nature scenes, and animals) in children and adults. These results demonstrated that both children and adults follow similar perception patterns within the valence-arousal space.

There is also evidence indicating changes in the perception of facial emotions from childhood into adulthood. Some studies found distinct developmental trajectories depending on the emotion type: For instance, Gao and Maurer (2010) conducted an emotion identification task where they varied the intensity of emotion of facial expressions, and measured the threshold necessary to achieve the correct response. In identifying positive expressions, children between the ages of 5 and 10 years showed adult-like identification thresholds, while negative expression showed higher thresholds relative to adults. Another threshold measurement study (Rodger, Vizioli, Ouyang, & Caldara, 2015) varied the clarity of facial images (by adding varying levels of noise to the visual stimuli) shown to children and adolescents between the ages of 5 and 18 (in age-bands of 2 years), as well as adults. The authors found adult-like threshold levels for correct labeling of positive emotions by the younger age groups, and a more gradual improvement trend for negative emotions. The authors also noticed the thresholds forming two groupings with children under 13 years of age being clustered together distinctly from participants over the age of 13 through to adults, suggesting two distinct phases of development.

These results show developmental differences in the perception and identification of emotional facial expressions, with responses differing for positive and negative expressions. Such differences are difficult to explain using the correlational arousal and valence results reported by Russell and Bullock (1985), Vieillard and Guidetti (2009), as well as McManis and colleagues (2001) indicating no developmental differences. Additionally, differences in the ability of participants to identify positive and negative emotional expressions have led some authors to speculate about valence-dependent categorical biases in the perception of emotional expressions. Some have proposed a 'positivity' bias indicating more efficient processing of positive emotional expressions (Leppänen & Hietanen, 2004), while others contend that negative emotional expressions are processed faster and more accurately, suggesting a 'negativity' bias (Vaish, Grossmann, & Woodward, 2008). This divergence of opinions could be explained by the variety of age groups and methods used in these studies. Thus, an experiment focused on directly comparing children and adults regarding the perceived arousal and valence of positive and negative facial expressions in addition to examining correlations could clarify how such categorical biases could manifest under this approach, and to what extent they might be affected by age. It is the aim of the present study to explore these questions by investigating the direct differences between children and adults in arousal and valence perception of positive and negative facial expressions.

To date, we are aware of only two studies that have analyzed and reported on such developmental differences in perceived arousal and valence. The first (Cordon, Melinder, Goodman, & Edelstein, 2013) examined ratings of valence and arousal for a general set of images (objects, faces, scenes, etc.) by 7–9 year old children and adults. The authors found that adults rated images as more negative in valence, and lower in arousal than children. However, due to the use of a broad range of visual stimuli without a separate analysis of ratings for faces, it is difficult to explain the previously discussed differences between children and adults in the ability to identify facial expressions in particular. The second study (Tseng et al., 2014) did indeed collect ratings of arousal and valence from both children and adults using only emotional faces as stimuli. The authors found some differences between typically developing children (7–17 years, mean age = 13.3 years) and adults in arousal ratings, with positive faces in particular eliciting higher arousal ratings from children. However, this broad range of children's ages presents difficulties in linking these findings to the effects observed in specific age-bands (Gao & Maurer, 2010; Rodger et al., 2015). Furthermore, given the relatively high mean age (13.3 years) of children studied by Tseng and colleagues (2014), it cannot be assumed with certainty that their findings would apply in equal measure to younger children.

Therefore, we chose to compare the arousal and valence ratings of adults to those of children who were at least 9 years of age, but no older than 9 years and 11 months. This narrow age-band was chosen because it covers the mid-point of the age range (from 5 years up to 13 years of age) in which Rodger et al. (2015) identified distinct emotion-perception patterns concerning emotional faces compared to adults. This age-band also fits the range of ages studied by Cordon et al. (2013), Gao and Maurer (2010), and Tseng et al. (2014), allowing us to examine the differences between adults and children within the stage of middle-late childhood.

Objective

The present study was carried out to compare in detail the perception of facial expressions along the dimensions of valence and arousal in 9-year-old children and adults. Participants viewed and rated photographs of 24 positive (happy, happy-surprised) and 24 negative (sad, fearful, angry) facial expressions by 8 actors.

In Experiment 1, 9-year-old children and adults rated arousal of each photograph on a 5-point SAM scale. In Experiment 2, a separate group of 9-year-olds and adults rated the valence of the same faces using a 7-point SAM scale.

Experiment 1 – Arousal rating

Method

Participants

The 9-year-old children's group consisted of 30 children (15 girls, 15 boys; mean age = 9 years, 5 months; SD = 3 months). The adult group consisted of 41 students from the University of Giessen (31 female, 10 male; mean age = 27 years, 5 months; SD = 6 years, 11 months).

Most children were recruited through a contact database at the University of Giessen, with a few children being recruited through mailing lists at the University of Marburg. Adult participants were recruited to the experiments through mailing lists at the universities of Giessen and Marburg.

Stimuli

Stimuli consisted of 48 color photographs (24 male, 24 female) of Caucasian adults provided to us by the Pell laboratory at McGill University (Pell, 2005), see Figure 1 for examples. Within each sex category, 12 faces expressed positive emotions (happiness, happy-surprise) and 12 expressed negative emotions (sadness, fear, anger). In total, the experiment contained 12 sad, 6 fearful, 6 angry, 17 happy, and 7 happy-surprise faces. Each of the 8 adult actors (4 male, 4 female) appeared in 6 of the 48 photographs (3 negative, 3 positive). All actors

Figure 1. Examples of positive (top, left to right: happy, happy-surprise, happy-surprise, happy) and negative (bottom, left to right: afraid, sad, sad, angry) faces from the Pell database.

Figure 2. 1–5 SAM scale used for collecting arousal ratings (Bradley & Lang, 1994).

had some theatrical experience and the expression-quality was verified by an identification survey conducted at McGill University, where the faces selected by us were recognized correctly (from a choice of 8 emotions) with an average accuracy of 90.8% (Pell, 2005). The Pell laboratory also provided us with the results of a survey of perceived emotional-intensity by adults for all faces. We used these results in selecting our stimuli to minimize the difference in average intensity between our positive and negative categories.

Procedure

For the group of 9-year-olds, all stimuli were presented in random order on 15.4 in LCD screens using OpenSesame version 2.9 (Mathôt, Schreij, & Theeuwes, 2012).

Participants were asked to indicate their own arousal on a 1–5 SAM arousal-rating scale (Figure 2). Participants had to click on the manikin which they best thought represented their arousal using a computer mouse, and each manikin was also presented with a number underneath (1–5) for additional guidance. Stimuli stayed on the screen until participants made a response, and a pause of 1000 ms followed each stimulus before the next stimulus presentation. Each child participant was given extensive verbal instructions and was trained on the use of the scale by experimenters prior to data collection. Testing took place over one session of approximately 40 min (including instruction).

The adults participated through an online survey platform jointly hosted by the universities of Giessen and Marburg. Adults also viewed each stimulus with the same arousal-SAM scale, and were instructed to select the best fit for their choice of rating.

Data analysis

The rating values for arousal were first tested for Spearman correlation between the adult and children's group using the average (across participants) values for each photograph.

All adults' and children's ratings were then further analyzed in a full-sample comparison using a subject-based repeated-measures ANOVA using SPSS version 22 with several factors taken into account: The age of the participants (2 levels: children and adults), the sex of each participant, and the emotion-category of each stimulus (positive or negative). Age and participant-sex served as between-subject factors, while emotion-category was a within-subject factor. In order to provide a more strict comparison between the age groups, a size-matched version of the same analysis was carried out again with the sample of adult participants reduced to 30 individuals to match the sample of 30 children. All the rating data from the child participants were again used in this analysis, but the adult sample was limited to the first 20 adult female participants and all 10 adult male participants to match the participant sex ratio as closely as possible to the children's sample. This size-matched comparison was carried out for verification purposes only, and only results which were detected as significant in both analyses were considered for discussion. All data shown in figures represent the full sample of ratings from all adult and child participants.

Finally, an analysis was carried out on the standard-deviation measures of each photograph for arousal ratings across all participants to assess the degree of agreement between participants as a measure of the difficulty in judgment for each item: If participants find a stimulus more difficult to assess, we anticipate greater variation in the collected responses. This analysis was carried out as an item-based repeated measures ANOVA design, with individual stimuli serving as the repetition factor, age as a within-factor, and emotion-category as a between-factor.

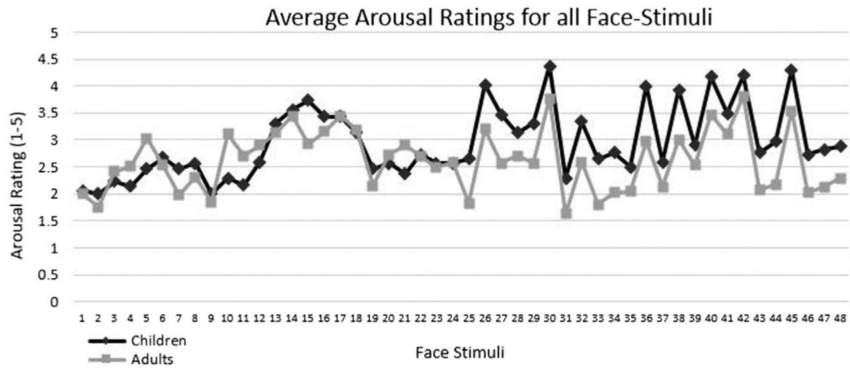


Figure 3. Arousal values for all 48 facial expressions by age (negative faces: 1–24; positive faces 25–48) from all participants.

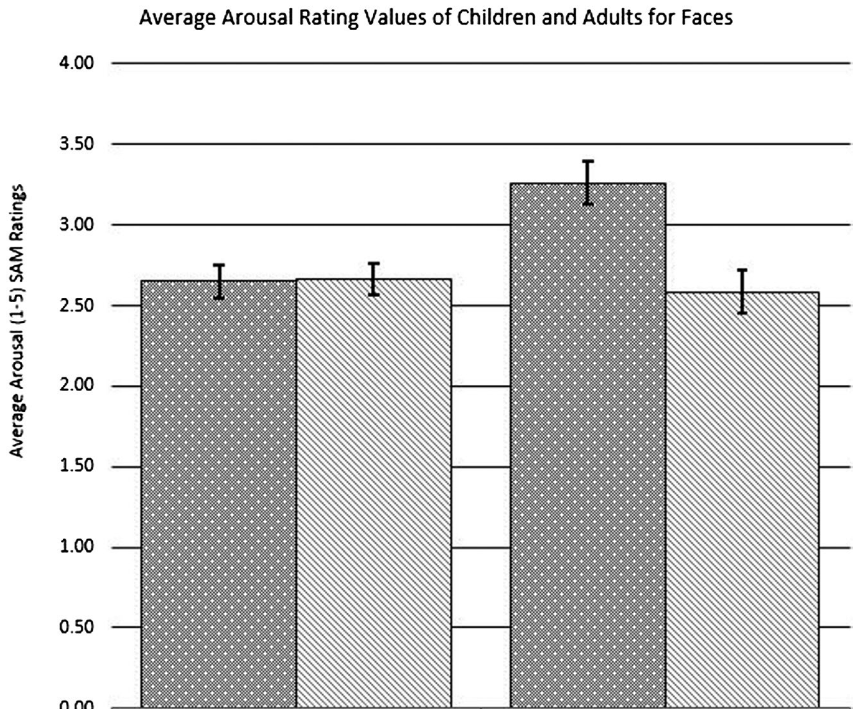
Results

The 9-year-olds' arousal ratings (Figure 3) showed a moderately high correlation to those of adults ($r_s = .654$, $p < .001$, $N = 48$).

A significant main effect of emotion-category, $F(167) = 5.042$, $p < .05$, $\eta^2_p = .07$, was observed in the full-sample ANOVA, with positive faces being rated higher than negative faces. This main effect is more clearly illustrated by an interaction between age and emotion-category, $F(167) = 10.781$, $p < .01$, $\eta^2_p = .139$: While negative faces showed similar arousal ratings in children and adults, positive faces showed significantly higher arousal ratings for children relative to adults (Figure 4) in the full sample analysis. The difference between children and adults in rating positive faces was confirmed to be significant by a *post hoc* *t*-test, $t(69) = 3.648$, $p < .01$, $d = .878$.

The size-matched ANOVA conducted for verification did not confirm the significance of emotion-category main effect $F(156) = 2.675$, $p = .108$, $\eta^2_p = .046$, but did confirm the significance of the interaction between the main effects of age and emotion-category, $F(156) = 11.649$, $p < .01$, $\eta^2_p = .172$. This interaction manifested itself with the same increased arousal rating of positive (but not negative) faces by children compared to adults as in the full-sample analysis, and was likewise further confirmed by a *post hoc* *t*-test comparison of children's and adults' ratings of positive faces, $t(58) = 4.154$, $p < .001$, $d = 1.091$.

The analysis of per-stimulus standard deviation showed a significant effect of age with children showing a more varied distribution of ratings than adults, $F(146) = 12.302$, $p < .01$, $\eta^2_p = .211$. The effect was qualified by a significant interaction between age and emotion-category with negative stimuli showing a greater difference between children's and adults' rating distributions, $F(146) = 24.128$, $p < .001$, $\eta^2_p = .344$.



	Negative Faces	Positive Faces
Children	2.65	3.26
Adults	2.66	2.58

Figure 4. A comparison of children's and adults' arousal ratings for positive and negative facial expressions from all participants. Error bars represent standard error.

Discussion

The high correlation between the arousal ratings of children and adults in the present study confirmed the results of earlier studies that also examined such correlations (Russell & Bullock, 1985; Vieillard & Guidetti, 2009). However, despite this overall correlation we found that children showed some differences in arousal ratings from adults, with these differences varying according to the valence of the stimuli. First, in the analysis of rating values positive faces were perceived by children as significantly higher in arousal than adults, showing a systematic difference in the arousal-perception of positive versus negative faces in children, something not observed in the adult group. Second, in the analysis of standard-deviations negative faces showed a greater within-group rating variation in children relative to adults. This could indicate a greater degree of difficulty in accurately judging the arousal of negative faces for children. This could be interpreted as an indication of a slower maturation process for arousal-perception in negative faces versus positive faces.

Figure 5. 1–7 SAM scale used for collecting valence ratings (Bradley & Lang, 1994).

Experiment 2 – Valence rating

Method

Participants

The 9-year-old children's group consisted of 30 children (16 girls, 14 boys; mean age = 9 years, 9 months; SD = 5 months). The adult group consisted of 160 students from the University of Marburg (138 female, 22 male; mean age = 35 years, 1 month; SD = 12 years, 11 months). The a priori minimum number of participants for each group was set at 24 to ensure sufficient statistical power, and the adult group ended up with a higher sample size thanks to an unusually high response rate to our online invitation to this experiment.

All participants were recruited in a similar manner to those in Experiment 1.

Stimuli

Stimuli consisted of the same 48 color photographs described in Experiment 1.

Procedure

The same procedure was followed as in Experiment 1, but participants now used a 7-point SAM valence-scale (Figure 5) to indicate their perceive valence ratings.

Data analysis

The same data-analysis procedures were carried out as described in Experiment 1. The sized-matched comparison in this experiment used ratings data from the first 15 adult male participants and first 15 adult female participants, as well as all ratings from the 30 child participants. All data shown in figures, as in Experiment 1, represent ratings from all participants.

Results

In the Spearman correlation analysis, the children's valence ratings (Figure 6) showed a very high correlation to those of adults ($r_s = .967$, $p < .001$, $N = 48$).

In the full-sample subject-based ANOVA, we observed a significant effect of age: Though the magnitude of the difference was low (Figure 7), children consistently rated faces as higher in valence (more positive) than adults, $F(1186) = 4.824$, $p < .05$, $\eta^2_p = .025$. We also observed an expected main effect of

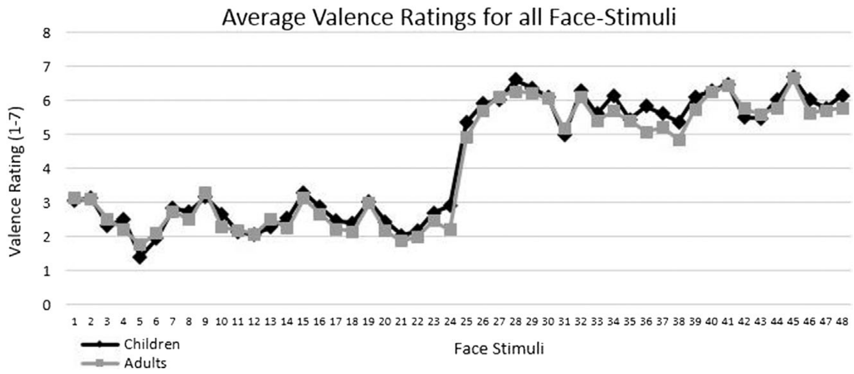


Figure 6. Valence values for all 48 facial expressions by age (negative faces: 1–24; positive faces 25–48) from all participants.

emotion-category, with positive facial expressions being rated higher in valence than negative expressions, $F(1186) = 2539.741$, $p < .001$, $\eta^2_p = .932$.

The size-matched ANOVA carried out for verification confirmed the significance of the main effects of age, $F(156) = 5.983$, $p < .05$, $\eta^2_p = .097$ and emotion category $F(156) = 1647.504$, $p < .001$, $\eta^2_p = .967$, with children rating faces higher in valence compared to adults, and positive faces being rated higher in valence than negative faces as expected.

The analysis of standard-deviations showed no significant effects or interactions (all p values >.161).

Discussion

As with the arousal ratings, we found that the valence ratings of children and adults were strongly correlated, matching the findings of earlier correlational studies that have compared adults' and children's ratings of arousal and valence (Russell & Bullock, 1985; Vieillard & Guidetti, 2009). Additionally, we found that children rated all faces systematically higher in valence (i.e. more positively) than adults. The analysis of standard-deviations showed that the within-group valence rating variances did not differ significantly between children and adults. This is an indication that the overall valence-perception ability of children for faces is nearing adult-like levels by the age of 9.

General discussion

Our study investigated differences in the perception of facial expressions that may occur between middle-late childhood and adulthood. We were motivated by a desire to examine the differences between children's and adults' perception of arousal and valence, as well as the possible connections to results of previous

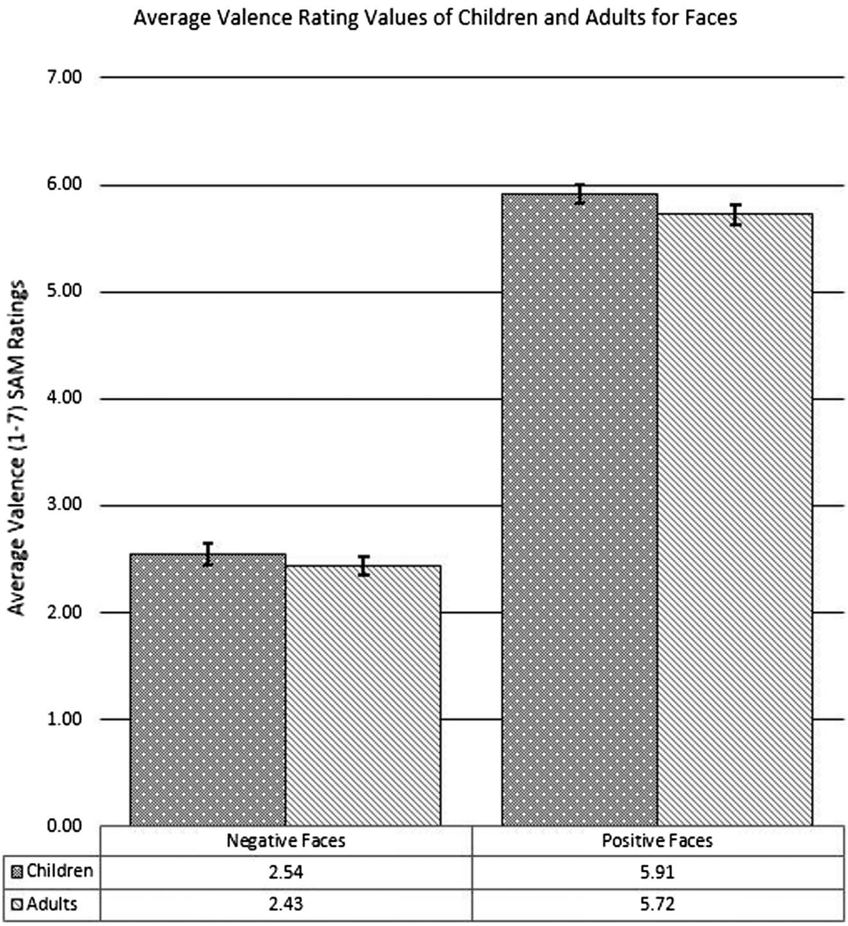


Figure 7. A comparison of children's and adults' valence ratings for positive and negative facial expressions from all participants. Error bars represent standard error.

studies on emotion identification. Several studies have reported high degrees of similarity between children and adults in arousal and valence perception of facial expressions using correlational analyses (Russell & Bullock, 1985; Vieillard & Guidetti, 2009). Meanwhile, other results indicated improvements with increasing age in accurately identifying facial emotions (Gao & Maurer, 2010; Rodger et al., 2015). However, there has been a lack of studies specifically examining facial expressions regarding values of arousal and valence in terms of direct differences, while using age groups similar to the emotion-identification studies mentioned earlier.

Thus, we conducted not only a correlational analysis of arousal and valence ratings of emotional faces, but also analyzed the direct differences in these ratings between children and adults. Despite finding high correlations between children's and adults' ratings in arousal and even stronger ones in valence, there were nevertheless significant differences due to age in both arousal and valence ratings. Namely, children systematically rated all faces as more positive than adults, while positive faces in particular showed much higher arousal ratings by children relative to adults. These findings may thus serve as a connection between earlier reported results of emotion-labeling studies, and what is known about arousal and valence perception, as will be discussed further below.

We observed that children rated facial expressions more positively in valence than adults. This 'positivity' bias might be explained by the everyday environment surrounding young children. We hypothesize that as young children are first cared for by their parents at home, and then attend kindergarten, they would likely encounter a greater proportion of positive faces, as most parents and educators strive to provide a nurturing atmosphere. To our knowledge, there have not thus far been any studies testing such a hypothesis in children past infancy under non-laboratory conditions, but one study (Sugden, Mohamed-Ali, & Moulson, 2014) has examined the characteristics of faces seen by infants during an ordinary day. Data were gathered by analyzing footage recorded by cameras worn by the infants. Analysis of this data indicated that infants are exposed to a greater proportion of positive faces relative to negative ones, suggesting that from an early age children could be developing a positivity bias in perceiving faces (N. Sugden, M. Moulson, personal communication, October 30, 2015).

Perhaps of even greater interest was our observed interaction between age and emotion-category regarding the arousal ratings, indicating that children perceive positive, but not negative, expressions with greater arousal relative to adults. These results allow the findings of Tseng and colleagues (2014) for pre- and post-adolescent children to be extended specifically to younger children in earlier stages of development. The higher perceived arousal for positive faces by young children could explain the processing advantage for positive emotional stimuli observed in children by other researchers (Gao & Maurer, 2010; Rodger et al., 2015): This advantage could result from increased arousal leading to positive faces being processed as a higher priority. Such an explanation is supported by previous observations (Schimmack, 2005; Vogt, De Houwer, Koster, Van Damme, & Crombez, 2008) that arousal drives attention and visual processing priority. Specifically, Schimmack found that regardless of valence, highly-arousing images were the most distracting to participants as they performed unrelated cognitive tasks such as line-detection or answering mathematical questions. Similarly, Vogt and colleagues (2008) found that high-arousal images caused stronger interference in a spatial-cueing task relative to low arousal images, regardless of image valence.

Though it is difficult to identify the cause of this difference in arousal perception with certainty, one explanation could be that the ability of a child to identify a positive face might be advantageous from an evolutionary perspective.

This runs contrary to the negativity bias view supported by studies in adults that negative faces such as those expressing fear and anger possess a processing advantage due to their relevance to survival (Eastwood, Smilek, & Merikle, 2003; Ohman, Lundqvist, & Esteves, 2001). However, one must remember that survival-relevant information to an adult might not be equally relevant to a young child who lacks the physical capability to use this information effectively (e.g. escape from a predator or hostile adult). In fact, even some who argue for a general multi-modal negativity bias acknowledge an early positivity bias in younger children and infants when examining reactions to facial expressions (Vaish et al., 2008). We hypothesize that in terms of evolutionary relevance, it may be crucial for a young child to find an adult that can provide care, protection, and sustenance, a task which could be assisted by the ability to effectively identify positive faces. This hypothesis bears further investigation as past studies that examined the looking preferences of young children and infants have not yet provided a definitive picture. For instance, one study (LaBarbera, Izard, Vietze, & Parisi, 1976) showed that 4- and 6- month old infants display a preferences for looking at happy faces over angry ones. Meanwhile, another study (Peltola, Leppänen, Palokangas, & Hietanen, 2008) found that 7-month old infants showed a looking preference for fearful faces relative to a scrambled control face that was not observed for happy-faces. Therefore, additional looking-preference studies with children past infancy using a full range of emotions will be required to investigate our hypothesis.

Our examination of the response distribution for both experiments also demonstrated that while the valence rating distribution for each item did not vary significantly from participant to participant due to participants' age or emotion-category of stimuli, the arousal ratings did show a significant effect of age (mainly due to higher response distribution for negative stimuli relative to positive stimuli in children). This seems to indicate a more rapid development in the perception of positive stimuli along the arousal dimension. Along with the previously mentioned model of arousal driving attention (Schimmack, 2005; Vogt et al., 2008), our results help explain the findings of other developmental studies (Gao & Maurer, 2010; Rodger et al., 2015) which show improved performance in classifying positive stimuli, despite the apparent conflict with earlier studies that argued for a processing advantage for negative faces in adults.

Limitations

Our study was limited by the inclusion of only a single age-band for children, and future studies with additional children's age groups would be necessary to fully track the development of valence and arousal perception in facial expressions. These follow up experiments could also feature emotion-classification tasks, which could provide additional evidence for the idea of age being the crucial factor in the appearance of emotional positivity biases. Such an experiment would also verify the participants' correct understanding of the emotion portrayed by the stimulus face, and could be a chance to introduce more variety into the category of positive faces with expressions such as calmness. Our study also made exclusive use of adult faces as stimuli, while children learn to interpret emotions from both the faces of adults (starting from observing the faces of caregivers such as the mother) and the faces of other children. Thus, additional research is needed to determine whether our results apply equally to the perception of children's faces.

Conclusions

Our findings show broad similarities in the perception of facial expressions along the dimensions of arousal and valence between children and adults. However, we also found that some emotional facial expressions were differentially perceived in different age groups. Positive faces seem to be perceived as more positive and arousing by children compared to adults, possibly explaining positivity advantages observed in children by earlier studies.

Disclosure statement

No potential conflict of interest was reported by the authors.

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References

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: The self-assessment semantic differential manikin and the semantic differential. *J. Behav. Ther. & Exp. Psychiat., 25*(1), 49–59.

Cordon, I. M., Melinder, A. M. D., Goodman, G. S., & Edelstein, R. S. (2013). Children's and adults' memory for emotional pictures: Examining age-related patterns using the developmental affective photo system. *Journal of Experimental Child Psychology, 114*, 339–356. doi:10.1016/j.jecp.2012.08.004

Eastwood, J. D., Smilek, D., & Merikle, P. M. (2003). Negative facial expression captures attention and disrupts performance. *Perception & Psychophysics, 65*, 352–358. doi:10.3758/BF03194566

Gao, X., & Maurer, D. (2010). A happy story: Developmental changes in children's sensitivity to facial expressions of varying intensities. *Journal of Experimental Child Psychology, 107*, 67–86. doi:10.1016/j.jecp.2010.05.003

LaBarbera, J. D., Izard, C. E., Vietze, P., & Parisi, S. A. (1976). Four- and six-month-old infants' visual responses to joy, anger, and neutral expressions. *Child Development, 47*, 535–538. doi:10.2307/1128816

Leppänen, J. M., & Hietanen, J. K. (2004). Positive facial expressions are recognized faster than negative facial expressions, but why? *Psychological Research, 69*, 22–29. doi:10.1007/s00426-003-0157-2

Mathôt, S., Schreij, D., & Theeuwes, J. (2012). OpenSesame: An open-source, graphical experiment builder for the social sciences. *Behavior Research Methods, 44*, 314–324. doi:10.3758/s13428-011-0168-7

McManis, M. H., Bradley, M. M., Berg, W. K., Cuthbert, B. N., & Lang, P. J. (2001). Emotional reactions in children: Verbal, physiological, and behavioral responses to affective pictures. *Psychophysiology, 38*, 222–231.

Ohman, A., Lundqvist, D., & Esteves, F. (2001). The face in the crowd revisited: A threat advantage with schematic stimuli. *Journal of Personality and Social Psychology, 80*, 381–396. doi:10.1037/0022-3514.80.3.381

Pell, M. D. (2005). Nonverbal emotion priming: Evidence from the "facial affect decision task". *Journal of Nonverbal Behavior, 29*, 45–73. doi:10.1007/s10919-004-0889-8

Peltola, M. J., Leppänen, J. M., Palokangas, T., & Hietanen, J. K. (2008). Fearful faces modulate looking duration and attention disengagement in 7-month-old infants. *Developmental Science, 11*, 60–68. doi:10.1111/j.1467-7687.2007.00659.x

Rodger, H., Vizioli, L., Ouyang, X., & Caldara, R. (2015). Mapping the development of facial expression recognition. *Developmental Science, 18*, 926–939. doi:10.1111/desc.12281

Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology, 39*, 1161–1178.

Russell, J. A., & Bullock, M. (1985). Multidimensional scaling of emotional facial expressions: Similarity from preschoolers to adults. *Journal of Personality and Social Psychology, 48*, 1290–1298.

Schimmack, U. (2005). Attentional interference effects of emotional pictures: Threat, negativity, or arousal? *Emotion, 5*, 55–66. doi:10.1037/1528-3542.5.1.55

Schubert, E. (1999). Measuring emotion continuously: Validity and reliability of the two-dimensional emotion-space. *Australian Journal of Psychology, 51*, 154–165. doi:10.1080/00049539908255353

Sugden, N. A., Mohamed-Ali, M. I., & Moulson, M. C. (2014). I spy with my little eye: Typical, daily exposure to faces documented from a first-person infant perspective. *Developmental Psychobiology, 56*, 249–261. doi:10.1002/dev.21183

Tseng, A., Bansal, R., Liu, J., Gerber, A. J., Goh, S., Posner, J., … Peterson, B. S. (2014). Using the circumplex model of affect to study valence and arousal ratings of emotional faces by children and adults with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 44*, 1332–1346. doi:10.1007/s10803-013-1993-6

Vaish, A., Grossmann, T., & Woodward, A. (2008). Not all emotions are created equal: The negativity bias in social-emotional development. *Psychological Bulletin, 134*, 383–403. doi:10.1037/0033-2909.134.3.383.Not

Vieillard, S., & Guidetti, M. (2009). Children's perception and understanding of (dis) similarities among dynamic bodily/facial expressions of happiness, pleasure, anger, and irritation. *Journal of Experimental Child Psychology, 102*, 78–95. doi:10.1016/j.jecp.2008.04.005

Vogt, J., De Houwer, J., Koster, E. H. W., Van Damme, S., & Crombez, G. (2008). Allocation of spatial attention to emotional stimuli depends upon arousal and not valence. *Emotion, 8*, 880–885. doi:10.1037/a0013981